THE DEVELOPMENT OF AUTOMATIC WORD RECOGNITION SKILLS

Richard F. West
James Madison University

Keith E. Stanovich
Oakland University

Abstract: Kindergarteners, first graders, and third graders performed a discrete-trial Stroop task in which they named the color of stimuli that either matched or did not match items that were being concurrently held in memory. Letters, high-frequency words, and low-frequency words were used as stimuli. There was a developmental trend toward the color being named faster when the stimulus matched the item held in memory. This finding was unexpected. While the color-naming times of the first and third graders did not depend on stimulus type, the kindergarteners named colors slower when the stimuli were letters and showed a tendency to respond slower to high-frequency words than to low-frequency words. Apparently, the kindergarteners had fully automated the recognition of only the letters and were beginning to automate the recognition of high-frequency words. In contrast, the older children had automated the recognition of letters, high-frequency words, and low-frequency words to an equal extent.

Numerous factors are undoubtedly involved in the acquisition of proficiency in reading. Reading researchers have often argued that one of the most important of these factors is the ability to use prior contextual information to facilitate word recognition (e.g., Goodman, 1987; Smith, 1971). However, several recent studies have suggested that such factors may play a less important role than single-word processing skills in accounting for differences in reading ability (Biemiller, 1977-1978; Perfetti, Finger, & Hogaboam, 1978; Perfetti & Hogaboam, 1975; Shankweiler & Liberman, 1972; West & Stanovich, 1978). For example, contextual factors have been found to have more of an influence on the word reading latencies of less skilled than more skilled readers (Perfetti, Goldman, & Hogaboam, 1979; Roth, Perfetti, & Lengold, Note 1: Schvaneveldt, Ackerman, & Semlir, 1977, West & Stanovich, 1978).

While word reading skills are frequently assessed in terms of accuracy criteria, consideration of the speed and automaticity of these skills may prove informative. A
In automatic word recognition, the study reported here attempts to remedy some of the problems discussed above in the following ways. An age range is investigated (kindergarten, first grade, and third grade) in which large changes in automatic processing of written material would be expected. A color-name task is used in which interfering stimuli are letters, high-frequency words, and low-frequency words, i.e., a stimulus that differs in frequency of exposure, and presumably automatization. Thus, changes in the automatic processing of these different types of written items can be observed across the age range under consideration. A ceiling effect would not be expected with these stimuli, since the low-frequency words should be difficult for the first-grade and kindergarten subjects. Finally, a discrete-trial presentation procedure is used, it is more precise and is less amenable to response strategies than the continuous-list procedure.

One additional manipulation of interest was included in the study to be reported. Warren (1972, 1974) found that interference increased in a discrete-trial word-stimulus task when the stimulus word matched a word that was concurrently being held in memory for later recall. This effect presumably occurs because the information from both the auditory and visually presented words is combined at a memory location (see Morton, 1969) and strengthens the word reading response that competes with the color to be named. In the present study, the hypothesis that word recognition becomes increasingly automatic with skill development is tested by the use of a procedure adapted from Warren (1972, 1974). Subjects from three grade levels were asked to name the colors of verbal items that either matched or did not match an item that was being concurrently held in memory. Stimuli of three difficulty levels were used. Since it was expected that the reading of familiar material is automated at an earlier age than the reading of unfamiliar material, it was predicted that the older readers would name the colors of the three stimulus types equally fast, while the younger readers would take longer to name the colors of letters and highly frequent words, because only these stimuli are automated at the youngest age levels. Based on Warren's (1972, 1974) findings, it was expected that these results would be most apparent when the colored target and word held in memory matched.

**METHOD**

<table>
<thead>
<tr>
<th>Subjects</th>
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<tr>
<td>The subjects were 24 kindergarten (10 males and 14 females), 24 first graders (15 males and 9 females), and 24 third graders (9 males and 15 females). The children, who were recruited from a predominantly middle-class elementary school, were tested near the end of the school year. The kindergartners had a mean age of 5.9 years, and their mean reading ability was at the 1.1 grade level as tested by the Reading Subtest Level I of the Wide Range Achievement Test or WRAT (Jastak, Bish, &amp; Jastak, 1963). The first graders had a mean age of 6.9 years, and their mean reading ability was at the 2.2 grade level as tested by the WRAT. The third graders had a mean age of 7.9 years, and their mean reading ability was at the 4.8 grade level as tested by the WRAT.</td>
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**Stimuli and Apparatus**

The stimuli consisted of the 26 letters of the alphabet, 26 high-frequency words,
28 low-frequency words - The selection of the words was based on an inspection of the Dolch list, the Kucera and Francis (1987) corpus, and a number of reading primers. The low-frequency words had a mean frequency of 16.0 based on the Kucera and Francis (1987) count and 24.0 based on the Carroll, Davis, and Richman (1971) count of third-grade literature. The high-frequency words had a mean frequency of 326.5 based on the Kucera and Francis and 500.0 based on Carroll, Davis, and Richman (1971). The stimuli were typed in IBM Courier 72 font. Only the lower-case was used. Black and white negatives of the stimuli were mounted on slides that were colored either red, yellow, blue, or green with acetate films. The slides were projected onto a white screen by a Kodak Carousel 700H projector. Subjects sat approximately 90 cm from the screen, and the size of the projection was such that a five-letter word subtended a horizontal visual angle of approximately 3 degrees. Stimulation onset was controlled by a Vincen Associates Unibits Shutter that was positioned over the lens of the projector. The shutter was electrically opened, and the projected image of the stimulus item appeared. Simultaneously, a National Electronic Systems Crystal Stopwatch was started by the same push of the control button. When the subject verbally responded, a voice-activated relay stopped the stopwatch and closed the shutter. The microphone that led to the voice-activated relay was held by the subject.

Procedure

Subjects were individually tested in a session that lasted approximately 30 minutes. Preceding each visual presentation of a stimulus the experimenter orally presented the subject with a word or a letter. While they were instructed to try to remember all of the orally presented items, no recall was actually required of the subject. Approximately .5 seconds after the experimenter presented the auditory item, the stimulus was exposed, and the subject named the color of the stimulus as rapidly as possible. After six practice trials the subjects completed two blocks of 72 experimental trials. Each block contained a random ordering of 24 trials of each of the three stimulus types (letters, high-frequency words, low-frequency words). Each subject saw the same sequence in each of the blocks. On half of the trials within a block the visual stimulus was the auditory item that had preceded it at the beginning of the trial. When a stimulus was matched in one block it was not matched by the preceding auditory item in the second block, and vice versa. The order in which the blocks were performed was counterbalanced across subjects.

RESULTS

Approximately 5% of the trials were dropped from the data analysis due to some type of experimental malfunction. Trials on which the subject articulated the wrong word or had a response time longer than 2000 msec were scored as subject errors and dropped from the analysis. Errors were made on less than 4% of the trials. There were no sex differences on any of the performance measures, and the data from males and females were pooled in the analysis that follows. Grade level was a between-subject factor. Stimulus type and match condition were within-subject factors. The ordering of blocks was included as a factor in all of the analyses so as to decrease the error term. Since neither the main effect of order nor any of the interactions involving this factor was significant, it will not be considered further. The mean color-naming times for each of the grade levels, stimulus type, and match conditions are presented in Table 1. A four-way analysis of variance (grade x stimulus type x match x order) on the color-naming times indicated a significant effect of grade level [F(2, 60) = 13.5, p < .001], stimulus type [F(2, 60) = 1.38, p < .025], and match condition [F(1, 60) = 6.35, p < .025]. The grade level by stimulus type interaction [F(4, 120) = 9.73] was significant at the .001 level. There was a tendency for matches to become faster (as lower matches as the children got older. However, the grade level by match condition interaction did not quite reach accepted levels of statistical significance [F(2, 60) = 2.45, p < .10]. None of the remaining interactions was significant. Virtually identical results were obtained when an analysis of covariance was carried out on the reaction times with the number of errors as a covariate. A planned orthogonal contrast indicated that the color-naming time on the matched condition button, the first graders were significantly slower than those of the kindergarteners and the third graders (p < .05). The latencies for the kindergarteners and the third graders did not differ significantly.

<table>
<thead>
<tr>
<th>Grade level</th>
<th>Stimulus type</th>
<th>Match condition</th>
<th>Match</th>
<th>Nonmatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten</td>
<td>High-frequency words</td>
<td>1213</td>
<td>1558</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low-frequency words</td>
<td>1002</td>
<td>1831</td>
<td></td>
</tr>
<tr>
<td>First grade</td>
<td>Letters</td>
<td>1150</td>
<td>1306</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High-frequency words</td>
<td>1232</td>
<td>1284</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low-frequency words</td>
<td>1308</td>
<td>1353</td>
<td></td>
</tr>
<tr>
<td>Third grade</td>
<td>High-frequency words</td>
<td>934</td>
<td>1063</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low-frequency words</td>
<td>949</td>
<td>1076</td>
<td></td>
</tr>
</tbody>
</table>

In order to further explore the grade level by stimulus type interaction, separate analyses were run on the naming times of each of the age groups of children. An analysis of variance on the color-naming times of the kindergarteners children indicated a significant effect of stimulus type [F(2, 60) = 0.945, p < .001]. A planned orthogonal contrast indicated that colors were named more slowly for the letter stimulus than for the two types of word stimuli (p < .001). Mean reaction times were longer for the high-frequency words than for the low-frequency words, but not significantly
DISCUSSION

While the color-naming times of the kindergartners and third graders did not differ from each other, their response times were significantly faster than those of the first graders in this study. Because normal reaction times increase markedly over the age range studied here (Doehring, 1976; Wicksin, 1974). However, this finding should not be considered anomalous since all the first graders, a group of heterogeneous interference trials. Some degree of color-word interference may be assumed on each trial in this light, with the inverted U-shaped response functions reported here consistent with results reported by Schiller (1969), who found that time to name the color of words was the longest in the second grade. Thus, the equality of the kindergartners and third graders in color-naming may be due to the fact that the times of the third graders have been differentially lengthened due to the relatively greater interference experienced by that group.

The color-naming task was found to have a significant effect on color-naming latency. The kindergartners' color-naming latencies were significantly slower when the target was a letter than when it was a word. There was also a trend towards slower response times for the high-frequency words as compared to the low-frequency words (however, this trend did not quite reach statistical significance). In contrast, the kindergartners' recognition latencies for color and reading were statistically significant for the first and third graders. Thus, the prediction concerning the interaction between stimulus type and reading ability was supported. Apparently the kindergartners had fully automatized the color-naming and reading of the high-frequency words. In contrast, the older children had automatized the recognition of all the stimuli, including the low-frequency words. Thus, the present study has demonstrated a developmental trend towards the automatization of more difficult verbal stimuli; however, it appears that developmental changes in this process occur very early in reading practice.

Colors were named significantly faster when the target matched the preceding auditory word. A tendency for matches to become faster than nonmatches with development was indicated by the nonsignificant match effect for the kindergartners and first graders, but significant match effect for the third graders. The finding that matches resulted in faster color-naming times was unexpected and contrasts with Warren's (1972, 1974) finding that color-naming times were slower when the target either matched or was associatively related to a word that was being concurrently held in memory. Perhaps the most important procedural difference between Warren's (1972, 1974) work and the present study is that, unlike the college students in Warren's studies, the young children in the present study were never asked to recall the auditory words.

A possible explanation of the match condition findings in the present study is that the effect of stimulus type (F(2,40) = 2.37) matches, collapsed across the stimulus type factor, were a significant 108 msec faster than the nonmatches (F(1,20) = 31.98, p < .001). The stimulus type by match condition interaction was not significant (F(2,40) = 1.17).

**FOOTNOTES**

1 The authors wish to thank Betty Tife for her assistance in collecting the data reported in this study. Requests for reprints should be sent to Richard F. West, Department of Psychology, James Madison University, Harrisonburg, VA 22807.
REFERENCE NOTE


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