IMPROVING WORD PRONUNCIATION

IMPROVING WORD PRONUNCIATION BY VISUALLY EMPHASIZING LETTER GROUPS

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ABSTRACT

Adults experience a surprising degree of difficulty when they attempt to sound out words written with novel alphabetic characters. This difficulty is experienced despite extensive prior practice on identifying those characters individually, and despite many years of prior experience with the English alphabetic system (Brooks and Anderson, 1976). Such difficulties seem in some ways akin to the "blending difficulties" experienced by beginning readers. The experiments in this thesis were designed to test whether this adult blending difficulty might in part be due to a disruption of the adults' ability to segment letters into groups that are relevant for further processing.

Experiment I demonstrated that response time to identify words written with novel characters could be reduced by visually emphasizing the vowels, thereby making orthographically relevant letter groups more salient. Moreover, practice on identifying vowel enhanced words resulted in improved performance on a new list of unenhanced words. Experiment II showed that performance on vowel enhanced words was also improved for both regularly and irregularly spelled words even when they were written with familiar Roman characters. These data

are discussed in terms of several possible components of word identification.

The fact that the effect was found for both artificial and Roman letters and for both regularly and irregularly spelled words suggests that vowel enhancement might aid word identification under a wide variety of conditions. Such generality offers some grounds for the speculation that vowel enhancement could improve word identification skills and perhaps aid in establishing appropriate visual inspection habits in children.

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INTRODUCTION

If one asks a fluent reader of English, who is in a particularly indulgent mood, to pronounce the character string PSFMB, a frequent response is some deliberation followed by an utterance similar to "PUS-EF-UMB(uh)". When asked to sound out PSFMB, one feels a momentary loss in "knowing where to begin", followed by the decision to doggedly proceed from left to right and generate a phonemic equivalent for each letter. However, replacing only a single character can evoke a rather sweeping reorganization of the response. For example, replacing F with A produces PSAMB, which is frequently pronounced "SAM". The visual grouping of the characters in PSAMB into PS and MB seems to occur automatically, without conscious mediation. This automatic grouping of characters may not result only because PS and MB generally correspond to single phonemes in the sound stream. The character string PLEST arouses a similar tendency to group the consonants PL and ST.

It is possible that the fluent reader's ability to recognize clusters such as PS, MB and ST is important in readily sounding out novel words. Furthermore, some of the difficulties in sounding out novel words experienced by beginning readers might arise because letter clusters such as PS, MB and ST are not easily recognized. This deficiency in visual recognition might leave no alternative when sounding out novel words other than to proceed left to right, generating phonemic equivalents for each letter. A strategy which necessitates considering each letter singly might possess inherent limitations which contribute to difficulties when sounding out novel words.

Let us consider a set of experiments which demonstrate that sounding out words from single letters is difficult, even for fluent adults (Brooks and Anderson, 1976). These experiments involved first teaching an adult subject (S) a 10 letter artificial alphabet shown in Figure 1. After learning to a high criterion a verbal response to each symbol, the time required to pronounce a four to seven character word written with the novel symbols was measured. This time was compared with the time required to name all of the symbols in a string of four to seven randomly ordered characters.

There were two major findings from these experiments. First, on nearly 5% of the words, 60% of Ss "blocked". That is, they were unable to respond with an English word for periods as long as five minutes. During this time, Ss would add, delete or substitute phonemes from the correct response, utter a nonword, re-examine the stimulus, utter another nonword and so on. This difficulty was not due to an excessive memory load--in fact, Ss would often repeat the correct letter sequence several times from memory. The words were not unusual in any obvious

Figure 1

Sample of Materials from the Blending Experiments. The materials shown above can be used to demonstrate the difficulty of sounding out. For either the English or the phonic orthography first study the alphabet. Then practice the correspondences by naming symbols anywhere on the page, possibly in the other column right-to-left, bottom-to-top. When this can be done with fair facility, compare the times you require for the two tasks in the column on which you started. Record your times for naming the symbols in each of the four strings in the top box. Then record your times for naming the words in the next box down.

	ENGLISH ORTHOGRAPHY		"PHONIC" ORTHOGRAPHY	
	A C E R S T		"uh" K Ē R S T	
	V Λ U ∩ I ∞		V Λ U ∩ I ∞	
NAME THESE SYMBOLS	∞U∩IU∞	ΛU∩UIV	∩∞IV∞I	Λ∩IV∞I
	IV∩UΛ	IU∞IV	IΛ∞VI	ΛV∩I∞
NAME THESE WORDS	I∞∩UU∞	Λ∩UVIU	∞∩VI∞I	I∞∩UΛI
	IΛV∩U	U∩UΛ∞	∞VIΛI	I∞∩VΛ
NAME THESE SYMBOLS	ΛUI∞∩V	IV∞UI∞	IUΛV∩∞	∞U∩U∞∩
	∞UΛ∩V	IU∞IV	IΛ∞VI	ΛV∩I∞
NAME THESE WORDS	∞∩VΛUI	∞VI∞UI	Λ∩VI∞U	∩U∞∩U∞
	Λ∩V∞U	VIIU∞	∞∩VΛI	Λ∩VΛI

way--"suffers", "tastes" and "clear" produced blocking in several Ss. When asked about possible causes of the difficulty, Ss could offer little beyond statements such as, "They (the letters) just would not go together..." and an expression of surprise that the task was so difficult.

The second major finding from these experiments was that when Ss did not experience any unusual difficulty, almost twice as long was required to identify words as to identify arbitrary sequences of characters equal in number to those in the words. The additional time required averaged nearly five seconds, and it was not uncommon for Ss to require, on the average, three or even four times as long to identify words as to identify arbitrary character sequences of equal length. One might expect to observe some difference in response time for these tasks; however, given that one expects a fluent adult to be proficient at blending phonemes, a mean difference as large as five seconds is rather surprising.

These observations pose an intriguing problem. One feels that the "blending skill" prized by many beginning reading programs ought to be general; that is, it ought to be easily applied to unfamiliar words. After all, is not the ease of identifying unfamiliar words a mainstay of the alphabet's elegance and alleged superiority over other writing systems? To be sure, adults might experience some difficulty when sounding out such monstrosities as "septaugesimal", "epinephrine" and "sesquipedalian". But why should an adult, even in the most bizarre circumstances, experience difficulty with "suffers", "clear" and "tastes" beyond that encountered in identifying the characters? Why should visual novelty so severely disrupt the ability to blend the phonemic components of words?

Difficulty in blending phonemes is a familiar phenomenon in the domain of teaching children to read. It seems that many children do not understand how the sound properties of whole words are reducible to the phonemic level represented in the alphabet, nor do they understand how discrete phonemes can be combined, or "blended", to yield whole words. For example, many children seem unable to comprehend that "man" and "mum" begin with the same sound or that both words are composed of three separable sounds (Chall, 1967; Gleitman and Rozin, 1975; Mathews, 1966; and Savin, 1972). Rozin, Bressman and Taft (1974) have found that many poor readers in the first and second grades were unable to select which of the written words mow and motorcycle corresponded to the spoken word, despite the gross differences in word length which would permit a correct decision by a nonreader who understood the principle of phonemic mapping.

It is unlikely that the difficulty experienced by adults in our experiments was generated by an inadequate understanding of the principles of alphabetic representation; however, difficulties could be generated because the phonemic properties of words are not immediately obvious.

Gleitman and Rozin (1975) report historical facts about the development of writing systems which suggest that phonemes are rather obscure linguistic units. It appears that the alphabet was invented only once while numerous independent developments of logographic and syllabic orthographies have been documented. Apparently, the principle of representing a word by a single sign, or as a combination of syllables, is more evident than the principle of representing a word as a series of phonemes. Furthermore, writing systems tend to evolve from logographic to syllabic systems, culminating in alphabetic orthographies. A reversal in this trend is not known to have occurred. The directed nature of the development of writing systems suggests that alphabetic orthographies may be at once the most efficient and the least intuitively obvious of the known writing systems (see also Mathews, 1966).

Gleitman and Rozin (1975) suggest that the ordered historical development of writing systems is a direct result of the differential accessibility of levels of phonological analyses. They assert that to learn to pronounce written words, one must be able to reflect upon certain facts about the nature of speech. They further suggest that some facts about the nature of speech are inherently easier to reflect upon than others. For example, it is easy to appreciate that speech consists of a series of words. That words are in turn composed of syllables is less easily realized, and that syllables are permutations of a much smaller stock of phonemes is quite obscure. Gleitman and Rozin argue that this gradient in the accessibility of different levels of phonological analyses is a possible consequence of the fact that while all words and all syllables can be uttered in isolation, many phonemes cannot. Thus, phonemes may be difficult to reflect upon because many of them cannot be made concrete. Gleitman and Rozin conclude that logographic systems develop prior to other writing systems because the relevant unit of phonological analysis is more apparent. By contrast, alphabetic systems are a much later development because the phonological unit represented by the single character is less accessible.

The nonintuitiveness of phonemes might make them difficult to deal with singly, even for a fluent adult. An adult typically generates the pronunciation for a novel word like MALAGASY by breaking it into segments like MA-LA-GA-SY, not into isolated "single letter" segments like M(uh)-A-L(uh)-A-G(uh)-A-S-Y (Gleitman and Rozin, 1975). This behaviour suggests that, despite years of experience with phonemic writing systems, adults find pronunciations easiest to generate from the phonological equivalents of groups of characters. The discrete phonemes signalled by single letters are rarely, if ever, used as the basis for pronouncing an unfamiliar word.

Sounding out characters in groups might be necessitated by the difficulty of pronouncing isolated consonants. In the MALAGASY example, "M" can be pronounced, but "L" is difficult and "G" impossible without the insertion of the neutral vowel "uh". Liberman, Cooper, Shankweiler and Studdert-Kennedy (1967) suggest that those consonants which cannot be pronounced in isolation are signalled in the speech stream by transitions from one sound to another. If this suggestion is correct, the reason for the inability to pronounce these consonants is clear--a phoneme which is a transition must be pronounced as a transition to something.

The preliminary inspection necessary to group characters so that transitions from one sound to another are preserved when sounding out a novel word might be severely disrupted by the use of the artificial characters shown in Figure 1. For example, if one sounds out the word "escape" by breaking it into esc + ape, the transition necessary for correct pronunciation of the letter "c" is missing. Problems due to inappropriate visual segmentation may arise with any phonemic mapping system--even with phonically regular orthographies. The "escape" example, phonemically transcribed, yields /esk/ + /eyp/. This segmentation makes correct pronunciation of the phoneme /k/ impossible.

Difficulties resulting from inappropriate visual segmentation could be greatly aggravated by the way in which pronunciation is signalled in English. These additional difficulties are not just a matter of the alleged irregularity of English spelling. Wijk (1966) offers a set of rules sufficient to derive the pronunciation of 97% of English words, provided that groups of letters are considered as the signals for phonemes. Considered in this way, the letter to sound mapping in English becomes highly regular. Most of the apparent irregularities in pronunciation of consonants involves consonant digraphs (e.g. lk, th, sh, mb, kn, ph, etc.) which are quite regular when considered as groups of letters. Undoubtedly, Ss in the blending experiments were aware of the phonemic equivalents of consonant digraphs such as "lk" and "sh"; nonetheless, difficulties could easily have arisen if recognition of these groups was hampered by visual novelty. For example, inappropriately segmenting talking could evoke a verbal response similar to "tall-king".

Cases of conditioned consonantal pronunciation are rare compared with cases of conditioned vowel pronunciation. Wijk's discussion of the conditioning of vowel pronunciation allows one crucial generalization to be drawn concerning the manner in which spelling reflects phonology. For simple words of the type used in the blending experiments, vowel pronunciation is determined by a simple algorithm:

> If there is only one vowel, assign the short pronunciation.
>
> If there are two vowels (V_1 and V_2) separated by n consonants, then when
>
> n = 0 V_1 long, V_2 silent (e.g. rain, boat); when
>
> n = 1 V_1 long, V_2 silent if terminal "e",

schwa ("uh") otherwise (e.g. fate, fatal, mode, modal); when

$n \geq 2$ V_1 short, V_2 silent if terminal "e", schwa otherwise (e.g. else, flannel, ballot).

Wijk's algorithm for determining vowel value (long, short, schwa, or silent) implies two exciting consequences. First, vowel value is largely a function of the local vowel-consonant environment, but is independent of the identity of those letters.[1] Second, if the initial vowel in a word is the n^{th} letter, the reader may have to identify both letters $n + 1$ and $n + 2$ before correct pronunciation for letter n can be established (e.g. rats, rate). One cannot establish the pronunciation for an initial vowel by phonological rules without some knowledge of the subsequent letters.

Wijk's algorithm suggests that one reason for the difficulties experienced in the blending experiments was because determining the pronunciation for at least the initial vowel required the identification of several additional characters. This requirement might have made

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[1] There is one major exception to this claim. If the consonants "l" or "r" are involved, there may be unusual conditioning effects. In many words, the effect of "l" or "r" intervening between two vowels is to make a two-consonant separation function as though it were a one-consonant separation (e.g. cable, maple, sabre, cobra, etc.).

sounding out difficult because inappropriate visual segmentations could break up orthographically relevant letter groups and prevent Ss from responding to vowel conditioning cues. Thus, attempts to sound out characters in groups could easily have come to grief if the groupings were orthographically inappropriate.

That difficulties arising from inappropriate visual segmentation occurred in the blending experiments was suggested by some of the erroneous responses. For example, Ss would occasionally respond "rattee" to the stimulus rate and "lee-ast" to the stimulus least. These errors might reflect visual segmentations which divided orthographically relevant letter groups. For example, segmenting the word least into one group containing le and another containing ast might encourage the S to respond "lee-ast". An examination of the response times for individual words produced support the possibility that Ss experienced difficulty in responding to orthographic cues contained in the visually novel stimuli. Words which intuitively seemed to be orthographically complex (e.g. those containing vowel or consonant digraphs) appeared to yield longer response times.

From considerations of both the inherent nature of consonants and the particular phonological signals of English, it seemed plausible that response time might be reduced by supplying visual cues which would encourage Ss to segment words into orthographically relevant letter groups.

A manipulation as simple as making the vowels look very different from the consonants might encourage orthographically appropriate visual segmentations by increasing the salience of vowel-consonant structures. For example, appropriate visual segmentations for the words rats, mats, rate, mate, dots, rots, dote and rote might be more apparent if vowel-consonant structures were highly salient. Evaluating this hypothesis is the focus of this thesis.

Two methods for visually distinguishing vowels and consonants have been tested. Both methods involve enhancing the vowels: one involved increasing their size and the other involved colouring them. The evaluation of the effectiveness of vowel enhancement involved three main considerations:

a) Are changes in response times associated with vowel enhancement attributable to increased patterning, regardless of any correlation between pattern and orthographically relevant letter groups?

b) Does practice in reading vowel-enhanced words improve performance on new, unenhanced words? That is, will any benefits transfer to words written in "normal" artificial characters where vowel-consonant distinctions are less clear?

c) Over what amounts of practice is vowel enhancement effective? Is any facilitation limited to only early stages of acquisition or can it be observed at more fluent levels as well?

EXPERIMENT I

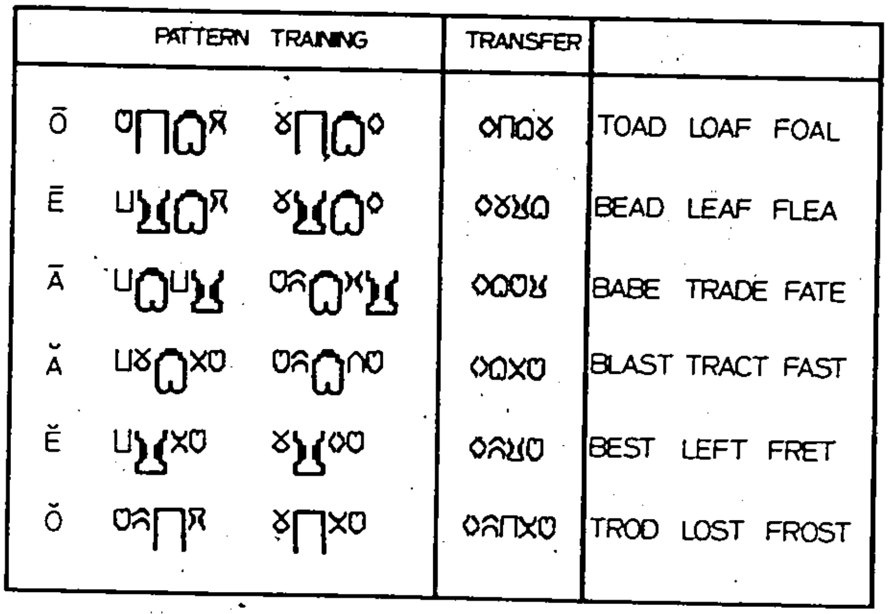
The effects of several types of visual patterning on response time to pronounce words written with artificial characters were assessed in this experiment. Each S was given ten training trials on each of three lists of words which were patterned according to one of the schemes shown in Figure 2a and b. Following each pattern training list, the S was transferred to a list of six unpatterned new words for four trials. The effects of primary interest are whether a group receiving vowel-enhanced stimuli performs better than a group receiving unenhanced "standard format" stimuli during pattern training, and whether the vowel enhanced group continues to show superior performance on the unenhanced transfer lists.

An additional group was run to clarify the interpretation of differences between the vowel enhanced and standard format. The artificial alphabet contained three vowels (A, E, and O), and it seemed very likely that facilitation in the vowel enhanced "AEO" group could occur because the distinctiveness of three of the characters had been changed. Altered distinctiveness might make discriminations among the novel characters much easier with vowel enhanced stimuli. Therefore, a group in which the letters T, L, and A were enhanced was also run. One or more

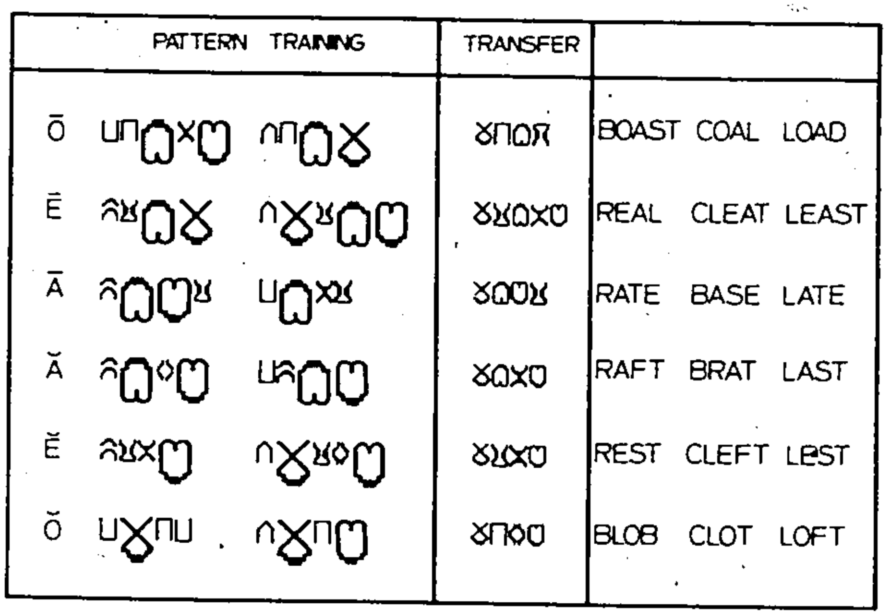
Figure 2

Sample of Materials from Experiment I. Each group received a pattern training list for ten trials followed by four presentations of a transfer list. This procedure was repeated for two additional training and transfer lists. In the diacritical group a "-" signals a long vowel, an "x" signals a silent vowel and the absence of a mark signals a short vowel. On all trials, the standard format group received stimuli like those shown in the transfer lists.

AEO GROUP



TLA GROUP



DIACRITICAL GROUP

	PATTERN TRAINING		TRANSFER			
Ō				COAST	BOAT	FLOAT
Ē				SEAT	BEAT	FEAST
Ā				SCALE	CRATE	FADE
Ă				SCAB	CRASS	FACT
Ĕ				SECT	BLED	FELT
Ŏ				CROSS	BLOT	FLOSS

members of the set of letters T, L, or A occurred in all but one stimulus word. If any advantage conferred by vowel enhancement is due to the altered discriminability of characters, the TLA enhanced group should show some facilitation as well.

Finally, a diacritical marking group was included. This group is interesting for two reasons. First, the marking system used made all of the vowels unambiguous in pronunciation but did not distinguish the vowels as a group. This was accomplished by making the absence of a mark indicate a short vowel, thereby making the vowels unambiguous in pronunciation but not visually distinct from the consonants. The performance of this group allows a distinction between the effect of sheer availability of unambiguous phonemic cues and the effect of increased salience of orthographically relevant letter groups. The second reason for including this group was that diacritical marking schemes have been applied to reading instruction materials for children and it was thought interesting to observe how adults respond to a similar manipulation.

METHOD

Subjects: In all, 40 Ss, who were McMaster University undergraduates, native English speakers, and naive to the task, were obtained by advertising. They were paid $2.00 per hour for participating in two one-hour sessions on consecutive days.

Ten Ss were assigned to each of the four groups. Assignment to the AEO and standard format groups was random. The TLA and diacritical groups were run consecutively at a later date.

Stimuli: The words were all four or five letters in length and were of six "orthographic types" (see Figure 2a and b): Ē A, Ō A, Ā (consonant) E (terminal), Ĕ, Ŏ, Ă (e.g. FEAST, FLOAT, FATE, FLED, FROST, and FAST). The words were selected so that the number of different letters required to spell all the items was small. The 72 words used required a total of 11 letters: A, B, C, D, E, F, L, O, R, S, and T (see Appendix for a complete listing of the words).

Each of four pattern training lists contained two instances of each orthographic type while each of four transfer lists contained one instance of each type. Initial consonants were partially counterbalanced across orthographic types within word lists. Any initial consonant was equally correlated with long and short vowel sounds. Furthermore, any consonant which was associated with, for example, the long form of "A" was also associated with the short form of "A". The six words within each transfer list all began with the same consonant (see Figure 2a and b). This balancing was designed to minimize the cueing of information about the word by the first letter.

The order of the items in each of the four pattern training lists was independently randomized 20 times. Ten orderings comprised form A for that list; the remaining 10 comprised form B. Similarly, four independent orderings comprised for A and an additional four comprised form B of the transfer stimuli for each list.

Each character was plotted on a 7 X 10 dot matrix which measured 3.5 X 7.0 mm. for unenhanced letters. In the AEO and TLA conditions, the size of the appropriate characters was doubled in the pattern training lists. In the diacritical group, a bar (—) appeared over long vowels and an "x" over silent ones. The absence of a mark indicated a short vowel. The marking scheme did not mark short vowels since this would result in the marking of every vowel, thus distinguishing the vowels and consonants as groups. All characters were of the same size in the standard format condition and in the transfer lists for all groups. The correspondences between the artificial characters and letters were clearly illustrated on a sheet to be examined by each S at the beginning of the first session.

Apparatus: The experiment was run using a PDP 8/L computer interfaced with a Techtronix model 602 display scope, a high speed punch, a crystal clock and two response keys.

Procedure: Subjects were given the sheet illustrating the correspondences between the artificial characters and letters of the alphabet and were asked to signify when they thought they could reliably give the English letter name for each symbol. Memorizing the names for the characters required approximately five minutes. Following memorization of these correspondences, the S was seated about 20 inches in front of the display scope and was told that randomly ordered sequences of the 11 characters would be displayed. The task was to name the symbols, from left to right, as quickly as possible without error. Timing of the response on each trial started with presentation of the character string and ended with the E depressing a button as the last character was identified. Presentation of different orders continued until the S succeeded in correctly naming all 11 symbols in less than 16.5 seconds on two consecutive trials. Trials to this criterion ranged from 3 to 45, with a mean of 15.4.

Subjects were then told that they would begin reading words formed from the symbols they had learned. Subjects in the standard format condition were told that the symbols would appear in the same format as during the symbol naming task. Those in the AEO and TLA groups were told, respectively, that the letters A, E and O, or the letters T, L and A would appear twice as large as any of the other letters. The marking scheme for the diacritical group was explained in detail, with the aid of several examples of words containing long, short and silent vowels.

Half the Ss in each group received form A lists and the remainder received form B lists. Each S received three of the four pattern training and transfer lists. The selection and ordering of the lists was partially counterbalanced within groups and yoked across all four pattern manipulations.

Words were presented singly following the starting signal "ready... one, two, three, go". Time from the onset of each stimulus to the first word uttered was recorded and the S was given immediate feedback as to the correctness of the response. The interstimulus interval was approximately five seconds. Following each presentation of the list, response times and error codes were punched on paper tape and the S was allowed a short (one minute) rest period.

After the tenth presentation of the pattern training list, the S was told that a new list of items was going to be presented. Subjects in the AEO and TLA groups were told that all characters would be the same size while those in the diacritical group were told that the markings would be removed. The transfer list was presented four times using the procedure described for the pattern training lists.

The first session concluded after the presentation of the first pattern training and transfer list. The second session commenced on the following day with a short symbol naming task wherein Ss named the characters in 12 anagrams formed from the words seen on the previous day. Following this, the remaining two lists were presented according to the procedure described for the first list.

RESULTS

The mean number of trials to criterion on the preliminary alphabet training task for the AEO, TLA, standard format and diacritical groups was 14.5, 19.1, 16.1, and 11.8, respectively. The number of trials to criterion for these four groups was submitted to a one-way analysis of variance, yielding a value of 0.89. The obtained value is very close to the expected value of 1.00, which suggests that the groups were comparable samples. The comparability of these samples is further suggested by the equivalence of error variances. The proportion of error variance contributed by any one group did not exceed 0.342, whereas the critical value of this proportion at the 0.05 level by Cochran's test for homogeneity of variance is 0.502 (Winer, 1962, p. 94).

It was felt that observations associated with erroneous responses or with "blocking" (see page 2) might not be directly relevant to the question of whether difficulties typically experienced are partially due to difficulties in visual segmentation. For example, errors and "blocking" may reflect incorrect character identification, or incorrect guessing of word identities. Accordingly, response times associated with errors were discarded, and "blocking" trials in the remaining data were identified by the following procedure. Response times were analyzed in blocks of six. Any response time which, when removed, reduced the variance of the remaining five by a factor exceeding 2.50 and reduced the mean of the five by 3.0 seconds or more was excluded. Of a possible 17,280 responses, the exclusion of erroneous and "blocked" response times yielded 16,422 usable observations. Thus, errors or blocking occurred on 4.97% of the words.

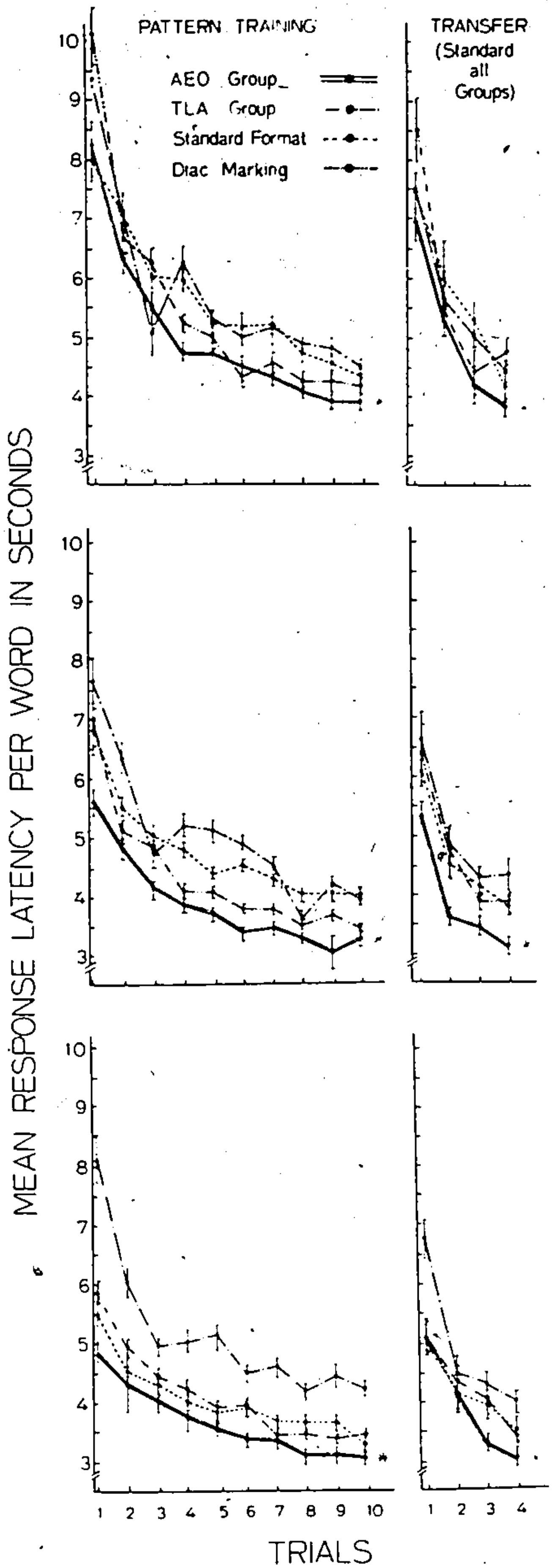
Mean response times and standard errors for these means were calculated for the remaining data within each list presentation for each group. The means and standard errors appear in Figure 3. An examination of this figure suggests that performance in the AEO group was generally superior to that of the other three groups during pattern training trials. Evidence for superiority of the AEO group during transfer is somewhat less clear; however, the vowel enhanced group does seem to yield better performance than the other three groups on the second transfer list and the last two trials of the third list.

The data shown in Figure 3 were then collapsed over trials within the pattern training and transfer conditions for each of the three lists in the four experimental conditions. Thus, one mean was obtained for each group in each of the six panels in Figure 3.

Differences among these means were assessed using Dunnett's <u>t</u>--a statistic which allows comparisons between a designated group and

Figure 3

Results of Experiment I Plotted by Trials.
The conditions were administered in the order shown, left-to-right, top-to-bottom. Note that the AEO group corresponds to the bottom line in each panel. The vertical bars represent $\pm$ 1 S. E.


PATTERN TRAINING
TRANSFER (Standard all Groups)
AEO Group
TLA Group
Standard Format
Diac Marking
MEAN RESPONSE LATENCY PER WORD IN SECONDS
TRIALS
10
9
8
7
6
5
4
3
1 2 3 4 5 6 7 8 9 10
1 2 3 4

n other treatments (Dunnett, 1955). In all, six independent t's were computed--one for the four means within each of the panels in Figure 3. Using the .01 alpha level for each of these comparisons yields a level of $1 - 0.99^6 = 0.058$ for all comparisons simultaneously.

Table I shows the obtained and expected mean response time differences ($p = 0.058$) between the AEO group and each of the other groups for the six panels in Figure 3. The AEO group was found to be faster than the other three groups on every pattern training list and on the second transfer list. On the first transfer list the AEO group surpassed the diacritical group, and on the last transfer list the AEO group was superior to the TLA group.

An important question in connection with transfer is the amount of disruption observed. Vowel enhancement was intended to foster orthographically appropriate inspection habits, whereas the diacritical manipulation, by supplying unambiguous pronunciation cues for individual vowels, might encourage Ss to disregard the orthographic pronunciation cues present in English spelling. If the diacritical manipulation does not train inspection habits appropriate to unmarked words, one would expect to observe greater disruption upon transfer in the diacritical group. Orthogonal t tests were computed to compare the absolute difference between training and transfer performance for the AEO group with that of the diacritical group. One t was computed for each of the three

Table I

Results of Dunnett's t. The performance of the TLA, standard format and diacritical groups was compared with that of the AEO group for each list in the pattern training and transfer conditions. The number to the left of the slash is the obtained difference while that to the right is the expected difference. A star (*) indicates that the obtained difference exceeded the expected difference ($\alpha = 0.058$ for all comparisons simultaneously).

		Condition	
List	Group	Training	Transfer
I	Standard	0.64/0.23*	0.22/0.62
	TLA	0.76/0.23*	0.58/0.62
	Diac	0.47/0.28*	0.73/0.62*
II	Standard	0.90/0.27*	0.72/0.61*
	TLA	1.16/0.28*	1.22/0.61*
	Diac	0.53/0.27*	0.73/0.62*
III	Standard	0.37/0.27*	0.26/0.62
	TLA	[illegible].47/0.27*	0.98/0.61*
	Diac	0.44/0.27*	0.30/0.61

training/transfer blocks. The obtained values of t for blocks one, two and three were +1.72, +2.08 and -1.15, respectively. A positive value for t indicates a smaller difference between training and transfer performance for the AEO group. The value of t required at the 0.05 level (one-tailed) is 1.64. This alpha level yields a level of 0.14 for all three comparisons simultaneously. The obtained values of t for the first and second transfer list suggest that disruption was, if anything, greater in the diacritical group. Thus, the absolute differences between the AEO group and the diacritical group upon transfer for the first and second lists found by Dunnett's t (see Table I) seem partially attributable to greater disruption in the diacritical group. On the third transfer list, greater disruption in the diacritical group cannot be demonstrated; however, on the third transfer list, there is also no difference between the AEO group and diacritical group in terms of absolute performance levels (see Table I).

CONCLUSIONS AND DISCUSSION

The results indicate that vowel enhancement was effective in reducing response time. The facilitation can be observed throughout the training trials, suggesting that the benefits are not transitory, at least within the limits of practice in this experiment. This result is rather surprising given that the Ss were fluent readers of English and well acquainted with the pleasures and pitfalls inherent in the orthography. Furthermore, there were no instructions to use the cues; indeed, Ss were not even told the manner in which vowel enhancement conveyed potentially important information, and most of them insisted that the cues were not helpful.

More importantly, the AEO group generally showed superior performance upon transfer to new, unenhanced words. The lack of clear superiority in the first transfer list is perhaps attributable to the relatively early stage of practice and to stimulus novelty. This was the first exposure to unenhanced words for the AEO group, while the standard format group had extensive prior familiarization with this type of patterning.

The evidence for superior transfer is clear on the second list by Dunnett's t. On the last two trials of the third transfer list the standard errors of the AEO group do not overlap those of the other three groups, suggesting that the AEO group may again be diverging (see Figure 3). Intuitively, one would expect that performance on new lists of words would be largely determined by visual familiarity--that the AEO group should ever surpass the performance of the standard format group on transfer is surprising.

The superior performance of the AEO group during training and transfer cannot be attributed to the altered discriminability of individual characters or whole words in the AEO group. The TLA group experienced changes in the discriminability of individual characters which were comparable to those experienced by the AEO group, yet performed more poorly throughout the training trials and during the second and third transfer list. It is also unlikely that facilitation in the AEO group resulted from changes in the discriminability of whole words within lists, thereby simplifying the task of selecting the appropriate response. Within each training list, the AEO group received about 25% (numerically about two) fewer distinct patterns than the TLA group. If vowel enhancement served only to increase the discriminability of whole words, one would expect the TLA group to have performed as well as, if not better than, the AEO group. In fact, the TLA group performed more poorly than did the AEO group.

The following discussion will focus on explanations which are consistent with the data. The mechanisms to be discussed are not mutually exclusive, nor do they exhaust all possibilities. Indeed, there is nothing which compels one to hold one view over the others--they are presented only because they seem likely candidates.

Direct phonemic cueing

The visual patterning in the AEO condition could aid the S in producing the appropriate response by serving as a "direct phonemic cue". For example, the pattern could indicate that the vowel sound in a particular word was long or short and this information could "set" the S to respond appropriately. Such cues may have aided the AEO group; however, the diacritical manipulation was intended to model a technique designed to make precisely this sort of information readily available. If the results obtained for the AEO group were contingent on the sheer availability of such information, it is surprising that the diacritical group performed more poorly during training. Moreover, the diacritical group generally performed more poorly during transfer in terms of absolute performance levels and possibly in terms of performance levels relative to those observed during training. The possibility that disruption upon transfer was greater in the diacritical group suggests that the poorer transfer found by comparing absolute response times may not be due only to a higher "baseline" set for the diacritical group during training.

On the basis of this argument, one cannot dismiss the possibility of direct phonemic cueing entirely. The diacritical manipulation might have produced a less salient visual pattern, resulting in poorer performance during training. The nature of the AEO manipulation makes it unlikely that the S could identify characters and remain unaware of size, since the two are integrally related. By contrast, identifying a character carries no such assurance that the corresponding diacritical mark has also been identified. Identifying a diacritical mark may require, among other things, a shift in attention with corresponding increases in response time. Similarly, poorer transfer might be observed in the diacritical group because the patterning during training trials was visually less integrally related to the transfer stimuli.

The position that the effects of the AEO manipulation were due to phonemic cueing is not unsupportable, though it is difficult to imagine how such a cueing device could sustain performance superior to that of the standard format group upon transfer. There are data which suggest that direct phonemic cueing improves performance in experiments employing artificial alphabets. A. Miller (1976) has found that cueing vowel sounds with word envelopes reduces the total time required to pronounce lists of words; and, indeed, the diacritical group in the present experiment did perform rather well during training (see Figure 3). But, it seems that to the extent that the method of direct phonemic cueing fulfills the ideal of unambiguously signalling sound values of isolated letters, a somewhat inappropriate inspection strategy would be encouraged. That is, the S would be encouraged to determine sound values by examining only single letters and to ignore the orthographic structure of the word. This strategy could yield relatively good performance as long as the cues are present, but would prove inadequate when the marks are removed upon transfer. Thus, while the hypothesis that vowel enhancement served primarily as a direct phonemic cue is consistent with the data, the mechanism whereby such a device could yield transfer superior to that observed for the standard format group is obscure. But, given the difference between the AEO and diacritical groups, even the most extreme formulation of the phonemic cueing hypothesis has to acknowledge the important effect of the exact visual form of the phonemic cues.

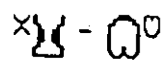
Word identification procedures directed by orthographic features

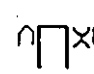
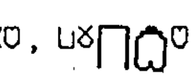
The remainder of this discussion will entertain the possibility that the facilitation observed in the AEO group was produced by increasing the salience of orthographically relevant letter groups. Specifically, the hypothesis is that orthographic segmentation information is important in analyzing a word _en route_ to pronunciation and it was this information, rather than "direct" phonemic information, which resulted in the faster response times observed in the AEO group. Two basic ways in which responses could be facilitated by consistent orthographic segmentation information will be discussed. Both rely on word identification procedures, the success of which depends upon the availability of information concerning the orthographic relationships among characters.

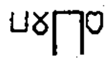
a) _Cueing of phonological analyses:_

From Wijk's (1966) discussion it is clear that the pronunciation of a vowel cannot be established by phonological rules if the vowel is considered independently of the other letters. It was suggested in the introduction that the visual novelty of artificial characters might disrupt the preliminary inspection necessary to segment the word into letter groups which signal vowel pronunciation. In fact, visual novelty might even constitute a strong inducement to follow the inappropriate strategy of segmenting words on the basis of overall visual similarity to previously presented words.

The disruption produced by generalizing segmentation schemes on the basis of overall visual similarity could be severe. Suppose the following stimuli were presented to an S in the standard format group: XƱ∩O, XƱΩO, ∩⊓XO and ∩⊓ΩO (sect, seat, cost, and coat). The S might break the first word into XƱ and ∩O. This segmentation is orthographically appropriate: it corresponds to the letters se (yielding /se/) and ct (yielding /kt/). Thus, the S responds "sect". Spurred by this success, the S might then segment the visually similar XƱΩO into XƱ and ΩO. Unfortunately, this segmentation yields /se/ and /æt/ or "s?ăt" (/se æt/). Similarly, the second pair of words might yield "cost" and "cŏ-ăt".

Vowel enhancement could reduce the frequency of inappropriate segmentations like XƱ - ΩO. In the AEO condition, the four stimuli would have appeared in the following format: XƱ∩O, XƱΩO, ∩⊓XO and ∩⊓ΩO. Comparing this to the case for the standard format group, it is immediately clear that one function vowel enhancement could serve involves altering the visual similarity among words. The word  no longer resembles  so closely; moreover, it now shares more in common with . If the S learned to weigh size heavily when making judgements of visual similarity, the AEO manipulation would differentiate orthographically unrelated words while increasing the similarity of related ones. These alterations in visual similarity might limit the generalization of word segmentation schemes to only those words which are orthographically similar. That is, vowel enhancement might increase the likelihood that the segmentation scheme from sect was applied to cost while decreasing the likelihood that it was applied to seat. Even if Ss did not habitually generalize segmentation schemes among words, misleading segmentations like  could be avoided in the AEO group if Ss learned never to segregate two enlarged letters.

To summarize, the AEO manipulation might encourage Ss to apply orthographically appropriate segmentations to the visually novel stimuli. By encouraging the examination of the relevant letters, the frequency of misapplications of phonological re-write rules ought to be reduced. For example, the appropriateness of the rule "$\ldots cv_1v_2c \longrightarrow v_1$long, $v_2$silent" over the rule "$\ldots cv_1c \longrightarrow v_1$short" is more apparent when the word is written , rather than , because the vowels and consonants are distinguished as groups. Given a list like , , ,

 , , ,  and  (coat, cost, bloat, blot, cleat, cleft, seat and sect) the task of selecting the appropriate rule ought to be very much easier.[2]

Superior transfer could be accommodated if S̲s in the AEO group were able to transfer the general strategy of determining the orthographic structure of the word before attempting pronunciation, thus avoiding the division of orthographically relevant letter groups. A second possible transfer mechanism arises if, having habitually analyzed sequences like st, bl, cl, ft, ct, oa and ea as groups, S̲s then placed boundaries around familiar clusters in the transfer list.

b) Cueing specific pronunciations:

Vowel enhancement could also be beneficial if S̲s were able to derive pronunciation by "analogy". For example, having seen the word beat and having remembered both the visual form () and the response (/biyt/), the S̲ can now interpret the new word seat () by reasoning that the new stimulus is identical to  except for the first letter. Thus, one ought to take the /b/ out of /biyt/ and add /s/ (corresponding to ), yielding "seat" (/siyt/) (see Baron, 1975, for a somewhat different formulation of analogy mechanisms in reading).

One problem with this strategy lies in recognizing the appropriate

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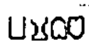
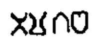
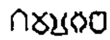
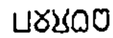
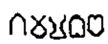
[2] The S̲ could also utilize specific associations of sound values to salient, orthographically relevant letter sequences (e. g.).

analogue. On a strictly visual basis,  (seat) is equally analogous to  (beat) and  (sect). Taking the /k/ out of /sekt/ and adding /æ/ (corresponding to ) would yield "sĕ-ăt" (/se æ t/). Similarly,  (cleft) and  (bleat) both seem appropriate to  (cleat). To avoid erroneous analogies, some sort of "weighting" is required to ensure that analogies are drawn on the basis of orthographically relevant letter groups. It is precisely here that vowel enhancement could help. When written  it is clear that the appropriate analogy is to  and not to . Similarly, , not , is appropriate to .

Superior transfer to unenhanced words in the AEO group could be accomplished if, during training, the S learned to weight orthographically relevant letter groups heavily in analogy formation. Subjects may also have organized previously presented items into "memory lists" of "ea" words, "oa" words, "short a" words and so on. The vowel structure of an unenhanced word might then have a high priority in determining which lists are searched for, and consequently, which items are retrieved as potential analogues.

GENERAL DISCUSSION

The results from this experiment on the effect of vowel enhancement pose a number of questions in connection with possible underlying mechanisms. However, given only one experiment, perhaps the most important questions concern the generality of the effects. First, it would be interesting to determine whether these effects can be observed at higher levels of fluency. Word identification in this experiment was ponderously slow and there are many reasons for supposing that vowel enhancement should become ineffective at more automated levels of word identification. The rationale behind vowel enhancement arose from a suspected difficulty in segmenting words written with visually novel letters, and there is a real question as to whether visual segmentation would continue to pose a problem if words are written in traditional Roman letters. Nonetheless, even when written with Roman letters, vowel enhanced words could produce superior performance to that associated with an enhancement scheme which does not reveal orthographically relevant letter groups. Vowel enhanced words might be more easily identified than words in which the enhanced letter groups are not orthographically relevant because vowel enhanced words are more compatible with established word processing mechanisms. A second extension concerns the effect of irregularity. Despite Wijk's (1966) discussion of word pronunciation, the fact remains that a large number of words are "irregular" or are covered by rules which apply to such a small number of cases that, for all intents and purposes, the words are irregular (e. g. of, have, said, done, most, to do (cf. go, so) etc.). It is quite conceivable that upon introducing spelling irregularities normally present in written English, vowel enhancement will become ineffective.

Extreme forms of these extensions concerning fluency and spelling irregularity were examined in the second experiment. The question of fluency was addressed by presenting words in upper case Roman characters to fluent adult Ss. The question of spelling irregularity was addressed by including two list types. One list consisted entirely of regularly spelled words, while in the other at least 50% of the words were irregular.

EXPERIMENT II

This experiment assessed the effect of vowel enhancement on fluent pronunciation of words written with familiar Roman characters. Adult Ss pronounced words presented under three visual manipulations. In the "vowel" condition the vowels were enhanced while in the "standard format" condition all letters appeared in unenhanced form. A third manipulation was a "pattern control" condition in which the patterns from the vowel condition were applied to words such that orthographically relevant letter groups were not enhanced (e. g. the pattern from BOAT was applied to BLED). If fluent word identification is affected by the salience of orthographically relevant letter groups, one would expect faster response times for pronouncing vowel enhanced words when compared with response times for pattern control words. It is intuitively unlikely that performance under the vowel condition could surpass that observed under the standard format condition because of the Ss' many years of experience with the standard format. However, if vowel enhancement produces patterns which are highly compatible with existing word processing mechanisms, the two conditions might yield nearly equal performance levels.

Given the expected automaticity of the responses in this experiment the pattern control seemed more appropriate than an analogue of the TLA group in Experiment I. The purpose of the TLA group was to assess the possibility that changes in the distinctiveness of the unfamiliar characters facilitated symbol identification in the AEO group, thus producing performance superior to that of the standard format group. When familiar Roman letters are used, it becomes considerably less likely that character identification is a problem in the standard format condition. By contrast, it seems much more probable that word identification in the vowel condition could be facilitated because the middle of the word, which is where vowels tend to occur, is distinguished from the ends. The beginning, middle, and end of the word may differ in importance to word recognition and be only coincidentally related to the position of the vowels. The pattern control retains the sequences of enhanced and unenhanced letters from the vowel condition; hence, superior performance in the vowel condition would indicate a dependence of the superiority on which letters, rather than which serial positions, are enhanced. A second possible source of facilitation in the vowel condition arises if Ss are able to associate verbal responses to patterns of enhanced and unenhanced letters. While such a strategy could decrease response time in the vowel condition, it should be equally effective in the pattern control condition, since this condition simply re-pairs the words and the visual patterns present in the vowel condition.

The three visual manipulations occurred within two list types designed to assess the effect of differing degrees of spelling regularity. The "regular" list consisted entirely of regularly spelled words. Most of these items came from the word pool of Experiment I. Words for the second "mixed" list were selected so that radically different pronunciations would correspond to the same letter groups (e. g. bough, tough, ought, mood, hood, flood, etc.).

"Irregularity" is an elusive concept; consequently, it is difficult to precisely estimate the degree of irregularity in the mixed list. However, the procedure for selecting the words for the mixed list suggests a rough estimate. The mixed list was generated by selecting words which were regularly pronounced according to Wijk (1966) (e. g. cost, dive, maid) and replacing the initial consonant of each word to yield a new word with a different vowel pronunciation (e. g. most, give, said). While most of the stimuli in the mixed list thus consisted of "contrasting pairs", some triples were possible (e. g. mood, hood, flood). This selection procedure suggests that the degree of irregularity, defined as the proportion of mutually inconsistent pronunciations, is at least 50%--clearly much greater than is normally encountered in written English.

This experiment was to be run using the apparatus described in Experiment I, and timing responses to single words with a voice key. However, pilot study using this equipment indicated that the variance in response time was so great that demonstrating differences among means would require an excessively large number of observations. It seemed that a better strategy would be to measure total response time to a large number of words presented simultaneously. Unfortunately, the video terminal cannot display more than about 20 characters before flicker becomes intolerable.

A second pilot study was run in which the Ss read lists of 20 words written on 8 1/2 X 11 inch bond using colour as the enhancement variable. Regular and mixed lists in all three pattern conditions were presented to each S. This procedure again produced small mean response time differences compared with the variance. One reason for the small differences seemed to be that the Ss would establish a "tempo" for reading the words. This tempo did not seem to change appreciably under different pattern manipulations in spite of occasional reports of differences in subjective difficulty.

At times, it seemed that Ss hesitated on particular words. One would expect such hesitations to affect total response but for the Ss' apparent "compensation" for the hesitation. It appeared that they systematically pronounced the next word(s) faster to "catch up" to the established rhythm. There was no convenient way of objectively demonstrating this "compensation", but it did suggest the dependent measure which was ultimately used--total interresponse time for each list.

The foregoing observations thus suggested several departures from the procedure used in Experiment I. In final form, the present experiment consisted of displaying 20 item word lists containing either vowel-enhanced, pattern control or standard format words to each S. The words were written in Roman characters and colour was the enhancement variable. The lists contained either regular or mixed spelling patterns, and total interresponse time for pronouncing each list was measured.

METHOD

Subjects: Sixteen Ss (technicians, undergraduate and graduate students), who were naive to the task and native speakers of English, were obtained by advertising. They were paid $1.00 for one 15-minute session.

Stimuli: The structure of the lists was determined by two variables. First, the lists for the pattern control condition were designed to assess the effect of the visual patterning present in the vowel condition when applied to words so that orthographically relevant letter groups were not enhanced. Second, the lists were designed so that word order could be counterbalanced within Ss across the three visual manipulations.

For the regular lists it was possible to retain the same sequence of initial consonants across several lists under each of the three pattern conditions. The regular lists contained a total of five different initial consonants; thus, the normal difficulty of pronouncing a list of unrelated words might be further aggravated by tongue-twisting articulatory difficulties. By minimizing changes in the sequence of initial consonants across lists, error variance ought to be reduced.

A) Regular lists for the vowel and pattern control condition

Eighteen of the words used in the regular list were obtained from two of the training lists in Experiment I. Two words not used in Experiment I were included to permit proper control of patterning in the pattern control condition. Two different orderings of all 20 words formed series 1 form A and series 2 form A in the vowel condition. The words used were then paired such that the two items within each pair had the same number of letters, the same initial consonant, but different vowel-consonant structures. Thus, boat was paired with bled, cleat with cleft and so on.

Series 1 form B was generated by substituting the paired word for each item in series 1 form A. Series 2 form B was generated by applying the same procedure to series 2 form A. Thus, form A of series 1 in the vowel condition began with boat while form B began with bled. The pattern control lists within a series were generated by using the word order from one form and the pattern structure from the alternate form of the vowel enhanced lists. The result of this procedure is illustrated below:

		VOWEL	PATTERN CONTROL
Series 1	form A	bOAt, RAtE ...	bLEd, RAfT ...
	form B	bLEd, RAfT...	bOAt, RAtE...
Series 2	form A	cLEAt, bRAt ...	cLEft, bASE ...
	form B	cLEft, bAsE ...	cLEAt, bRAt ...

The sequence of enhanced and unenhanced letters was identical for corresponding lists and each word order appears in both conditions. In addition, the same sequence of initial consonants was retained within a series. Colour was the enhancement variable: vowels were printed in red and consonants in black. In the text, large letters represent red characters and small ones represent black.

B) Mixed list for the vowel and pattern control condition

Owing to the larger number of initial consonants in this list, it was not possible to match the sequence of initial consonants between lists in the same manner as described for the regular lists. Words of the same length but different vowel-consonant structures were paired without regard to initial consonants. Thus, love might be paired with most. Otherwise the procedures for generating the four lists for each condition were as described for the regular list. A sample of the structure of these four lists is illustrated below:

		VOWEL		PATTERN CONTROL	
Series 1	form A	LOVE,	FLOOD ...	MOST,	ROOST ...
	form B	MOST,	ROOST ...	LOVE,	FLOOD ...
Series 2	form A	OUGHT,	HEART ...	TOUGH,	BREAD ...
	form B	TOUGH,	BREAD ...	OUGHT,	HEART ...

The difference between these lists and the regular lists is that in these lists word order and initial consonant sequences covary. This is not bothersome in itself since both conditions receive all word orders and, therefore, all sequences of initial consonants. The cost is an additional sequence of initial consonants within each series and possibly a resultant increase in error variance. In addition, one cannot compare absolute performance levels between the regular and mixed lists. However, comparisons between the regular and mixed lists would require control over many additional variables, such as the number of initial consonants overall, the number of letters within words, and word frequency.

C) <u>The standard format condition</u>

It proved logically impossible to introduce a third set of word orderings and retain the controls for pattern and word order present in the vowel and pattern control conditions (see Appendix). Faced with this impossibility, it seemed that the standard format condition could best be included by presenting unenhanced lists having only the four word orderings of the enhanced lists in the regular and mixed conditions.

D) Practice lists

In addition to the 24 test lists, two practice lists, each containing a mixture of vowel enhanced, pattern control and standard format words were prepared. None of the words in the practice lists occurred in any of the test lists.

E) Visual layout of lists

The 20 words for each list were written in five rows of four items on 8 1/2 X 11 inch bond. Words were printed in upper case Roman characters 3/8 inch in height, with the appropriate characters coloured red. A complete list of the words used appears in the appendix.

F) Sequencing of conditions and lists

Lists within word spelling types (regular or mixed) were presented two blocks at a time, each block consisting of one list under each pattern condition (vowel, pattern control, and standard format). Following two blocks of one spelling type, the S received two blocks of the alternate type, then an additional two blocks of the first type and finally, two blocks of the second.

Corresponding vowel and pattern control lists (e.g. series 1 form A in both conditions) were always the first two lists within a block. The standard format list was always presented last and was always an unenhanced version of the first list in that block. The standard format list used the same order as one of the lists within the same block to minimize the number of prior presentations of particular word orders used in subsequent vowel or pattern control lists. For the same reason, the standard format list was presented last within each block.[3] This method of presenting standard format stimuli is preferable to generating four standard format list orderings which differ from those used in the vowel and pattern control conditions, since the difficulty of the new orderings for the standard format condition would be unknown. By adopting the method described, it seems that performance in the standard format condition would be, if anything, better than it would otherwise have been.

The sequencing of list orders was counterbalanced across the 16 Ss. An example of one ordering for one S appears in Figure 4. Having fixed the time of presentation and the list order for the standard format condition, there remain 16 permutations of lists for the first block (list form (A or B) X spelling type (regular or mixed) X list series (1 or 2) X pattern manipulation presented first (vowel or pattern control)). One of

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[3]The effect of these two sources of familiarization with word order could also be counterbalanced, but this procedure could obscure performance differences due to visual patterning if familiarization produced a very large, but variable, change in performance. Moreover, this procedure would require many times more observations.

Figure 4

Ordering of Lists for one S. Only the initial word in each list is shown. This figure also illustrates eight of the possible 16 starting blocks. In the remaining eight, the pattern control (P. C.) was presented first.

	VOWEL	P.C.	STANDARD	
1.	BOAT...	BLED...	BOAT...	(form A; regular series 1; vowel first)
2.	CLEAT...	CLEFT...	CLEAT...	(form A; regular series 2; vowel first)
3.	LOVE...	MOST ...	LOVE	(form A; mixed series 1; vowel first
4.	OUGHT...	TOUGH...	OUGHT	(form A; mixed series 2; vowel first)
5.	BLED...	BOAT...	BLED	(form B; regular series 1; vowel first)
6.	CLEFT...	CLEAT...	CLEFT	(form B; regular series 2; vowel first)
7.	MOST...	LOVE...	MOST	(form B; mixed series 1; vowel first)
8.	TOUGH...	OUGHT...	TOUGH	(form B; mixed series 2; vowel first)

these starting blocks was assigned at random to each S. The presentation sequence for subsequent lists for that S was determined by factorially alternating the values of list series (1 or 2), spelling type (regular or mixed) and list form (A or B) in that order. That is, list series alternated the fastest, then spelling type, then list form (see Figure 4).

Apparatus: The lists were positioned inside a large wooden box with a 5 inch circular hole in one end. A forehead rest was positioned immediately above the hole and the microphone for a voice key was positioned immediately below. Viewing distance to the lists was 18 inches.

A pushbutton and a voice key were connected to a Lafeyette multi-choice reaction timer so that the clock ran whenever the button was depressed and the voice key was not activated. Thus, the clock would accumulate "silent" intervals over the duration of a button press.

Procedure: Each S was seated before the box and told that he was going to be reading lists of words while a response time measure was taken. The timing equipment was demonstrated and the S was told that his task was to accumulate the lowest time possible for each list by reading the words as quickly as possible. The S was encouraged to be accurate, but not to correct any errors should they occur. He was instructed to depress the pushbutton synchronously with uttering the first word and to hold it down throughout the list. As he was uttering the last word he was to release the button. The two practice lists were presented twice each to familiarize the S with the procedure. The test lists were then presented and the total interresponse time for each list was recorded.

RESULTS

The data were collapsed over list series and forms yielding the six treatment conditions of major interest. The times for each S were then summed over the four trials within each pattern condition. Since the data from the regular and mixed lists are not directly comparable (see page 49), each list was submitted to a separate three-factor one-way analysis of variance with repeated measures.

Both F statistics exceeded the .005 level. The F for the regular list was 8.50 and for the mixed list was 8.73 while $F_{.005;\,2,\,30} = 6.35$. The data were then submitted to Scheffé contrasts at the .05 level. These contrasts, shown in Table II, indicated a significant difference between the vowel and pattern control conditions and between the pattern control and standard format conditions in both the regular and mixed lists. The differences between the vowel and standard format conditions in both the regular and mixed lists did not even approach significance.

Performance across the four trials within regular and mixed lists is shown in Figures 5 and 6. These figures indicate that the differences

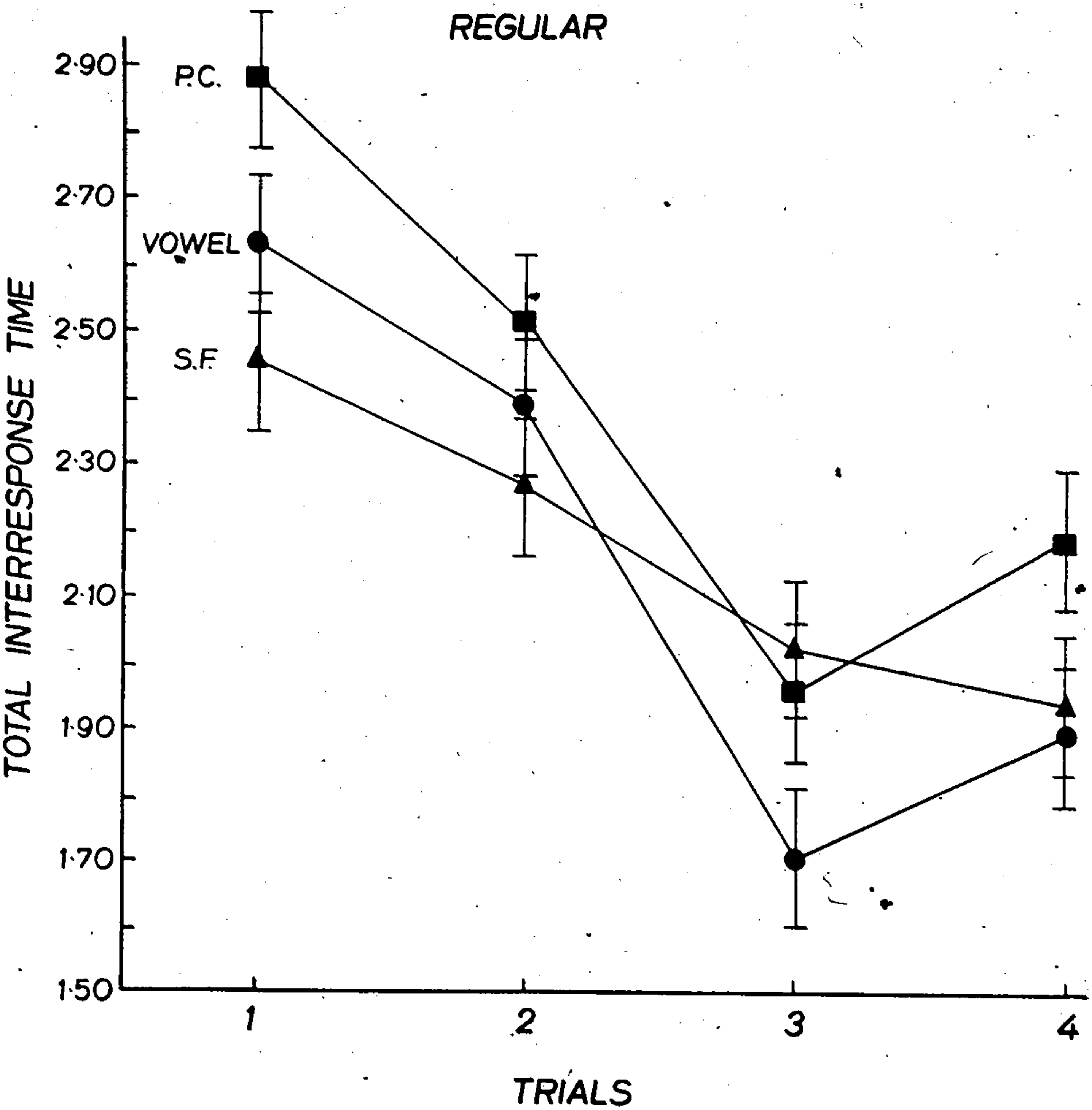
Table II

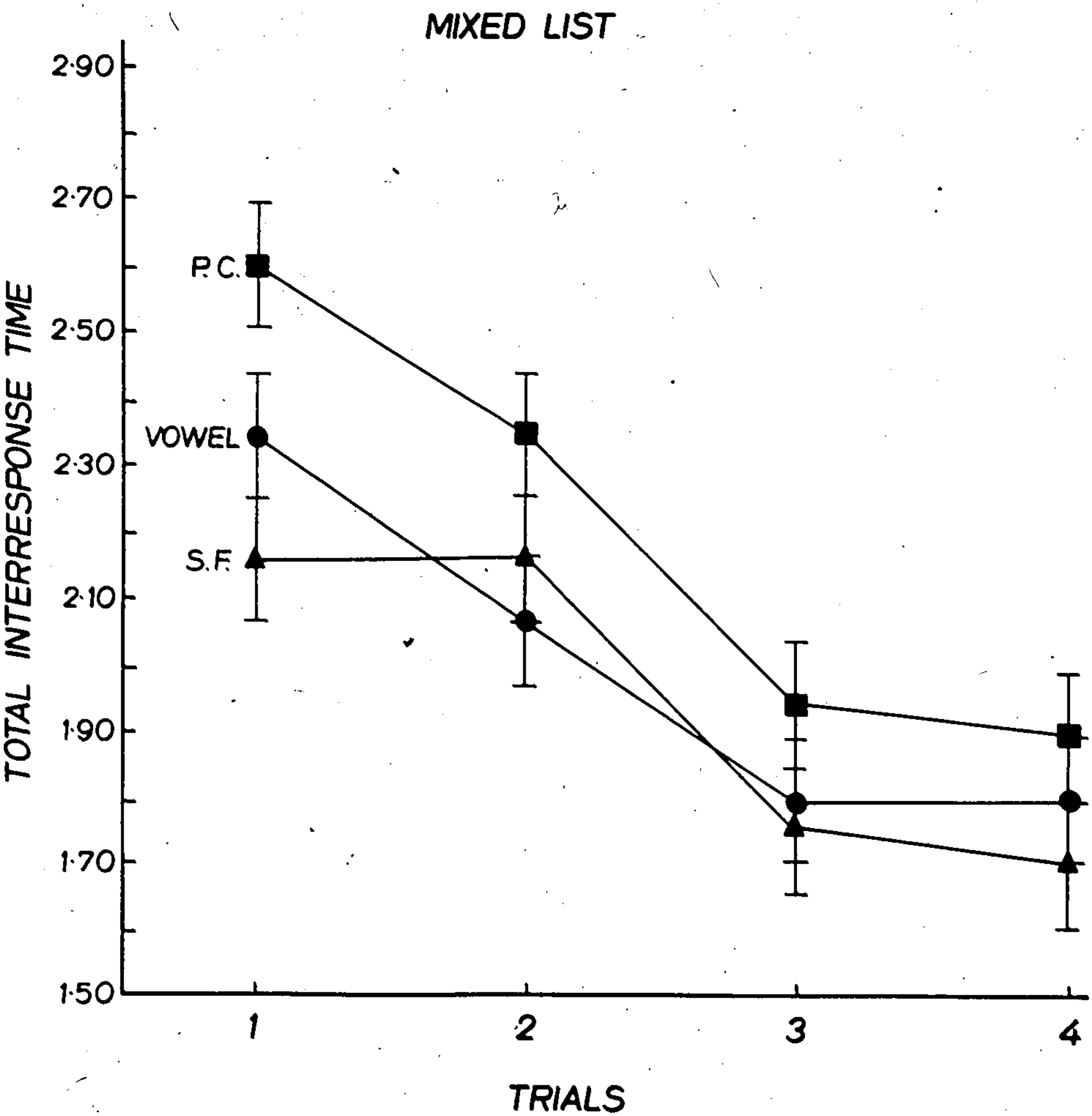
Results of the Scheffé Contrasts. The number to the left of the slash is the obtained difference while that to the right is the expected difference A star (*) indicates that the obtained difference exceeded the expected difference. The simultaneous alpha level for the three comparisons within each list spelling type is 0.05.

	List Spelling Type			
	Regular		Mixed	
	Pattern Control	Standard Format	Pattern Control	Standard Format
Vowel	0.91/0.82*	0.06/0.84	0.75/0.65*	0.27/0.65
Pattern Control		0.84/0.80*		1.02/0.65*

Figures 5 & 6

Results of Experiment II Plotted by Trials for the Regular and Mixed Lists. The "P. C." group is the pattern control and the "S. F." group is the standard format group. The between Ss variance was very large in this experiment; the vertical bars do not represent ± 1 S. E.; rather, they are estimates of error variance associated with treatment means obtained from an analysis of variance with repeated measures across trials and conditions.


REGULAR
P.C.
VOWEL
S.F.
TOTAL INTERRESPONSE TIME
2·90
2·70
2·50
2·30
2·10
1·90
1·70
1·50
1
2
3
4
TRIALS


MIXED LIST
TOTAL INTERRESPONSE TIME
2·90
2·70
2·50
2·30
2·10
1·90
1·70
1·50
P.C.
VOWEL
S.F.
1
2
3
4
TRIALS

found by analyzing overall performance did not result from large differences present only on one trial. In addition, Figures 5 and 6 indicate that the pattern of results observed for the regular and mixed lists was similar, not only in terms of overall performance, but also in terms of performance observed on single trials.

CONCLUSIONS AND DISCUSSION

With this set of materials[4] it has been possible to obtain results qualitatively similar to those observed in Experiment I. Specifically, performance under the vowel enhancement condition was found to be superior to performance in the pattern control condition. This finding suggests that the salience of orthographically relevant letter groups affects the time required to pronounce a word, even at very high levels of fluency. Comparing the standard format and vowel conditions is

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[4]The generality of these results and those obtained in Experiment I is difficult to assess. H. H. Clark (1973) argues that in most experiments using verbal materials, generalizing beyond the stimuli actually employed requires that the materials be treated as a random effect. His suggestions are a matter of current debate (Wike and Church, 1976, and Clark, Cohen, Smith and Keppel, 1976). Regardless of the outcome of this debate, such treatment cannot be applied to these data, for only total response times were measured (Experiment II) and the words used in both experiments were not, in any sense, selected randomly. Furthermore, given the strict counterbalancing constraints in both experiments, there is a very real question as to number of such lists possible, and correspondingly, as to the size of the populations to which one could generalize on statistical grounds. In anticipation of the following discussion, perhaps the best testimony to the generality of the effect of vowel enhancement lies in the similarity of the results obtained from Experiments I and II, which employed quite different materials and fluency levels.

difficult due to unknown familiarity effects arising from Ss' pre-experimental experience and from the position of the standard format condition within trial blocks. However, there is no evidence to suggest that vowel enhancement hindered performance.

The similarity in performance under the vowel and standard format conditions is extremely interesting, especially given the possibility of interference from the unknown familiarity effects. This similarity is not due to patterning alone, nor is it due to the possibility that the Ss ignored patterning in the vowel condition. Both these explanations are unlikely given the results of the pattern control condition, which employed identical patterns yet yielded poorer performance.

That a similar pattern of results was obtained for both the regular and mixed lists indicates that the benefits of vowel enhancement do not require lists which contain only regularly spelled words, such as were used in Experiment I. Indeed, the mixed list contained a much higher proportion of irregularly spelled words than is normal in written English. The similarity of the results obtained for the regular and mixed lists, despite gross differences in the degree of spelling regularity, suggests that vowel enhancement could reduce response time to pronounce lists of words which are more representative of the spelling patterns normally encountered in written English.

The data from the mixed list raises questions for the two mechanisms outlined in connection with Experiment I (analogy and the cueing of phonological analyses). It seems that on the mixed list, false analogies ought to be drawn and phonological rules appropriate only to regular words ought to be incorrectly applied to irregular words. In fact, this expectation might be quite correct. The similarity in performance under the vowel and standard format conditions indicates only that vowel enhancement does not seem to produce difficulties in responding which are not normally present. If drawing analogies and applying phonological rewrite rules are a part of normal reading processes, similar difficulties in applying these mechanisms might have arisen in both conditions.

While the mixed list might have engendered similar setbacks in both the vowel and the standard format conditions, it is also possible for the two mechanisms to facilitate responding to both regular and irregular words. It could be that any "OO" word can be interpreted by analogy to words like moon or by analogy to words like hook. While vowel enhancement could not aid the decision between these alternatives, it could aid in determining that the stimulus was indeed an "OO" word. By contrast, the pattern control could obscure the information necessary to define the set of potential analogies. If phonological rewrite rules are used, a parallel argument can be made in that vowel enhancement could aid in defining a set of potential letter group to sound mappings.

Salient orthographic segmentation information could aid word identification in the mixed list even if regular and irregular words are processed in utterly different ways (e. g. by general algorithms versus specific associations). Selecting one of a number of possible processing modes may require a prior decision as to whether or not the word is regular. Determining regularity may, in turn, require an examination of orthographically relevant letter groups, together with some cursory phonological analysis. Word regularity might be more easily determined for vowel enhanced words than for pattern control words because orthographically relevant letter groups are more salient. In short, if words are routinely submitted to an analysis for orthographically relevant letter groups, prior to certain phonological decisions, then a visual pattern in which orthographic segmentation information is readily available ought to yield faster response times than one in which this information is more obscure.

To summarize, the findings of this experiment constitute a remarkable extension of those obtained in Experiment I. Despite many good reasons to expect negative results, it seems that vowel enhancement is effective at fluent levels of performance if compared with an enhancement manipulation which does not reveal orthographically relevant letter groups. In addition, the benefits of vowel enhancement do not require mutually consistent pronunciations for the spelling patterns present within word lists. The fact that the effect was found for both artificial and Roman characters and for lists containing widely differing degrees of spelling regularity suggests that the effects of vowel enhancement might be very general. That is, these extensions offer support for the speculation that increasing the salience of orthographically relevant letter groups might be helpful over widely different rates of word identification and across a broad range of stimulus materials.

SUMMARY AND GENERAL DISCUSSION

Experiment I assessed the hypothesis that one reason for the surprising difficulties experienced by fluent adults in the blending experiments lay in segmenting the visually novel stimuli into orthographically appropriate letter groups. It seemed that enhancing the vowels should cue orthographically appropriate word segmentation, thereby resulting in faster response times than those associated with visual manipulations which do not cue appropriate segmentations. The results from Experiment I suggest that increasing the salience of information concerning the orthographic relationships among characters decreases the time required to pronounce words written with novel characters. Furthermore, the results indicate that the salience of orthographic segmentation information is affected by simple visual manipulations. Finally, the data suggest that pronouncing vowel enhanced words fosters segmentation skills which can be applied to new, unenhanced words.

Experiment II demonstrated the effect of vowel enhancement on pronunciation of words which were written with Roman characters and organized into lists containing differing degrees of spelling regularity. The results from the vowel and pattern control conditions indicate that the salience of orthographically relevant letter groups influences pronunciation, even at very fluent performance levels. The pattern of results was similar for the regular and mixed lists, suggesting that vowel enhancement is effective even when the lists contain a much higher proportion of irregularly spelled words than is usual in written English. These results from the three visual conditions would be expected if orthographic segmentation information aids word identification and if this information, while readily available in the vowel and standard format conditions, is obscured in the pattern control condition.

Two possible ways in which word identification could be facilitated by readily available cues to orthographically appropriate word segmentation have been discussed. The first relied upon rules for converting printed characters into sound. It was suggested that the nature of phonological mapping rules in English made the judicious application of these rules difficult if information concerning the orthographic relationships among characters was not salient. By making information about orthographic relationships more salient, vowel enhancement could decrease response times to pronounce words. A second way by which response times could have been reduced assumed that Ss could identify new words by drawing analogies to previously presented words. Vowel enhancement could ensure that analogies are drawn on the basis of orthographically relevant letter groups. For example, vowel enhancement could clarify the orthographically appropriate analogies within the set of items:

RATE, RATS, MATE and MATS (cf. RATE, RATS, MATE, and MATS).

It seems that there are several potentially profitable paths which could be followed from this point. First, there is an immediate need to extend the conclusions of Experiment II to wider populations of words. Broader generalizations would be possible following replication of those results with different words. A more attractive method of extending generality involves modifications to the procedure of Experiment II to allow measurement of response times to pronounce single words written with Roman characters. Such data would permit greater generalizability on statistical grounds and would allow a much more thorough assessment of the effect of vowel enhancement on the pronunciation of irregularly spelled words.

A second area in need of investigation concerns the effect of vowel enhancement at different levels of reading proficiency. The results from Experiment II indicate that if vowel enhancement becomes ineffective in reducing pronunciation time at high levels of fluency, that level must be very high indeed. However, it is quite possible that a reduction in pronunciation time attributable to vowel enhancement requires word inspection skills which might be associated only with the attainment of a certain minimum level of fluency. It is possible that the usefulness of vowel enhancement as an instructional aid will be limited if the reader lacks the appropriate visual inspection skills; however, it seems equally possible that vowel enhancement could be used to help establish appropriate inspection skills.

Finally, and perhaps most importantly, the effect of vowel enhancement under different task variations must be evaluated. Experiments I and II assessed only the time required to pronounce words and the focus on this single variable limits the theoretical and practical implications of this investigation. One task which could yield a wealth of information has recently been described by Kleiman (1975). Kleiman's experiments involved making a variety of decisions about verbal materials under conditions of concurrent shadowing. Comparing performance while shadowing to performance while not shadowing, Kleiman found that phonemic (rhyming) decisions about word pairs were slowed to a greater extent than graphemic (visual similarity) or synonomy decisions. When Ss judged words within sentences, graphemic and category memberships decisions were less affected by concurrent shadowing than phonemic or sentence acceptability judgements. Kleiman (1975) concludes that acoustic recoding provides a more efficient code for complex syntactic analyses and analyses concerning the meaning of large numbers of words. Acoustic recoding is not required for simple semantic judgements about isolated words.

By assessing the effects of concurrent shadowing on decisions about vowel enhanced stimuli and standard format stimuli, a more precise determination of the effects of vowel enhancement might be possible. If vowel enhancement facilitates acoustic recoding, phonemic and sentence acceptability judgements about vowel enhanced stimuli ought to be less disrupted by shadowing than similar judgements about standard format stimuli. However, if vowel enhancement facilitates a very early stage of processing such as "visual coding" (Kleiman, 1975), synonomy and category membership judgements about vowel enhanced stimuli should also show less disruption than that observed for standard format stimuli.

Even if vowel enhancement is found to affect only the pronunciation of isolated words with response time as the dependent measure, further study is still merited on both theoretical and practical grounds. The ability to pronounce written words is certainly not to be taken for granted. The blending experiments (Brooks and Anderson, 1976) clearly demonstrate that pronouncing written words is disrupted to an astonishing degree by the use of visually novel characters in spite of extensive training on identifying those characters. The visual manipulations in Experiments I and II suggest that orthographically appropriate visual segmentation is important when accessing verbal responses at both very slow and very rapid rates of word identification. Further study using methods similar to those of Experiments I and II might allow specification of the stimulus conditions under which vowel enhancement is most effective and allow a characterization of certain mechanisms which can be employed when processing written words. In addition to providing theoretically interesting data, further study of vowel enhancement could have direct practical relevance. A method for improving performance in pronouncing isolated written words could be useful as an instructional device, perhaps as an adjunct to remedial reading programs. At the very least, vowel enhancement might make it easier to talk about methods for identifying unfamiliar words. Implementing vowel enhancement as an instructional device would clearly require a great deal of additional research. However, the transferability of skills acquired under vowel enhancement demonstrated in Experiment I suggests that the additional effort might well be rewarded.

Finally, as a potential aid in beginning reading programs, vowel enhancement possesses two additional positive features which should not be underestimated. First, the expense in producing the materials is comparatively small. A different type font or bold face characters for the vowels might provide the necessary patterning. Second, a repetition of the adverse reaction of some parents who discovered that they could not read their children's initial-teaching-alphabet textbooks would be avoided.

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APPENDIX

NOTE: Words in upper case are training stimuli; those in lower case are transfer stimuli.

LIST 1

BOAT	BEAT	CRATE	CRASS	BLED	BLOB
COAST	SEAT	SCALE	SCAB	SECT	CROSS
float	feast	fade	fast	felt	floss

LIST 2

LOAF	LEAF	TRADE	TRACT	LEFT	LOST
TOAD	BEAD	BABE	BLAST	BEST	TROD
foal	flea	fate	fact	fret	frost

LIST 3

COAL	CLEAT	BASE	BRAT	CLEFT	CLOT
BOAST	REAL	RATE	RAFT	REST	BLOB
load	left	late	last	lest	left

LIST 4

TOAST	TREAT	CASE	CAST	TEST	TROT
COAT	SEAL	SAFE	SLAB	SLED	COST
bloat	bleat	blade	brass	bless	boss

REGULAR LIST

BASE	FEAST
BEAT	FELT
BLED	FLOSS
BLOB	FOAM
BOAT	RAFT
BRAT	RATE
CLEAT	REAL
CLEFT	REST
CLOT	SAFE
COAL	SALB

MIXED LIST

BOUGH	LOVE
BREAD	MAID
COST	MOOD
DIVE	MOST
FIND	MOVE
FLOOD	OUGHT
GIVE	ROOST
GRIN	SAID
HEART	STOVE
HOOD	TOUGH

Let us suppose that we have four words: <u>boat</u>, <u>bled</u>, <u>cleat</u> and <u>cleft</u>. Pairing <u>boat</u> with <u>bled</u> and <u>cleat</u> with <u>cleft</u> controls for the patterning produced by vowel enhancement. Thus, we might present:

vowel:	BOAT, CLEFT, CLEAT, BLED	(order A)
pattern control:	BLED, CLEAT, CLEFT, BOAT	(order B)

The difficulty of the two word orders can be counterbalanced by presenting:

vowel:	BLED, CLEAT, CLEFT, BOAT	(order B)
pattern control:	BOAT, CLEFT, CLEAT, BLED	(order A)

Can these controls be retained while introducing a third word ordering so that the vowel, pattern control and standard format conditions each receive a different word ordering? Counterbalancing the difficulty of this third ordering (order C) requires that order C appears in each of the three conditions with the other two orderings occurring in each of the remaining two conditions equally often. The following discussion demonstrates that the counterbalancing requirements are incompatible with the manipulations of visual pattern required in the vowel and pattern control conditions.

If order C occurs in the vowel condition with order B in the pattern control condition, the first word in order C must have the structure cvvc so that BLED controls patterning. The second word must have the structure ccvcc so that CLEAT controls patterning and so on. Given this structure, it is clear that order C cannot occur in the pattern control condition with order A in the vowel condition, since the enhancement pattern from order A would also distinguish the vowels from the consonants in the pattern control condition. Nor can order C occur in the vowel condition with order A in the pattern control condition. If BOAT is to control for patterning of the first word in order C, that first word must have the structure ccvc. This is incompatible with the case when order B is in the pattern control condition which requires that the first word have the structure cvvc.

Let us consider only the first word in each of these three hypothetical lists. These first three words form a triple (w_1, w_2, w_3) which must satisfy mutually inconsistent constraints. The nature of the pattern control requires that the enhancement pattern of a word in the vowel condition does not distinguish the vowels from the consonants when applied to the corresponding word in the pattern control condition. If any word in the triple (w_1, w_2, w_3) is to serve as a pattern control for either of the other two words, it is clear that the vowel-consonant structure of each word in the triple must differ from that of the other two. That is; three different vowel-consonant structures must be represented. While necessary to counterbalance order, this requirement makes it impossible for a word which serves as the pattern control for one member of the triple to also serve as the pattern control for the other. For example, if w_2 is in the pattern control condition with w_1 in the vowel condition, w_2 thereby has that enhancement pattern from w_1 imposed upon it. It follows that w_2 cannot also serve as the pattern control for w_3, since the vowel-consonant structure of w_3 must differ from that of w_1.