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Context and the Allocation of Resources in Word Recognition

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Three experiments are reported that investigate the effects of context on the use of limited processing resources in word recognition. On each trial in all of the experiments, the subjects were presented with an incomplete sentence followed by a target display containing a word and two digits. In all cases, accuracy at reporting the word was affected by context, as expected. The effect of context on processing resources was examined by considering the accuracy of reports of the digits in cases in which the word did or did not fit the context. Accuracy of digit report was greater for digits surrounding words in related context, but only when the subjects were required to report the word before reporting the digits. There was no effect of word context on the digit report when subjects had to report the digits first. There was likewise no effect on accuracy of digit report when subjects were required to report only the word or only the digits, even when the cue was presented 250 msec after the target display was replaced by a patterned mask. The results suggest that the effect of context on the resources consumed in word recognition is restricted to aspects of processing that can be delayed until the subject is required to select an overt response, and a simple interpretation of the results may be given in terms of a slight modification of Morton's model of the interaction of stimulus information and context.

It is a well-known fact that context facilitates the tachistoscopic identification of words (Tulving & Gold, 1963; Tulving, Mandler, & Baumal, 1964). This effect is consistent with a wide range of current models of word recognition within the context of the reading and listening processes (Becker, 1976; Forster, 1976; Marslen-Wilson & Welsh, 1978; Morton, 1969; Rumelhart, 1977). An important unresolved issue, however, is the role of context in modifying the attentional demands of word recognition. Does the presence of related context permit the recognition of a word with less expenditure of limited-capacity processing resources (Norman & Bobrow, 1975)? If so, to what aspects of the processing of the word do these limited-capacity resources apply? In the present series of experiments, we hoped to begin exploring this question by examining accuracy of performance on a secondary task under conditions in which the primary task required processing of briefly presented words in related and unrelated contexts.

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Experiment 1

The logic of Experiment 1 is simple. If context permits the identification of a target word with a lesser expenditure of resources, then there should be processing capacity left over to perform a secondary task when target words are shown in related context.

Therefore, the facilitating effect of context should not be restricted to the target word itself but should spill over to affect accuracy in identifying unrelated material presented in the same display as the target.

In this experiment, the context was provided by an incomplete sentence. The target display, which followed the presentation of the context sentence, contained a word surrounded by two digits. The target word either provided a good ending to the context sentence (related context condition) or did not make any sense with the rest of the sentence (unrelated context condition). The task required that the word and then the digits be reported.

Whether or not context can free resources, the word report should be more accurate in the related than in the unrelated context condition. However, the digit report should also be more accurate in the related context condition if fewer limited processing resources are consumed when the word is presented in related context.

Method

Subjects. Twelve undergraduate subjects with normal or corrected-to-normal vision participated for course credit in one session lasting approximately 1½ hr.

Stimuli. Eighty sentences ending with a six-letter word were constructed. The sentences were designed so that the last word would be highly congruent with the context and, in fact, predictable a reasonable proportion of the time. For example, one of the sentences used was "The avid photographer will go nowhere without his camera." Each of these sentences was typed on a separate card with the last word missing. The sentences were arranged so that they would appear at the top of one field when inserted in the tachistoscope.

Each of the 80 target words was typed on a separate card, surrounded by two different randomly selected digits from the set (2, 3, 4, 5, 6, 7, 8, 9). The digits were typed three spaces to the left and to the right of the word so that the entire target display was 12 characters long. When presented tachistoscopically, the target display appeared in the middle of the field and subtended 1.75° of visual angle.

Design. The word–digit targets were paired with the context sentences so that in half of the pairs, the target word was the correct ending of the context sentence. In the other half of the pairs, the target word and the context sentence were repaired by random reassignment of final words to preceding contexts with the constraint that the resulting context–word pairs were all anomalous. Each subject saw all 80 pairs once, so that for any given subject, each word–digit target appeared either after a related or an unrelated context. Words presented in related context for half of the subjects were presented in unrelated context for the other half and vice versa, so that each target appeared equally often in both related and unrelated contexts across subjects.

Procedure. A trial began when a context sentence appeared in the pretarget and posttarget field, above a patterned mask consisting of three contiguous rows of 30 characters formed by superimposing uppercase Xs and Os. The subject was asked to read the sentence out loud and then to fixate on the center of the mask and press a key. The key press triggered the offset of the mask and the onset of the target display, which was centered in the area occupied by the mask. The exposure of the word–digit target was immediately followed by the reappearance of the pretarget and posttarget field containing the mask and context sentence.

On each trial, the subjects had to give four verbal responses. They were asked to identify the word, then the left and right digits. A response had to be made for each stimulus on each trial, even if it was a guess. The responses had to be made in the previously mentioned order because the scoring of the digit reports was position specific. No feedback was given concerning the accuracy of any of the responses. Finally, the subjects also rated their confidence in the preceding word report. The confidence ratings were made on a 3-point scale ranging from A, which meant "I am sure of my response," to C, which meant "My response was a total guess." The rating procedure was intended to address issues different from those central to this article and will not be reported.

Eighty practice trials were used to find an exposure duration at which the subject performed near the 50% correct level on the word report, averaged over the two context conditions. Threshold values were determined with a modified staircase procedure, working downward from a starting duration of 100 msec in small steps until the subject began to make errors, then adjusting as required after every fourth trial. No context sentence was presented to the subjects for the first 40 of these 80 practice trials. For the remaining 40 trials, an equal number of word–digit targets were presented following a related and an unrelated context sentence. None of the stimuli used during these practice trials were presented as test stimuli.

The 80 test trials immediately followed the practice trials. They were arranged in two blocks of 40 so that an exposure duration adjustment could be made between blocks, if necessary, based on overall accuracy reporting the words in the first block. An equal number of related and unrelated context trials were mixed together within each block.

Results

Word report. The context sentences used in the experiment produced a large

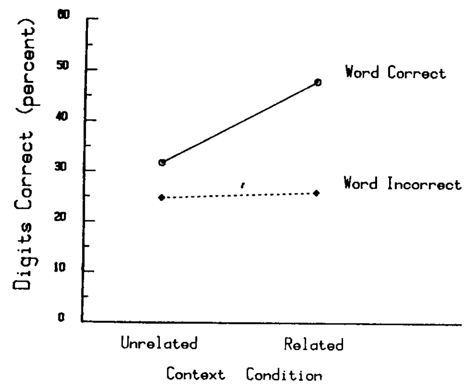

Figure 1. Proportion of correct digit reports for words presented in related and unrelated context, broken down separately for reports of digits following correct and incorrect reports for the target word.

effect on the word report. The words were identified with 75% accuracy when they were related to the context sentence. By contrast, the accuracy level was only 39% when the words followed an unrelated context. The difference was highly significant, $F(1, 11) = 112.0, p < .001$.

Digit report. The subjects were also able to report the digits more accurately when the word–digit target had appeared in related context. The proportion of correct digit reports was 43% in the related context condition versus 28% in the unrelated context condition, $F(1, 11) = 31.1$, $p < .001$. The proportion of correct reports was the same for the digits located to the right and to the left of the word (36% and 35%, respectively), $F(1, 11) < 1$, and there was no interaction between context and digit position, $F(1, 11) < 1$.

These results suggest that the context did affect the resources allocated to the digit identification task. However, this pattern of results could be obtained if the amount of resources available to the digit identification task were determined solely by the accuracy of the word report. This interpretation assumes that it is easier to report the digits when the accompanying word is correctly reported than when it is not. Since there are more trials in which the word is correctly reported in the related context condition, more digits would also be accurately reported in the related context condition.

Conditional digit report. To test the preceding interpretation, the proportion of correct digit reports was computed separately for each context condition for the trials in which the accompanying word was correctly reported and for the trials in which the word was not correctly reported. The results are shown in Figure 1.

The figure indicates that the accuracy of digit report is greater with correctly identified words in related context than with correct words in unrelated context. This fact suggests that, indeed, the correct identification of a word in related context requires less resources than correct identification in unrelated context. When the word is incorrectly reported, on the other hand, digit report accuracy falls to a uniform low level, and there is no effect of the context manipulation. As we would expect, when the target word is not identified, the relatedness of the context to the target word is ineffectual. These findings were supported by statistical analyses as follows: Analysis of variance revealed main effects of context and of word accuracy, $F(1, 11) = 13.8, p < .01$, and $F(1, 11) = 28.4$, $p < .001$, as well as an interaction of these factors, $F(1, 11) = 4.87, p < .05$. Tests for simple main effects showed that the effect of context was reliable for correct words but not for incorrect words.

Discussion

The results of Experiment 1 show that the word and digit report tasks did share some resources and, more importantly, that context had some effect on the allocation of these resources. The superior digit report performance that was obtained in the related context condition, when the word had been correctly reported, indicates that the digit identification task benefited from extra resources freed by the presence of related context. Some aspect of the processing involved in identifying the word correctly must have consumed more resources when the word was preceded by an unrelated context than when the word was related to the context. The digit report performance was poorest when the word was not correctly identified. Apparently, the fewest resources were allocated to the digit identification task when all resources available for word identification were still insufficient.

Experiment 2

Do the results of Experiment 1 depend on the requirement that the subject report the word before the digits? To get evidence on this point, we replicated Experiment 1, this time adding a manipulation of the order of report. In one half of the trials, the subjects reported the words first, as in Experiment 1; in the other half they reported the digits first.

Method

Subjects. Sixteen subjects naive to the purposes of the experiment participated for pay in one session lasting a little over 1 hr. The data of 4 of the subjects were rejected because when these subjects reported the word first, they performed with an accuracy level that was not between 30% and 80%. This accuracy range was chosen because it corresponds to the one that had been obtained in the first experiment.

Stimuli. A new set of 80 sentences was used, including some that had been used in the previous experiment. The new sentences ended with a word composed of from 3 to 10 letters. As previously, the digits appeared three spaces on each side of the target words. Because of the varying length of the target word, the entire word–digit display subtended between 1.3° and 3.3° of visual angle.

Design. Experiment 2 was similar in design to Experiment 1 except for the addition of the report-order manipulation. Each subject reported the word first in half of the session and the digits first in the other. Over all subjects, each word–digit display appeared equally often in both report order conditions, as well as in both contextual conditions.

Procedure. Experiment 2 was run and controlled by computer, and the stimuli were presented on an oscilloscope rather than through a tachistoscope. The procedure had to be adapted to this new experimental situation. Some aspects of the procedure were motivated by the design requirements of Experiment 3, and their incorporation here shows that they were not responsible for the difference in results between Experiment 1 and Experiment 3.

The context sentences were divided into three parts, each of which was successively presented on the upper part of the screen. The subject read each part out loud and then pressed a key that caused the next part to be displayed. After the third key press, the last part of the context sentence disappeared and a patterned mask was presented in the center of the screen. The mask was replaced, after 750 msec, by the target display, which stayed on for 40 msec. The target exposure was immediately followed by the mask, which stayed on until the subject initiated the next trial by pressing a key.

The subject responded verbally, naming first the word, then the two digits, or the reverse, depending on the experimental condition. These verbal responses were monitored by the experimenter via intercom. After responding verbally, the subject wrote the responses on a form, following the same order as the report. Spot checks revealed no loss of report accuracy in this transcription; responses that the subjects successfully verbalized were virtually always recorded correctly. No confidence rating was required nor was there any predetermined order for the report of the left-versus-right digit.

The experimental session was divided into two parts, with a short rest period in between. The first part started with 80 practice trials without context sentences. During these trials, the exposure duration of the word–digit display was gradually reduced from 100 msec to 40 msec. These trials were followed by 50 trials with context sentences, the first 10 of which being considered practice. For the second part of the session, the order of report was reversed and the subjects were given only 40 practice trials without context sentences, followed by 50 trials with context, of which the first 10 were practice.

Table 1
Probability of Correct Report of Word and Digit Targets: Experiment 2

Target	When reported first	When reported second
Word		
Related context	.89	.78
Unrelated context	.35	.29
Context effect difference	.54	.49
Digit		
Related context	.61	.56
Unrelated context	.57	.40
Context effect difference	.04	.16

Results

The results shown in Table 1 clearly indicate that the two report orders had different effects on the results. When the words were reported first, the results were similar to those obtained in Experiment 1. The word identification task was performed 54% more accurately in the related context condition than in the unrelated context condition. The following digit identification was also more accurate in the related context condition; the difference between the two conditions was 16%. However, when the digits were reported first, the difference between the digit report performance obtained in each context condition was reduced to 4%. The analysis of variance computed on the digit identification data showed the interaction between the context and the report order variables to be significant, $F(1, 11) = 5.89$, $p < .05$. Analysis of the interaction revealed a reliable effect of context in the word-first condition but not in the digits-first condition.

Reversing the order of report did not have such a drastic effect on the word identification performance. The overall accuracy was reduced when the word was reported last: 54% versus 62% when the word was reported first. But the effect of context remained almost the same, independently of the order of report. The analysis of variance performed on the word identification data revealed a significant effect of context, $F(1, 11) = 72.0$. $p < .001$, and of report order, $F(1, 11) = 6.49$, $p < .05$, but no interaction between these two factors, $F(1, 11) = 1.10$, $p > .25$.

Discussion

The major finding of Experiment 2 is that the effect of context on the digit report performance essentially disappeared when the digits were reported first. This finding is compatible with the view that context affects the resources required to select an overt response or to perform some aspect of processing that is not carried out until the decision to select an overt response is made. However, an alternative possibility is that the report order manipulation induced subjects to preallocate resources to the two tasks differentially, effectively freeing resources for the processing of the stimuli to be reported second only after sufficient resources had been devoted to the processing of the material to be reported first. According to this interpretation, it is the knowledge of the order in which the stimuli are to be reported that affects allocation of resources, rather than the resource demands of processes actually associated with generating the report itself.

Experiment 3

Experiment 3 was designed to provide more evidence concerning the locus of the effect of context on the allocation of resources. Subjects were required to identify either the word or the digits, never both. The identification task that the subject had to perform varied randomly over trials, and the subject was cued to report the word or the digits at various times before or after the presentation of the target display.

On the basis of the results of Experiment 2, we would expect precuing to eliminate the context effect for digit reports. But what about postcuing? If context can affect the amount of resources allocated to processes that must be carried out while the stimulus remains perceptually available, then there should be an effect of context on the digit report performance when the task to be performed is cued after the target display has been replaced by a patterned mask. On these trials, the subjects have to process both the word and the digit information into some form that the mask will not interfere with so that they may retain both until the presentation of the cue. However, they are only required to make an overt identification response to the word or to the digits. Therefore, we would not expect to obtain any effect even with a postcue if the effect of context on digit reports is restricted to processes that are only invoked when the time has come to formulate an overt response.

Method

Subjects. Forty new subjects participated in Experiment 3, receiving either $2 or class credit for the 1-hr. session.

Stimuli. Two sets of 100 test stimuli were constructed, with the same constraints as in Experiment 2.

Design. There were five cue-timing conditions, using different intervals between the cue and the onset of the word–digit display. These intervals covered the range from 500 msec before onset (−500) to 300 msec after onset (+300) in steps of 200 msec. Trials were blocked according to interval type, and the order of presentation of the blocks was balanced across subjects. Randomized within each block were 20 test trials, 5 from each combination of the two context conditions (related vs. unrelated), with the two report conditions (word vs. digit report). Each target display appeared only once for a given subject. Therefore, each subject saw only one of the two sets of stimuli (20 trials × 5 interval blocks = 100 stimuli). However, across subjects, all stimuli from both sets appeared equally often in each cell of the Cue-timing × Report × Context design.

Procedure. For each test trial in Experiment 3, the sequence of events was identical to the one already described for Experiment 2, with the following exceptions: First, the exposure duration of the word–digit display was 48 rather than 40 msec. Second, the subjects heard either a high or low tone at a certain time before or after the onset of the word–digit display. The high tone signaled that a digit response was required, and the low tone called for a word response.

There were 100 practice trials without any context. During these trials, the exposure duration of the target display was gradually reduced from 100 msec to 48 msec. Like the test trials, the practice trials were blocked according to the time interval between the tone and the target onset. During the practice phase, the order of presentation of the blocks was the same for all subjects (−500, −300, −100, +100, +300 msec).

The practice phase was immediately followed by 150 trials with context sentences. The exposure duration of the target display was not modified during these trials. There were 30 trials per block, the first 10 of which were considered practice with the cue-timing condition in force for that block.

Results

The right panel of Figure 2 shows the proportion of digits that were reported correctly in the various cue-timing conditions. As can be seen, the context did not have much influence on the digit report performance in any cue-timing condition. There was no main effect of context, $F(1, 39) < 1$, nor was the context variable involved in any interaction. In fact, the cue interval was the only factor to have a significant effect, $F(4, 156) = 5.12$, $p < .001$. The performance was best at −500 msec, decreasing slightly as the interval between the cue and the target was reduced. The performance was worse when the cue followed the target, but it did not matter whether the cue followed by 100 or 300 msec.

Because of the longer exposure duration of the target in Experiment 3, the digit report performance was much higher than in the previous two experiments. It seems unlikely, however, that the longer exposure

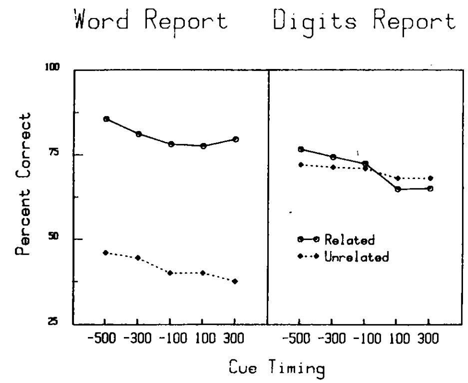

Figure 2. Proportion of words (left panel) and digits (right panel) reported in related and unrelated context conditions, as a function of cue-timing condition in Experiment 3.

duration made the word–digit display too easy to see, thereby preventing the possibility of any context effect, since performance remained well below ceiling levels on both word and digit reports.

As can be seen in the left panel of Figure 2, context did have a big effect on the word report performance. The difference between the two contextual conditions averaged 39% over the various cue intervals, $F(1, 39) = 139.0$, $p < .001$. The analysis of variance computed on the word report data did not reveal any other significant effect.

General Discussion

Our data suggest that context reduces the demand for limited-capacity processing resources that is made by some aspect of the processing involved in identifying and reporting a briefly presented target word. Apparently, this aspect of processing need not be invoked until the subject is informed of the type of stimulus material to be reported, at least if this information comes within 250 msec after the presentation of the stimulus display. In Experiment 1, in which subjects had to report target words before a pair of extraneous digits, they were better able to report the digits correctly when the word fit a preceding sentence context than when it did not. In Experiment 2, this effect was replicated, but we found that the accuracy of digit report was unaffected by the relationship between the word and the sentence context if the digits were reported before the word. In Experiment 3, we found that accuracy of digit report was unaffected, even when the subject did not know whether the word or the digits were to be reported until 250 msec after the target had been replaced by a patterned mask.

These findings fit in well with models of attention that fall into the category of late selection models (Deutsch & Deutsch, 1963; Norman, 1968). Perhaps, for familiar words and digits at least, the early stages of perceptual processing are automatized, in the sense that their performance is unaffected by the allocation of processing resources (LaBerge & Samuels, 1974; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977).

It is, of course, difficult to say exactly which perceptual processes are to be treated as automatic and which as resource dependent, since we lack an accepted list of these processes, as well as any firm indication of their time course. However, it is possible to give one reasonably explicit account of our results in terms of a slight modification of Morton's (1969) logogen model of word recognition. Doubtless this is not the only model that is compatible with our results, but it is at least one model within which we can make reasonably good sense of the data. In the standard version of Morton's model, the presentation of a stimulus display gives rise to activations in a set of detectors or logogens, as does the presence of a context. The effects of context and stimulus input add together to determine the central tendency of the activation of each individual logogen. Activations of logogens reach a peak shortly after stimulus presentation and then decay back to the base level as time goes on, although contextual inputs are assumed to have a much slower decay rate than perceptual inputs. Each logogen has a threshold, and when the threshold of a logogen is exceeded, the presented item can then be transferred, via a limited-capacity channel, into a response buffer for recirculation and/or overt response.

The only aspect of this model that we would change is the notion of a logogen threshold. We prefer instead the notion (embodied in the actual mathematical formulation of Morton's, 1969, model, though not the verbal statement) that the item to be reported is *selected* from a set of activated logogens. It may be in the process of selection that limited-capacity processing resources are engaged.

Our suggestion is simply this. In choosing a response, the subject attempts to select the most strongly activated logogen from the set of activated units. When one logogen's activation is much stronger than the activation of all of the others, this selection task is easy, but when there are several weakly activated logogens so that the activation of no single logogen stands out above the others, the selection task is more difficult. One view of the attentional demands of the task is that subjects can invoke the selection mechanism only for a single item at a time, and selection simply takes more time when it is more difficult than when it is easy. As time goes by, the activations of other logogens begin to decay so that identification processes that must be delayed will simply be less accurate than those that can be invoked earlier. To account for our results, we need only add the assumption that the subjects devote the selection mechanism first to the stimulus that must be reported first, so that the time it takes for selection to be completed for the first item determines when the selection mechanism can be turned to other items.

We can now account for the fact that digit reports are more accurate following correctly reported words in related context than following correctly reported words in unrelated context. On average, the logogens for words presented in related context receive a stronger combined activation from the stimulus and from context than do the logogens for words presented in unrelated context. Further, in the case of words presented in unrelated context, there will tend to be several logogens with partial activations from context alone. Thus, the task of selecting a response is more likely to be correct in related context (this follows from Morton's, 1969, original formulation), and when it is correct, it should also take less time. Thus, the selection mechanism will be freed sooner to deal with digits when the context is related to the target word than when it is not, and there will be less time for decay of the logogens for the digits before selection in related context.

This account can be extended to account for the poor performance in reporting digits after words that are incorrectly identified. Presumably, incorrect responses occur predominantly on those trials when no logogen is particularly strongly activated, so we would expect these trials to require the most selection time of all.

The preceding account applies, of course, only when the word must be identified first. The results of the digits-first condition of Experiment 2 showed greater overall accuracy on the digits than in the word-first condition, as we would expect if delaying the selection process hurts performance. They also showed no effect of context on digit reports, as we would expect from the assumption that the selection of the word response is delayed until after the digit responses have been selected, since it is the selection process that requires the limited-capacity mechanism. After the digit has been reported, however, the subject can turn the limited-capacity mechanism to deal with the word. Requiring the digit report before the word report would thus be expected to reduce accuracy on the words (compared to the word-first condition), just as we found. The fact that we found no reliable reduction of the size of the advantage for words in related context over words in unrelated context is compatible with the model as well. We would expect decay of the input to reduce the activation of the logogens for the target words in both conditions. Following Morton's assumption of a longer time constant for decay of contextual input, we would not expect the differential activation of logogens for appropriate and inappropriate words to change rapidly, thus preserving the wide separation of performance between related and unrelated context conditions.

The model also accounts for the failure to find any effect of context on digit reports in Experiment 3; it is simply assumed that the selection process is not invoked, either for the word or the digits, until the cue has been processed. This assumption also accounts for the trend, visible for both words and digits, but only significant for the latter, for performance to be less accurate at greater cue delays. The earlier the selection is directed to the appropriate stimulus type, the greater the accuracy will be, because of the decay of the activation of the relevant logogens.

In this model, we have assumed that the selection mechanism must be devoted in its entirety to one and then the other part of the stimulus display, in all-or-none fashion. It is equally possible, however, to account for our data in terms of a model in which the selection mechanism is a sharable resource whose performance is reduced when it must be divided among different tasks. In this formulation, we could account for our results by assuming that the items to be reported first receive the bulk of resources, whereas the items to be reported second receive only what remains until selection is finished for the item to be reported first.

According to the model that we have outlined, resources are consumed by selecting a logogen from a partially activated set and not by the processes whereby a stimulus results in logogen activation. Just how much such a resource-limited selection process might be required during the process of reading is not clear. Under normal reading conditions, there may be sufficient stimulus information available to effectively eliminate all but one possible logogen from consideration, thus reducing the selection task to the simplest possible case, regardless of the degree of contextual support for a particular word. In such a case, however, we might imagine that stronger contextual constraints would make the single activated logogen available sooner (Marslen-Wilson

& Welsh, 1978). In such a case, context would not directly affect the resource demands made by logogen selection; it would simply reduce the time required for the stimulus information to uniquely determine which word is correct. On the other hand, it may be that readers do not wait for sufficient stimulus information to accumulate all of the time but use up resources in selecting from a set of partially active logogens before all of the stimulus information is in. Perhaps, then, context does help free up the processing resource requirements of the selection process, at least some of the time.

The foregoing discussion suggests that context may aid reading by either speeding up or reducing the resource requirements of word identification, or perhaps a little of both. But does the use of contextual information require the use of limited-capacity resources? This is a matter about which our own results are silent. There is some evidence from a variety of studies that there is some automatic spreading activation from the logogens for active words to those for semantically related words (Conrad, 1974; Fischler & Goodman, 1978; Warren, 1972), but it is unclear whether this is the whole story about the effect of context. Recently, Fischler and Bloom (1979) reported evidence that facilitation and inhibition by sentence context may not be completely under voluntary control. Whether these processes nevertheless still require the use of processing capacity otherwise available for allocation to other aspects of reading remains to be seen.

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Judgments of Probabilistic Events: Remembering the Past and Predicting the Future

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Two experiments were conducted to determine the quality of judges' memories of relevant events and how judges use such information in making decisions. Experiment 1 involved a cue probability learning task in which subjects had to recall specific and average past events as well as predict future events. The second experiment required estimating means and modes of past events and predicting future events of univariate distributions in which the relationship of these central tendency measures was manipulated. Results indicated that although judges have adequate knowledge about the behavior of events in the past, they do not correctly and consistently apply this knowledge in making decisions about future events.

Decision making is one of the most fundamental of all cognitive processes. Yet, we lack a theory of the cognitive components in decision making. In some areas of the decision-making literature, hypotheses and models have evolved, for example, Castellan and Edgell's (1973) hypothesis generation model, Brehmer's (1974) hypothesis testing model, Estes's (1972) probability-learning model, and Norman's (1974) attention model.

Before a comprehensive cognitive theory of decision making can be formulated, it is necessary to investigate the role of memory in human judgment and choice behavior. Decisions are based on not only available current information but also on available past information. In the typical task, these two variables are confounded. It is necessary to distinguish the process of retrieving information about past events from the process of using information to make decisions. This article represents an attempt at exploring the role of memory in human inference.

Although memory is logically involved in the process of making decisions, it has received surprisingly little experimental attention. Reber and Millward (1965) found that subjects could not accurately recall more than six prior events in a binary prediction task. However, Brehmer and Lindberg (1970, 1973) found no evidence of forgetting over a 1-wk. retention interval in a single-cue probability-learning task. In their latter article, they suggest that subjects are not learning single events but rather rules that are easier to remember. This has been supported by Brehmer (1974, 1978).

Hammond and Summers (1972) suggested that poor performance in cognitive tasks, such as cue probability learning tasks, is more the fault of poor cognitive control than of a lack of knowledge. Experimental evidence supporting this statement comes from studies showing no improvement in prediction performance when subjects were supplied with information about task probabilism and statistical strategies (Brehmer & Kuylenstierna, 1978) or memory aids to induce perfect knowledge about past events (Kuylenstierna & Brehmer, Note 1). Peterson and Miller (1964) also gave subjects information analogous to that of a perfect memory but obtained suboptimal performance when the task required predicting the mean of a univariate distribution.

Probability Judgment Tasks

Researchers have experimentally examined decision making with various tasks,

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