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CORRECTION OF FUNCTIONAL MISARTICULATION UNDER AN AUTOMATED SELF-CORRECTION SYSTEM. FINAL REPORT.

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PUB DATE 65
EDRS PRICE MF-$0.25 HC-$1.12 28P.

DESCRIPTORS- *ARTICULATION (SPEECH), *SPEECH THERAPY, *PROGRAMED INSTRUCTION, *AUDITORY TRAINING, *TEACHING MACHINES, SPEECH HANDICAPPED, CHILDREN, AUDITORY DISCRIMINATION, SPEECH IMPROVEMENT, TEMPLIN DARLEY ARTICULATION TESTS

THE AUTOMATED SPEECH CORRECTION PROGRAM (ASCP) WAS DESIGNED TO TEST THE USE OF PROGRAMED INSTRUCTION IN THE REMEDIATION OF FUNCTIONAL ARTICULATION ERRORS. A SERIES OF PROGRAMED TAPES WHICH TAKE THE STUDENT THROUGH AUDITORY IDENTIFICATION, AUDITORY DISCRIMINATION, PRODUCTION, AND SELF-EVALUATION WERE DESIGNED. SUB-GOALS OF THE EXPERIMENT WERE A COMPARISON OF CORRECTING (REPRESENTATION OF A STIMULUS WHEN SUBJECT RESPONDED INCORRECTLY) AND NON-CORRECTING (SUBJECT NOTIFIED OF ERROR BY A TONE) TECHNIQUES AND THE EFFECTIVENESS OF PERSONALIZED SUBJECT-THERAPIST CORRECTION OR NO CORRECTION BETWEEN THE DISCRIMINATION PHASE AND THE SELF-CORRECTION PHASE. SUBJECTS WERE 100 ELEMENTARY SCHOOL CHILDREN WITH FUNCTIONAL MISARTICULATIONS. SUBJECTS WERE ASSIGNED TO VARIED TREATMENT AND CONTROL GROUPS. RESULTS INDICATED -- (1) ASCP PRODUCED IMPROVED AUDITORY DISCRIMINATION AND ARTICULATION PATTERNS AS MEASURED BY THE TEMPLIN SHORT TEST OF SOUND DISCRIMINATION AND THE TEMPLIN DARLEY SCREENING TEST, (2) THE GROUP WHICH RECEIVED CORRECTION OF ERROR DID NOT DEMONSTRATE A SIGNIFICANT DIFFERENCE FROM THOSE WHO RECEIVED THE NON-CORRECTING PRESENTATION, AND (3) THERE IS NO DIFFERENCE AMONG GROUPS WHICH RECEIVED OR DID NOT RECEIVE INDIVIDUALIZED THERAPY BETWEEN THE DISCRIMINATION AND SELF-CORRECTION PHASES. (EB)

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FINAL REPORT

~~SUMMARY~~

ED013013

EC 001 217

Title: CORRECTION OF FUNCTIONAL MISARTICULATION UNDER AN AUTOMATED SELF-CORRECTION SYSTEM

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Institution: New Mexico State University
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Project Number: 2749

Duration: September 1964 to October 1965

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A. BACKGROUND

The number of children and adults in need of but not receiving speech therapy, and the recent application of operant conditioning and automation to human learning combine to form the basic problem studied in this project. Speech has lately come to be viewed as a learned process resulting from approximations under operant conditioning with the articulatory aspect conceived of as a servo-mechanism governed by an automatic control system. From this viewpoint, functional misarticulation is learned behavior which results when the control system approves the feedback of articulatory productions which are in fact incorrect; the servomechanism and control system are adequate, but they have been programmed through inappropriate learning with faulty data. Research conducted by A. L. Holland at the University of Pittsburgh in 1960 indicated that auditory discrimination training could be successfully presented in the form of programmed instruction. During 1962-63, an automated speech correction program machine was designed and built at New Mexico State University, and programmed instruction material for auditory discrimination and for self-correction was developed and recorded. In the fall of 1963, a pilot study to test the Automated Speech Correction Program (ASCP) was conducted and found to be effective with college age students. The major concern of the present project, then, was the testing of an automated system of programmed instruction for the training of auditory discrimination of speech sounds and for the self-correction of functional misarticulation in a public school setting. Positive findings would indicate that public school therapists could be relieved of their greatest source of cases thereby enabling them to concentrate their efforts upon other aspects of speech correction; and that such a system could also be utilized with proper safeguards in those school settings where a therapist is not available.

B. OBJECTIVES

It was hoped that the following objectives would be achieved:

1. The major objective of this project was the development, application, and evaluation of programmed instruction for the rehabilitation of functional misarticulation of children in the elementary school with the application being made through a completely automated system known as the Automated Speech Correction Program (ASCP).

The specific aims under this objective were:

a. The development of programmed tapes based upon Skinnerian straight-line programming for training in the auditory discrimination of speech sounds and for the self-correction of functional misarticulation.

b. A comparison of the effectiveness of the auditory discrimination training of the ASCP when the material was presented in a "correcting" and in a "non-correcting" teaching machine.

c. A comparison of the effectiveness of the self-correction phase of the ASCP in changing articulation patterns when a transitional period of individualized subject-therapist correction was provided between the auditory discrimination training phase and the self-correction phase, and when no subject-therapist correction was provided.

d. The further testing, refining, and/or modifying of the design and operation of the prototype ASCP machine.

2. The secondary objective of this project was an evaluation of the retention of articulatory skills acquired on the ASCP under conditions of 1) no reinforcement, 2) ASCP auditory discrimination tapes reinforcement only, 3) ASCP auditory discrimination and self-correction tapes reinforcement, and 4) under a specially devised classroom teacher program for speech improvement.

C. PROCEDURE AND RESULTS

1. Modification of the ASCP Machine

One purpose of this project was to investigate the feasibility of a relatively low-priced instrument which would be capable of presenting programmed instruction automatically and would be sufficiently reliable to be placed in a school situation where no technician was available for servicing. Within these limitations, a low-priced, four-channel tape recorder with electronic control of rewind was selected and a new system of instrumentation for the control unit was devised. Fifty-pin plugs at the rear of the control unit established the proper circuitry for the presentation of the corrective or non-corrective treatments. The n control unit utilized digital circuitry which analyzed the number of code impulses associated with each stimulus frame on the tape and compared these with the signal generated by the button which the subject pressed to signify his selection of response to the stimulus. Under the "correction" presentation when a child's response was correct he was reinforced with a 600 cycle pure tone in the earphones and the teaching machine advanced automatically to the next frame. In the event of an incorrect response the child received a "raspberry" or saw-tooth tone in the earphone, and the teaching machine automatically rewound to the beginning of the missed frame and presented it again. Under the "non-correction" procedure, the child again received a pure tone reinforcer through the earphones and the teaching machine automatically advanced to the next frame. In the event of an incorrect response, the child received the saw-tooth tone through the earphones, and the teaching machine "froze" for a three second period before proceeding to the next frame. During the self-correction phase of the program, the rewind presentation consisted of having the student listen to the master stimulus and record his own version, following which the teaching machine automatically rewound and presented the master version and the student's recorded version for audition. The non-rewind treatment consisted of having the child listen to the master stimulus and then receive his production at an amplified level through the earphones without an actual recording being made.

The ASCP machines proved to be relatively reliable under the extreme demands which were placed upon them. Several parts within the tape recorder did fail during the time that the units were within the schools and appropriate modifications were made. The one design error which appeared lay in the half-second period at the end of each frame during which the control circuitry was going into operation for the rewind procedure in Phase I training. If a child pressed a button during this period the rewind was erratic and the program would reverse an unpredictable number of frames before the counting circuitry stabilized and started the forward motion again. This problem appeared only with those children who were hesitant in their responses and delayed responding. Revisions are being made in the control unit to remove this element of uncertainty. In all other aspects, the ASCP machine was successful. The four-button choice circuitry fulfilled all needs of the programmed instruction and allowed for the finest type of stimulus-control discrimination available in a low-priced instrument.

2. Development of Programmed Tapes

Skinnerian straight-line (intrinsic) programming calls first for an operational definition of the terminal behavior desired. Materials are then selected which will produce the specified behavior and are then reduced to a large number of extremely small steps or programmed frames. These frames or items are ordered in difficulty to guide the subject through a series of approximations to the desired behavior. Skinnerian programming calls for each subject to advance through the entire sequence of programmed items, to respond to each item, to be given immediate confirmation of the correctness of his response, and to progress at a self-paced rate. The terminal behavior desired for each subject receiving the programmed tapes was a change in behavior so that the child could correctly identify and produce the phoneme presented in the respective programmed tapes.

The phonetic materials for the programmed instruction were partially generated by an IBM 1620 digital computer at New Mexico State University. An original intent of this research was to incorporate into the computer program, and subsequently into the programmed instruction, all pertinent information concerning confusibility of phonemes, relative intelligibility of phonemes, developmental order and frequency of phonemes, frequency of misarticulation, and word frequency. Two factors prevented the incorporation of all the available information. First, the modifications on the IBM 1620 were not completed as scheduled with the result that disc storage and high speed print-out were not available. Second, much of the research reported was not in a form applicable to the purposes of the project. For example, the common denominator in confusibility and intelligibility studies has to do with the signal-noise ratio. Since our purpose was to insure intelligibility in so far as signal-noise ratio was concerned, the signal was presented to the ear of the subject at some 20 db above ambient noise and some 60 db above system noise. Similarly, knowing that the syllable nucleus is shorter when followed by a voiceless consonant and longer when followed by a voiced consonant was of no practical use since the cueing of the stimulus in the program included marked variations in loudness, pitch, and stress. The various developmental studies, spectographic analyses, and the like, similarly proved to be beyond either the storage capacity of the computer and/or of a nature not amenable to numerical translation.

Studies of the frequency of use of phonemes were of value. Of the various studies and their interpretations, the one most obviously fitting the needs of this project was that carried out by Peter Denes. Denes' analysis was in a matrix form which was readily adaptable to fit the most probable word model being used in our computer program. To insure the maximum contrast with the target phoneme, the Denes' frequency data was biased so that nasals and then stops were given a priority in the earlier portions of the computer-generated word lists.

The majority of misarticulation studies are not quantified although they agree generally in the patterns of misarticulation reported. The study by Snow does present quantitative data, with a frequency listing of correct production as opposed to moderate distortion, severe distortion, omission, and substitution by phoneme. In the computer program Snow's frequencies provided the basis, with some bias built in to allow for the frequencies reported in other studies. Additionally, the program was so biased that phonemes involved in omission or substitution did not appear until a specified number of frames had been generated, and then they could appear only in the proportion of their specified frequency of appearance in the misarticulatory pattern programmed in the computer. The model used is presented below.

A Model for "Probable" Words

$$P_{cvc} = E_1E_2E_3 = WB\ C_1\ \overline{WB}\ V_1\ \overline{WB}\ C_2\ WB$$

$E_1 = WB\ C_1\ \overline{WB}$ (The probability that a word boundary occurs before a given consonant but does not occur after the consonant.)

$E_2 = (WB\ C_1\ \overline{WB})\ V_1\ \overline{WB}$ (The probability that a given vowel occurs after C_1 and that a word boundary does not occur after the vowel.)

$E_3 = (WB\ C_1\ \overline{WB}\ V_1\ \overline{WB})\ C_2\ WB$ (The probability that C_2 occurs after V_i and that WB occurs after C_2.)

With the computer-generated lists providing the basic information, the actual programmed instruction was written with modifications being incorporated for the necessary cueing, fading, and reviewing of the phoneme, with the phoneme being presented within a large variety of contexts, and with frequency of word usage being incorporated.

The programmed instruction followed the form found most effective by Audrey Holland and by the principal investigator in their earlier studies. This type of programming was the one which had proved successful in eliciting a spontaneous production of the phoneme, the spontaneous production appearing to be a result of the operation of a stimulus control process within the program. Stimulus control training in other aspects of human learning has shown that an increase in the ability to discriminate between stimuli can also produce an improved production even though no specific practice has been made for that production. Stimulus control in the sense used here is a matter of presenting programmed items so that the probability of proper discrimination is at an optimum level. The learning tasks presented in the programmed instruction progressed from easy to difficult over some 600 auditory discrimination frames. The total program was broken into seven separate tapes as follows:

Tape I: Presented the target phoneme in a nonsense syllable with the phoneme appearing initially, finally, and medially. The student's response was to press Button #1 if he heard the target phoneme, and to press Button #2 if he did not hear the phoneme.

Tape II: Presented the phoneme in the initial position. Two nonsense syllables, which later became sense words, were contrasted. The student's task was to press Button #1 if he heard the target phoneme in the first syllable or to press Button #2 if he heard the target phoneme in the second syllable. As Tape II progressed, he was presented with the additional discrimination task of pressing Button #3 if the target phoneme appeared in both syllables; and the fourth task added was one of pressing Button #4 if the target phoneme did not appear in either syllable.

Tape III: Presented the same four button task for the target phoneme in the final position.

Tape IV: Presented the same four button task with the target phoneme in the medial position.

Tape V: Presented individual words or nonsense syllables in which the subject was to indicate how many times the target phoneme appeared in the stimulus. Ordinarily this was a matter of a one phoneme or a two phoneme choice; occasionally, the phoneme appeared three times in a word; and at times the target phoneme was not in the stimulus. Progression within the tape again was from easy to difficult with the initial items presenting only the target phoneme and with later items incorporating phonemes which could be confused with the target phoneme.

Tape VI: Presented the task of identifying the position of the phoneme within a word, with presentations of the phoneme being made in initial, medial, and final positions, and without the phoneme being presented.

Tape VII: Presented the task of selecting the correctly articulated phoneme in a given word which was presented in a paired presentation of correct and incorrect articulation. Again, the task was sequential; the first items on this tape were as obvious in their contrast as was possible, while, toward the end of the tape, the discrimination task was much more difficult. Also included in this tape was the task of identifying the paired words which were both articulated correctly.

The program tapes for self-correction were also seven in number and called sequentially for the identification and production of the target phoneme in the following sequences:

Tape I: In nonsense syllables.

Tape II: In nonsense syllables and monosyllabic words.

Tape III: In nonsense syllables, monosyllabic and polysyllabic words.

Tape IV: In monosyllabic and polysyllabic words patterned into simple phrases.

Tape V and VI: In monosyllabic and polysyllabic words, patterned into phrases and short sentences.

Tape VII: In phrases and sentences.

The actual recording of the programmed instruction tapes was done in such a manner that the signal-noise level met the minimums noted above, and utilized three male and three female voices recording in essentially random order. The individuals making the recordings all had

General American dialects, spoke with clear articulation in their everyday speech, and did not in any way provide unwanted cues in the tapes. While the final version of the tapes were not equal to "studio" standards, they were better than the intelligibility conditions found in a public school classroom situation.

3. General Design

A modified randomized blocks design was used with 100 children as subjects. All subjects were selected as indicated below and then ranked from high to low according to the summed raw scores of the various pre-tests. Upon the basis of this ranking, blocks of ten subjects each were formed. The ten subjects in each block were assigned at random to one of the eight treatments with two subjects from each block being assigned to control. Analysis of the pre-test scores showed that the pre-treatment group variance was non-significant ($p > .8$).

TABLE I
GENERAL DESIGN
(Project No. 2749)

	TREATMENT	AUDITORY DISCRIMINATION	TRANSITION	SELF-CORRECTION
I	$A_1B_1C_1$	Correction	Transfer	Rewind
II	$A_1B_1C_2$	Correction	Transfer	Non-Rewind
III	$A_1B_2C_1$	Correction	Non-Transfer	Rewind
IV	$A_1B_2C_2$	Correction	Non-Transfer	Non-Rewind
V	$A_2B_1C_1$	Non-Correction	Transfer	Rewind
VI	$A_2B_1C_2$	Non-Correction	Transfer	Non-Rewind
VII	$A_2B_2C_1$	Non-Correction	Non-Transfer	Rewind
VIII	$A_2B_2C_2$	Non-Correction	Non-Transfer	Non-Rewind
IX		CONTROL		

In all ASCP treatments the programmed tapes were presented to the subjects on an ASCP machine. The auditory discrimination tapes were presented by either a "correction" or "non-correction" method of presentation. The "correction" presentation consisted of a re-presentation of a stimulus when the subject made an incorrect response. This re-presentation continued until the subject made a correct response. The "non-corrective" type of presentation consisted of the student being informed by means of a saw-tooth tone that his answer was incorrect and having the entire ASCP system turn off for a period of three seconds. During the self-correction phase of the program a similar presentation was made. Subjects assigned to a "rewind" treatment received an automatic rewind after they had recorded their version of a master stimulus. They could listen to this recording for a maximum of five times before being required to proceed to the next item. The "non-rewind" treatment consisted of the subject receiving an amplification of his oral production over the earphones. Following the completion of Phase I (Auditory Discrimination Training) and within the original randomized assignment, subjects were given a "transfer" or "non-transfer" treatment. Those receiving transfer were given individual or small group therapy based upon placement and kinesthetic cues. When in the opinion of a qualified clinician they were producing the given phoneme correctly 50 percent of the time upon demand, they were assigned to Phase II training. The non-transfer subjects were given only a brief 5 to 10 minute period of instruction which, again, was based upon placement and kinesthetic cues and then proceeded immediately to Phase II.

The administrative officers of the Las Cruces Public Schools selected five of the fourteen elementary schools in the system for participation in this project. A survey was made to select children who exhibited functional misarticulation problems and a random selection of children was made from the original survey population. Although the original design had called for each school to function as a block providing 20 experimental subjects, the screening of the schools' population resulted in the following distribution:

TABLE II
DISTRIBUTION OF SUBJECTS

SCHOOL	TOTAL	EXPERIMENTAL	CONTROL
C. C.	26	18	8
H. H.	21	18	3
M. P.	21	16	5
U. H.	18	16	2
V. V.	14	12	2
	100	80	20

All of the subjects met the following conditions: a) Normal physical condition and not exhibiting severe emotional maladjustment; b) Normal intelligence as defined by an I. Q. score of 90 or above on the Peabody Picture Vocabulary Test; c) Normal hearing as evidenced by a sweep hearing check at 250, 500, 1000, 2000, and 4000 cps with the SPL fixed at 15 db (in cases of extremely noisy testing conditions, 20 db was the SPL used); d) Not possessing any structural or mechanical abnormality of the articulatory organs. The requirement that each subject exhibit misarticulation of at least two phonemes could not be met. Judging that involved misarticulation was more important than age range, seven subjects were incorporated into the experimental sample who were slightly younger or slightly older than the specified 7 year 9 month to 12 year age span.

Data for the statistical analysis in the project were secured from the following instruments: the Templin Short Test of Sound Discrimination which tested general sound discrimination ability; a specially designed auditory discrimination test for each target phoneme studied; the Templin-Darley Screening Test to test general articulatory skill; and a specially designed articulation test for each target phoneme studied. The Oseretsky Tests of Motor Proficiency were eliminated during preparatory stages of the project since exploratory testing showed that the motor skills tested by the Oseretsky had no direct bearing upon the operation of the four button format of the ASCP machine.

The auditory discrimination tests were recorded under controlled conditions and presented by tape recorder with every effort being made to equalize the testing situation from school to school. Recordings were made of each subject's responses to the articulation tests, and these recordings were used by the principal investigator to establish the subject's numerical rating. The auditory discrimination tests were administered pre-Phase I, post-Phase I, and post-Phase II. The articulation tests were administered pre-Phase I and post-Phase II only to avoid the possibility of training effect contaminating the score on these particular tests.

The major objective of this project was evaluated through the following null hypotheses:

a. The ASCP will not produce changes in the auditory discrimination of the children with functional articulatory problems. This hypothesis was rejected following Phase I as shown in Table III below:

TABLE III
ANALYSIS OF CHANGE IN AUDITORY DISCRIMINATION
FOLLOWING PHASE I TREATMENT

MEASURE	TREATMENT	MEAN DIFF	S. E. DIFF	t	P
Templin	Correction	5.68	1.13	5.03	<.001
Discrimination	Non-Correction	3.75	0.81	4.63	<.001
Depth	Correction	1.00	0.33	3.03	<.01
Discrimination	Non-Correction	0.43	0.44	0.95	N.S.

b. The ASCP auditory discrimination training group which receives treatment under the "correcting" teaching machine will not demonstrate more change than the group which receives the "non-correcting" treatment. This hypothesis was not rejected. Both treatments produced statistically significant changes in the Templin as noted above, and a significant change for the Depth Discrimination Tests of those subjects receiving the correcting treatment on the ASCP machine. (Certain clinical qualifications are discussed later under the section on Conclusions and Implications.)

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c. <u>The ASCP will not produce changes in the articulation patterns of children with functional articulatory problems.</u> This hypothesis was rejected following Phase II as shown in Table IV below:

TABLE IV

ANALYSIS OF CHANGE IN ARTICULATION FOLLOWING PHASE I AND PHASE II TREATMENT (<u>t</u>)

MEASURE	I	II	III	IV	V	VI	VII	VIII
Templin-Darley Articulation	<.01	<.001	<.02	<.01	<.01	<.01	N.S.	<.001
Depth Articulation	<.01	<.001	<.01	<.01	<.05	<.02	<.05	<.01
△ Change: T-D	6.53	5.46	5.86	4.81	6.32	7.93	4.18	8.07

d. <u>The ASCP self-correction group which receives a transitional period of individualized therapy between the auditory discrimination phase and the self-correction phase will not demonstrate more change than the ASCP self-correction group which does not receive transitional therapy.</u> This hypothesis was not rejected. In addition to the results shown in Table III, analysis of variance indicated that no significant difference appeared in the performance of the subjects receiving transitional therapy as opposed to those who did not receive transitional therapy: F=1.95 or less.

The secondary objective of the project, which was to be an evaluation of the retention of articulatory skills under four different treatments, was not achieved. The delay in delivery of parts for the construction of the ASCP machines resulted in a loss of approximately two months from the projected time schedule; sufficient time remained only for the completion of the study proper. However, the programmed instruction material on articulation and phonetics for the cooperating classroom teachers who were to have conducted the speech improvement retention activities, had been written, tested, revised and retested, and was ready for use.

D. CONCLUSIONS AND IMPLICATIONS

1. The positive findings of this research indicate clearly that functional misarticulation in children between the ages of 7 years 9 months and 12 years can be treated successfully with the Automated Speech Correction Program. Of the 80 subjects assigned to the experimental treatments, all except three completed both phases of the program. Two subjects were dropped because of excessive absences and a subsequent inability to complete the program within the school year; only one subject was dropped because of inability to respond to the teaching machine and programmed instruction. Of the 77 subjects who completed the experimental treatments, 61 subjects or 79.2 percent, demonstrated improved auditory discrimination as measured by the Templin Short Test of Sound Discrimination. Of these 77, 72 or 93.4 percent demonstrated improved articulation as measured by the clinical judgement of the principal investigator from recordings of the Templin-Darley Screening Test.

Five phonemes were presented in programmed instruction form to the experimental subjects: [s], [r], [l], [θ], [ʃ]. Item analysis of the Templin Short Test indicated that all of the programs produced major changes in the subjects' ability to discriminate the nonsense syllables in the Templin. This was an unexpected result since it was anticipated that the subjects would show the greatest improvement in the discrimination of the target phoneme for the program which they received. One possible explanation is that the large number of nonsense syllables in the programs used in this study provided training for the task posed by the Templin. Another explanation is that the use of stimulus control programming in a discrimination setting provided broader training than had been anticipated. Whatever the reason, the improved performance has definite clinical implications in that auditory discrimination training of this type is much more effective than the traditional ear training techniques ordinarily employed in speech and hearing clinics, providing both a saving of time and a broader response.

The discrimination task in Phase I and the production task in Phase II are apparently well separated insofar as the programmed instruction is concerned. This was evidenced in two ways: First, the scores on the Templin Short Test and the Depth Discrimination Test deteriorated following Phase II treatment to the point that no significant difference was available between the pre-ASCP and post-ASCP treatment although an actual and impressive mean increase remained. Second, three subjects in the transition therapy treatment did not achieve

50 percent production of their target phonemes on demand prior to their beginning Phase II treatment, and rather than dropping them from the study it was simply noted that these three subjects had not met criterion. The production of these three subjects remained below criterion during their work on the first five tapes of Phase II. But on Tapes Six and Seven, they suddenly improved their production to well above criterion. Since the experimental subjects generally demonstrated a decrease in measured discrimination ability following Phase II, it can only be assumed that the improvement in the production of the three non-criterion subjects was the result of the Phase II program.

A matter of clinical interest appeared in the improved articulatory performance of the subjects in the control group. Statistically, the control group showed improvement, as evidenced by the t test, of $< .01$ on the Templin-Darley and of $< .001$ on the Depth Articulation Test. The mean change, however, was 2.49 as opposed to 6.14 for the experimental subjects. Rather than raising any question concerning the effectiveness of the ASCP, a count of subjects not showing improvement indicates that the ASCP was very effective: seven of the control subjects, or 35 percent, showed no improvement. In contrast, all of the experimental subjects except 5, or 6.6 percent, showed positive changes. So this study, too, confirms the old observation that some children of elementary school age with functional misarticulation show improvement without therapy; but that a significantly larger number change when therapy is available.

2. The lack of a significant difference in the performance of the subjects receiving the "correcting" as opposed to the "non-correcting" auditory discrimination treatments agrees with findings in other areas of programmed instruction. Apparently the important factors involved are the employment of small step, response, and immediate confirmation; not the re-presentation of the missed item. While the statistical analysis dictates this conclusion, there is a clinical impression which was reported by all of the graduate assistants involved, that the subjects receiving the correction treatment showed the greater facility in handling the programmed material for auditory discrimination.

3. The four-button multiple choice discrimination task was one of sufficient complexity to call for the institution of a training tape in the operation of the four buttons of the teaching machine following Tape Two of Phase I. Tape Two introduced the sequence of locating the sound in the first word, second word, both words, or neither of the words. Questioning during Tape Two work revealed that the subjects did understand the task as far as the actual discrimination was concerned, but that they were experiencing difficulty in adapting their button-pushing behavior. A short twenty-frame tape with explanations and examples served to overcome this particular problem.

4. Information from the statistical analysis indicates that the subjects were at their peak of auditory discrimination following Phase I. At the same time, 50 of the 77 experimental subjects, or 65 percent, were also spontaneously vocalizing the target phoneme. And 21,

or 54 percent, of the 39 subjects scheduled for transitional therapy were also producing their phonemes 50 percent of the time upon demand without having received any individualized therapy. Of the remaining 18, 15 reached criterion in less than a half hour of therapy. The implication of these findings is that a public school therapist might well rely upon some type of automated presentation for auditory discrimination training which utilizes stimulus control programming and then proceed directly into group therapy rather than employing the self-correction phase of the ASCP. Certain time saving features would be lost, but it is entirely possible that a strong transfer to connected speech could be made at this point in the total therapy program.

5. Special attention needs to be directed to the stimulus control format of the programming employed. The effectiveness of this type of programming is evidenced in the broad general improvement in auditory discrimination. The nearest comparable auditory discrimination program is that of A. L. Holland which did not produce a generalized response. An obvious part of the discrimination task present in the current programs is the four button choice which in information theory terms calls for the resolution of an uncertainty of 2 as opposed to the resolution of an uncertainty of 1.585 under Holland's program: ($H = \log_2 \Sigma pi's$).

6.

TABLE V

TIME SPENT ON ASCP

TREATMENT	TIME IN MINUTES	
	Mean	Range
Phase I Correction	138	93 to 312
Phase I Non-Correction	98	86 to 121
Phase II Rewind	210	190 to 280
Phase II Non-Rewind	74	---------

The obvious time-saving factor in the non-correcting, non-rewind presentations is a matter of importance when a large number of children are in need of therapy. At the same time, as was noted above, a strong clinical impression remains that the total productiveness of the correction treatment for auditory discrimination is a factor which must not be overlooked. On the contrary, the clinical impression concerning the Phase II treatments was that the children became much more restless while dealing with the rewind function than with the non-rewind presentation. Over all, it would appear that a correction presentation for auditory discrimination combined with a non-rewind presentation for self-correction offers the maximum in clinical usefulness with these particular programs.

7. Although the final analysis of errors made by the subjects during Phase I has not been completed, it is known that the percentage of errors will be higher than the 10 percent usually advocated in programmed

instruction. After the analysis of error count and of latency of response of the subjects is completed, it may be possible to analyze the specific source of errors and to subsequently modify the programmed instruction to eliminate these errors. Such an analysis and revision is in line with the majority of current thought about the writing of programmed instruction. At the same time, the significant changes produced by the programs in their present form indicate that the present ASCP is a very effective method of influencing the behavior of children with functional misarticulation problems. Clinically, the error rate is not a significant factor since the total behavioral changes were positive.

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