EVIDENCE OF STRATEGIC PROCESSING 
DURING WORD RECOGNITION 

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All 95 undergraduates in this study decided if letter strings formed real words or not. Word meaning (ambiguous, unambiguous words) was manipulated within subjects while stimulus proportion (proportion of ambiguous and unambiguous words) was manipulated between subjects. These factors interacted, suggesting that strategic factors influence word recognition. These results support the view that word recognition is strategic and, thus, an attention demanding process.

For many years, the prevailing assumption within the word recognition literature was that word recognition was automatic and did not demand any attentional resources for successful completion (Stroop, 1935; but see Besner & Stolz, 1999). More recent studies, however, have indicated that although word recognition is a quick and accurate process for many people, it still demands attentional resources (e.g., Herdman, 1992; Kellas, Ferraro, & Simpson, 1988; Simpson, Kellas, & Ferraro, 1999).

The present study attempted to provide converging evidence in support of the position that word recognition is a strategic and, thus, an attention-demanding process. We chose the lexical decision task (LDT), in which subjects must decide whether or not a string of letters form a real English word (CAT) or an orthographically legal pseudoword (BLANT). This is the premiere task for investigating how people process words. We also chose multiple meaning words. By definition, ambiguous words are words that possess more than one specific meaning. The word BANK is a good example of an ambiguous word. There are multiple meanings of the word BANK, and these include the MONEY aspect of BANK as well as the RIVER aspect of BANK. Conversely, unambiguous words (like CAUSE) have only one distinct meaning. We also chose ambiguous and unambiguous words as stimulus materials primarily because the effect associated with them (ambiguity effect) is quite robust. The ambiguity effect is operationally defined as the difference between ambiguous and unambiguous words, and this difference typically favors ambiguous

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words. That is, people respond to ambiguous words faster and more accurately than to unambiguous words.

To examine the impact of strategic processing, we varied the proportion of ambiguous and unambiguous words presented to subjects. In one condition, there were 30 ambiguous words and 60 unambiguous words. In a second condition, there were 60 ambiguous words and 30 unambiguous words. In each condition, there were also 90 pseudowords. Strategic processing has been shown to involve attentional resources and has been shown to affect word recognition performance (Carr, Davidson, & Hawkins, 1978; Henderson, 1982; Manelis, 1974; Neely, Keefe, & Ross, 1989). For instance, Milota, Widau, McMickell, Juola, and Simpson (1997) revealed that although phonological information can be automatically activated during lexical access and word recognition, such activation is strategically contingent upon task demands. In other words, skilled readers do have strategic control over various coding and recoding mechanisms thought to impact visual word recognition, such that they can attend to such information or to neglect it if it negatively affects overall performance.

In the present experiment if we observe differential word recognition performance across the two proportion manipulation conditions we use, especially when examining the ambiguity effect [unambiguous - ambiguous], that would suggest that subjects used different strategies. If true, an interaction between the proportion manipulation and the stimuli types would be significant. This, in turn, would be suggestive that word recognition is indeed an attention-demanding process.

Alternatively, no effect of proportional manipulation, conversely, would be indicative that word recognition is an automatic process, immune to outside interference such as stimulus proportional manipulations. No interaction would be the primary result here. Showing that varying the proportion of ambiguous and unambiguous words affects word recognition performance would be important because a different methodological manipulation would have produced the effect, thereby providing converging evidence that word recognition is strategic and attention demanding. Such a pattern of results would also support the view that good readers are flexible in how they process lexical stimuli and exert some control over this flexibility such that it is reflected in the impact of strategic processing differences.

Methods

Subjects

Participants in this study were undergraduates, \((n = 48)\) in Condition 1 and \((n = 47)\) in Condition 2. In Condition 1, the A-U-PW (where A indicates ambiguous, U indicates unambiguous, and PW indicates pseudoword) proportion was 30-60-90. In Condition 2, the A-U-PW proportion was 60-30-90. All were native speakers of English and had normal or corrected-to-normal vision. Age \((M = 18\ yr.)\), education level \((M = 13\ yr.)\), and vocabulary ability \((M = 56;\ Wechsler, 1981)\)
were equivalent across these three groups of subjects (all $p > .05$). This ensured that there was no unintentional confounding of demographic and psychological information across the two groups of subjects. Each subject only participated in only one condition.

**Materials**

All stimuli were taken from Kellas et al. (1988) and included 60 ambiguous, 60 unambiguous, and 90 pseudoword (PW) stimuli. Subsets of (A) and (U) words (i.e., the 30 A words in Condition 1 and the 30 U words in Condition 2) chosen such that they were equal in number of letters, number of syllables, number of phonemes, Kucera and Francis (1967) frequency of occurrence, familiarity (Gernsbacher, 1984), and bigram frequency of the larger set they were drawn from. This process ensured that stimuli subsets were equivalent to the larger population they were drawn from, thereby reducing potential confoundings related to a subject being harder or easier to process.

**Procedures**

In the present experiment we used two specific stimulus proportion conditions. We ensured that the number of word stimuli (the combination of A and U words, 90 words) was the same as the number of PW stimuli (90 PWs), as is typical in lexical decision/word recognition experiments. In Condition 1, the proportion of A-U-PW stimuli 30-60-90, respectively. In Condition 2, the proportion was 60-30-90. Subjects were randomly assigned to one of these two possible conditions as they appeared at the laboratory. Each subject participated in only a single condition.

For each subject a typical trial went as follows. A warning signal (+) appeared in the middle of the computer screen for 1000 milliseconds (ms). This was replaced by either a word or a pseudoword stimulus that remained in view until the subject responded. Subjects pressed the "1" key with their left-hand index finger if the letter string was a word and the "0" key with their right-hand index finger if the letter string was a pseudoword. All subjects received 20 practice trials (not used in either Condition 1 or 2) which included 5 ambiguous words, 5 unambiguous words, and 10 pseudowords.

**Design**

There were two factors that were manipulated. The first was condition and there were two levels (30-60-90, 60-30-90) manipulated between subjects. The second factor was stimuli, which also had two levels (ambiguous, unambiguous) and was manipulated within subjects. The dependent measures were mean reaction time (RT), measured in milliseconds (ms), and mean percent correct responses. Although subjects responded to PWs, we did not include PWs responses in any RT or error rate analyses.
Results

Speed-Accuracy Trade-Off

As is typical in reaction time experiments, a speed-accuracy trade-off analysis was performed. Results indicated that there were no speed-accuracy trade-offs in the present experiment, and this was indicated by the fact that increases in RT resulted in increased percent error rates across the various conditions ($r = +.77, p < .01$).

Reaction Time (RT)

Next, we examined mean reaction time (RT) performance and performed a 2 (condition) x 2 (meaning) mixed analysis of variance (ANOVA). This ANOVA resulted in a main effect of condition, $F(1, 184) = 6.41, p < .05$, with responses in Condition 2 ($M = 629$ ms) faster overall than responses in Condition 1 ($M = 651$ ms). There was also a main effect of meaning, $F(1, 184) = 9.93, p < .01$, with ambiguous words ($M = 627$ ms) responded to faster than unambiguous words ($M = 653$ ms). These main effects were qualified by a Condition x Meaning interaction, $F(1, 184) = 6.10, p < .05$.

To examine the source of this interaction, we examined meaning (operationally defined as the difference between A and U words) as a function of condition. For Condition 1 (30-60-90), the meaning effect (U-A) was 12 ms (657-645, $t(93) = .92, p > .05$). For Condition 2 (60-30-90), the meaning effect (U-A) was 40 ms (649-609, $t(93) = 3.08, p < .01$).

Error Rate

Error rates were unremarkable, and increased in the predicted direction with fewer errors committed on ambiguous words, followed by unambiguous words. Analysis of mean percent error rates corresponded to a 2 (Condition) x 2 (Meaning) mixed-factor ANOVA and resulted in a main effect of condition, $F(1, 184) = 4.75, p < .05$, and a main effect of meaning, $F(1, 184) = 25.87, p < .01$. As with mean RTs, these main effects were qualified by a significant Condition x Meaning interaction, $F(1, 184) = 23.94, p < .01$.

Discussion

The present results support the notion that word recognition is strategic and, thus, an attention demanding activity, supporting other researchers (e.g., Besner & Stolz, 1999; Herdman, 1992; Simpson et al., 1999). The present study varied the proportion of ambiguous and unambiguous stimuli and this manipulation affected how the various words were processed. The ambiguity effect size (operationally defined as the difference between ambiguous and unambiguous words) differed as a function of the proportion of A and U words presented, while keeping the number of pseudowords constant. When there were 30 A words and 60 U words (and 90 PWs), the ambiguity effect size was 12 ms ($p > .05$).
When there were 60 A words and 30 U words (and 90 PWs), however, the ambiguity effect size was 40 ms ($p < .01$). This observation has implications for how reading may be taught and how individual differences contribute to reading ability differences (e.g., Hamburger & Slowiaczek, 1996; Milota et al., 1997) and suggests that skilled readers are flexible in how they process lexical information and exert some strategic control of what they are processing.

The question remains as to what specific strategy subjects are adopting or are influenced by to alter their performance. Examination of Table 1 may offer some clues as to this specific strategy. Specifically,

<table>
<thead>
<tr>
<th>Proportion Type</th>
<th>30-60-90</th>
<th>60-30-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Reaction Times (ms)</td>
<td>645</td>
<td>609</td>
</tr>
<tr>
<td>Mean Percent Error (%)</td>
<td>67</td>
<td>55</td>
</tr>
<tr>
<td>%E</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 1

Mean Reaction Times and Percent Error Rates as a Function of Proportion Type and Meaning

Note. The three numbers under proportion type indicate the number of ambiguous words, unambiguous words, and pseudowords, respectively. $M$ indicates mean, $SD$ indicates standard deviation, %E indicates percent error.

when there were more A words presented to subjects, RTs were much faster (609 ms when there were 60 A words versus 645 ms when there were 30 A words). No such effect appears present for U words (RTs were 657 ms and 649 ms, respectively, when there were 60 U and 30 U words processed across Conditions 1 and 2). It may be the case that RTs got faster to A words in Condition 2 because there were more A words in absolute terms. To examine this possibility further, the 60 A words in Condition 2 were separated into Trials 1-30 and Trials 31-60. These values did not differ significantly ($p > .05$), and the average A word RT across Trials 1-30 was 604 ms, whereas the average A word RT across Trials 31-60 was 614 ms. Thus, processing more A words (60 vs. 30) did not affect performance significantly and, as a result, practice at a particular decision route can not be used to explain the present set of results.

It may also be the case that the subset of 30 A words used in Condition 1 were somehow more difficult and harder to process than the 60 A words used in Condition 2. However, an analysis of this subset of 30 A words revealed that they shared the same characteristics statistically as the 60 A words used in Condition 2. The same can be said of the subset of 30 U words used in Condition 2 as compared to the 60 U words used in Condition 1. Again, the subset of words shared the same stimulus
property characteristics as the larger sample. Thus, it appears that differential stimulus characteristics can not be used as an alternative explanation of the present set of results.

The fact that manipulations in the specific proportion of stimuli presented is indicative of the potential vast individuals differences that affect word recognition performance (Marfo & Ryan, 1990). It also suggests that the possible strategies that subjects are following relate to the flexibility they possess regarding lexical processing. Recently, Milota et al. (1997) revealed that college-aged subjects were quite flexible in how they processed phonological information during word recognition and lexical access. In their study, subjects were able either to control their access to phonological information strategically or to ignore it altogether, especially when it negatively affected overall task performance.

The same possible mechanism is in operation in the present set of results. The subjects in the current experiment can be classified as skilled readers, based on the information gathered about them at the beginning of the experiment. They may have induced a decision-based strategy in which they learned to respond to the multiple-meaning (ambiguous words) stimuli as soon as any meaning came to mind, rather than waiting for a specific meaning to arrive or waiting for all known meanings to arrive before making a decision. This decision-based strategy fits well within the flexible nature of strategic processing in lexical access and word recognition, and it suggests that the skilled readers in the present experiment had control over how they processed ambiguous words such that when there were more A words than U words (Condition 2) they adopted a possible strategy of responding with the first meaning of the ambiguous words that came to mind, rather than waiting for additional meanings or their preferred meaning before responding. This result can not be explained by either stimulus characteristics between conditions or within subsets of stimuli, nor can this effect be explained by a practice effect in which A word RTs are faster because there are more A words in one condition versus another. The fact that responses to U words across both conditions (despite 60 U words in Condition 1 and 30 U words in Condition 2) also makes sense from the decision-strategy explanation, as there is only one meaning to select and process for U words and thus there should be no difference between conditions if subjects were adopting such a decision-based strategy.

Despite these results, some shortcomings need to be discussed. First, the stimuli were a specific type of word (ambiguous, unambiguous). Although these stimuli were equal on several variables known to affect word recognition, additional studies should be run to examine which types of lexical stimuli are most (or least) affected by strategic processing. These could include words that vary on frequency of occurrence, familiarity, and a host of other factors that are known to affect word recognition. As mentioned, we used A and U words because of the vast literature that suggests a processing difference exists between these stimuli. Second, all subjects were college undergraduates who
participated for research credit. Additional experiments should target
groups that are known to differ on their ability to use strategies during
lexical processing, such as good and poor readers. We are assuming that
the college-level students in the present study are good or skilled readers
based on their demographic and psychometric data collected at the
beginning of the experiment. However, we did not manipulate these
factors and only made sure that they did not differ across the two
conditions. Third, the present results are based solely on the lexical
decision task. Additional studies would want to confirm the present results
by using another task (such as the naming task) to ensure that the
present results are not task dependent.

Despite these concerns, the present results suggest that word
recognition is not as automatic as once thought and that strategic
processing plays a key role. These strategic processes seem to be
related to a decision-based strategy regarding how multiple-meaning
stimuli are processed. Future studies will need to examine any additional
effects that may possibly be attributed to such strategic processing.

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