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ABSTRACT

The purpose of Experiment I was to investigate the context effect of letter perception for nonword material. The significance of finding a context effect for nonwords would be that the basis of the effect would have to be a product of a person's knowledge of the phonological or orthographic structure of the language rather than attributable to a person knowing a particular letter string as a word. Letter strings composed of an initial consonant, a medial vowel pair, and a terminal consonant pair (CVVCC) were compared with strings composed of the same initial and terminal units but with a medial consonant pair (CCCCC) in a tachistoscopic recognition task. Exactly the same letters in the same positions (first, fourth and fifth letters) were detected with much higher accuracy in the CVVCCs as compared to the CCCCCs. The objective of Experiment II was to see if the presentation interval used in Experiment I was too short to allow maximal performance for the CCCCCs. It seemed possible that iconic memory deteriorated too quickly after the offset of presentation to allow the subjects viewing CCCCCs to extract enough information for maximal performance. The hypothesis was confirmed in that performance for the CCCCCs improved by extending the presentation time. (Author/WR)

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Relationships Between Memory and Reading

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U. S. DEPARTMENT OF
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Summary

Experiment I

The purpose of Experiment I was to investigate the context effect of letter perception for nonword material. A context effect is a mutually facilitory effect on letter perception produced by certain combinations of letters. Such an effect has been unambiguously established only for word materials. The significance of finding a context effect for nonwords would be that the basis of the effect would have to be a product of a person's knowledge of the phonological or orthographic structure of the language rather than attributable to a person knowing a particular letter string as a word. Letter strings composed of an initial consonant, a medial vowel pair, and a terminal consonant pair (CVVCC) were compared with strings composed of the same initial and terminal units but with a medial consonant pair (CCCCC) in a tachistoscopic recognition task. Exactly the same letters in the same positions (first, fourth and fifth letters) were detected with much higher accuracy in the CVVCCs as compared to the CCCCCs. There was a strong context effect for the nonword materials. The superiority of the CVVCCs over the CCCCCs for the initial consonant also held up on the occasions when the medial context was not correctly detected. Thus a response bias interpretation would not be very plausible.

Experiment II

The objective of Experiment II was to see if the presentation interval used in Experiment I was too short to allow maximal performance for the CCCCCs. In Experiment I the condition producing the highest performance was a 40 msec. presentation interval and a 500 msec. delay of mask. It seemed possible that iconic memory deteriorated too quickly after the offset of presentation to allow the Ss viewing CCCCCs to extract enough information for maximal performance. The duration of iconic memory was extended by increasing the presentation interval in one case to 100 msec. and in another case to 300 msec. The hypothesis was confirmed in that performance for the CCCCCs was improved by extending the presentation duration.

Introduction

The present experiments developed out of recent research in the fields of visual perception and memory which has implications of considerable potential importance to the study of reading. An important initial development was the investigation of iconic memory (Sperling, 1960,1967). Sperling's studies established the existence of a type of memory which preserves visually-presented material for a brief period of time, approximately 200-250 milliseconds (msec.), after the physical offset of the material. Because this type of memory has been shown to preserve the literal, spatial features of the material, it has been called iconic memory (Neisser, 1967). Reading is a prime example of rapid visual stimulation, and there may be some significant advantages in interpreting it as a process of extracting information from iconic memory. As Haber (1970) has stated, "It should not be regarded as mere coincidence that the duration of iconic storage and the minimum fixation time in reading are both about a quarter of a second."

Besides the findings concerning the pictorial form of the information in iconic memory and its brief life, another property of iconic memory of considerable importance for the study of reading is "backward masking". Averbach and Coriell (1961) as well as others have found that a visual stimulus which follows closely <u>after</u> a visual display can drastically reduce -- in some cases completely destroy -- the detection accuracy for items in the display. The masking pattern used by Averbach and Coriell was a visual noise pattern (a random pattern of irregular spots), but any relatively dense visual pattern such as normal printed text provides a very effective mask. Averbach and Coriell interpreted their findings as indicating that the masking stimulus "erases" iconic memory. One implication of masking for the study of reading is that the reader prevents masking from interfering with reading by holding his fixation for about 250 msec., the approximate life of iconic memory. Another implication is that masking provides an extremely useful experimental tool for controlling the length of time for which <u>S</u>s have material available in iconic memory. Indeed, the recent research on iconic memory and masking implies that a large number of earlier studies which used visual materials and did not use masking substantially underestimated the amount of time for which <u>S</u>s had access to the material.

A second line of research, one of primary importance to the present experiments, is concerned with the question of what happens to material during the time span of iconic memory. In the case of reading, a verbal unit is eventually identified as a letter, a word, or possibly some type of higher level grammatically-defined unit. The implication is that the spatial representation of letters in iconic memory must in some sense be encoded by addressing representations in the reader's memory. A potentially important question for the investigation of reading is, what features of the verbal material affect the encoding process?

An earlier literature concerned with this general question is exemplified by the studies of Howes and Solomon (1951) and Miller, Bruner, and Postman (1954) which were concerned with the "familiarity" effect; the frequency of occurrence of a verbal unit in the language was found to be inversely related to tachistoscopic threshold. A recent extension of this line of research which takes advantage of the concept of iconic memory and the technique of masking is a study by Mewhort, Merikle, and Bryden (1969). These authors presented 8-letter sequences of either a zero-order or a second-order approximation to English words for exposure durations of 50, 125, or 200 msec. The construction of the letter sequences was done according to the method of Miller, Bruner, and Postman (1954) which essentially means that letter pairs of higher frequency of occurrence in the language comprised the second-order strings as compared to the zero-order strings which were constructed by random selection. The strings were masked at 0, 75, or 125 msec. after the end of the presentation duration, and the major dependent variable was the number of letters correctly reported. The presentation duration plus the delay of mask period was taken as the total amount of time for which the Ss had the material available in iconic memory. Accuracy of report increased monotonically as the amount of processing time in iconic memory increased and was higher for second-order sequences than it was for zero-order sequences. These results were confirmed in a second experiment. An important question raised by these results is, what is the basis of the familiarity effect? Is the effect based simply on the number of times that the person has previosly experienced the material? Higher order strings of letters are also those which tend to conform to the orthographic and phonological rules of the language. Therefore, phonological or orthographic structure would provide another possible explanation of the familiarity effect. One of the objectives of the proposed research was to separate the effect of frequency of occurrence from that of phonological or orthographic structure.

The Mewhort, et al. (1969) study strongly suggests but does not firmly establish the existence of a "context" effect; i.e., the accuracy with which a given letter or letter combination is detected depends on the context of letters in which it appears. In the Mewhort, et al. (1969) experiment different strings of letters were used in the different approximations. More compelling evidence for a context effect would stem from a procedure in which one or more letters were held constant while varying the context in which they appeared. This type of approach for the case of complete words has been employed by Reicher (1968) and Wheeler (1970). In the Wheeler study, letters presented tachistoscopically were detected with higher accuracy in all positions of four-letter words than when the same letters appeared singly. The only way for the S to produce the correct name of the letter would be for the visual information to have made contact with information stored in the S's memory. Presumably, the letter strings comprising words referenced the S's memory more effectively than did the same letters presented in isolation.

One way to account for a context effect would be to assume that the memory referencing process deals with units composed of more than one letter and that certain letter combinations produce mutually facilatative effects. Wheeler (1970) has suggested this possibility for the case where the context forms an actual word. A question with important implications for reading would be whether the same sort of faciliting effects could be found for the case in which the context plus the target letter does not form a word and for which the S would not have a memory representation associated with the letter string. According to the present version of this idea, tachistoscopic identification of phonologically or orthographically lawful letter strings which are not words might be superior to that of unlawful strings because of more efficient referencing of memory. Studies such as those of Mewhort, et al. (1969) and Mewhort (1966) strongly suggest but do not umabiguously establish the existence of a context effect for the case of nonword material. The major objective of the proposed research was an investigation of the influence of phonological and orthographic structure on the context effect.

Experiment I

Method

Subjects.--The Ss were 36 paid undergraduate volunteers from the Introductory Psychology Class at Oklahoma State University. Payment was $1.75 for the experimental session. Recruitment was done in two lecture classes of approximately 60 students each. The requirements for participation were normal vision (corrected or uncorrected) and that the S be a native speaker of English.

Materials.--The reference for the construction of the materials was a set of norms compiled by Venezky (1962) which is a large-scale frequency analysis of the spelling-to-sound correspondence of the English language. The frequency with which a letter or letter combination occurred as a phoneme or phoneme combination in a given position of a word was tabulated for a sample of approximately 20,000 words from the Thorndike Century Senior Dictionary. A somewhat more detailed description of the norms may be found in Stanners (1970). For the purposes of the present study the data of interest were the frequencies of initial consonants, medial consonant pairs and vowel pairs, and terminal consonant pairs based on their occurrence as specific sound units in words.

Items were constructed from an initial consonant, a medial vowel pair, and a terminal consonant pair (CVVCC), or, alternatively, with a medial consonant pair in place of the vowel pair (CCCCC). The initial consonants used to construct the items were R, P, H, B, S, J, C, W, and F. Medial vowel pairs were AI, AY, OA, OI, IE, AU, EA, IA, and OU. Medial consonant pairs were NC, BL, NS, NF, SC, ND, MP, MB, and PH; final consonant pairs were CK, NT, SH, SM, NK, LT, CT, NG, and LD. The criterion for the selection of the letters and letter pairs was that the percentage of occurrence as a particular sound in a given position (initial, medial, or final) be the highest available in the norms. The basis for this procedure was that there be a minimum of ambiguity about the sound associated with a given letter or letter pair. The average frequency of occurrence in the norms of the medial vowel and consonant pairs was compared. A pilot experiment indicated that performance would be considerably better for CVVCCs than it would for CCCCCs. If sheer frequency were to be eliminated as an explanation of this result, then the frequency for medial consonant pairs should be equal to or higher than that for medial vowels. Average frequency for the medial vowel pairs is 145.4; that for medial consonant pairs is 260.0

From the letters and letter pairs 54 CVVCCs and 54 CCCCCs were constructed with each letter or letter pair being used an approximately equal number of times. Each CVVCC had a counterpart among the CCCCCs with an identical initial consonant and terminal consonant pair; e.g., HAUSH, HNDSH. Two additional sets of materials were formed from a permutation of the letters within each CVVCC and CCCCC. The restrictions on the permutations were that no letter was left in the same position as in an original item and no letter pairs were the same. These materials offered the comparison of an item having exactly the same letters as original items but in different positions.

All the items were typed in uppercase with an IBM sign typewriter, reproduced onto transparencies by the diasochrome method, and mounted in 35-mm. slide holders.

Procedure.--The items used in one of the between-Ss conditions were the 54 CVVCCs and their 54 permutations; the items for the other between-Ss condition were the 54 CCCCCs and their permutations. Within each set of 108 items for a between-Ss subcondition the items were arbitrarily divided into six subsets of 18 items each. The delay of mask conditions used in the present study were 0 msec., 10 msec., 50 msec., 100 msec., 200 msec., and 500 msec. The six delays of mask conditions were associated with the six subsets of items in such a way that each subset (and therefore each individual item) occurred once with each delay of mask condition within a block of six Ss. Three blocks of Ss were used in each between-Ss condition. Assignment of Ss to a particular condition, block, and also within a block was random. After the assignment of delay of mask conditions to the items for an individual S, his slides were ordered randomly with the restriction that no more than four intact items or permutations occur in sequence.

Prior to S's experimental session a set of taperecorded instructions was played. The S was instructed that the first thing he would see in the eyepiece of the tachistoscope (Scientific Prototype Model GB Autotachistoscope) is an illuminated white field with two horizontal dotted lines, one above the other. The S was told that he should fixate his eyes between the lines and that when he had a good fix he should press the thumbswitch held in his nonpreferred hand. When S pressed the thumbswitch the second field was activated which had the materials in a position corresponding to the space between the dotted lines of the first field. A 40 msec. presentation of the materials was followed by a dark delay interval of one of the six durations which was in turn followed by a mask composed of a double row of ampersands. The mask completely covered the area previously occupied by the materials. The visual angle of the materials was 1.67° and the illumination level of all fields was 20.6 Ml. Presentation of the mask also served as a cue for S to write on a scoring sheet all of the material he could. The scoring sheet was a single 2 in. X 4 in. piece of paper which had five horizontally aligned lines. The S was instructed to write all the letters he could in positions corresponding to those in presentation.

The 108 data trials were preceded by 20 practice trials for which the materials consisted of 5-digit numbers with size and spacing equivalent to the letter materials. The pacing of the trials was under the control of S, but on the great majority of trials, a rather short (5-sec. or less) intertrial interval was used.

Design.--The experiment had four factors, delay of mask (DM), serial position of the letter (SP), type of item, CVVCC vs CCCCC (Type) and order of letters within an item, intact item vs. permutation (Order). Type was maniuplated between-Ss. Each condition had 18 Ss randomly assigned from the pool of Ss. The other three factors of the experiment were maniuplated within-Ss.

Results

An individual score used in the analyses of the data was the number of letters correct for a given combination of the four factors. Such a score could range in value between 0 and 9. A descriptive summary of results collapsed over Ss appears in Table 1 and Table 2. The overall statistical analysis was a 4-factor analysis of variance. The number of levels of each factor was as indicated in the Procedure and Design sections with the exception of SP. Since a major emphasis in the analysis was investigation of the context effect, only those serial positions were considered for which the letters in the CVVCCs and CCCCCs were identical, namely, the first, fourth and fifth. Inclusion of the second and third letters, because they are different for the CVVCCs and CCCCCs, could very well produce effects not attributable to context. Three within-Ss factors produced some risk of positive bias in the F tests due to unknown correlations in the data, so the conservative Geisser and Greenhouse (1958) procedure was used to offset the possible positive bias. The effect of using the Geisser and Greenhouse procedure in the present analysis was to reduce the degrees of freedom for testing all effects to 1, 34. Only effects with probability values at or beyond the .05 level were considered significant.

All the main effects were statistically significant. For Type, $F = 4.95$, $p < .05$; as can be seen in Tables 1 and 2, performance was generally better with CVVCCs than with CCCCCs. The test for SP yielded $F = 107.75$, $p < .001$ and that for DM, $F = 143.52$, $p < .001$. Both results are very obvious in Tables 1 and 2. Performance generally decreases with increasing values of SP except for an upturn in the fifth serial position, and performance increases with increasing values of DM. The large difference between intact items and permutations produced a large main effect of order, $F = 158.86$, $p < .001$. The Type X Order interaction term is significant, $F = 29.28$, $p < .001$, reflecting the fact that the difference between CVVCCs and CCCCCs is much larger for intact items than for permutations. The significant Order X SP interaction, $F = 44.95$, $p < .001$ indicates that the U-shaped relationship between performance and SP is more exaggerated for permutations than for intact items. The SP X DM interaction term $F = 7.70$, $p < .01$, is a result of the U-shaped relationship gradually becoming less exaggerated, i.e., flatter, with increasing values of DM. Two of the 3-factor interaction terms were significant. The Type X Order X SP effect, $F = 8.98$, $p < .01$, is a result of the divergence between serial position means for intact items and permutations being greater for CVVCCs than for CCCCCs. The Type X SP X DM interaction effect, $F = 6.31$, $p < .01$, is attributable to a faster rise in the serial position means over levels of DM for CVVCCs as compared to CCCCCs.

Two subanalyses were performed to focus more closely on the context effect and also to allow interpretation of some of the interaction effects of the foregoing analysis. A 3-factor analysis of variance was conducted at each level of the Order factor. The Geisser and Greenhouse (1958) procedure was again applied resulting in degrees of freedom of 1, 34, for all tests.

In the analysis of the permutations two main effects were significant; for SP, $F = 119.64$, $p < .001$, and for DM, $F = 110.27$, $p < .001$. The same trends are reflected as in the overall analysis. A significant SP X DM interaction, $F = 6.30$, $p < .025$, is a result of the U-shaped relationship between performance and SP becoming

Table 1

Average Number of Letters Correct by Serial Position, Delay of Mask Interval, and Type: Intact Items

Serial	Delay of Mask					
Position	0	10	50	100	200	500
			CVVCC			
1	6.44	7.89	8.89	8.94	8.89	9.00
2	3.83	6.67	7.94	8.89	8.67	8.72
3	2.55	5.05	7.22	8.33	8.39	8.78
4	2.11	5.17	7.00	7.55	7.83	8.39
5	2.00	6.17	7.67	8.28	8.28	8.50
			CCCCC			
1	2.83	7.22	8.72	8.89	8.61	8.72
2	1.39	4.17	5.78	7.28	7.44	7.83
3	0.78	3.39	4.89	6.17	7.28	7.55
4	0.67	3.55	4.05	5.39	5.67	5.89
5	1.00	4.83	5.50	7.11	7.17	6.78

Table 2

Average Number of Letters Correct by Serial Position, Delay of Mask Interval, and Type: Permutations

Serial Position	Delay of Mask 0	10	50	100	200	500
			CVVCC			
1	4.55	7.44	8.55	8.72	8.83	8.89
2	1.50	4.50	5.28	7.89	7.55	8.11
3	0.72	2.78	3.61	6.50	6.67	7.11
4	0.33	2.22	3.17	5.44	5.61	5.78
5	0.83	3.67	5.33	6.83	5.72	6.72
			CCCCC			
1	2.89	6.89	8.44	8.44	8.78	8.89
2	0.89	3.61	5.39	6.28	7.55	7.44
3	0.67	3.61	3.89	5.72	6.83	7.39
4	0.39	2.83	2.50	4.17	4.94	5.33
5	0.50	3.61	4.22	5.67	6.11	5.89

less exaggerated with increasing values of DM.

The 3-factor analysis for CVVCCs produced a significant effect of Type, $F = 11.51$, $p < .005$. Since the data for only serial positions 1, 4, and 5 were used in the analysis, the result means that exactly the same letters in the same positions were detected with considerably greater accuracy when they occurred in CVVCCs as compared to CCCCCs. The effects of SP and DM were also significant; $F = 66.07$, $p < .001$ and $F = 123.30$, $p < .001$, respectively. The same trends were present as in the overall analysis. A significant SP X DM interaction term reflects the same effects as in the overall analysis, i.e., greater flattening of the SP curves with increasing values of DM. Finally, the Type X SP X DM is attributable to a faster increase in serial position means over levels of DM for CVVCCS as compared to CCCCCs.

Discussion

The large main effect of Order indicated that performance is strongly affected by the order in which the letters appear. The same letters in an order which violates phonological and/or orthographic rules are much more difficult to detect. This finding is in good agreement with the results of Mewhort, et al. (1969) who used statistical approximations to the structure of English. A much more specific context effect is indicated by the main effect of Type in the subanalysis done on intact items. Here the letters being compared are identical and are also in identical positions, and yet there is a substantial difference in performance. This result is clearly evident in Table 1 by comparing serial positions 1, 4, and 5 across CVVCCs and CCCCCs. The higher level of detection for the first, fourth and fifth letters of the CVVCCs may be unambiguously attributed to the vowel-pair context. The context has an effect on both the left and right sides and also operates with an intervening consonant as shown by the difference in performance for the fifth letter.

A further question regarding the context effect is whether the context needs to be detected correctly for the effect to appear. An answer to the question is provided by looking at the data for only those occasions when the context material, i.e., letters 2 and 3, have been given incorrectly or not at all. Examination of these data would have to be restricted to the 0-msec. delay of mask condition since the performance level on letters 2 and 3 is two high for longer delays of mask. The percentages of correct and incorrect responses on the first letter of CVVCCs when letters 2 and 3 are incorrect are 48% correct and 52% incorrect. The comparable values for CCCCCs are 25% and 75%. The value of the frequency chi-square is 11.57, $p < .001$, and it appears that the context effect is present even in the absence of correct responding on the context letters.

The results indicate that the context effect is not restricted to instances in which the letter string forms a word (Reicher, 1968; Wheeler, 1970). The facilitating effects of certain contexts cannot be completely attributable to S having a memory representation of the letter string but must be at least partially a consequence of phonological and/or orthographic structure.

Experiment II

In Experiment I only performance for the CVVCC intact items approached the maximum level of 9 correct at the 500 msec. delay of mask. Performance for the CCCCC intact items and both types of permutations remained well below maximum. The possibility exists that a 40 msec. presentation interval produced a state of iconic memory which decayed before S could extract all the letter information. The purpose of Experiment II was to see if performance for these latter items could be improved by delaying the decay of iconic memory, thereby giving the Ss more time to extract the letter information. The method of delaying the decay of iconic memory was to increase the presentation interval while holding constant at 540 msec. the total time between presentation of the material and the mask.

Method

Subjects.--The Ss were 18 paid undergraduate volunteers selected in the same manner as for Experiment I.

Materials.--The materials for Experiment II were the same as for Experiment I.

Procedure.--The procedure for Experiment II was the same as for Experiment I with the following exceptions: Rather than the delay of mask intervals of Experiment I, presentation-delay combinations (P-D) were used. These were 40 msec. presentation-500 msec. delay -- a replication of the last delay of mask condition of Experiment I -- a 100-440 condition, and a 300-240 condition. Since the delay of mask manipulation was reduced from 6 levels to 3, 18 items rather than the 9 of Experiment I were assigned to each subcondition of the experiment. Finally, 9 rather than 18 Ss were assigned to each level of the between-Ss factor (intact item vs. permutation).

Design.--The experiment had four factors, presentation-delay combination (P-D), serial position of the letter (SP), type of item, CVVCC vs. CCCCC (Type), and order of letters within an item (Order).

Results

An individual score used in the analyses of the data was the number of letters correct for a given level of the other four factors. The score could range in value from 0-18, but the means were scaled by a factor of .5 so that the results of Experiment II could be conveniently compared with those of Experiment I. A summary of the results collapsed over Ss appears in Table 3 and Table 4. The first statistical analysis was a 4-factor analysis of variance. The Geisser and Greenhouse (1958) procedure was again used.

All main effects were statistically significant. For Type, $F = 8.81$, $p < .01$; for SP, $F = 31.83$, $p < .001$; for P-D, $F = 15.50$, $p < .005$; and for Order, $F = 47.90$, $p < .001$. The directions of the differences are indicated in Tables 3 and 4. A significant Type X SP interaction effect, $F = 9.16$, $p < .01$, reflects the fact that performance falls off more rapidly over serial positions for CCCCCs than for CVVCCs. The Type by P-D interaction effect, $F = 5.29$, $p < .05$ is attributable to the greater increase in performance over levels of P-D for CCCCCs as compared to CVVCCs. The highly significant Order X SP effect is a result of the more rapid decrease in performance over levels of SP for the CCCCCs as compared to the CVVCCs. Finally, the SP X P-D interaction effect, $F = 5.62$, $p < .05$, may be interpreted as a consequence of the somewhat flatter serial position curves for increasing values of the presentation intervals.

Subanalyses were conducted for the intact items and permutations to see if (a) there was a significant improvement in performance over levels of P-D for both types of material and (b) the improvement in performance over levels of P-D was different for CVVCCs and CCCCCs. There was a significant effect of P-D for both the intact items ($F = 12.50$, $p < .005$) and the permutations ($F = 6.18$, $p < .025$). The interaction of Type and P-D was significant only for the intact items, $F = 5.98$, $p < .05$.

Discussion

The significant effects of P-D for both intact items and permutations indicate that Ss were able to extract more information from iconic memory when it was extended by increasing the presentation interval. For the permutations, the extension to 300-240 was still not enough to produce near maximal performance for the last two letters. However, for the intact items, the performance levels at 300-240 for CVVCCs and CCCCCs are both highly similar and close to maximum.

Table 3

Average Number of Letters Correct by Serial Position, Presentation-Delay Intervals, and Type: Intact Items

Presentation-Delay Intervals	Serial Position 1	2	3	4	5
		CVVCC			
40-500	8.94	8.50	8.28	8.33	8.39
100-440	8.72	8.44	8.33	8.39	8.50
300-240	9.00	8.78	8.83	8.72	8.50
		CCCCC			
40-500	8.94	8.55	7.55	5.28	6.05
100-440	8.72	7.89	7.55	5.78	6.22
300-240	9.00	8.83	8.67	7.16	7.44

Table 4

Average Number of Letters Correct by Serial Position, Presentation-Delay Intervals, and Type: Permutations

Presentation-Delay Intervals	Serial Position 1	2	3	4	5
			CVVCC		
40-500	8.50	8.11	7.16	6.67	7.44
100-440	8.83	8.00	8.00	7.44	7.55
300-240	8.78	8.61	8.22	7.22	7.72
			CCCCC		
40-500	8.50	7.44	6.44	4.50	4.83
100-440	8.61	7.83	7.28	5.22	5.33
300-240	8.72	8.11	7.94	5.50	5.94

General Discussion

The sizable differences between the same letters in the same positions for CVVCCs and CCCCCs indicates that the context effect is not dependent on the S having a representation of the item in memory but is rather a product of S's knowledge of orthography or phonology. The basis of this knowledge, i.e., whether it is based simply on frequency of experience with letter patterns or based on implicit knowledge of linguistic rules, remains somewhat speculative. The context effect could not be attributed to differences in the frequency of the complete 5-letter strings, because this frequency is essentially zero for both the CVVCCs and the CCCCCs. Nor could the effect be attributed to the frequency of the context, since the frequency of the medial CCs was greater than that of the medial VVs (cf. Materials section). There remains as a potential frequency basis for the effect the frequency with which the context in conjunction with either the initial consonant or the terminal consonant pair has been experienced. Although the Venezky norms do not give frequency counts for vowel-consonant combinations, such frequency would undoubtably be greater for CVVs and VVCCs than for CCCs or CCCCs. Possibly, the problem could be approached by investigating the mutually facilitating effects of vowels and consonants together as compared to only vowels or only consonants. It is likely that CVs or VCs could be matched in frequency with CCs or VVs.

One aspect of the results of relevance to the field of reading is that sizable facilitation effects in letter perception do occur as a result of context. If individual letters can be detected with differential accuracy depending on the context, then it seems very likely that there would also be facilitating effects on the perception whole words or groups of words. This is not to argue that each letter of a word need be detected for correct identification of the word. However, it seems likely that some information about individual letters would have to be extracted in order to identify a word, and to the extent that the rate of information processing for letters was facilitated by context, whole word perception would be facilitated. Consider an example such as "BLACK" and "BLOCK"; the only locus of difference is in the middle letter. To the extent that rate of information processing for the middle letter was enhanced, it would seem that correct identification of the whole word would be enhanced. The effect is of sufficient size to play a meaningful role in reading. For example, in the zero delay of mask condition the average performance for the first, fourth, and fifth letters taken together is 3.517. For the same letters of the CCCCCs, the average is 1.500, a ratio of 2.3 for exactly the same letters in different contexts.

Another aspect of the results of interest to the field of reading is that the facilitation effects in letter perception occur in letter strings which do not form words, i.e., it is not necessary for a person to have learned the letter string as a word to produce the facilitation in perception. The clear indication is that the basis of the effect is the individual's knowledge of the orthographic or phonological structure of the language.

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