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AUTHOR Holland, James G.; Solomon, Carol
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ABSTRACT

Emphasis is placed on the experimental analysis of behavior in this spelling program of computer-assisted instruction (CAI). The spelling program is of special interest because it is based on a good behavioral analysis of the nature of the spelling task, and it offers a chance to review computer instrumentation. Results of the review indicates the dangers in failing to insure the occurrence of the behaviors described in the task analysis. Objectives of spelling instruction and program rationales, and rules for non-readers are appended. (Author/DS)

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JAMES G. HOLLAND AND CAROL SOLOMON

University of Pittsburgh

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Abstract

This paper reviews the Learning Research and Development Center's Computer-Assisted Instruction spelling program in the light of the experimental analysis of behavior. The spelling program is of special interest because it is based on a good behavioral analysis of the nature of the spelling task, and because it offers a chance to review the state of the art in computer instrumentation of the learning process. Results of the review indicate the dangers in failing to insure the occurrence of the behaviors described in the task analysis--a problem aggravated by inadequate instrumentation.

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James G. Holland and Carol Solomon

Learning Research and Development Center
University of Pittsburgh

Teaching materials and procedures are reviewed as part of a project that aims to facilitate the application of the principles of operant behavior to instructional design. The role the reviews play is to generate a rich supply of exemplars of behavioral principles in operation. These exemplars, combined with research focused on providing tools or procedures for development and with an increased effort at interpreting the basic literature, will, it is hoped, result in a updated presentation of how to design instruction that is optimal with respect to the science of behavior.

The formal reviews also meet a secondary objective of providing feedback to the developers of the material we have examined. We hope that this repays the trouble often involved in introducing us to their work and that we can provide constructive comments useful for those who are oriented toward preparing materials that reflect the best utilization of learning principles.

Interest in CAI Spelling Programs

The CAI spelling programs are of special interest because of three characteristics that set them apart from all too many programs. First,

the programs were preceded by a creative behavioral analysis of the nature of the spelling task (see Simon & Simon, 1972). It has long been the ideal for programming to provide a technique for the analysis of knowledge or skills. A precise behavioral analysis is followed by the design of tasks with precise response requirements for reinforcement. Reinforcement follows if, and only if, the task is performed. The response contingencies are arranged in order of prerequisites, and the success of students upon completion of the program demonstrates experimentally the merit of the original analysis. CAI spelling is interesting to examine because it seems to fit this paradigm. If all is well with the instructional design, it will not only be a good spelling curriculum, but it will also be an experimental confirmation of an analysis of spelling behavior.

The second reason for special interest in the spelling program is that the analysis of spelling on which it is based involves discriminated feedback as an important element in spelling and hence in the teaching of spelling. One part of the task analysis involves the generation of possible spellings and a judgment on the part of the speller. Development of good discriminations of the products of skilled behavior is important in a wide variety of skills, for example, knowing the "feel" of good form by the athlete, hearing the self-produced good sound by the musician, or recognizing the well-written paragraph by the author.

The power of teaching these discriminations is often not fully realized. When learners can discriminate the merit of stimuli produced by their own behavior, they are automatically differentially reinforced. Reinforcement is "automatic" in the sense that no one else needs to evaluate the response and arrange to reinforce it, and it is differential in that behaviors which produce stimuli they have learned to judge as adequate are reinforced, while quite similar behaviors which produce stimuli they have learned to judge as inadequate go unreinforced. (For further information on programming discriminated feedback, see Unit 9 of "The Use of Learning

Principles in Instruction" [Holland, Solomon, Doran, & Frezza, Note 1].) The importance of discriminated feedback and the too frequent neglect of it in educational material make instances of programs in which discriminated feedback plays an important role especially valuable for our aim of finding useful exemplars.

The third reason for special interest in the spelling program is that it offers a chance to estimate the state of the art in computer-assisted instruction.

Basis for Review

The criteria by which materials are reviewed are those of the experimental analysis of behavior. We assume the task of anyone applying these principles to be "the construction of carefully arranged sequences of contingencies leading to the terminal performances which are the objects of education" (Skinner, 1963, p. 169). The most explicit and detailed description of the principles implied in Skinner's statement is found in our course, "The Use of Learning Principles in Instruction" (Note 1). The principles, however, can be briefly summarized here. If behavior is to be learned, it must be emitted and reinforced. Obviously, however, it is inefficient to simply wait for a child to emit some complex piece of behavior. Complex behaviors are shaped through gradual progression from simpler behaviors. The curriculum designer must analyze the task to be taught into its discrete components and their prerequisite tasks. These tasks are then sequenced, and a teaching program is developed for each. Children learn what they do, so each teaching program must assure that appropriate behavior occurs and that only appropriate behavior is reinforced. Thus, a low error rate is only one goal for the designer. An equally important goal is the precise design of response contingencies. Teaching material which inconsistently applies these principles may fail to achieve its objectives.

Instrumentation

Potential Values of Instrumentation

In conjunction with proper interface devices, the computer should be able to provide the best possible instrumentation. Whether general-purpose computers or specially designed teaching machines are used, appropriate use of instruments presents strong advantages. The advantages relate directly to the difficulty of implementing important features of the learning process without proper stimulus presentation, without seeing the student's response, without evaluation of the often subtle response requirements that are the requirements for reinforcement, and without the ability to provide instant and salient reinforcement. (For further discussion see Glaser & Cooley, 1973; Holland & Doran, 1973.)

The behavioral analysis determines many of the requirements, or at least the options, in instrumentation. For example, teaching comprehension of a spoken language requires some form of auditory presentation. If the advantages of individualization are to be realized without live individual tutors, use of audio recordings seems essential. Similarly, different responses designated by the task analysis indicate different instrumentation requirements for the response modalities. A few of the advantages of good instrumentation follow.

1. It can assure that students do the right thing in order to achieve the correct response. Without the machine, they may see cues from other items on the page, or peek at the confirmation, wherever it may be, or, in many cases, see it faintly appearing through the page of any but the heaviest paper.

2. Instrumentation can provide the right form of the stimulus and require the right form of the response as dictated by the behavioral analysis of the skill to be taught.

3. Reinforcement can be immediate.

4. A snappy, attention-holding pace is set by having new frames appear instantly. (A program teaching an inductive reasoning skill to young children in 234 frames could be completed in 20 to 30 minutes on a good machine. The same program adapted to paper and pencil required many sessions, and children usually quit before finishing it [Holland, 1962].) With good instrumentation students have no break in the action which would allow their attention to drift away from the task.

5. Even in an otherwise very unstructured teaching situation (especially characteristic of colleges and more extreme forms of open classrooms), the teacher knows precisely what students have done on the machines.

6. With good instrumentation, a well-developed teaching program can be transported without distortions which can greatly degrade its effectiveness. The teaching technique is communicated automatically.

Instrumentation of the Spelling Programs

Some of the advantages offered by instrumentation are found to a greater or lesser degree in the spelling program. (Anyone not throughly familiar with this program should read the description in Appendix A before reading further.) Answers cannot be attained by "peeking", there is immediate reinforcement for spelling a single word, even when the total plan involves listing many words, and such individual reinforcement can be provided while allowing the list to be generated in any order.

Unfortunately, in several ways the instrumentation falls far short. The most serious shortcoming is the failure to include stimulus forms required by the behavioral analysis. The developers are attempting to teach the concept of alternate spelling patterns for sounds (for example, /K/ may be spelled <K>, <C>, or <CK>). But the student interface (the Datapoint 3300) has only a screen on which words can be printed and a typing keyboard for responding. There is no provision for auditory

presentation, even though phonemic analysis of the spoken word is crucial to the behavioral objectives. The lack of the necessary auditory interface device presents a severe challenge to the developer. In SPLPAT the target words are visually presented along with other words and the children are expected to pronounce them carefully enough and correctly enough to perform the phonemic analysis on their own utterance. A child who reads this well, never even misreading when the same grapheme is used for different phonemes (C spells /K/ or /S/), has a high proficiency in decoding (going from grapheme to phoneme) which may indicate high previous proficiency in spelling (going from phoneme to grapheme). But many children may not decode this well, at least not when they most need the spelling training. Instead, they probably base their responses on the graphemes displayed. In other words, some children may copy the visual stimuli and accept the few errors that result. For these children, the targeted behavior may be missed completely, and a major advantage of instrumentation in providing the right form of the stimuli is lost. Moreover, children can often achieve a correct answer by visual matching, hence, the advantage instrumentation offers in assuring responding for the right reason is sacrificed.

The presentation to the child also has severe deficiencies in the immediacy and clarity of reinforcement. The printing time for word and confirmation phrases such as 'good, find another' are quite quick and completely acceptable, unless school hour time-sharing imposes delays. However, getting confirmation on the screen and making the student aware of that confirmation are two different matters. Until the confirmation message is read, it is not reinforcing. And the problem here is that the confirmation message looks like all the other changes that occur on the display screen. A prominent, immediate stimulus different from all others is needed as a reinforcer.

The possibility that instrumentation provides for a snappy, efficient pace is lost because of the use of a typing keyboard which taxes children with the slow and laborious task of finding the right key, letter by letter, in order to type out the response. While doing so, their eyes are diverted from the display which contains all the stimulus material and confirmation.

In general, the interface equipment suffers from a lack of consideration of some basic principles of human engineering. However, LRDC has long been aware of the exciting possibilities offered in CAI with the development of ideal interfaces. The interested reader is directed to the excellent, insightful papers quoted here.

On displays:

> This process of learning by discovery or by induction means that the learner has the ability to explore or to manipulate a particular subject matter, and not only must the instructional program have the logical capability to cope with this requirement, but the interface devices must contain enough alternative states or controllable configuration to allow a wide range of selection or response alternatives. (Glaser & Ramage, 1967, p. 53)

On the response:

> In many instances, the nature of the media through which instructional information is presented forces restraints on "realism," realism in the sense of changing the characteristics of the task eventually to be learned. . . . What is required is an analysis of the component tasks involved so that behavior is taught which insures transfer to the noisy situations that will be encountered in real life. . . . In considering the response requirements of an interface, learner capability also should be introduced as a consideration. Young children can speak and point to things before they have developed the fine motor skills for manipulating a pencil or a typewriter key. (Glaser & Ramage, 1967, p. 54)

The subject matter:

> Quite obviously, different subject matters and different bodies of knowledge have varying stimulus and response requirements which determine the kind of interface suited to them. Some trade-off is involved between the design of general-purpose consoles versus consoles specially designed for particular instructional topics. (Glaser & Ramage, 1967, p. 55)

> I am aware of the difficulties of console design, but in the course of development of CAI, a significant amount of attention is required to match the properties of console displays and controls to the properties of subject matter in order to design relevant conditions for learning. (Glaser, 1969, p. 91)

Thus, there was the promise of a new technology that took account of the characteristics of the learner, the learning process, and the subject matter in the design of efficient instruments for teaching. There were, no doubt, good practical reasons for accepting an available, somewhat flexible interface and getting something going quickly. It would be a shame, however, if the short-run gains have now precluded the possibility of fulfilling the long-run dream reflected in the above-quoted papers.

Behavioral Objectives and Behaviors Programmed

As indicated in the introduction, one very provocative aspect of this program is its relationship to an analysis of how people spell and what happens when they misspell. If the elements of the task analysis are actually embodied as contingencies in the program, and if children who have completed the program score nearly perfectly on an appropriate posttest, the program may serve as a confirmation of the task analysis. For this reason we have payed particular attention to the relationship between the behavioral analysis of spelling (see Simon & Simon, 1972) and the actual response contingencies that constitute the behavioral program.

The Objectives

The developers state that a child who has attained the concept of optional spelling patterns for sounds can do these three things:

1. analyze words into their component phonemes;

2. use phoneme to grapheme correspondence to write the spellings of new words;

3. use graphemic options... to write different spellings for the same word (Block, Note 2, pp. 29-30).

The objectives describe at least three different major processes-- auditory discrimination of the phoneme, production of the graphemes, and association of several graphemes to a phoneme. This is a useful task analysis, which could result in a clear statement of what behaviors must be reinforced in order to teach these skills.

First, the child must learn to hear the phoneme and to discriminate it from surrounding phonemes in a word. So discrimination of the target phoneme in a word should be reinforced. The child must also be able to write or type the grapheme which stands for the phoneme. (We presume that children using this program already possess this ability.) Finally, the child must learn to produce several graphemes in response to a particular phoneme. Thus, sound-to-grapheme associations should be reinforced.

SPLPAT and TRYSPL are companion programs which teach these three objectives. The design of the lessons in these two programs will be examined to clarify what behavior may be evoked and reinforced, and to compare this to the behaviors described by the behavioral analysis. In addition to producing alternate spellings for the target word, TRYSPL requires that the student discriminate the correct spelling. In considering TRYSPL, then, the additional problem of teaching discrimination of self-produced stimuli will be discussed.

SPLPAT Format I

The SPLPAT program trains audio discrimination of target phonemes indirectly. As indicated in the discussion of the instrumentation, the lack of audio input or output seriously limits the possibilities of getting contingencies for correct auditory analysis. Nevertheless, the developers have produced an innovative lesson design that seems to partially overcome this limitation and teach discrimination of phonemes using only a visual format. In Format I of SPLPAT, students are given a sentence and are asked to identify the words which contain the target sound. Here is a sample display:

```
 1    2    3    4
KATY CAN COME AND
  5     6     7     8     9
SKATE BACK WITH THE CHICKEN.

READ THE SENTENCE TO YOURSELF.
LOOK FOR WORDS WITH THE /K/ SOUND.

FIND A /K/ WORD. TYPE ITS NUMBER. TYPE NO IF NO MORE.
***
```

The desired behavior is the discrimination of words containing the target sound (spelled in various ways) from words not containing that sound. The design of the format allows an effective use of reinforcement each time such a discrimination is made, at each word.

There are some problems with regard to exactly what behavior may be evoked, however. There is no assurance that students will work on the basis of sound at all. If they do not sound out the words, some errors will result. But errors can be kept fairly low after the first set of words in the lesson, when they learn that the visual stimulus /K/ signals "find the visual symbol K, C, or CK."

SPLPAT Format II

The second and third formats in SPLPAT should teach the association of graphemes to the target sound. The second format consists of all words from the previous sentence which contain the target sound, and the following directions:

> LOOK AT THE WORDS. THE /TARGET/ SOUND IS SPELLED SEVERAL WAYS. COUNT THE WAYS THE /TARGET/ SOUND IS SPELLED. TYPE THE NUMBER.

The behavior desired has several components. Children must locate the target sound in each word and decide which letters probably spell it. They then must compare the spellings of several target sounds to decide if the sounds are spelled the same or differently. They finally type a number representing the number of spellings for that sound from this list of words.

This format is not well suited to teaching either the discrimination of graphemes for the target sound or the association of graphemes to a phoneme There is no provision for immediate reinforcement for a correct decision at each word. Some words can even be ignored, and the child will still get the correct answer. For example, one 10-year-old working on the /J/ sound program could not pronounce the word APOLOGIZED when it appeared in Format 1 and did not identify it as having a /J/ sound. When it appeared in the list for Format II, she expressed surprise and ignored it, yet typed the correct number anyway. Also, there is a question of what behavior may really be evoked by this format. The correct answer is nearly always the number 3.[1] It is possible, and

[1] In the /J/ sound lesson described in the appendix, this display occurs four times. The number 3 is the correct answer three times, the number 2 is correct for the last presentation of the display.

even likely, that children will soon begin typing the number 3 whenever this format appears, with little or no observation of the words listed. This behavior is possible, and would be reinforced by this message.

YOU ARE RIGHT.

THE /K/ SOUND IS SPELLED 3 WAYS IN THESE WORDS.
IT CAN BE SPELLED <C> <K> <CK>

HIT THE RETURN KEY WHEN YOU WANT TO CONTINUE***

SPLPAT Format III

The third SPLPAT format consists of the words from Format II and the target sound spelling patterns arranged like this:

<C> <K> <CK>

KATY
CHICKEN
CAN
COME
SKATE
BACK

NOW YOU CAN SORT THE WORDS UNDER THEIR
SPELLING PATTERNS FOR THE /K/ SOUND.
WATCH THE SCREEN TO SEE IF YOUR WORDS ARE RIGHT.
TYPE NO WHEN YOU RUN OUT OF WORDS WITH
ONE SPELLING PATTERN.

HIT RETURN FOR THE FIRST PATTERN.***

Sample responses--Words correctly typed or given as feedback are printed in appropriate column.

TYPE A WORD WHERE <C> SPELLS THE /K/ SOUND.
*** CAN (CAN is printed under <C>. Response is erased.)

To perform this task, the child should locate the /K/ sound in each word, note which letters spell it, compare that grapheme to the sample grapheme,

and type the whole word or go on to the next word, depending on whether or not the graphemes match. If the learner performs the task in this way, an association should be formed between the target sound and its graphemes, because the child is sounding out the word and locating the grapheme that represents the target sound in that word.

However, there are two problems with this format which make it likely that some children will not perform the task in the desired manner. First, the association of one sound with the several graphemes is presumably a new skill for these children. But they already have a skill that can adequately solve this task. The child can compare the letters of each word to the sample grapheme, performing the task as if it were a visual match-to-sample task and, thus, not forming a phoneme-grapheme association. A child carefully performing the /K/ sound task in the typical example shown above relying purely on visual stimuli might make only one error--placing the word CHICKEN under the <C> spelling pattern because of the initial C.[2] All other words can be correctly placed by visual matching. In the /J/ sound lesson, the target sound occurs a total of 27 times in the four displays of this kind. A child placing those 27 spelling patterns by visual matching alone would make only two errors. The words JUNGLE and GRUDGE must be placed under the <G> spelling pattern if the child works without attending to sound.

Item types like CHICKEN, JUNGLE and GRUDGE are particularly important in Format III. In these items the sample grapheme is present, but pronounced differently from the target phoneme. Therefore, these

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[2]The other probable error, placing the <CK> words under the <C> or <K> spelling pattern, could happen whether the child used visual matching or sound-to-grapheme association.

items can only be correctly solved by sound-to-grapheme correspondence. A student solving this task by visual matching will necessarily make errors on them. Therefore, these words seem to embody a strong contingency for sounding out the words. (In fact, it is only the presence of the rather small number of such words that prevents a visual matching strategy from yeilding a perfect score in Format III.)

Unfortunately, correct decisions on these items are not immediately reinforced. For example, suppose a child performing the task in the sample above notes the initial letter C in CHICKEN as a possible <C> spelling pattern. The child pronounces the word and decides correctly that this letter does not spell the /K/ sound in this word. The decision to omit this word is not directly confirmed. Only after the child indicates that there are no more examples of the <C> spelling pattern and the computer confirms this decision is the decision to omit CHICKEN also confirmed by implication. This is a very delayed and indirect form of reinforcement.

Moreover, this format results in a contingency problem for words to be excluded from lists. The omission of a word might not have been the result of the student's decision at all. A student could be "correct" simply by failing to consider a word, or, in the case of words like CHICKEN, by considering the matter settled when the word was classed as a <CK> spelling.

TRYSPL

TRYSPL is designed to teach both the use of graphemic options learned in SPLPAT to write different spellings for the same word and the discrimination of the correct spelling from among those produced. TRYSPL vocabulary differs from that used in SPLPAT, but the target sounds are the same for both programs. A sample TRYSPL protocol looks like this:

Introductory Message - I

TO FIND A WORD IN A DICTIONARY THAT YOU DON'T KNOW HOW TO SPELL, YOU HAVE TO TRY OUT DIFFERENT SPELLINGS.

FIRST -- YOU SOUND OUT THE WORD.

SECOND -- YOU SPELL IT DIFFERENT WAYS

THIRD -- YOU LOOK UP YOUR SPELLINGS

LAST -- YOU FIND ONE OF YOUR SPELLINGS IN THE DICTIONARY. THAT SPELLING IS THE CORRECT SPELLING

TRYSPL GIVES YOU PRACTICE IN -- STEP 2

PRESS RETURN TO GO ON.
•••(Screen is cleared)

Introductory Message - II

LOOK AT YOUR WORKSHEET FOR THIS LESSON.

THERE IS A SENTENCE FOR EACH WORD AND A PRONUNCIATION TO HELP YOU SOUND IT OUT.

TYPE THE SPELLINGS FOR EACH WORD THAT YOU WOULD TRY. USE WHAT YOU KNOW ABOUT HOW SOUNDS ARE SPELLED -- SEE IF YOU CAN MAKE THE CORRECT SPELLING. TYPE NO IF NO MORE.

PRESS RETURN TO BEGIN.
•••(Screen is cleared)

The child's worksheet has these phonetic symbols printed on it:

hat, âge, câre, far;	cup, pu̇t, rūle, ūse,	ə represents *a* in about,	ch, child; ng, long;
let, bē, tẽrm; it, ĩce;	oil, out;	*e* in taken, *i* in April,	th, thin; TH, then;
hot, gō, ôrder;		*o* in lemon, *u* in circus.	zh, measure;

The word to be spelled appears in phonetic transcription in a sentence like this: Word 1. There was a /nok/ at the door.

TRY WORD 1:

SPELLING 1? *** nok
SPELLING 2? *** nock
SPELLING 3? *** knock
SPELLING 4? *** no

LOOK AT YOUR SPELLINGS.

TYPE THE NUMBER OF THE SPELLING YOU THINK IS CORRECT.
***2
NO. THE CORRECT SPELLING IS 3.— — KNOCK

COPY THE CORRECT SPELLING FOR WORD 1 ON YOUR WORKSHEET.

PRESS RETURN TO TRY THE NEW WORD ***(Screen is cleared).

Children who have learned that <K>, <C>, and <CK> can spell the /K/ sound, when given the word /nok/ should produce three spelling alternatives (assuming they do not know the correct spelling):

1. NOK
2. NOCK
3. NOC

The TRYSPL program provides no information on the acceptability of any attempted spellings until one is chosen as correct, and then students learn only whether that choice is indeed spelled correctly. Even their final score does not reflect their production of spelling alternatives based on use of the spelling options learned in SPLPAT. A student who produces only one correct spelling for each word and identifies that as correct receives a final score of 100%. It is perhaps a good idea not to encourage students to produce spellings that they know are incorrect just to insure that they are applying the rules well. Yet if students do not know the correct spelling and use the SPLPAT rules to produce an acceptable alternative, they get no feedback on their production unless they choose

it as correct. TRYSPL has problems, then, because of its limited feedback regarding the acceptability of the student's productions.

However, in situations where learners must make fine discriminations of their own productions, teaching the discriminations prior to teaching production can then help the production process. The discriminating learner then has his or her behavior immediately differentially reinforced by the stimuli which the behavior produces. In SPLPAT each spelling word appears in three different formats, and the student possibly makes some response to it each time it appears. However, the response made is never a discrimination of the correct spelling. It seems likely that the exposure to the correct spellings would provide some "incidental learning" which would increase the learner's ability to choose the correct alternative, but programmed contingencies establishing this skill are absent. Yet, in TRYSPL students are expected to show the effects of discriminated feedback when they discriminate the correct spelling from among such alternatives.

Summary

The task analysis on which the spelling programs are largely based seems to be an excellent example of identifying the behaviors involved in spelling. It would have been a significant feat to have been able to confirm this analysis by having a program that assures the occurrence of each component behavior. Unfortunately, SPLPAT and TRYSPL fail to provide such a test because the tasks are not designed to assure the occurrence of the desired behaviors. The elements of the behavioral analysis have not successfully been made the exclusive basis for attaining the correct answers. Indeed, without the use of auditory stimuli, the design of suitable response contingencies for a spelling program is extremely difficult.

Regarding SPLPAT, the three formats do not insure that the student execute the behavior described in the task analysis. It is expected that

some students would carefully sound out words and behave as the behavioral analysis would suggest. Others, we believe, would to a greater or lesser extent, fall into the easier modes described above without greatly affecting their overall error rate. (See Appendix B, "Rules for Non-Readers," for further details.) If students are posttested through an auditory presentation of the target word and a written response, we would expect some students to do well and many to do poorly, depending on whether they worked from self-generated auditory cues or strictly visual cues during the program. A crude test of this position should be available in data collected by the developers. Many lessons have a couple of words in Format III that contain the "target" spelling pattern in a position in which it does not produce the target phoneme, for example, CHICKEN in the /K/ sound program. A student who is not sounding out the words would erroneously classify such a word as an example of the <C> spelling of the target sound. Therefore, we would expect a correlation between correct classification of these few "trap" words and the pretest-posttest gain (to the extent that there is not a problem of ceiling effect). In TRYSPL the contingencies are arranged to reinforce only correct spellings, despite objectives which imply that the production of "acceptable" alternate spellings will be encouraged.

Finally, a number of problems with the Datapoint 3300 interface system of CAI are suggested by the implementation of the spelling program. A return to an emphasis on designing (or using already available) interface devices tailored to the needs of the student, the curriculum requirements, and the learning process is much to be desired.

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APPENDIX A

From "Spelling Categorization and Language Concepts"
(Block, Note 2)

The Objectives of Spelling Instruction and Program Rationales

The traditional method of teaching spelling involves dictated lists of words for the child to write and oral spelling by the child for teacher checking and correcting. The view of spelling developed by this project emphasizes the basic knowledge and skills that the speller needs to know to learn new words efficiently. Some of these basic skills are explicitly taught by the computer-assisted programs, others are practiced in computer-assisted lessons. . . . Briefly, the objectives that have guided the CAI work are:

(1) The child can analyze words into their component phonemes.

(2) The child can use phoneme-to-grapheme correspondences to write the spellings of new words.

(3) The child can use graphemic options (two or more spellings for the same sound, e.g., /f/ → <f>, <ph>) to write different spellings for the same word for the purpose of checking which is correct or for looking up a word in a dictionary.

(4) The child can find misspelled words in his written work.

(5) The child can perform structural affixation properly.

(6) The child can use the words he knows how to spell, especially the homophones, properly in sentences.

The four CAI spelling programs which have been developed are directly related to one or more of these objectives. All four . . . were in operation at the school [Oakleaf Elementary School] beginning September 1973. . . . [Only two of the four programs are included in this selection.]

The SPLPAT and TRYSPL Programs

The design of the SPLPAT (= Spelling Patterns) and TRYSPL (= Try Spellings) programs was in part shaped by the model of spelling performance developed by Simon and Simon (1972). This model describes how children perform spellings: They use phoneme-to-grapheme correspondences to generate a trial spelling; then, they use word recognition information (what they know about the correct spelling of a word from having encountered it in reading) to test the trial spelling. The SPLPAT program was developed to teach the ways in which a phoneme can be spelled, and the TRYSPL program was developed to encourage the application of this knowledge to the spellings of new words containing the phonemes taught in SPLPAT. These two programs, taken together, promote the objectives of efficient auditory analysis, attention to optional spelling patterns, and development of dictionary and proofreading skills.

SPLPAT. SPLPAT is a tutorial program that runs on a cathode-ray terminal. It is designed to teach the concept of optional spellings for sounds. It has three major instructional routines illustrated in the displays of Figure 2. In the first, a sentence is presented and the child finds all the words in that sentence with a particular sound. In the second, the words with the target sound are listed and the child counts the spelling patterns contained in those words. In the third, the child sorts the words into columns according to their spelling patterns. He does this by typing in succession the words on the list that contain a designated pattern. The instructional strategy involves feedback after each response: "Good" for a correct response and an appropriate message for an error. After a second error on the same item at any point in the program, the correct answer is given and the program moves on to the next task.

(Student response underlined).

Initial Display

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  1    2    3    4
KATY CAN COME AND
   5    6    7    8    9
SKATE BACK WITH THE CHICKEN.

READ THE SENTENCE TO YOURSELF.
LOOK FOR WORDS WITH THE /K/ SOUND.

FIND A /K/ WORD. TYPE ITS NUMBER. TYPE NO IF NO MORE.
***
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Sample Responses Response disappears from screen before feedback is given.

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*** 1
1 --GOOD. FIND ANOTHER.
*** 4
4 --LOOK AGAIN. THAT WORD DOES NOT HAVE THE /K/ SOUND.
*** 5
5 --GOOD. FIND ANOTHER.
*** NO
NO --LOOK AGAIN. THERE IS ANOTHER.
*** 9
9 --GOOD. FIND ANOTHER.
*** NO

THE /K/ SOUND IS ALSO IN 2, 3, 6.

HIT THE RETURN KEY WHEN YOU WANT TO CONTINUE.***
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(After "return", screen is cleared).

Second Display and sample responses.

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KATY
CHICKEN
CAN
COME
SKATE
BACK
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Figure 2. SPLPAT protocol for sample sentence.

LOOK AT THE WORDS. THE /K/ SOUND IS SPELLED SEVERAL WAYS.
COUNT THE WAYS THE /K/ SOUND IS SPELLED.
TYPE THE NUMBER. *** 2
TRY AGAIN. COUNT THE WAYS THE /K/ SOUND IS SPELLED.
TYPE THE NUMBER. *** 3

YOU ARE RIGHT.

THE /K/ SOUND IS SPELLED 3 WAYS IN THESE WORDS.
IT CAN BE SPELLED <C> <K> <CK>

HIT THE RETURN KEY WHEN YOU WANT TO CONTINUE***

(List remains on display. Messages disappear. Spelling patterns appear at top of screen).

Third Display

<C> <K> <CK>

KATY
CHICKEN
CAN
COME
SKATE
BACK

NOW YOU CAN SORT THE WORDS UNDER THEIR
SPELLING PATTERNS FOR THE /K/ SOUND.
WATCH THE SCREEN TO SEE IF YOUR WORDS ARE RIGHT.
TYPE NO WHEN YOU RUN OUT OF WORDS WITH ONE SPELLING PATTERN

HIT RETURN FOR THE FIRST PATTERN.***

Sample responses -- Words correctly typed or given as feedback are printed in appropriate column. (See below for Final Display).

TYPE A WORD WHERE <C>	SPELLS THE /K/ SOUND.
*** CAN	(CAN is printed under <C>. Response is erased).
CAN -- GOOD. FIND ANOTHER.	(Feedback message with request for next response).

Figure 2 (cont'd). SPLPAT protocol for sample sentence.

*** COEM
COEM ---CHECK YOUR TYPING. TRY AGAIN. (Error Message)
*** CHICKEN
CHICKEN ---LOOK AGAIN. THAT WORD DOES NOT HAVE THE <C >
SPELLING PATTERN. (Error Message)
*** NO
NO ---LOOK AGAIN. THERE IS ANOTHER.
*** NO
NO ---THE <C > SPELLING PATTERN IS ALSO IN COME. (Come is printed under <C >).

HIT RETURN TO CONTINUE.***

(If all words of the target pattern have been typed, the message is. GREAT. YOU HAVE FOUND ALL THE WORDS WITH THE <C > SPELLING PATTERN).

(Each of the other patterns is presented in this manner).

Final Display

	<C >	<K >	<CK >
KATY	CAN	KATY	BACK
CHICKEN	COME	SKATE	CHICKEN
CAN			
COME			
SKATE			
BACK			

NOW YOU KNOW HOW TO SPELL SOME WORDS
WITH THE /K/ SOUND. (End-of-Sentence message)
STUDY THE WORDS.

HIT RETURN WHEN YOU ARE READY TO CONTINUE.***

Figure 2 (cont'd). SPLPAT protocol for sample sentence.

Appendix A (Cont'd)

A SPLPAT lesson consists of four to six sentences and each sentence deals with a single target sound. Figure 2 shows a sample protocol for one sentence. The target sound for the lesson . . . is /K/. The child will learn that /K/ ⟶ <K>, <CK>, <C>. Figure 2 shows the visual and textual displays used in the program. The program requests a response from the child by three asterisks (***), the child's responses are underlined in Figure 2. Also, sample responses for items in the program are shown, along with associated prompts and error messages.

There are 16 SPLPAT lessons, written by the staff and the teachers. They teach 20 different sounds, 40 percent of the phoneme base of English. At an estimated average of 50 minutes per lesson, there are 13 instructional hours.

TRYSPL. TRYSPL can best be characterized as a novel kind of "generate and test" program designed to provide practice in applying the optional spellings learned in SPLPAT to new spelling words. For the older children (Grades 4 and 5) it also provides experience with the important dictionary skill of decoding dictionary pronunciation symbols. At this level each training word is identified, via an off-line worksheet, by a numbered sentence in which the word is written in phonetic transcription. . . . With the younger children (Grade 3), words can be pronounced by cassette while the child is at the terminal.

In the TRYSPL program, the children are encouraged to sound out a word and think hard about a spelling. They have the opportunity to generate alternative spellings for a word if they wish and then are asked to select the one that looks right. Immediate feedback--yes or no and the correct spelling--is given. They are requested to copy the correct spelling onto their worksheets. The lesson is completed with one cycle through the list. Displays and a sample protocol are shown in Figure 4.

Introductory Message - I

TO FIND A WORD IN A DICTIONARY THAT YOU DON'T KNOW HOW TO SPELL, YOU HAVE TO TRY OUT DIFFERENT SPELLINGS.

FIRST -- YOU SOUND OUT THE WORD.

SECOND -- YOU SPELL IT DIFFERENT WAYS.

THIRD -- YOU LOOK UP YOUR SPELLINGS.

LAST -- YOU FIND ONE OF YOUR SPELLINGS IN THE DICTIONARY. THAT SPELLING IS THE CORRECT SPELLING.

TRYSPL GIVES YOU PRACTICE IN -- STEP 2.

PRESS RETURN TO GO ON.
*** (Screen is cleared)

Introductory Message - II

LOOK AT YOUR WORKSHEET FOR THIS LESSON.

THERE IS A SENTENCE FOR EACH WORD AND A PRONUNCIATION TO HELP YOU SOUND IT OUT.

TYPE THE SPELLINGS FOR EACH WORD THAT YOU WOULD TRY. USE WHAT YOU KNOW ABOUT HOW SOUNDS ARE SPELLED -- SEE IF YOU CAN MAKE THE CORRECT SPELLING. TYPE NO IF NO MORE.

PRESS RETURN TO BEGIN.
*** (Screen is cleared)

(Sample responses -- Word 1 is /nok/, Word 2 is /haf/ . The children would know this from their worksheet. Response underlined and in lower case type).

Figure 4. TRYSPL protocol for sample words.

TRY WORD 1:

SPELLING 1? ***nok
SPELLING 2? ***nock
SPELLING 3? ***knock
SPELLING 4? ***no

LOOK AT YOUR SPELLINGS.

TYPE THE NUMBER OF THE SPELLING YOU THINK IS CORRECT.
***2
NO. THE CORRECT SPELLING IS 3 -- KNOCK

COPY THE CORRECT SPELLING FOR WORD 1 ON YOUR WORKSHEET.

PRESS RETURN TO TRY THE NEXT WORD *** (Screen is cleared).

TRY WORD 2:

SPELLING 1? ***half
SPELLING 2? ***haf
SPELLING 3? ***no

LOOK AT YOUR SPELLINGS.

TYPE THE NUMBER OF THE SPELLING YOU THINK IS CORRECT.
*** 1
YES. THE CORRECT SPELLING IS 1 -- HALF

COPY THE CORRECT SPELLING FOR WORD 2 ON YOUR WORKSHEET.

(The program continues in this fashion for the rest of the spelling words on the list).

Figure 4 (cont'd). TRYSPL protocol for sample words.

When a child completes the program, he has a list of correctly spelled words on his worksheet. The program also gives him a percentage score on the lesson which summarizes how well he performed. This score is given to the teacher who decides whether any more activity should be undertaken on this lesson.

A comprehension output program has been designed, which collects all the data necessary for a useful evaluation. A sample printout from this data recording program appears as Figure 5 [not shown in this selection]. Column 1 contains the training words, columns 2 and 3, the student's generated spellings in the order that they were generated; column 4, the evaluation of each of the generated spellings, column 5, the spelling designated correct by the child, and in column 6, the evaluation of the student's choice of the correct spelling, when the correct spelling has been generated by him. Other response history statistics are computed, as shown at the bottom of the data record. At the present time, a study has been designed to evaluate the effects that prior experience on SPLPAT has on performance in TRYSPL and to gather data on how many words are learned and remembered from a TRYSPL lesson.

There are 16 lessons of TRYSPL that require the application of concepts for sounds learned in the SPLPAT lessons, one lesson based on words in the students' spelling text, and two that deal with sound and spelling pattern concepts not previously taught by these programs. With an estimated average of 40 minutes per lesson for these 19 lessons, there are about 13 instructional hours available.

APPENDIX B

"Rules for Non-Readers"

SPLPAT /J/ Sound Lesson

The desired behavior in the spelling program SPLPAT is the examination of certain words, particularly certain groups of letters in those words, and the association of these letters with the phoneme they represent. Yet, a child could complete the entire /J/ sound lesson without reading the words presented and without ever associating the target phoneme with its graphemes. In other words, a smart non-reading child could develop certain rules which would get him through the SPLPAT lessons illegitimately. Here are some rules that would work.

In the /J/ sound lesson, the first sentence presented is:

Display 1

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Gina of the jungle jumped on the giraffe and rode to the edge of the bridge.

The child is directed to type the numbers of words which have the /J/ sound. Our child will not read the sentence, so he must type all the numbers listed, typing each only once. Of course, each wrong number results in an error message, but this is a relatively small consequence. The child can continue through to the end, and is never recycled despite his many errors. In fact, the final message is "Great. You have found all words with the /J/ sound." Our non-reader takes 10 errors on this first display.

The second display presents the /J/ sound words from the sentence: Gina, jungle, jumped, giraffe, edge, bridge.

The child is directed to count the ways the /J/ sound is spelled and type that number. A child familiar with the SPLPAT programs would be likely to type the number 3, since that is the most frequently reinforced response to this display. Let's assume that our child types a 3 whenever this display occurs. The result is the message, "You are right. The /J/ sound is spelled three ways in these words. It can be spelled <G> <J> <DGE >." No errors on Display 2.

Display 3

<G> <J> <DGE >

Gina
jungle
jumped
giraffe
edge
bridge

Directions for Display 3 are to sort the words under their spelling patterns. Each spelling pattern is presented in order. The child is first told to type a word where G spells the /J/ sound.

Rather than reading these words and listening for a /J/ sound, our non-reader searches the list for words with the relevant letters. He would first look for the letter G unaccompanied by D and E. He finds this letter in the words Gina, jungle, and giraffe, and types these words. The result is one error since the G in jungle does not represent the /J/ sound. The error message, however, says instead "That word does not have the G spelling pattern." Our child knows very well that there is a G in jungle, so this message, if read, will confirm his opinion that the computer is not to be taken seriously. All other words for the remaining two spelling patterns can be correctly matched visually. The result is 1 error for Display 3.

A new sentence is presented:

Display 1 a

1 2 3 4 5 6 7 8 9 10 11
A generous gypsy pledged to give fudge to the stingy judge.
12 13 14 15 16 17 18 19 20 21
The joyous judge apologized and no longer carries a grudge.

Our non-reader is smart and familiar with the program, so he has noted that the letters to watch for a G, J, and DGE. This time he does not have to type all the numbers; he simply searches each word for the target letters. The result is 2 errors for Display 1a (give, and longer).

Display 2a presents the /J/ sound words from that sentence and the instruction to count the ways the /J/ sound is spelled and type the number. Our kid types the usual number 3 and gets the usual confirmation message. No errors.

Display 3a presents those words and the three spelling patterns, with directions to again type a word where <G> (or <J> or <DGE>) spell the /J/ sound. Again he proceeds by visual matching, with 1 error on the word "grudge" as a result.

Our non-reader proceeds similarly through the last six displays, making 1 or at most 2 errors. The error(s) would occur in the final display in which the child is asked to count the ways the /J/ sound is spelled. The correct answer this time is 2 rather than 3. So, our kid would necessarily make 1 error. If he next tries the number 2, this is the only error he would make. If he tries any other number, the computer will give him the correct answer, so 2 errors are the most he could make.

The final result of proceeding in this fashion through the entire /J/ sound lesson is 15 to 16 errors for a final score of approximately 77%.