PERFORMANCE DETERMINED INSTRUCTION FOR TRAINING IN REMEDIAL READING¹

BURL B. GRAY, RICHARD D. BAKER, and SUSAN E. STANCYK

MONTEREY INSTITUTE FOR SPEECH AND HEARING

A system called Performance Determined Instruction (PDI) is presented as a methodological tactic for training in remedial reading. The system incorporates aspects of binary logic, instrumental conditioning, and programmed instruction. Results suggest that PDI is a high-precision instructional procedure effective in obtaining desired changes in reading-task performance.

Concern over reading skill is not new (Huey, 1908), but the importance of this ability appears to be in a geometric progression through time. Anyone familiar with reading is aware of the enormous volume of literature on the subject. The wide unevenness in quality of information and the appearance of conflicting results contribute to a very hazy, disorganized, and confusing situation. A rather large number of variables have been investigated in respect to their influence upon the reading prognosis and/or ability of children. Included in this list of variables are social class, personality, perception, auditory-visual abilities, methodology, meaningfulness of material, instructional techniques, intelligence, family structure, *etc.* (Harris, Sarwer, and Gold, 1968).

From the mass of evidence presented in the literature it is quite possible to substantiate a variety of positions based upon selectively choosing the appropriate references. Thus, from a larger perspective it would appear that the general findings from much of the research data are inconclusive. In this regard the findings of Bond and Dykstra (1967) appear to provide a very meaningful commentary on the situation. From their studies and their data analysis they make four important statements. First, they indicate that the best single predictor of first-grade reading achievements is the ability to recognize letters of the alphabet. Second, they suggest that there is no methodological advantage for any single approach for pupils of differing levels of readiness. Third, they say that neither class size, teacher experience, nor teacher efficiency is correlated significantly

with pupil success. Fourth, and possibly most important, they state that emphasis should be placed upon the learning situations and procedures rather than upon methods and materials. They further state that the great range among classrooms using any one particular method emphasizes the importance of principles of learning over methods used.

Overt attention to, and use of, learning principles in reading is not new. The work of Staats, Finley, Minke, and Wolf (1964a, 1964b), Butterfield (1965), Whitlock (1966), Wolfe, Giles, and Hall (1968), and Frazee (1968) are examples of strategies developed around the principles of reinforcement. Results of these studies demonstrate the efficacy of conditioning principles in reading training. The situation can be generally summarized as one where the child should be started at his present level of performance and continued through a series of tasks where success is in large quantity (and thus apparent) and leads to realization of the target behavior. The child should be immediately and meaningfully rewarded for successful performance. This has been shown to hold true not only for general learning tasks but also specifically for reading (Frazee, 1968).

In an effort to extend and hopefully systematize training in remedial reading via principles of learning, a research project was initiated at the Monterey Institute for Speech and Hearing. After developing a basic design for precision instruction in remedial reading, an evaluative procedure was designed and executed to test the validity and feasibility of the system. A description of the procedures and a report of the initial findings of that evaluation are presented below.

¹Reprints may be obtained from Burl B. Gray, Monterey Institute for Speech and Hearing, 969 Pacific St., Monterey, California 93940.

METHOD

In designing the system, various assumptions had to be made. These occasionally conflicted with certain popular concepts but they were based upon empirical data and/or principles of learning. In cases where the above were not available the assumptions were based upon the judgment of those directing the study.

1. Reading is a learning task; therefore, it is responsive to the laws of learning.
2. Decoding is antecedent to comprehension and therefore, should be attended to first.
3. The system should provide success in abundant quantities and should provide frequent and immediate reward for that success.
4. Characteristics such as visual perception, I.Q., visual motor coordination, visual and auditory sequencing, *etc.*, *etc.* are considered not to affect differentially prognosis for skill mastery unless the deficiency is of such a marked and gross degree that it results in reduced functional ability in nonreading activities.

General Description of the Remedial Reading Training Procedure

Initially, all children who come to the clinic are evaluated in terms of current level of performance in reading. After this evaluation, the child is assigned to a reading training procedure called Performance Determined Instruction (PDI) if he has demonstrated at least a minimum level of performance ability. The minimum criterion for inclusion in PDI is knowledge of the alphabet and the most common sound-symbol relationships. If during the evaluation session the child does not demonstrate mastery at this minimum level, he is placed in an alternate program, which is a pre-reading training situation. This procedure is based upon branching programming techniques (Gray and Fygetakis, 1968). The routine of this pre-training activity is simple, straightforward, and common in the psychological literature on task mastery. Only children who demonstrate a lack on skill in this area are placed in this activity. No child is placed in PDI until this task mastery is demonstrated. The remainder of this paper is con-

cerned with the procedures and results of training on the PDI only.

Once a child has been placed in PDI, he is grouped with one other child of approximately similar abilities. Thus, each training session involves one teacher and two students. Training sessions are 30 min long and are held twice a week.

The bi-weekly 30-min training sessions in PDI are divided into two performance activities. The first 15 min of a training session are devoted to training in word attack skills. Specifically, this involves the reading of words on a word list. The lists of words increase in difficulty in a sequential manner in terms of phonetic complexity and word length. One of the two students will begin reading aloud his word list. The teacher, who keeps a record of correct, correct reinforced, and error responses on a tally sheet, dispenses poker-chip tokens for correct performance (correct reading of a word) according to the particular reinforcement schedule in effect at that time. When the child makes an error, the other child is then given an opportunity to perform on his word lists. Error responses may be pointed out by the teacher but there is no emphasis on error responses nor any practicing of error responses leading to correct production. An error response is simply an event that was not counted as correct or rewarded or counted towards the accumulation of a reward. The occurrence of an error response occasions the transfer of opportunity to read from one student to the other. The teacher is the sole judge of the correctness of a response. This procedure is continued until the first 15 min of the session have elapsed.

During the second 15 min the activity switches to contextual reading. Each student, based upon the initial evaluation, is placed in a graded reading series at a starting point just below his tested reading-grade level. During the second 15-min segment, one student will read from his graded reading series book. For each correct sentence he receives one poker-chip token. An error results in the second child being given the opportunity to read from his reader. Again, teacher activity is one of keeping a record of correct, correct reinforced, and error responses. In addition, the teacher dispenses the poker chips and manages the transfer of response opportunity throughout the session.

If during either the first or second 15-min segment of a training session a child continues to respond correctly for 3 min he is stopped by the teacher. At that point the teacher gives the student a bonus chip and transfers response opportunity to the second student. This is done so that each student will have more than one opportunity to perform during each segment of a session. At the end of each 30-min session, the poker chips are redeemable for M&Ms at a conversion rate of five chips for each M&M. During the time when one student is responding, the other student merely sits quietly and awaits his turn. This situation is consistent during all training activities.

Materials

In PDI activities, with which this paper is concerned, the main emphasis is upon teacher activity, rather than upon particular materials *per se*. As such, a wide latitude is permitted in the choice of materials. The general guideline for material is that it present word attack material (word lists) in such a manner that the introduction of target phonemes is controlled and sequential. This usually means that difficulty and complexity of material increase in some type of hopefully linear manner throughout the course of the material. In the present instance, material was taken from Bloomfield (1961) or Flesch (1956). Later explanation of the PDI system will relate specifically to the Flesch word lists.

In the contextual (sentence) reading area, material such as graded reading texts is used (Heath Publishing Co., Harper & Row, Harr and Wagner Co., Sullivan). Again, wide latitude is permitted in the selection of the materials, the basic requirement being that the material be presented in some type of sequentially graded manner. A variety of graded texts is available and choice is often dictated by topic interest level on the part of the student. There is no necessary correlation between the words on the word list material and the words in the sentence reading material.

Training Management

Decision making is often related to an intuitive process called clinical judgment, or teacher judgment, or clinical inference. Today, there is a sufficient body of evidence to conclude that (a) the amount of professional training and experience of the judge does not

relate to his judgmental accuracy, and (b) the validity of the judgment is not related to the amount of information available to the judge (Goldberg, 1968). Thus, intuitive judgment is not reliable nor necessarily valid. Goldberg (1968) goes on to state that "... rather simple actuarial formulae typically can be constructed to perform at a level of validity no lower than that of the clinical expert" (p. 485).

Since the main object of the PDI system is to provide an efficient means of high-precision learning of a decoding skill, some requirement of performance levels (performance targets) has to be established. Also, procedures have to be developed to cause the performance of the child to approximate the target. Finally, some method of decision making has to be arrived at in order to determine which of various procedures will be employed and when they will be employed.

Therefore, in an effort to provide a standardized type of training management and to provide a uniformly valid process for making such decisions, a model was constructed following the test-operate-test-execute (TOTE) procedures used in some forms of computer logic. The specific fundamentals selected for the design of the present model were taken from Miller, Galanter, and Pribram (1960).

Based upon preliminary work done at the Monterey Institute for Speech and Hearing in 1968, it was determined that performance limits would be set for the performance of the word list activity only. The target performance was 92% correct responding. The target range was $\pm 2\%$. Thus, the performance requirements are violated when the level of per cent correct responding is less than 90% correct or greater than 94% correct. These values were chosen for the following reasons: (1) students who have experienced a great deal of failure in reading and reading-associated activities should be placed in a situation where success is frequent and apparent, thus performance of less than 90% correct begins to jeopardize this goal; (2) pilot research in PDI indicated that continual performance of less than 90% correct would result in insufficient gains in reading ability; (3) excessively high amounts of correct responding, greater than 94% correct, will contribute to boredom on the part of the student; (4) continual performance above 94% correct does not improve the acquisition of target behavior. The last point is expanded

and discussed further in later portions of this paper.

The variables to be manipulated in order to approximate the target were schedule of reinforcement and amount of work (practice) at any one task-difficulty level. The schedule of reinforcement is as follows: continuous reinforcement, one token for each series of five successive correct responses, one token for each series of 10 successive correct responses, one token for each series of 15 successive correct responses.

Since TOTE is described in this paper in terms of the Flesch word lists, a brief description of that material is in order. Each page of the Flesch word lists contains five lists of 18 words each. Every new page introduces a new phonetic element and/or greater word complexity. Thus, each page is operationally defined as a difficulty level. The options for amount of material per difficulty level are reading five word lists of 18 words each, reading four word lists, reading three word lists, reading two word lists, reading one word list, reading only the review lists covering the previous four difficulty levels but not reading word lists at each difficulty level. The matrix of options generated by these variables is presented below.

	Lists/Difficulty Level					
	5	4	3	2	1	R
C						
5						
10						
15						

By definition, the child always starts at continuous reinforcement and five word lists. After three sessions he is automatically switched to 15 successive words per token and three word lists per difficulty level. From this point forward all decisions are controlled by the TOTE model. This model is presented in Fig. 1.

The chart is read in the following manner. A response (reading performance) enters the system and some operation is performed (reinforcement schedule and material). Question 1 is then asked—is the performance level within

Fig. 1. Schematic diagram of the test-operate-test-execute (TOTE) system designed for instructional management in PDI.

the range? (Any three successive sessions in which performance is $\geq 92 \pm 2$ = a "no" answer.) If the answer is yes, then Question 2 is asked—is the reading age level up to the target age level?² If the answer is yes, then the decision is to terminate the training. If the answer is no, then the decision is to continue with the original operation.

If the answer to Question 1 is no, then Question 3 is asked instead of Question 2—is the performance above the range? If the answer to this question is yes, (three successive sessions in which per cent correct exceeds 94% correct), then the decision is to advance in the matrix 1 binary unit towards matrix combination 15 words-review or previous level at which the range was violated. This operation would then be performed and the entire series of questions repeated. If the answer to Question 3 is no (three successive sessions in which per cent correct was less than 90%), then the decision is to move the procedures one binary unit towards the matrix combination on which the performance was last within the range. Thus, if the current operation was 15 words and three lists and Question 1 was no and Question 3 was yes, then the change would be an advance equal to

²The answer to this question is determined either by the level of the graded reader in which the child is successfully reading or, more properly, by a standardized test of reading grade level.

one-half of the distance between 15 words and three lists and 15 words and review. That would be five words and one list. If subsequently when that operation was tested, and Questions 1 and 3 were both answered no, then the change would be one-half of the distance between five words and one list and 15 words and three lists. This would be 10 words and two lists. This same type of management operation would continue throughout the course of the training, using a combination of binary logic and information theory techniques.

The interface between PDI and its management system, TOTE, is as follows. On any given day the teacher will execute a training situation under one of the matrix combinations of reinforcement and word lists for a given student. This particular combination is maintained for the entire session. After the session, or sometime before the next session, the teacher goes through the TOTE process in order to determine if there should be some

change in the combination of reinforcement and word lists used with that student on the occasion of the next training session. In other words, TOTE management decisions are made only between training sessions. During a training session the teacher merely carries out the results of the TOTE judgment that was made before that session.

When TOTE judgment is either to advance or to decrease procedures, then the binary concept of dividing the remaining alternatives by 50% is employed in the matrix to determine which combination of reinforcement and lists is to be used. This particular method is used in an effort to arrive at the appropriate matrix combination as quickly as possible and with as few changes as possible.

It can be seen that the entire judgment process can be handled by combination of any two of three questions that can be answered yes or no. Appropriate numbers can be coded into the matrix squares and a table constructed for ease of interpretation within the matrix. Such

TEST	YES	NO
1	2	5
2	3	10
3	4	12
4	16	3
5	6	8
6	7	15
7	1	6
8	14	9
9	8	0
10	13	11
11	10	1
12	3	2
13	2	10
14	5	8
15	6	5
16	-	4
0	1	-

		Lists/Difficulty Level					
		5	4	3	2	1	R
Words/Reinforcements	C	0		6			
	5	9	5		11	2	3
	10	8		7	10		4
	15	14	15	1	13	12	16

Fig. 2. Matrix system of variables used in PDI. System is based upon concept of binary units. Each change in the matrix is such that the movement represents one-half the distance between the current point and a finite end point.

a schedule is presented in Fig. 2.³ Record keeping for this operation involves only the tabulation (usually in graphic form) of the per cent correct responding.

In the case of the sentence-reading task the process is at a fixed level. As mentioned earlier, the child receives a token for each sentence that is read without error. As he continues to read he then, of course, begins to encounter more and more difficult material as per the graded reader. During each session the student begins in the graded reader at the point at which he stopped during the last session. This, then, is the entire structure of the system designed for remedial reading.

EVALUATION AND RESULTS

In an effort to test the design and the effectiveness of the system, a three-month study was designed. It consisted of following for a three-month period a population of children, classified as remedial readers, who were enrolled in the PDI system. The subjects were taken from the clinical services department of the Monterey Institute for Speech and Hearing. No selection criterion other than classification as remedial reading by the school and/or by Institute clinical staff was employed. The subjects were nine male children with a mean age of 9 yr, 6 months, with a standard deviation of 1 yr, 1 month. The mental-age average of the group was 9 yr, 3 months with a standard deviation of 1 yr, 4 months. The reading-grade level of the group, as measured by the Gray Oral Reading Passage, was 2.5. There were two teachers involved, each taking a portion of the group. The subjects were seen in groups of two to three for 30 min, twice a week. There were a total of 24 sessions over the three-month period for each child. The results, then, are based upon a total of 216 sessions, or 108 hr of instruction, each child receiving a total of 12 hr of training. The three-month sampling interval represents the first exposure of the subjects to PDI.

Figure 3 is the data chart for one subject. The top line is the per cent correct sentence scores. The bottom line is the per cent correct word scores. The shaded area running through this latter plot is the target range. The arrows

designate those times when the TOTE system determined that the variables should be changed. It can be noted from the upper plot of sentence scores that there was a gradual increment in performance as a function of the number of sessions. It should be remembered that this increment occurred while the difficulty level of the reading material was also increasing. The inset histogram shows the change in reading-age level as measured by the Gray Oral Reading Passage before and after PDI. The lower of the two lines indicates the level to which one might speculate that reading-age level would have advanced as a linear function of increment in chronological age. The uppermost line is the level where

Fig. 3. Performance chart for one subject. Uppermost graph is per cent correct sentences and lower graph is per cent correct words. Shaded area through lower graph represents the target range. Arrows designate points at which TOTE decision was to change the matrix one position. Inset histogram shows reading grade level before and after 12 hr on the PDI. Upper horizontal line is reading grade level where subject should be operating as per age and school placement. Lower horizontal line represents the level to which initial reading-grade level would be expected to advance if it were assumed that reading-grade level increased as a function of chronological age.

³For a more complete discussion of this procedure see Gray and Fygetakis, 1968.

this child should be reading as per his educational placement and age.

Figure 4 is a similar chart reflecting the performance and change for the entire group. All scores are mean scores for the entire group. Again, the uppermost chart plot for sentences shows an increment in performance during increasing difficulty of material. The histogram shows that reading-grade level, as measured by the Gray Oral Reading Passage, advanced from 2.4 to 3.4. This increment was statistically significant beyond $p = 0.01$ with $t = 5.14/df = 7$. When adjusted for increase in chronological age, the increment of reading ability beyond the advance in chronological age was significant beyond $p = 0.05$ with $t = 2.5/df = 7$. This figure of 1 yr for 12 hr on the PDI agrees with two previous pilot studies run on this same system.

The average child, during the word attack task, made 61.2 responses per session for a total

Fig. 4. Performance chart for nine subjects. Scores are in mean per cent correct responses. Uppermost graph is per cent correct sentences and lower graph is per cent correct words. Shaded area through lower graph represents the target range. Inset histogram shows reading grade level before and after 12 hr on the PDI. Upper horizontal line is mean reading-grade level where subjects should be operating as per age and school placement. Lower horizontal line represents the mean level to which initial reading-grade level would be expected to advance if it were assumed that reading-grade level increased as a function of chronological age.

of 1469 responses for the 24 sessions. He averaged 92.9% correct with a standard deviation (target range) of $\pm 1.99\%$ correct. This indicates that of the 1469 responses, 1391 were correct and 78 were error responses. Earlier in this report it was indicated that the system was designed to yield a performance target of 92% correct with a standard deviation of $\pm 2\%$. These figures indicate that the target performance was missed by nine-tenths of 1%. The data also indicate that the target range was missed by only one one-hundredth of 1%. These figures strongly indicate that the PDI was successful in achieving the targets of performance for which it was designed. Figure 5 is a graphic representation of the target and actual performance scores.

In the sentence-reading task, the average child read 39.4 sentences per session for a total of 905.8 sentences for the 24 sessions. He performed at an average of 81.1% correct, which reflects that of the 905.8 total responses, 735 were correct and 170 were error responses. (Any sentence that was not read correctly in its entirety was counted as an error response.)

The results of this study are in agreement with two previous pilot studies carried out at the Institute. One of the previous studies, carried out with a group of five children, was initiated because of some initial concern about the possible negative effects of limiting the upper level of percentage correct performance. The primary concern was that it might cause sentence performance to go down. The group of five had a mean age of 10 yr, 10 months, and a reading grade level of 3.1. They went through exactly the same PDI procedure as the original test group except that they were

Fig. 5. Target and actual performance scores. Shaded areas represent the range or standard deviation from the target and actual performance score. The target performance score = 92% correct responding. The target range = $\pm 2\%$ correct responding. Actual mean performance score = 92.9% correct responding. Actual mean range = $\pm 1.99\%$ correct responding.

not restricted from achieving performance scores on the word lists in excess of 94% correct. Figure 6 is the word and sentence performance scores of the group of five superimposed on the performance chart for the original population in Fig. 4. It can be seen that the per cent correct responses for words was higher for the group of five than for the original test population. However, there appear to be no significant differences in sentence correct performance scores. If any difference can be speculated it would be that the original population demonstrates a more orderly increment in performance scores than does the group of five. The group of five had a reading grade level of 4.1 after the 12 hr on PDI. This increment is in accord with that for the original group.

Fig. 6. Performance chart for nine subjects (see Fig. 4) with superimposed performance scores for group of five subjects. Scores are in mean per cent correct responses. Uppermost graphs are per cent correct sentences and lower graphs are per cent correct words. Shaded area through lower graph represents the target range. Group of $N=5$ was not restricted in upper amount of per cent correct responding for words.

DISCUSSION

A general conclusion that can be drawn from these preliminary data is that the PDI would appear to be an efficient method for

precision training of decoding skill associated with reading. Any statement about general application of this procedure will have to await specific information in at least two areas. First, the matter of comprehension will have to be explored more fully. The original hypothesis was that experientially and linguistically, these types of children are quite sophisticated. Thus, once they were trained in the decoding skill necessary for reading, their comprehension would also improve sufficiently. This was not tested in the current study to a sufficient extent, although the Gray Oral Reading Passage does include some comprehension information. In addition, there are those children who can apparently decode quite well but have little or no comprehension of the material. This population needs to be defined more closely. That is, are these children a sub-set of the general remedial reading population or does their performance suggest a special discreet population. Second, it may be more advantageous to place the contextual reading activity under TOTE control for precision behavior. This aspect, and its effect on the overall reading performance of the children, should be determined.

As explained in the present paper, the management procedure of TOTE and the matrix for the high-precision instruction may appear to require some degree of skill and knowledge about the system. Recognizing this problem, the authors designed and built an electro-mechanical apparatus that makes all the necessary determinations automatically. The device is operated by a small number of on-off switches. As such, the man-machine interface is quite simple and can be operated effectively by a teacher with only a minimum of instruction. Thus, at the present time, all such "clinical judgments" concerning the performance management of students in remedial reading are handled by the electro-mechanical device.

Some reflection upon the activities of the teacher in PDI, with regard to both the actual in-class activity and the management decisions, suggests that the entire process can be carried out by an aid or an instructional technician. Another consideration is that more frequent training sessions might further increase the ratio between an increment in reading level and the increment in chronological age. Although the system is not complete, the preliminary data to date suggest that PDI is a

promising methodological tactic for training in remedial reading.

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