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Expectations Increase the Benefit Derived From Parafoveal Visual Information in Reading Words Aloud

James L. McClelland
University of California, San Diego

J. K. O'Regan
Centre d'Etude des Processus Cognitifs et du Langage, Centre National de la Recherche Scientifique, Paris, France

We report two experiments demonstrating that a priori expectations and context greatly increase the benefit subjects gain from a preview of a word in parafoveal vision. Subjects named visually presented words preceded by a "preview" stimulus presented in parafoveal vision. When there was no constraint on which word would be shown, the preview had little effect on the time required to name the foveal presentation of the target word. However, when the target was chosen from a constrained set of eight words seen repeatedly by the subject, the preview produced a large naming facilitation. Likewise, when constraints were generated by preceding context, the preview again produced a large naming facilitation. Interestingly, a weak context, which by itself was insufficient to facilitate performance, nevertheless was sufficient to increase the size of the preview benefit effect. The results suggest that subjects are able to take two sources of information, each of which by itself is insufficient to facilitate performance, and combine them in a way that allows them to derive a substantial benefit.

Since the pioneering work of Dodge (1907), it has been observed that a preview of a word presented in parafoveal vision can facilitate the later identification of the word when it is fixated following an eye movement. Rayner (1978) and Rayner, McConkie, and Ehrlich (1978) recently explored this phenomenon using a paradigm in which the preview may or may not be identical to the target word viewed after the eye movement. They found that facilitation was greatest when the preview was identical to the target word, and fell off as the similarity between the preview and the target word was reduced. Even so, there was some facilitation even when most of the internal letters in the preview differed from the target.

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Requests for reprints should be sent to James L. McClelland, Department of Psychology, C009, University of California, San Diego, La Jolla, California 92093.

These preview effects are interesting because they bear on the integration of information over successive fixations in reading. The findings to date suggest that subjects are able to make use of preview information, particularly in the area surrounding the point where the next fixation will fall, to facilitate reading during the next fixation.

To what extent do these "preview" effects depend on the viewer's expectations about which word will be presented? Although it is well known that context improves accuracy in tachistoscopic word identification (Tulving & Gold, 1963) and that it speeds responses in word pronunciation and lexical decision tasks (Meyer, Schvaneveldt, & Ruddy, 1975), it is not known how context interacts with the utilization of parafoveal information to facilitate reading on the next fixation.

At first glance, the Rayner (1978) and Rayner et al. (1978) results appear to indicate that subjects can derive considerable benefit from the preview of a word in the absence on any expectations at all, since there was no context operating in these experiments to constrain which target words might be shown. However, subjects in these studies viewed repeated presentations of the same set of 30 target words, and in many of the experiments there is reason to believe that the subjects were familiar with the list of target words in advance of the experiment. Whether this had any effect on performance was not clear.

The present experiments consider directly the role of expectations in deriving benefits from preview information. In Experiment 1, we demonstrated that the effects obtained in the Rayner et al. (1978) paradigm strongly depend on a subject's expectations about the possible set of target words. We replicated the preview benefit effects obtained by Rayner et al. using a constrained target set, but found much less of a preview benefit when there was no basis for any expectation about which word would be shown. In Experiment 2, we demonstrated that expectations derived from context could also increase the beneficial effects of the preview.

Experiment 1

Experiment 1 compared facilitation from the use of preview information under two conditions. In one condition, the target was always one of eight different words and the preview was either some distortion of the target or a neutral stimulus. In the other condition, the target word was different on each trial of the experiment and the subjects had no prior information about which word would be shown, although they did know that all the words would be five letters long.

One aspect of the procedure was different from that used by previous investigators (Rayner, 1978; Rayner et al., 1978). The previous studies monitored eye position and replaced the preview with the target word only after the apparatus had detected eye movement. In our study, we simulated this sequence of events. We presented the preview for 100 msec, followed by a blank interval of 100 msec, followed by the presentation of the target word in the same location as the preview. These temporal parameters ensured that the subject would not have time to initiate an eye movement before the offset of the preview but would be likely to have enough time to reach the new target position slightly before the presentation of the target.

Our method has the advantage that it is easily adaptable by other laboratories and does not require expensive eye movement equipment; further, it does not interrupt concentration on the task by recalibrations. We show below that the method produces results that are roughly comparable to those obtained when fixations are monitored, and that there is no indication that subjects are failing to comply with the fixation instructions of the experiment.

Method

Subjects. Six volunteer undergraduate subjects received course credit for participating in the experiment, which lasted between 30 and 50 min.

Stimuli. A list of 392 words of five letters was prepared for use in the experiment. All words occurred with frequencies of between 9 and 55 per million in the Kucera and Francis (1967) word count, with a mean frequency of 24.5. Proper nouns, acronyms, obviously foreign words, contractions, plurals, inflected forms, and words containing hyphens were not included. An additional 48 five-letter words with frequencies of between 56 and 74 per million were used for practice.

Design. Each subject participated in two blocks of trials in each of two conditions. In the *no-expectation* condition, the target words used were presented only once each, in random order, and the subjects had no way of anticipating in advance which word would be shown on any given trial. In the *constrained-set* condition, the target word on each trial was a member of a small set of eight alternative words, and subjects were informed that the words would be drawn only from the small set.

For each subject, 8 of the 392 words were selected to be used in the constrained-set condition. Selection was random, with the restriction that all of the words in the set had to begin with a different initial letter. The remaining 384 words in the experimental list were divided into two groups, one for use in each of the two no-expectation blocks for that subject. Thus, for a given subject, the target words used in the constrained-set condition were not seen in the no-expectation condition, and none of the words used in the no-expectation condition were presented more than once.

Each block consisted of 192 trials. A sixth of these were in each of the following preview conditions: In the *word* preview condition, the preview was the target word itself without any distortion. In the *shape–end-letter* preview condition, the preview was a distorted version of the target word in which the second and fourth letters were replaced by another letter with the same "shape." That is, letters with ascenders were replaced by other letters with ascenders, letters with descenders were replaced by other letters with descenders, and "small" letters were replaced by other small letters. Thus, the previews in this condition had the same outline shape and end letters as the target word. In the *end-letter* condition, the same distortions were introduced except that the replacement letter always had a different shape from the original letter. Letters with ascenders or de-

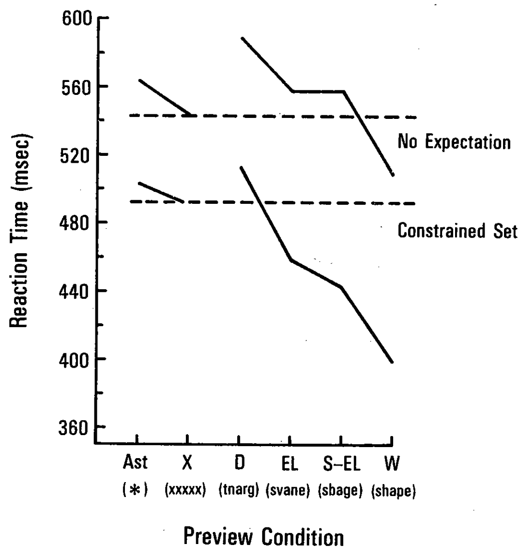

Figure 1. Mean reaction times for vocal naming of the target word as a function of preview condition for the no-expectation and constrained-set conditions. (Ast = asterisk, D = different, EL = same end letters, S-EL = same shape and end letters, W = same word.)

scenders were replaced by small letters, while small letters were replaced by a letter randomly selected from the set of letters with ascenders or descenders. Thus, the end letters were the same as those of the target, but the outline shape of the item was different. In the *different* condition, the first, second, fourth, and fifth letters were different in shape from the corresponding letters in the target word. Thus, the previews in this condition had neither the same outline shape nor the same end letters as the target. Only the third letter was the same as it was in the target word. The above distortions were generated by the computer at run time. It is possible that some of the items so generated might in some cases have been words other than the target word.

Two more control conditions were also included. In the X condition, the preview was simply a string of five lowercase *x*'s. In the *asterisk* condition, the preview was simply a single asterisk presented in the position that would be occupied by the third letter in a word.

Half of the preview stimuli were presented to the left of the fixation point and half were presented to the right. The target appeared on the same side of the fixation point as it did in the preview, so the preview served both as a preview and as a signal for an eye movement.

Each subject received a different random assignment of stimulus materials to conditions, permitting a single *F* test to be used to determine the reliability of the results over the subject and item populations.

Viewing conditions. Subjects were seated in front of a Tektronix 602 oscilloscope, on which all of the displays were presented. A forehead rest bar was used to maintain head position at a distance of 37 cm from the oscilloscope face. Characters were presented in a 7×9 dot matrix font, with the size of the matrix equal to 2.5×2.15 mm, of which .5 mm was blank space between characters. The matrix subtended .33° visual angle in the horizontal dimension. Displays were presented beginning 2.5 character spaces to the left or right of fixation so that the center of the 5-letter target word was 5 character spaces, or 1.67°, from the fixation point. Dim background illumination was kept on throughout testing.

Procedure. Subjects were tested individually in soundproof chambers. At the beginning of the experiment, the experimenter explained the procedure to be followed and illustrated with an example. The practice phase of the experiment then commenced. In this phase of the experiment, target words were each presented only once, as in the no-expectation condition. After 48 trials in the practice phase, there was a short break, followed by the main experiment. This was divided into four blocks, with constrained-set and no-expectation blocks alternating. Presentation of the constrained-set block preceding or following the no-expectation block within each pair was counterbalanced over subjects.

Each trial began with the presentation of a fixation point on the oscilloscope screen. Subjects were instructed to fixate the point and then press a button. The press was followed after 300 msec by the preview stimulus. The preview stimulus remained on for 100 msec, after which there was a 100-msec blank interval. The target item was then presented in the same location as the preview. The target remained on for 1,500 msec, during which time the subject was supposed to read the word aloud. Speech onset was detected by computer analysis of the digitized auditory signal monitored by a microphone positioned in front of the subject. An assistant transcribed all responses and noted any errors or false starts. Errors and false starts occurred in fewer than 2% of the trials, and in another 1% of the trials the response failed to reach the criterion of the speech onset detection software. Results from such trials were excluded from the analysis.

Subjects were instructed to fixate on the fixation dot and then make an eye movement to look at the preview when it appeared. Subjects' eye movements were not recorded, but our own experiences as subjects as well as our observations of naive subjects suggest that the instructions are extremely natural, and subjects find it easy to conform to the requirements of the task.

Before the beginning of the first block in the constrained-set condition, the subjects were informed that a small set of words would be used repeatedly in the block. They were told the same thing before the second block. The same list of eight words was used in both blocks.

Results

Mean reaction times for each preview condition in both the no-expectation and the constrained-set conditions are shown in Figure 1. The results indicate that the benefit extracted from a preview related to the target was greatly increased in the constrained-set condition. Analysis of variance revealed significant main effects of expectation condition and preview condition as well as an Expectation Condition × Preview Condition interaction ($p < .005$ in each case). The presentation position factor did not interact with the other factors, and produced only a 3-msec advantage for items presented to the right of fixation, which approached significance only because of the very small size of the associated error term, $F(1, 5) = 5.97$, $p < .06$, $MS_e = 46$.

The control conditions differed slightly, with faster reaction times in the X condition compared with the asterisk condition. A subanalysis of variance including only the two control conditions at the two levels of expectation revealed that the difference between the control conditions was significant, $F(1, 5) = 34.13$, $p < .002$, and did not reliably interact with expectation condition. We used the X condition as a baseline to assess the costs and benefits to target-naming time of the other four preview conditions. A discussion of this assumption is presented in the Discussion section that follows.

Separate analyses were carried out on the results of the constrained-set and no-expectation conditions to obtain error terms for use in the examination of differences between the X condition and the remaining conditions. Using the X baseline, we reached the following conclusions: In the no-expectation condition, only the word condition showed any significant facilitation (Dunnett's test, $p < .01$). In the constrained-set condition, on the other hand, the end-letter, shape–end-letter, and word conditions all showed significant facilitation (Dunnett's test, $p < .01$). The *different* preview condition seemed to produce some interference compared with the X control, but this was statistically reliable only in the no-expectation condition. However, a subanalysis of the X condition versus the Different Condition × Expectation Condition produced a significant main effect of the preview condition, $F(1, 5) = 15.01$, $p < .01$, and the interaction was not significant, $F(1, 5) = 1.89$, $p < .227$.

Discussion

Experiment 1 replicates the findings of Rayner et al. (1978) with respect to the facilitation produced by a preview that includes the target word or a distortion of that word involving only internal letters. However, the replication holds only in the constrained-set condition. When the experiment placed few restrictions on subjects' expectations of what the target word might be, there was slight facilitation only for the word preview condition. This strongly suggests that expectation plays a role in conferring benefit from preview information in reading.

Our data demonstrate that it is not necessary to monitor eye movements to study integration of information over successive fixations. Indeed, Rayner et al. (1978) show that it is not even necessary to have the subject make an eye movement. In a condition in which the preview was presented in the periphery but the target was presented at the fixation point, they obtained data very similar to those produced in their eye movement condition. In unreported experiments we compared the performance of two groups of six subjects, one receiving our version of the eye movement condition and the other receiving a condition in which the target was presented at the fixation point. We likewise found no differences between the two conditions, either with or without a constrained target set. Both groups produced data quite similar to those shown in Figure 1.

Our results do not give any indication that subjects are failing to abide by the fixation and eye movement instructions, thereby invalidating the experiment. First, we found no indication that subjects were simply looking at one of the previews and ignoring the other. The overall left–right difference of only 3 msec, coupled with the lack of any interaction of the preview or expectation condition with the visual field, suggests that, on the average at least, our subjects did not strongly favor either side. Second, examination of the results of individual subjects failed to reveal any indication of a systematic bias to the left on the part of some individuals and to the right on the part of others. The possibility remains that subjects randomly picked a side to attend to on each trial in the experiment, switching back and forth from left to right of fixation. Although this may have happened sporadically, we doubt from observation of the subjects that they were following this strategy any significant amount of the time. Further, the fact that we obtained approximately the same results whether the target was always presented over the fixation point or in the position of the preview also argues against this possibility, for when the target is presented at the fixation point subjects quickly adopt the strategy of remaining fixated on the fixation dot to facilitate processing of the target.

Perhaps a word should be said about our use of the X condition as a baseline. The X preview strikes us as superior to the asterisk preview for several reasons. First, just in terms of total stimulus luminance, a row of *x*'s is more comparable to a row of letters than to a single asterisk. Second, the row of *x*'s has the same word length as the target, and so may serve as a better cue for optimal positioning of the eye to view the subsequent presentation of the target. While the preview of the *x*'s is of course considerably more wordlike than the preview of the asterisk, neither provides any information suggesting anything about the subsequent word to be shown. For these reasons, the X preview appears to provide a better baseline for examining the effects of other five-letter preview types than does the asterisk preview.

The difference in performance between the constrained-set and no-expectation conditions calls out for interpretation. However, a more empirical issue will be addressed first: Could constraints imposed by linguistic context also increase the benefits of the preview? Experiment 2 examined this question.

Experiment 2

In this experiment, constraint on the target word was provided by an incomplete sentence context presented before the fixation point. In the no-expectation condition, the incomplete sentence was the unconstraining phrase "The next word will be. . . ." In the constrained-set condition, the incomplete sentence permitted the subject to generate some expectations about what the final word in the context might be, and the target word was always a reasonable and appropriate completion of the context sentence. The constraining contexts were subdivided into one subset containing those which subjects tended to complete with the actual target word or a word closely related to it and another subset containing those contexts that tended to suggest some other word or words even though the target was generally viewed by the reader as acceptable in the context. To keep the total number of conditions in the experiment manageable, only three preview conditions were used: the word condition, the shape–end-letter condition, and the X condition.

Method

Subjects. Twelve new subjects from the pool used in the first experiment participated for pay or credit.

Materials. A total of 400 sentences were used in the study. Each sentence contained from four to eight words, and in each case the final (target) word was either five or six letters long, occurred between 10 and 19 times per million in the Kucera-Francis (1967) word count, and conformed to the other constraints on target words applied in Experiment 1. A group of 12 judges read all but the last word of each sentence on a computer terminal and then guessed a word to complete the sentence. Then the actual final word was shown, and the subject had to rate the relation of the word shown to the word guessed. A rating of 5 meant that it was the same word, 4 a synonym of the same word, 3 a word related to the guessed word, 2 that the word guessed was different from the word shown but that the word shown nevertheless served as an adequate completion of the sentence, and 1 that the subject did not even find the word shown to be an adequate completion. The 144 sentences with the highest mean ratings (3.67–5.00, $M = 4.18$) were placed in the strong-context group while the 144 sentences with the lowest mean ratings (1.67–3.00, $M = 2.61$) were placed in the weak-context group. The remaining 112 sentences (representing the middle of the distribution) were used for practice. Since running the experiment, we presented the context sentences from the high- and low-constraint groups to 15 subjects and simply asked them to guess the word they thought might have completed the sentence. Probability correct was 10% for the low-constraint contexts and 37% for the high-constraint contexts.

Design. Each subject received 24 sentences from each of the strong- and weak-context groups in the six conditions resulting from the factorial combination of the three preview conditions with the neutral- and constraining-context conditions.

In the constraining-context condition, the target presentation was preceded by the sentence context rated previously by the judges. In the neutral-context condition, the preview target presentation was preceded by the context "The next word will be. . . ." The three preview conditions had the following characteristics: The word preview was, of course, just a preview of the target word itself. In the shape–end-letter condition, the second and next-to-last letters of the target were replaced by other letters of the same shape (as defined for Experiment 1). In the X condition, each letter was replaced by a lowercase *x* so that there were as many *x*'s as letters in the actual target word.

Within the strong- and weak-context groups, sentences were assigned randomly to context and preview conditions. This random assignment was repeated for each subject in the experiment so that each subject received a different assignment of particular sentences to conditions, combining subject and stimulus item effects in the same error term.

Procedure. The procedure was identical to that of Experiment 1 except for the following changes. First, all trial types were mixed together in one long list, with a break after the end of the practice period and another after half of the test trials were completed. Second, the trial then began with a presentation of the context (either the actual sentence, leaving out the last word, or the neutral context). Subjects were given as long as they wished to read the context and were told that it was important for them to try to comprehend the meaning of the sentences, but they were encouraged to try to read the sentences naturally and not to try to make explicit predictions about the possible identity of the target word. When the subject finished reading the context, he or she had to press a button that initiated the fixation–preview–target sequence just as in Experiment 1.

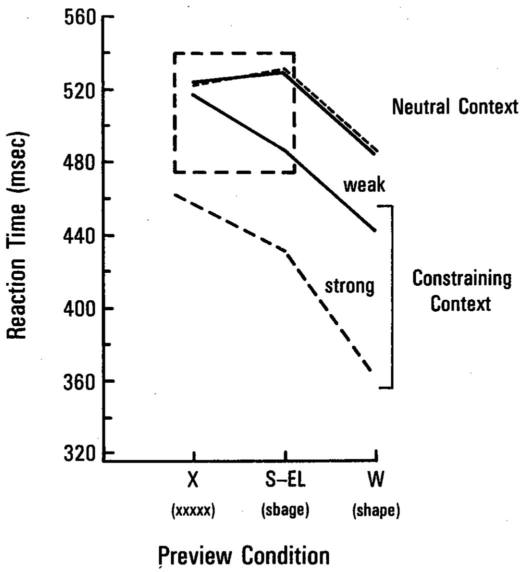

Figure 2. Naming time results for Experiment 2. (S-EL = same shape and end letters, W = same word.)

Results

Naming times for items in the strong- and weak-context conditions, by context and preview conditions, are shown in Figure 2. An analysis of variance revealed that the main effect of the neutral condition versus the constraining-context condition was reliable beyond the .001 level, as was the main effect of preview conditions. The interaction of these two factors was also reliable beyond the .001 level. The presentation position factor (left vs. right) produced a marginally significant 11-msec advantage for the right visual field, $F(1, 11) = 5.18$, $p < .05$, and had no significant interactions. Thus, although this experiment seems to have produced a slight bias favoring targets presented in the right visual field, there is no indication that the effects of interest came only from stimuli presented on one side of the fixation point.

In the no-context control condition, the reliable main effect of preview condition, $F(2, 22) = 14.95$, $p < .001$, resulted from the fact that only the word preview produced benefit compared with the X preview (Dunnett's test, $p < .01$). The shape–end-letter and X conditions produced about the same mean reaction times, with no significant difference ($p > .1$). There was no main effect for whether the word came from a strong or a weak context and no interaction of this factor with preview condition (all *F*s < 1), so there was no indication that the different target words used in the strong- and weak-context conditions were intrinsically different in the way they benefited from the preview.

The pattern of results is quite different in the constraining-context conditions. Collapsing over strong and weak contexts produced an overall preview effect that was highly significant, $F(2, 22) = 69.23$, $p < .001$. There was benefit both for the word preview and the shape–end-letter preview over the X preview (Dunnett's test, $p < .01$). The benefit of the word preview over the shape–end-letter preview was also significant ($p < .01$). The two levels of context strength differed mainly in that the stronger context produced much faster reaction times overall: The main effect of context strength was highly significant, $F(1, 11) = 81.08, p < .001$. In addition, the preview benefit may have been slightly greater for high-constraint than for low-constraint items: The interaction of the strong versus the weak constraining context by preview condition approached significance, $F(2, 22) = 3.32, p = .055$.

The comparison of the weak-context condition against the no-context control is particularly interesting (see box in Figure 2). Considering just the X and shape–end-letter previews for the two context conditions, we find a highly reliable interaction, $F(1, 11) = 7.45, p < .02$. The weakly constraining context followed by the X preview did not produce any benefit compared with the neutral context followed by the X preview, $F(1, 11) = .47, p = .507$. Thus, weak context by itself does not appear to provide enough information to facilitate naming. Looking at the neutral-context control condition, we find that the shape–end-letter preview by itself is likewise insufficient to produce any benefit compared with the X preview when there is no context, $F(1, 11) = .16, p = .694$. But when the shape–end-letter preview is combined with the weak context, a significant benefit is obtained, either compared with the weak context and the X preview, $F(1, 11) = 14.94, p < .003$, or compared with the neutral context and the shape–end-letter preview, $F(1, 11) = 12.16, p < .005$. Thus, it appears that two weak sources of information, each of which individually is insufficient to facilitate naming, can produce facilitation when they are combined.

General Discussion

Our findings demonstrate that some prior expectation about which word will be next to fall across the fovea is necessary to obtain a facilitation of naming reaction time from the presentation of a preview in parafoveal vision. In Experiment 1, these expectations were manipulated by simply repeating the same items over and over again in one condition while selecting words at random from a much longer list and presenting them only once each in the other condition. In the former condition, the constrained target set condition, a preview of the actual target word facilitated naming the word on later foveal inspection by about 100 msec compared with a baseline preview consisting of a row of *x*'s. A preview consisting of the first, third, and fifth letters from the actual target word with shape-preserving distortions of the second and fourth letters produced a facilitation effect of about 50 msec. Even when the distortions of the second and fourth letters were not shape preserving, there was some facilitation.

These results contrast sharply with those obtained in the condition where the subjects could not reasonably have had any particular expectations about which target word might be shown. Under these circumstances, the actual target word did produce some facilitation when presented in parafoveal vision, but the shape–end-letter and end-letter conditions produced, if anything, a slight inhibition.

In Experiment 2, we demonstrated that the same effects could be produced by manipulating expectations through the use of context. As in Experiment 1, we obtained a large preview facilitation effect for words that were expected, in this case as a result of a prior partial sentence context. Both the same word in parafoveal vision and a changed version preserving the end letters and overall word shape led to facilitation compared with the row of *x*'s presented as a preview. Again, when there was no basis for an expectation, there was only a weak facilitation when the same word was presented in the periphery and no facilitation for the changed version. The pattern of results is particularly interesting in the case of expectations generated by the low-constraint context sentences. Here, we found that the context alone failed to produce any reliable facilitation and that the shape–end-letter preview alone also produced no facilitation, but when the shape–end-letter preview was presented following the presentation of the context, context and preview worked together to produce a reliable facilitation effect.

These results have several important implications for theories on the nature of the use of preview information in reading. First, we can observe, as Rayner (1978) and Rayner et al. (1978) have done, that subjects seem to be sensitive to information derived from all of the letters in a word presented in parafoveal vision. This appears to be true either with or without prior expectations, since in both cases subjects named the target word faster when it was preceded by the actual target word compared with a distortion that differed from the target only in internal letters but left the word with the same shape. Indeed, it would appear that sensitivity to the visual detail present in the parafoveal display is not what is primarily affected by prior expectations.

It does appear, however, that the ability to derive benefit from preview information is affected by these expectations, since a preview that facilitates performance when some information is available constraining the possible identity of the target can fail to facilitate performance in the absence of constraining information. Indeed, the point could be turned around: Our experiments show just as clearly that the ability to derive benefit from contextual constraints is facilitated by a preview. This is particularly clear in Experiment 2, where the weak context produced no advantage over a neutral context when the preview was an uninformative row of *x*'s but produced a sizable advantage when the preview was similar or identical to the target word.

How can we account for the fact that two weak sources of constraint, neither of which facilitated performance by itself, could nevertheless work together to produce facilitation? One possibility is that a single weak source primes not only the target but other possible words as well, and that these spurious alternatives tend to neutralize in some way the benefit that would be produced by the target word. A second weak source of constraint might by itself tend to have the same effect, but when combined with the first, the two sources of constraint would tend to pinpoint the target word, each canceling the other's effects on spurious alternatives.

To make this suggestion concrete, it can be framed in the terms of a variant of Morton's (1969) logogen model of word recognition. The logogen model assumes that logogens accumulate excitation from both contextual and sensory input and that the preview simply acts as a preliminary source of sensory input to logogens. Each logogen is assumed to have a resting activation level prior to the influence of context, item repetition, and preview. In the present version of the model, the input arising from the preview tends to excite (to varying degrees) logogens for words visually similar to the target and to inhibit logogens for words that are very different from the target. Likewise, input arising from context tends to excite logogens for words that are related to the context and to inhibit logogens for words that are completely different. In addition to these influences, logogens whose activations pass what we might call an "interaction threshold" value tend to inhibit all other logogens (Grossberg, 1978). We can capture this idea by setting the resting level of all of the logogens to a value below zero and using zero as the threshold value. Thus, logogens with positive activation (henceforth simply called "active logogens") tend to inhibit all other logogens. A given logogen, then, receives input from context, from the preview, and from the set of other active logogens. To keep matters simple, let us assume that these inputs act to determine a base activation on which the activation produced by the presentation of the target in the fovea is superimposed. The foveal target presentation then acts to drive up the activation of the logogen for the target word. Finally, the activation of the logogen reaches an output threshold and triggers an overt response. Thus, the more strongly the logogen for a target word is preactivated as a result of preview and contextual influences and the less strongly logogens for other words are activated, the less time it will take for the presentation of the target word to drive the logogen to a level sufficient to trigger a response.

In essence, the model says that the preview and the context will fail to produce a preview benefit if the direct excitatory effect of the context and the preview on a particular logogen is less than the inhibition generated by spurious activation of other logogens.

Let us examine, in this light, the separate and joint effects of a weak context and a shape–end-letter preview obtained in Experiment 2 (see box in Figure 2). First, consider what might happen when a shape–end-letter preview is presented without any prior context or repetition of the target word. This preview will tend to weakly activate the logogen for the target word and will also tend to weakly activate the logogens for several other words. Most words, of course, will receive inhibition because they will be very dissimilar to the preview, but on the average, a few may be similar enough to receive some activation. Thus, the excitatory effect of the preview on the target will tend to be canceled by its indirect inhibitory influence resulting from the excitation of other logogens.

Now consider the effect of a context that only weakly suggests a particular target word. The target in question will receive some direct activation, but several other words will also receive activation from the context. Once again, of course, most words will be incompatible with the context, but we are assuming that there will be some that are compatible with words other than the target word. These words, then, enter the active state as a result of the context alone and tend to cancel the direct excitation of the target logogen. Now finally consider what would happen when this weak contextual input is combined with the shape–end-letter preview input discussed above. Since words that are semantically related to a context are not, in general, visually similar to each other in any particular way, it is likely that in most instances the only word that will receive excitation from both the context and the preview will be the target word itself. Those that would have been excited by the context will be inhibited by the preview, and those that would have been excited by the preview will be inhibited by the context. Thus, both sources of pretarget input have the effect of combining the benefits of each source while at the same time eliminating the costs. It is for this reason that two influences, each of which in isolation is insufficient to produce a benefit, can nevertheless produce a sizable benefit when combined.

The preceding discussion presupposes that the X preview acts as a neutral preview, neither exciting nor inhibiting the logogens of any words. While this seems somewhat unlikely, it is possible that subjects learned to ignore it. In debriefing sessions, many of the subjects noted that they could recognize the row of *x*'s when it occurred.

The remainder of the results of Experiment 2 need little further discussion. The advantage for the word preview over the shape–end-letter preview, visible in all conditions, suggests that the former activates the target logogen more strongly than the latter, as we would naturally expect. The magnitude of this effect is about the same in all context conditions, although it may be somewhat larger in the strong-context condition than in the neutral- or weak-context condition.

It is possible to flesh out our model to provide a full account for the results of Experiment 1, but it is not particularly satisfying to do so because there are too many unknowns. However, one or two points are worth noting. In this experiment, we found that a preview that was very different from the target could actually interfere with the report of the target word. Our model accounts for this fact by supposing that the different-shape preview has two separate effects: (a) to directly inhibit the logogen for the target word and (b) to excite logogens for other words, thereby interfering with the correct logogen. According to this account, we would expect the interference to be less in the constrained-set condition because the set constraint manipulation would act to keep the preview from activating logogens for words not in the set above the interaction threshold, and would also tend to suppress activation of most of the words in the small target set. Although the interference effect is smaller in the constrained-set condition (20 msec, as compared with 40 msec in the no-expectation condition), the difference in the size of the effect is not statistically reliable, so the evidence on this point is somewhat equivocal.

There are a few reasons to suppose that the model we have described is an oversimplification. First, Schiepers (1980) has recently shown that the time course of accumulating information from parafoveal vision is slower than the time course of accumulation from the fovea, at least in the sense that the time it takes to correctly recognize a parafoveal presentation of a word is longer than the time it takes to correctly recognize a foveal presentation. This fact suggests that the preview does not so much act as a static base activation but, rather, as one that is influencing the logogens dynamically at the same time that they are being influenced by direct perception of the target at the fovea.

Second, the model assumes that inhibition drives the activation of the unit down below its resting level as strongly as the equivalent amount of activation drives it up. This may not be the case. In fact, it is possible that there is a floor activation level for units that is not far below their resting activation level.

Third, the assumption that the X preview has no excitatory or inhibitory effects may also be an oversimplification. Perhaps a more sophisticated version of the model could be formulated in which the X preview had some inhibitory effect on all of the logogens that could be compensated by some process that reset the baseline in some fashion.

There are also other models that might be formulated to account for these results. We formulated this model in terms of activations of logogens, but it could equally well have been formulated in terms of activations of responses. Indeed, our data do not really specify where in the processing system the effects of context and preview are combined, nor do they specify whether priming affects the perceptual decision process or the actual formulation of an overt response. It could well be, for example, that effects of context and preview combine in a set of logogens dedicated to visual word recognition, and that these effects are propagated through to a response preparation process, even before there is decisive information in the visual logogen system favoring any particular word response.

While the details of an adequate model of the combined effects of a preview and a context remain to be clarified by further research, our experiments have clarified one point: The ability to derive benefit from the preview we receive of upcoming words in parafoveal vision depends on a prepared mind.

An important empirical question is: To what degree can the mind be prepared by context in the actual process of reading? On the one hand, the reader usually does not have the chance (or at least does not take the opportunity) to pause and reflect on the context for a second before viewing the preview, as did our subjects in Experiment 2. For this reason, it is possible that our experiment allowed subjects to make better use of context than they would normally be able to do in reading. On the other hand, readers are usually engaged in reading connected passages of prose rather than discrete sentences, and they may have time, at least once they are a little way into what they are reading, to generate general expectations about the overall subject matter. Perhaps the continuity of a passage would permit a reader to maintain at least weak constraints on what words might be coming along next, even when reading at a fairly constant rate. Indeed, Rayner (1975) reported results analogous to the results of our expectation condition in an experiment investigating fixation time as a function of preview target similarity during paragraph reading. In conjunction with our findings that some expectations are necessary to obtain a preview benefit effect, Rayner's (1975) results seem to suggest that expectations do function to facilitate the use of preview information in actual reading. It is also possible that expectations about the occurrence of such frequent and predictable words as articles and conjunctions could be quickly generated during the process of reading. O'Regan (1979) has reported results indicating that subjects skip over such words when they are presented in parafoveal vision within short sentences. It would be interesting to determine the extent to which this effect depends on constraints generated as a result of processing the immediately preceding context.

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