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ABSTRACT

Students learned lists of spelling words in a computer-assisted drill program where the correct spelling was printed in standard form or with spaces between letters or with spaces between pronounceable orthographic clusters. Words having sounded and unsounded medial clusters (e.g., "holiday" versus "Wednesday") were taught under each display method. Results showed learning rates were influenced by the way the correct spelling was displayed. Retention level was unaffacted by method of display. Focal unit treatment differentially affected ease of acquiring the two word types, but not retention level, measured at two and six weeks. Audio had no effects. It was suggested that variations in focal unit influence the encoding stage of learning. Additional analyses of the data confirmed findings from other studies regarding latencies of responses, serial position effects, and massed versus distributed practice effects. (Author)

# LEARNING RESEARCH AND DEVELOPMENT CENTER

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## SPELLING LEARNING AND RETENTION UNDER VARIATIONS IN FOCAL UNIT OF WORD PRESENTATION IN A COMPUTER-ASSISTED SPELLING DRILL

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## Abstract

Students learned lists of spelling words in a computer-assisted drill program where the correct spelling was printed in standard form or it was printed with spaces between letters or with spaces between pronounceable orthographic clusters. Words having sounded and unsounded medial clusters (e.g., holiday versus Wednesday) were taught under each display method. Results showed learning rates were influenced by the way the correct spelling was displayed. Retention level was unaffected by method of display. Focal unit treatment differentially affected ease of acquiring the two word types, but not retention level, measured at two weeks and six weeks. Audio had no effects. It was suggested that variations in focal unit influence the encoding stage of learning. Additional analyses of the data confirmed findings from other studies regarding latencies of responses, serial position effects, and massed versus distributed practice effects.

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## Introduction

The purpose of the present experiment was to study the effects of three methods of displaying the correct spelling of a word after the student typed an incorrect spelling of that word in a computerized spelling drill. Two methods broke the word into parts and printed spaces between the parts. The third method displayed the word in standard fashion, with no spaces between the parts. Words were divided into parts in two ways; either they were diviued into pronounceable orthographic clusters (chunks), e.g., hol-i-day, or they were divided into constituent letters. The two methods of dividing words (chunk or letter, so named to refer to the focal unit of word division) were compared to a whole (undivided) word method to determine their relative effects on learning and retention in spelling.

Our interest in methods of presenting spelling words was generated by a controversy in the spelling literature over the relative effectiveness of the methods for supporting learning (Horn, 1969). Classroom experiments have produced contradictory findings (see, e.g., Wolfe & Breed, 1922; Green, 1923). We considered this "methods" variable to be theoretically interesting and chose to study it in the context of a computerized spelling drill. Computerized drills are an excellent mode for studying the effects of instructional variables because learning conditions can be well controlled.

A theory about the nature of spelling learning was developed from the basis of information processing theories that describe learning as a series of information processing acts: encoding, rehearsal, storage, and retrieval. We hypothesized that displaying spelling words in segmented form would influence the encoding stage of learning and we made four assumptions to generate predictions about the effects of variations in focal unit on learning. We assumed that (1) in order for spellings to be learned, their orthographic units must be encoded phonemically; (2) phonemic encoding occurs at the level of the individual phoneme to grapheme relationship; (3) encoding completeness is a function of the amount of attention directed to the individual letters and graphemes of the word; and (4) encoding completeness is also a function of the availability of the phonemic units of the words. These assumptions are revealed in analyses of the spelling learning process (detailed below) that occurs when different visual displays must be processed.

Assumption 1 follows from the notion that learning spelling requires processing orthographic information so that it can be recalled. This means that words to be learned are not simply "recognized" when they are presented as feedback in a spelling drill. If they were only "recognized," spellings could not be recalled because recognition processes do not seem to involve the internal parts of a word (Kooi, Shutz, & Baker, 1965; Gibson & Levin, 1974). We therefore assumed that the way a spelling gets entered into memory is through its phonemic code. Spelling learning processes are more like decoding processes in reading than recognition processes.

Phonemic encoding is a sequential process that involves attending to each phoneme of a word long enough to write its associated grapheme into memory. The phonemic representation of a word to be learned is usually in memory when the word is displayed because the word was just spelled by the child. Phonemic encoding involves associating graphemes with the phonemes that are in memory. The topography of the phonemic encoding process is slightly different depending upon the visual features of the displayed word, i.e., whether it is segmented or not.

A more detailed analysis of phonemic encoding shows that it requires sounding out individual graphemes and matching each generated phoneme against its coordinate phoneme in memory. At syllabic boundaries, the word is reauditorized so the sounding out-matching process can continue into the next syllabic unit. This conjunctive process, sounding out and matching, requires shifting attention in two directions--from the visual stimulus to the phonemic representation and vice versa. Assumptions 2 and 3 allow us to predict that letter-segmented displays should be very effective for learning because they slow the shift process. Spaces between letters slow the grapheme input rate, thereby maintaining attention to individual graphemes so there is sufficient time to write them into memory. By contrast, a chunk-segmented display slows the shift process only at the boundaries of the orthographic clusters and not within the cluster itself. Thus a chunk-segmented word might not be completely encoded.

Segmenting words into parts is a method of presenting spelling feedback that is used to induce certain kinds of learning processes in children who are learning spellings. If a child can control his learning processes in an optimal way, there is no need to design specially structured learning environments. In the case of this study, if children can themselves slow their shift processes enough to write the spelling in memory, there would be no need to use special segmentation schemes. Learning data from the whole word condition in which the spelling word is simply printed in standard unsegmented fashion, provides information on the regularity with which children automatically apply processes that are necessary for learning. In sum, it was predicted that letter-segmented displays would produce faster learning than chunk-segmented displays and that learning rate with whole word displays would be a function of the children's capacities to apply the processes necessary for learning in the absence of specially designed displays.

Are all classes of polysyllabic words taught best by segmenting them into letters? When words contain medial orthographic clusters that are not sounded when the word is spoken, e.g., Wednesday (Wed-nes-day), letter-segmented displays probably interfere with learning. Learning to spell words with unsounded medial clusters requires extracting the syllables by reading the word and holding the extracted syllables in memory while performing phonemic encoding. The phonemic representation of this class of words is not available from running speech as it is with words like holiday. When learning words with unsounded clusters, the phonemic representation must be created by reading the printed word and then it must be held in memory while encoding is performed. It seems reasonable to expect that encoding activity might cause the newly created phonemic representation to be forgotten, so that it would need to be reconstructed for encoding to be completed. This fact is embodied in Assumption 4, and a more detailed analysis of the meaning of phonemic availability is given below.

Reconstructing a phonemic representation can be made easy or difficult by the features of the word display because they influence the syllable extraction process. Forming syllables from printed words requires forward scanning of the visual display to determine whether a given syllabic unit should continue or be terminated--in a sense, unit _n_ is defined on the basis of what unit _n + 1_ will be. Letter-segmented displays make forward scanning difficult because they have spaces between letters. Therefore, the phonemic representation is somewhat difficult to reconstruct when it is forgotten; as a consequence, phonemic encoding might not be restarted in the right place or other events may intervene to cause incomplete encoding. By contrast, a chunk-segmented display provides external stimulus support for the phonemic representation because the word is separated into orthographic clusters that make it easier for the child to reconstruct the syllabic units of the phonemic representation. Although whole word displays do not syllabicate the word for the child, they do not pose the problem for extracting syllables that is found with letter-segmented displays. Hence, one would expect learning to be slowest with letter-segmented displays when compared to either chunk or whole word. Chunk-segmented displays might produce faster learning relative to whole word displays if spaces slow the shift process and increase encoding efficiency.

In sum, it is predicted that words with medial unsounded clusters would be more difficult to learn than words whose clusters are sounded in the pronunciation. This prediction is based on Assumption 4 that was motivated by an analysis of the task posed by words with unsounded clusters. It is also predicted that the effectiveness of certain displays for supporting learning would vary with the type of word learned, with letter-segmented displays producing the largest differences in learning rate.

To test these predictions, students learned both word types under one of the three display methods, whole word, chunk, or letter. The word types are referred to here as "W" words (standing for Wednesday-type" words that contain unsounded medial clusters) and "non-W" words (words whose clusters are pronounced).[1] A third variable was included in this study primarily out of concern for what happens in the classroom teaching of spelling. When teachers teach spellings, they show and they tell, that is, they write the word on the blackboard while naming or pronouncing its parts. This is done to enhance students' attention to the display and conveys no new information. However, heightened attention means more learning. It is possible that learning from visual displays might be increased when those displays are enhanced by an audio analogue. To test this, half the students in each display condition received audio enhanced displays. In the whole word condition, the whole word was displayed and pronounced; in the chunk condition, the clusters were pronounced; in the letter condition, the letters were named.

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[1]The list of W words contained business, chocolate, temperature, Wednesday, interesting, everywhere, vegetable, general, different, diamond, camera, several, preference, aspirin.

A "matched" list of non-W words contained success, separate, furniture, holiday, surprising, anything, capable, capital, president, piano, formula, hospital, confidence, bulletin.

Program Design and the School Spelling Curriculum

The computerized spelling drill was designed to fit the management system of an individualized spelling curriculum used in the elementary school in which the study was run. The curriculum used a basic spelling text (Kottmeyer & Ware, 1964) with specially constructed supporting materials designed to permit individualization. For each unit in the graded-by-year spelling texts, pretests and posttests were recorded on cassettes. Students take pretests on words of a target unit; if they pass an 88 percent mastery criterion, they proceed to the next unit. If they do not meet the mastery criterion on the pretest, the teacher prescribes instruction on the units. The student completes the prescription and takes a posttest; if he passes the posttest, he proceeds to the next unit; otherwise, he receives more instruction on the unit until he masters the posttest.[2]

The computerized drill followed this same general system of instruction: words were pretested; when they were incorrectly spelled the program presented them again so they could be learned. The teaching treatments were used with words that had been incorrectly spelled. A word missed on its initial test was presented until it was spelled correctly three times. Each student learned words he could not spell, as determined by the first test on a word. The logic of the drill program is described in more detail in the section outlining our procedures.

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[2] This system for individualizing spelling is generalizable; it can be and is used with various spelling texts. It has been made commercially available by Research for Better Schools, Inc. (Individualized Spelling and Writing Patterns. Teacher's Manual) using the text by Botel, Holsclaw, Kammarota, and Brothers (1970), Spelling and Writing Patterns.

## Method

Subjects. Forty-eight students from the fourth and fifth grade spelling classes of a suburban elementary school managed under a system of individualized instruction were run as subjects. All the subjects who scored at or above grade level on standardized spelling tests were placed in the fourth or fifth book of the school spelling series at the time of training.

The Computer System and Terminals. An interlinked PDP-7/PDP-9 computer system located at the Learning Research and Development Center on the University of Pittsburgh campus was connected to student terminals at the school via telephone lines. The computer configuration was time-sharing, capable of handling users simultaneously from a number of input devices. The audio was provided by a rapid random access audio component, the Westinghouse CROW, controlled by the computers.

The student terminals were located in the school in a converted conference room in a location central to the intermediate classrooms. Each student station was equipped with a Datapoint (a cathode ray tube [CRT] and a response keyboard), and a set of earphones.

From one to three students were run simultaneously using the same controlling program. Each student user was serviced sequentially, but rapidly enough to give the impression of "full attention" service.

Daily operation. Students came to the terminal room during their morning classes. A monitor was on duty whenever the children were using the terminals. Her presence after the initial session was primarily a precautionary measure so that an adult was available in case of an emergency. The actual check-in, presentation, and evaluation of the drill and sign-out were all handled by the CAI system.

During the initial session, the experimenter read instructions concerning the nature of the task and the control keys. "You will be learning some new words with the help of this Datapoint and a computer--the words we have chosen are words you might not know how to spell now. We want to study the best way to teach students how to spell new words." The use of three control characters was explained until the subject could identify a key and its function. These keys were used when the subject wanted to hear a word repeated, to correct a response, and to signal response termination.

After the initial session, the subject entered the room, sat at a free terminal, put on his earphones, and typed "B" to begin. The program printed "What is you name?" The student typed his name and the return key, the response termination key used throughout the program. The program then printed "how many minutes" and the student typed between five and twenty-five, depending on the amount of time he wished to practice that day. The program was then set in operation and followed the event schedule shown in Figure 1.

Program Logic. The audio pronounced a word and a sentence with blanks for the target word and was displayed on the screen. The cursor was then left adjusted two spaces beneath the sentence and functioned as a signal for the student to respond. If the student did not respond in MAXTIME (10 seconds times the number of letters in the word), the message "....X.... Time is up" was printed. If the student wished to hear the word again, he could type the question mark key; otherwise, he typed the spelling and depressed the return key (the signal to the computer that he had completed his response). A correct

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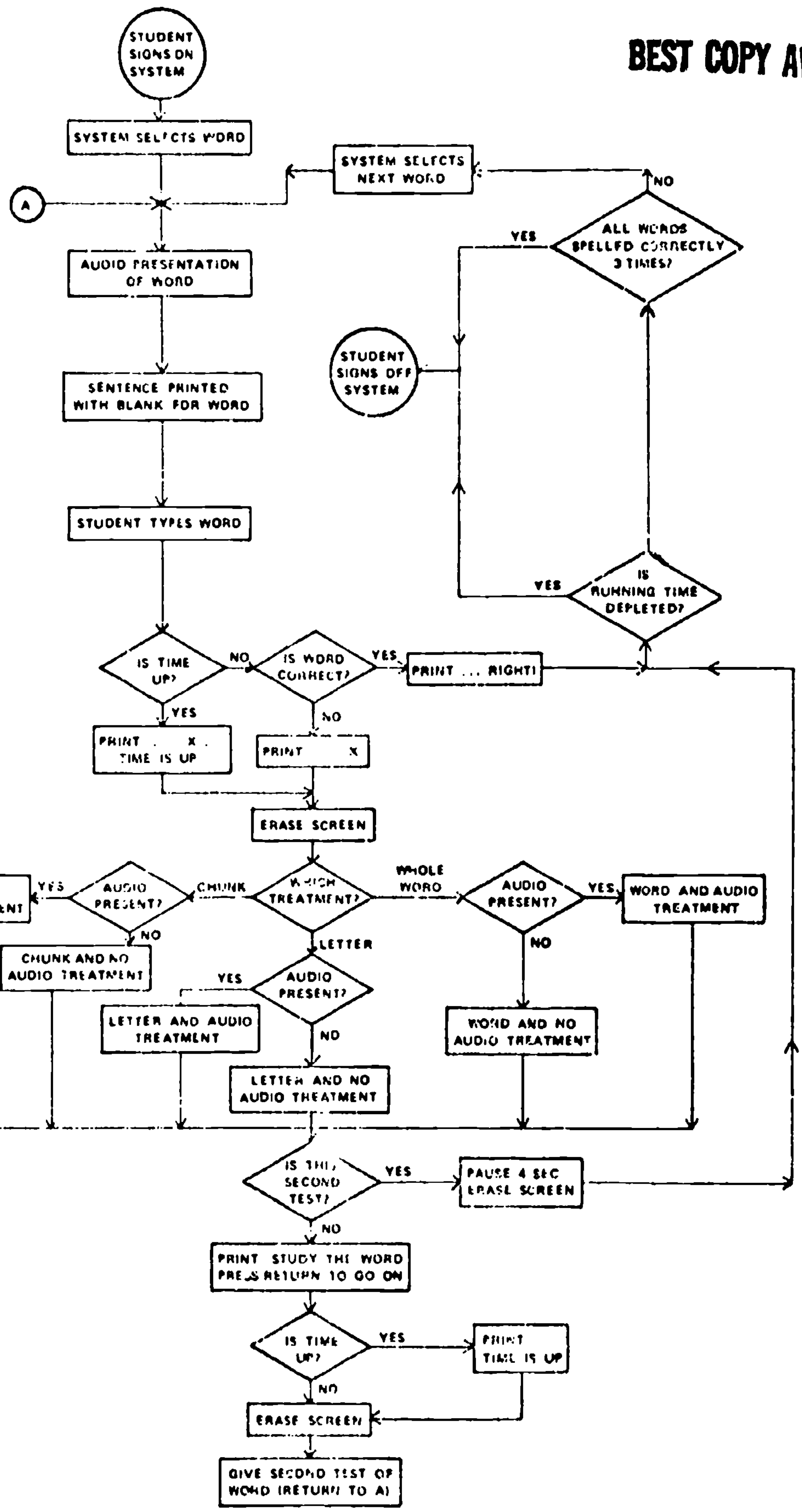


Figure 1. Flow Diagram of the Computer-Assisted Drill Program.

response on the first test of the word was followed by "....Right!"; and presentation of the next word. An incorrect response was followed by an "....X" and a teaching treatment, followed by another test and treatment. For responses exceeding MAXTIME and incorrect responses, the correct spelling of the word was presented according to one of the six treatments defined by focal unit and the presence or absence of audio. Following the treatment, the spelling was available to study as long as the student wished, up to 60 seconds. When the student completed study of the word (signaled by the depression of the return key), or exceeded the 60 second limit, the screen was erased and the spelling was retested (return to Point A on the flowchart). When the second spelling was correct, the system selected the next word for presentation, or signed the student off. When the second spelling was incorrect, the word received the same feedback messages and treatment as given on the initial test, except self-paced study was not provided. After the treatment, there was a short (four second) pause. and the treatment display was erased. The system then either selected the next word or signed the student off. Students signed off when their running time was depleted or when they met the mastery criterion (each word initially spelled incorrectly was spelled correctly three times).

Program Review Features. In any one session at the terminal, a subject was tested on and practiced both new words (words he had not spelled before) and old words, due to a spaced review feature in the program. The program cumulated all words to date that had not been spelled correctly three times in a row, up to a maximum of five words. When five words occupied this "review list," the most removed item (i.e., the first tallied) was presented in the two-test routine of Figure 1. Each time a word was spelled correctly (on either the first or second test), the correct counter was increased by one; when the correct counter was three, the word was deleted from the review list and not presented again. The next word selected was either a "new" word or another review word if the review list was not empty. This scheme resulted, on the average, in six interpolated presentations of other items between an item's $\underline{n}^{th}$ and $\underline{n+1}^{st}$ presentation.

Word Sampling Scheme. The words were selected from lists of W and non-W words, alternating between the lists. An attempt was made to include at least five words from each list (and no fewer than ten words total) for each student to learn; however, sometimes students learned fewer words because they were able to spell them prior to entering the drill. An attempt was also made to keep the pool of words to be learned as homogeneous as possible across individual students by ordering pairs of matched words according to difficulty and presenting the words in the order of difficulty, with the most difficult presented first. Frequency of words learned from each list is shown in Table 1.

Program Termination and Response Statistics. When a session was finished, the system recorded the student's history to that point, i.e., the correct counters, review lists, next new word, etc. In the subsequent session, the history was activated, and the student continued training as if there had been no interruption. Training ran, on the average, for three twenty-minute sessions separated by one or two days.

The system recorded for each student the session date and time spent in training, the words presented and reviewed, the student's response and response latency at each response request point, along with the response evaluation. At no time during training were students given word lists to study.

Words: List Construction and Pronunciation. The word lists were constructed by sampling words from elementary school spelling

TABLE 1

Word Lists Learned by Subjects in the Experiment

| | Splits | | Number of Subjects | Number of Words per Subject |
|---|---|---|---|---|
| | W-words | non-W-words | | |
| | 5 | 5 | 34 | 10 |
| | 6 | 5 | 5 | 11 |
| | 6 | 4 | 2 | 10 |
| | 6 | 3 | 1 | 9 |
| | 5 | 4 | 4 | 9 |
| | 5 | 3 | 1 | 8 |
| | 3 | 5 | 1 | 8 |
| Totals | 36 | 29 | 48 | 65 |

texts and, trying to achieve the best match between W and non-W words, on difficulty as measured by the Iowa Scale (Greene, 1954), on Thorndike-Lorge frequency, number of letters, and number of pronounceable chunks. The resulting match is probably the best that could be obtained with real words.

The audio system pronounced the words according to Webster's <u>New World Dictionary</u>, because its editorial board tried to make pronunciations representative of common speech. This dictionary confirmed our judgment of which words contained unsounded chunks; in only one case we disagreed with the dictionary (for "<u>preference</u>"). <u>Webster's Seventh International</u> showed an unsounded medial chunk so <u>preference</u> was included and pronounced according to that dictionary.

The audio system used the same pronunciation for each whole word when its spelling was requested. In the chunk treatment, the chunks of non-W words were pronounced consistent with chunk pronunciation in the whole word. The unsounded chunk in W words was said in a way to make transitions from the normally sounded chunks easy. The words were recorded onto the CROW by a graduate speech major with excellent articulation.

<u>Methods of Presenting Words</u>. Alternative displays were used when a word was incorrectly spelled on a test (see Figure 1). In the letter condition, each letter of the correct spelling was printed in sequence separated by one space with a pause of about one second between individual letters. If audio accompanied the treatments, it pronounced the letter names concurrent with the tempo of print on the screen. In the chunk condition, each chunk was printed as a unit separated by three

spaces.[3] If audio accompanied the treatment, it pronounced each chunk concurrent with the tempo on the screen. Likewise, in the whole word condition, the entire word was printed (and pronounced by the audio if it accompanied the treatment) as a unit. When the entire spelling was displayed, the study message or pause occurred (see Figure 1).

Experimental Design. There were two between-subject factors: focal unit (chunk, letter or whole word) and audio accompaniment of the treatment (present or absent). The word variable was a within-subject factor: each subject learned both types of words, W and non-W words.

Students from three classrooms placing at or above grade level in spelling participated in the study. Students were grouped according to their half-year placement in the spelling book and were randomly assigned to each of the six cells in a way that counter-balanced classrooms. Table 2 shows the sample characteristics of each cell of the experiment.

Retention Tests. Retention tests were administered at the terminal two weeks and six weeks after the end of acquisition. Each student was tested on the words he learned in training. The students did not receive any computerized drill between the training and test days; however, after the first retention test, subjects copied the correct spelling of words missed and took them home for study. Every student who missed words left the test room with a study list.

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[3] Orthographic clusters were formed by using syllabication rules of Burmeister (1968, pp. 86-87). Structural syllabication (separating roots from affixes) was performed first.

TABLE 2



Sample Characteristics

| Experimental treatment | Book | | | | Characteristic: Teacher | | | Sex | |
|---|---|---|---|---|---|---|---|---|---|
| | 4-1 | 4-2 | 5-1 | 5-2 | 1 | 2 | 3 | M | F |
| WA | 2* | 4 | 1 | 1 | 4 | 4 | 0 | 2 | 6 |
| WNA | 2 | 4 | 1 | 1 | 4 | 3 | 1 | 3 | 5 |
| LA | 2 | 4 | 1 | 1 | 4 | 3 | 1 | 2 | 6 |
| LNA | 2 | 4 | 2 | 0 | 4 | 4 | 0 | 4 | 4 |
| CA | 2 | 4 | 2 | 0 | 3 | 5 | 0 | 6 | 2 |
| CNA | 2 | 4 | 1 | 1 | 4 | 3 | 1 | 4 | 4 |
| TOTALS | 12 | 24 | 8 | 4 | 23 | 22 | 3 | 21 | 27 |

Note: Focal Unit = W, C, L; Audio = A, NA; Book = 4-1, 4-2, 5-1, 5-2, where 1, 2 indicate placement in first or second half of grade 4 and 5 spellers; Teachers = 1, 2, 3; Sex = M, F.

* Entry is number of subjects found in this category.

The basic retention test procedure consisted of an audio request for a spelling; the student responded; the response was stored and the next spelling was requested. No feedback was given until testing was completed.

## Results and Discussion

Learning Rate and Retention. Learning rate comparisons are based on the number of times a word needed to be presented to the student prior to his spelling the word correctly three times in a row. A correct spelling was defined as a perfect match between the stored spelling and the student generated spelling. Failures to match were caused by incorrect spellings, by excessive use of special request keys, or by a failure to respond within the time limit. The latter two were very infrequent; out of a total of 1555 requests for a spelling during training, only 28 (2 percent) fell into this category.

The number of words acquired by each student was divided by the total number of times the word needed to be presented to achieve the criterion. These proportions were transformed using an arcsin $\sqrt{X}$ transformation and subjected to a three-way analysis of variance, using Program 4 of the MULTIVARIANCE program (NYBMUL) (Finn, 1969). Neither the main effect of audio, nor the main effect of focal unit nor their interaction reached significance ($F < 1$ for the main effects; $F = 1.40$, df = 2 and 42, $P < .26$ for the interaction). However, the main effect of word type was highly significant ($F = 13.64$, df = 1 and 42, $P < .001$) with mean number of words divided by trials for W words = .37, and non-W words = .48, indicating W words took more trials to acquire. The interaction of word type and focal unit was also significant ($F = 3.65$, df = 2 and 42, $P < .035$); the results are graphed in Figure 2.

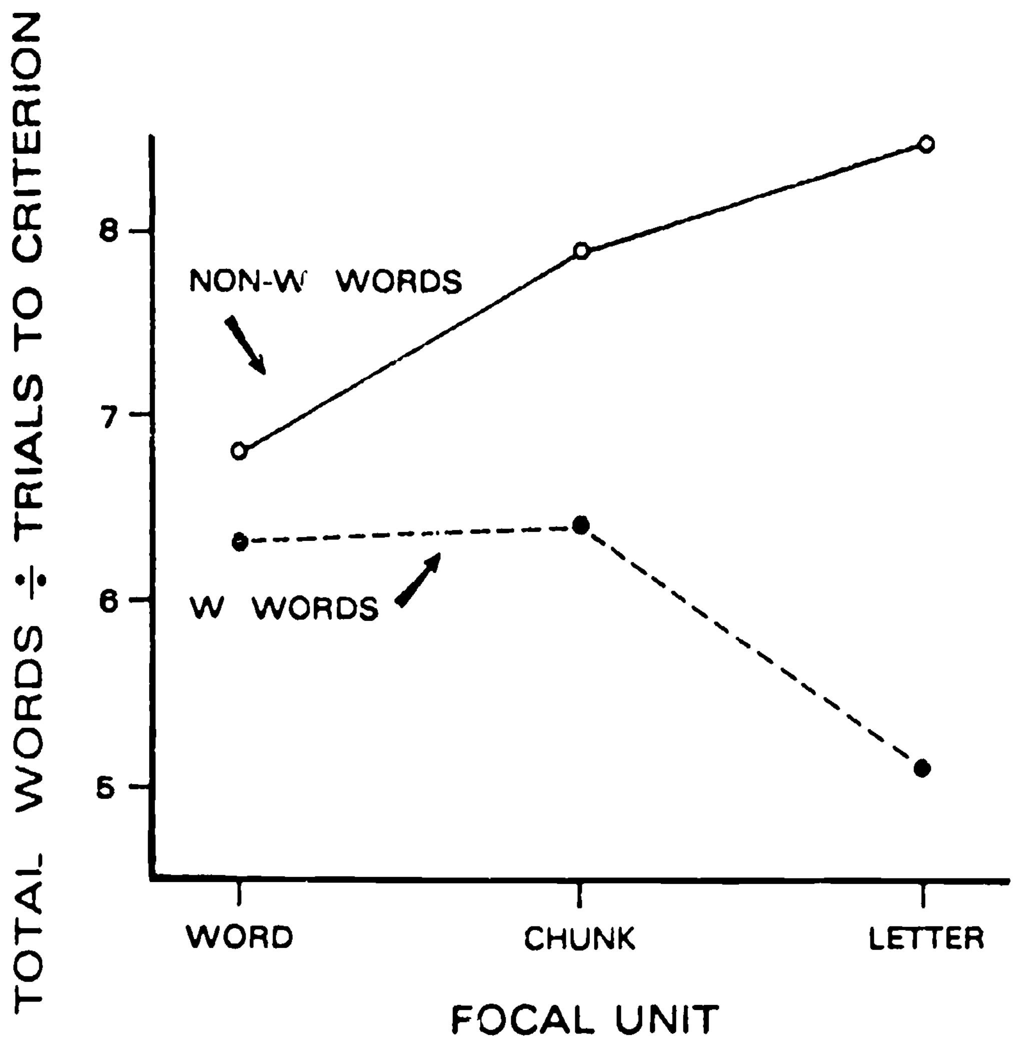


Figure 2. Acquisition Rate as a Function of Focal Unit Treatment.
Note: Higher values on the ordinate indicate more rapid acquisition.

The audio and list interaction was not significant ($F < 1$), while the three-way audio and focal and list interaction approached significance ($F = 2.75$, df = 2 and 42, $P < .075$).

Analyses of simple effects were performed to find the locus of the interaction. An analysis of the simple effects of focal unit at each word level revealed no significant difference among the three treatments for either word type. An analysis of the simple effects of word type at each focal unit revealed that for the two segmentation treatments, chunk and letter, W and non-W words were acquired at significantly different rates ($F = 6.18$, df = 1 and 42, $P < .05$; $F = 30.90$, df = 1 and 42, $P < .01$, respectively), but they were not acquired at different rates under the whole word treatment. From Figure 2 it is clear that the letter treatment maximizes the difference between the trials required to learn the two word types while the whole word treatment minimizes the difference with the chunk treatment in between.

A second analysis of variance was performed on $\arcsin\sqrt{X}$ where the $X$ was the number of words taught to each student divided by number of errors (misspellings or excessive use of special keys) prior to mastery. The results of this analysis generally confirmed the pattern of results in the previous analysis with word type as a highly significant main effect ($F = 7.53$, df = 1 and 42, $P < .01$), but the effect of word type and focal unit was slightly reduced ($P = .10$). The three-way word type and audio and focal unit interaction was not significant ($P > .40$).

The proportion of words correctly spelled on the first retention test was close to that of the second retention test (.63 and .67, respectively), indicating a stable retention level across a long period of time. An analysis of variance on the proportion of words correctly spelled on the first retention test (two weeks after acquisition) revealed no significant effects among the audio, focal, or word type variables nor among their combinations. A second analysis of variance on proportion of words correctly spelled from the second six-week retention test also revealed no significant effects among the variables.

It is quite clear from these data that no single teaching treatment, considering six separate treatments (focal unit broken out by audio) or three focal unit treatments collapsed across audio, is optimal for rapid overall acquisition and high retention. All treatments produced the same overall rate and retention level; however, two focal unit treatments, chunk and letter, produced different learning rates for different classes of words. The whole word treatment produced no such difference, indicating that learning rate can be influenced by segmented displays.

Figure 2 shows that the difference between learning rate of W and non-W words is greatest in the letter condition. Apparently, this difference is due to two combined effects: facilitation of non-W word learning produced by decreased encoding speed and inhibition of W word learning produced by the absence of external support for the mediating phonemic representation. When external support is present (as in chunk) or when the representation can be easily reconstructed (as in whole word), learning rate of W words is not depressed.

In the chunk condition, the learning rate difference appears to come from facilitation of non-W word learning as revealed by a comparison to the rates in whole word. This facilitation is due to decreased encoding speed produced by spaces between orthographic clusters. The learning rate of W words was equivalent with chunk and whole word displays. This indicates that external support for the phonemic representation is not necessary for W words (when it can be easily reconstructed) and that spaces between orthographic clusters do not increase rate.

In sum, these learning rate data tend to confirm the hypotheses proposed regarding the effects of the word display variable. The data showed that when W and non-W words are segmented, their learning rates were influenced. The learning rates reflected the combined effects of facilitation due to decreased encoding speed (for non-W words) and inhibition due to the difficulty that letter segmented displays pose for syllable extraction with W words. Oral enhancement did not promote faster learning, indicating that learning at a terminal is not disrupted by other situational features of the learning environment so that oral enhancement is required to draw and maintain attention to the word that is being learned.

None of the variables manipulated here had significant effects on spelling recall measured at two points in time. This may mean that the amount of effort devoted to rehearsal of encoded items was the same in each of the three focal unit conditions. Possibly, initial differences in the ease of encoding do not influence the frequency of subsequent rehearsal activities.

Some additional analyses were performed on these data to determine the degree to which its characteristics conform to effects found in other spelling studies and to isolate any additional effects of the teaching treatments.

<u>Massed versus Distributed Practice Comparisons.</u> Although all words taught in this study were learned to the same criterion their practice distribution could be different. A word could meet criterion on a single day or it could be practiced on several days (two, three, or more days). The training words were divided into two sets--those acquired in one session (massed--comprising about 40 percent of the words) versus those acquired in more than one session (distributed--

comprising 60 percent) collapsing across the experimental variables. For each subject having at least two massed and two distributed words, the proportion of words spelled correctly was computed for each retention test. Thirty-four subjects qualified for this analysis. A two (massed versus distributed) by two (retention tests one and two) analysis of variance revealed a main effect of massed versus distributed that was highly significant ($\underline{F}$ = 25.942, df = 1 and 33, $P < .001$) in favor of distributed words, whose mean proportion correct was .70, in contrast to massed words with .58 proportion correct. These results confirm the results of a previous study (Fishman, Keller, and Atkinson, 1968) that showed a similar advantage for distributed practice in spelling on two tests, 10 days and 20 days following training. The test factor was not significant ($F < 1$) in this analysis. This study and the Fishman et al. (1968) study show that spaced practice gives superior retention at both shorter term and long term retention intervals.

Latency Analysis. The latency of a correct spelling was computed by adding the latency of each letter together and dividing that number by the number of letters. Latencies for misspellings were computed in a similar manner, except the number of letters varied with the misspellings. The latencies for correct (C) and incorrect (I) spellings were computed for each subject who missed at least one word on each retention test. For each subject qualifying for this analysis, the median latency of his C spellings and the median latency of his I spellings were computed. These were compared in a test that showed them to be significantly different on each retention test (retention one, $t = 3.15$, df = 45, $P < .005$; retention two, $t = 4.09$, df = 45, $P < .005$). Mean C latencies were shorter than mean I latencies on both tests ($\bar{X}_C$ = 1.726 seconds, $\bar{X}_I$ = 2.061 seconds for retention one; $\bar{X}_C$ = 1.833 seconds, $\bar{X}_I$ = 2.188 seconds for retention two). These results replicate the findings of another spelling study (Knutson, 1967) that also showed correct spellings are emitted in shorter time than are incorrect spellings.

Serial Position Curves. Serial position curves were computed for words having the same number of letters. Truncated misspellings such as sc for success, furni for furniture (4 percent of the total misspellings) were not included in this analysis. The serial position curve for seven letter words, computed separately for each focal group, can be seen in Figure 3. The number of misspellings on which the curves are computed are 26 for word, 29 for chunk, 25 for letter, or 80 total misspellings. The curve for seven letter words is representative of those for words of other lengths. It shows the typical peak in the middle of the word found in other studies (e.g., Kooi, Shutz, & Baker, 1965; Simon & Simon, 1972). The graph also shows that the distribution of errors across positions is not dependent upon the focal unit of segmentation. Kolmogorov-Smirnov tests were made on the curves coming from pairs of focal conditions, for words of length 7, 8, and 9. The number of misspellings, n, was chosen as the lowest number found in any pair of distributions. The test revealed no pairs were significantly different.

One can conclude that by recall time the various teaching treatments had not differentially influenced the word parts recalled. Regardless of treatment, when a word is incorrectly spelled, the central parts are likely to be wrong. By contrast, other teaching treatments such as highlighting the central parts of a word using colors or underlining flatten the error distribution (Jass & Gillooly, 1972) while maintaining the same proportion of errors. This suggests that spaces between letters do not function as highlighting cues; possibly highlighting cues and other stimulus emphasizers influence rehearsal processes while spaces influence encoding.

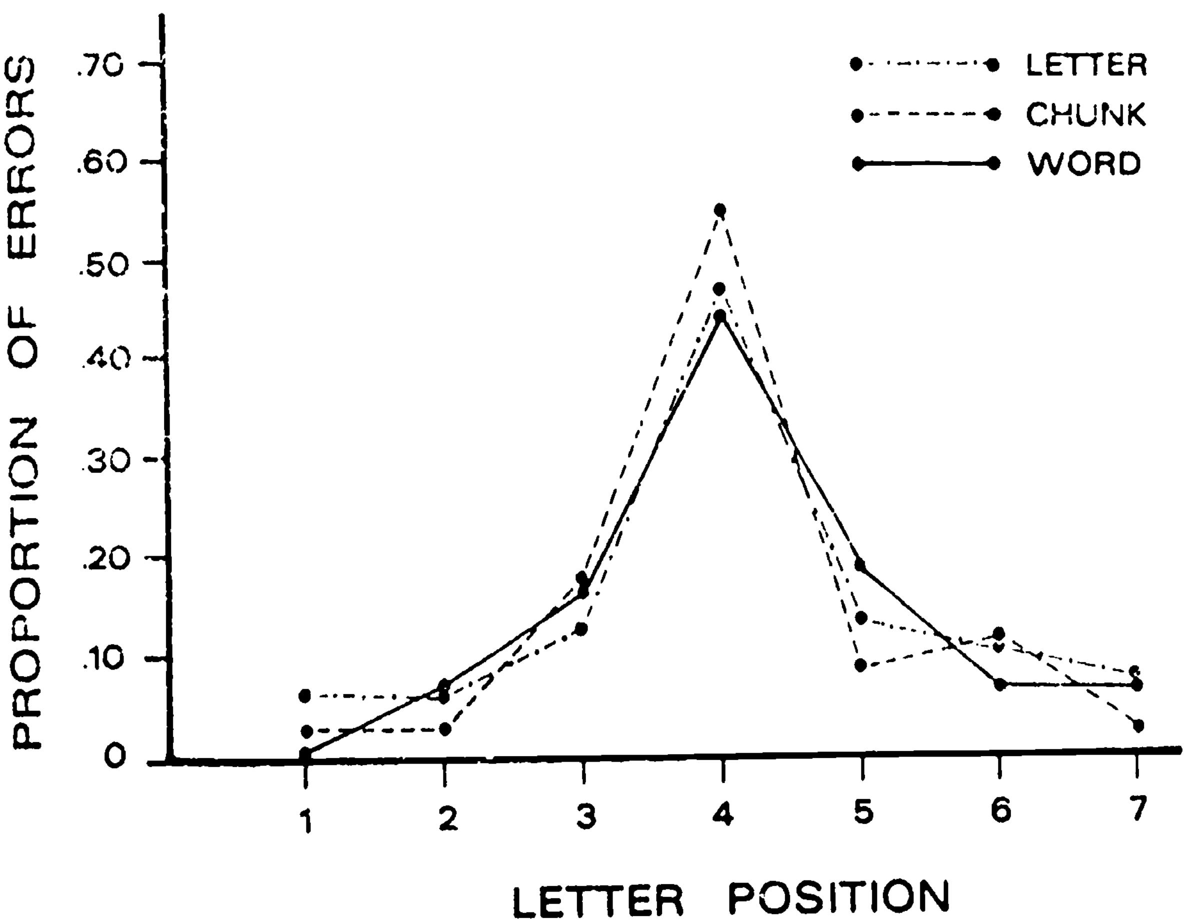


Figure 3. Serial Position Curves for Seven-Letter Words as a Function of Focal Unit Treatment.

_Missing Chunks._ The 207 misspellings emitted in the retention tests were scored for the omission of a pronounceable chunk. Each misspelling was pronounced aloud by three adult readers who pronounced each misspelling by parts, where a part was defined as pronounceable chunk. The pronunciation was scored for the number of pronounced chunks; if the number of chunks was greater than or equalled the number used in the chunk treatment of the word, a score of zero or no omitted medial chunk was assigned. If the number of chunks was less than the number used in the chunk scheme, then a score of one, or omitted chunk was assigned. Almost all of the misspellings could be easily broken into pronounceable chunks, e.g., _temprature_ (3) and _chokolate_ (3) and there was high agreement among the readers (98 percent).

Only 19 out of 141 (13.5 percent) non-W misspellings contained missing chunks. By contrast, W words contained many misspellings with missing chunks: 91 out of 166 (54.8 percent). The effect of focal unit on retention of the missing chunk in the W words was assessed by analyses of variance on the proportions of total spellings (correct and incorrect) scored zero and the proportions of misspellings scored zero. The analyses were done separately for each retention test. Focal unit had no significant effect in any of the four separate analyses.

These data indicate that failure to recall W words is in part due to failure to recall the phonemic representation that mediated learning. However, even when the spoken word contains all the syllabic units of the word, recall is far from perfect, indicating that recall of the phonemic representation might be a necessary, but not sufficient condition for spelling recall.

The data from this study show that variables that influence acquisition do not influence retention, either of complete spellings or of unsounded chunks. Apparently, the best way to insure retention is to space practice, an instructional principle known for a long time, rather than expect retention to be heightened by specially designed acquisition procedures. The locus of influence of the teaching procedures used here seems to be on the encoding stage of learning rather than on oth. stages. However, procedures designed to guide initial learning can make learning more efficient because they can influence learning rate. Of course, any consumer of "new" procedures should decide whether the significant differences that our research detected make a practical difference for the child or the school.

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