# EXPERIMENTS ON THE T-T SYSTEM

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The system for the pronunciation-hearing test using a hybrid magnetic tape system has been developed since 1968 and was reported on in Fujimura (1969), Ishida (1969), Hanauer (1970), and Smith et al. (1970). The present paper presents an interim report of the first stage of systematic experiments we have been conducting using this system since October 1970. We shall first outline basic concepts in our system and then describe the procedures of the experiments. Tentative analyses of the test results shall be given together with some suggestions about possible modifications of the system. The tests to be concerned with here are those in English mainly for Japanese students.

## 1. OUTLINE OF THE SYSTEM

The placement of participants in the actual test sessions is given in Chart 1. The test session proceeds as follows: a prerecorded word to be tested is presented; the student then, with or without the display system, listens to the word and repeats it; the evaluator then compares the repeated word with the presented word and types in his judgment of OK or NO through a teletype keyboard writer. This instruction initiates the presentation of the next word which is determined by the computer based on the algorithm described in Fujimura (1969).

### 1.1 Basic notions and working terminology

We have been using as test material, a list of monosyllabic words in English, each of which consists of the initial consonant cluster ($C_i$), the vocalic nucleus (V), and the final consonant cluster ($C_f$), where $C_i$ and $C_f$ may be null. Each word was recorded on magnetic tape by a native speaker of English, and was supplied with some digital information associated with the word (label). In this digital label, each component (i. e. $C_i$, V, or $C_f$) of the monosyllabic word, is represented by means of a word feature (WF) identification code. To each WF, the following information is assigned, according to the program designed originally by Hanauer (1970).

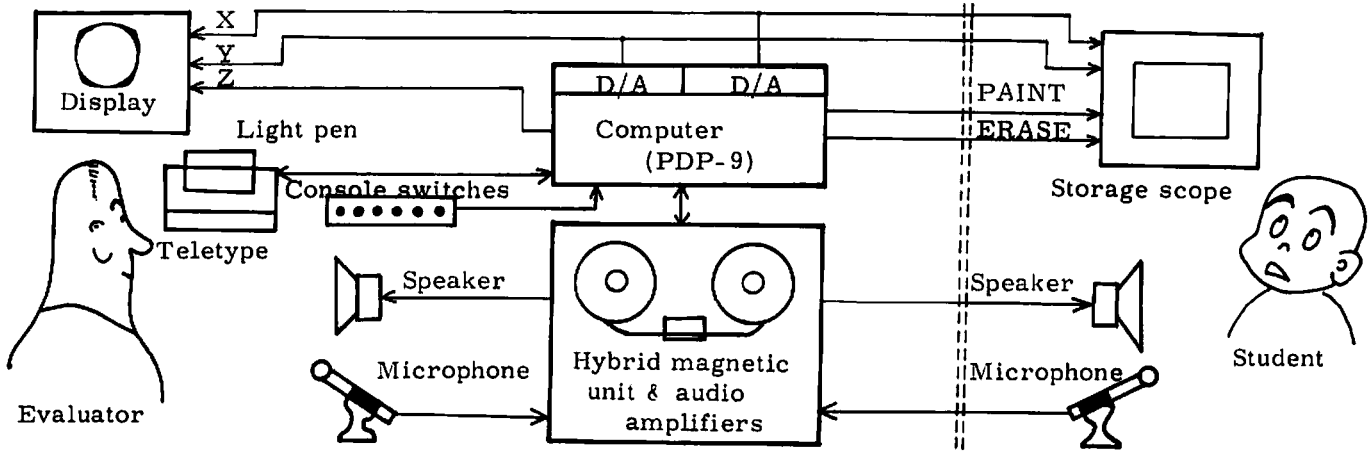
X
Y
Z
Display
Light pen
D/A
D/A
Computer
(PDP-9)
PAINT
ERASE
Storage scope
Console switches
Teletype
Speaker
Speaker
Microphone
Hybrid magnetic
unit & audio
amplifiers
Microphone
Evaluator
Student

CHART 1

(1) The phonetic transcription of the component it identifies,

(2) Two constant digital values, viz.

(i) WF-number (identification code)

(ii) WF-level, i. e. an integer from 1 to 6 which indicates the degree of difficulty in learning (for the Japanese students), where higher numbers are assigned to more difficult items*, and

(3) Two variable digital values, viz.

(i) WF-count (c), i. e. the number of occurrences of the WF up to the moment from the start of the test session,

(ii) WF-state (s), i. e. the grading of the testee for the WF in question, determined by the algorithm described in Fujimura (1969)**.

Moreover, each word is assigned a word level (i. e. the degree of difficulty of the entire word), which equals the greatest WF-level in the word. The words are ordered according to the word levels assigned to them in such a way that easier items may be presented before harder ones and a test session is divided into 6 subsession-levels (SL):SL 1 contains only the words whose word level is 1; SL 2 contains the words whose word level is 2, etc. After a test session has been completed, the computer punches out the results of the test, in the format described elsewhere. *** These results then serve as input to the post-session analysis programs for further analyses. (See section 3. 2 below for details. )

* Since this was the first series of experiments, the WF-levels were tentatively determined by an expert teacher of English. As discussed below, these assignments will be modified according to the results of the first stage experiment.

** The algorithm was designed according to the general requirement that sample words be skipped if they are too difficult or too easy for the student. A measure for such a judgment is given for each WF in the form of two threshold values L and M. The upper threshold L is set for the particular session before it starts, at an integer ranging from +1 to +9, and the lower threshold M is set at a negative threshold ranging from -1 to -9. The word is skipped from the set of test samples when either any WF in the word has a current state below M or all the WF's in the word have states over L. The state-value of each WF is zero when the session starts, and varies within the range between M and +9. The positive state-value becomes saturated at +9, cf. Section 3. 1. 3.

*** The format consists of seven columns: the first column represents the state (s) of the WF in question at the end of the subsession of Level 1 (SL 1), the second its state at the end of SL 2, etc., and the seventh (i. e. the rightmost column) represents the count (c) of the WF. (See Fujimura (1969)).

1. 2 Display system

A display system, which may be used by the student to verify the word he is supposed to repeat has been made available and is now utilized in our experiments as an option. * Here we are concerned solely with the linguistic and pedagogical aspects of the system.

The phonetic transcription is given after Kenyon and Knott (1953). The correspondence between our special phonetic codes for WF's and the phonetic symbols of Kenyon and Knott are summarized in Chart 2.

The display system allows us to select any of the following three modes of presentation of the material to the student in the test session:

(1) only sounds are presented,

(2) only displays on the oscilloscope are presented,

(3) combinations of both are presented.

When the first mode is chosen, we can test the student's overall ability in hearing and pronunciation of the word. The second mode enables us to test the student's combined ability in reading phonetic transcription and pronouncing it as a word. The final option is probably appropriate in some cases for testing mainly student's pronunciation alone. The third mode allows further variations in effect depending on the order of presentation of the sound and the display. A few possibilities are enumerated below:

(a) first display, then sound

(b) first sound, then display

(c) first display, then sound, and again display

(d) first sound, then display, and again sound.

In the present series of experiments we have used the mode (1) for some students, (2) for two,** and (3-c) for most students.

Although the Kenyon and Knott system of phonetic representation has been tentatively adopted in the present display system, this choice is being reexamined, since the Kenyon and Knott system is not commonly used in

* See Fujimura (1969) for its proposal and Saito (1971) for technical details of implementation.

** This mode of presentation was actually given to students who were learning how to read phonetic symbols and who were willing to take a test for evaluating their ability in reading them. The results, however, are omitted from the description of the experiments below.

CHART 2

A. Phonetic Symbols for English

| VOWELS | | CONSONANTS | |
|---|---|---|---|
| K & K | T-T SYSTEM | K & K | T-T SYSTEM |
| I | I | p | P |
| ɛ | E | b | B |
| æ | AE | t | T |
| a | A | d | D |
| ɔ | OA | k | K |
| ʊ | UU | g | G |
| ʌ | UA | f | F |
| ə | UR | v | V |
| ɚ | URR | s | S |
| i | IJ | z | Z |
| e | EJ | l | L |
| u | UW | r | R |
| aɪ | AJ | m | M |
| aʊ | AW | n | N |
| ɔɪ | OJ | h | H |
| o | OW | w | W |
| | | j | Y |
| | | θ | TH |
| | | ð | DH |
| | | ʃ | SJ |
| | | ʒ | ZJ |
| | | tʃ | TJ |
| | | dʒ | DJ |
| | | ŋ | NG |

B. Computer display of phonetic symbols on the oscilloscope

teaching English in Japan, e. g. in high school textbooks or in dictionaries of English compiled in Japan. The most popular system seems to be that of Daniel Jones, which differs from the Kenyon and Knott system especially in the representation of tense vowels. Kenyon and Knott's transcriptions for tense vowels, [i], [e], [o], [u], correspond respectively to Daniel Jones' [i:], [ei], [ou], [u:] (and, correspondingly, Kenyon and Knott's lax vowels [I] and [U] are transcribed as [i] and [u] in Jones' system). Native speakers of General American often seem to consider the tense vowels mentioned above as single vowels, as noted by Kenyon and Knott, and the present test is designed for American English. Japanese students of English, however, tend to regard them as diphthongs, and are more familiar with their transcriptions as diphthongs, perhaps partly due to the moraic characteristics of Japanese phonology and also to the fact that most Japanese teachers of English are more or less influenced by the British school of phonetics.

Fujimura (1969) mentions the following as the possible task of the student in the test session:

(1) oral repetition of the presented speech

(2) pronunciation of the typewritten word

(3) spelling (type in) of the presented speech.

A combination of a mode of presentation and one of these tasks will give us a number of different ways of utilizing our T-T system.

## 2. DESCRIPTION OF THE EXPERIMENTS

Chart 3 tabulates the conditions of the thirty-six experiments we conducted during the period October 1970 - January 1971. Explanations of this chart are in order.

(1) The prefix in the test number identifies the tested language and the status of the student. EF stands for "an English test for a native speaker of French," EJ for "an English test for a native speaker of Japanese," and EJJ for "an English test for a native speaker of Japanese in junior high school."

(2) Three students took the entire test twice. These tests are indicated by a prime following the student's identification code, viz. EJ 2, EJ 2'.

(3) We kept it as a general rule that one evaluator be in charge of a single test session. In the case of EF 4, however, two evaluators were in cooperation for the whole session. Hence the occurrence of two initials (R/S) in the

CHART 3

| STUDENT | EVALUATOR | AVERAGE s/c | THRESHOLD L | THRESHOLD M | DISPLAY | 1 or 2 |
|---|---|---|---|---|---|---|
| EF 1 | S | | +1 | -4 | - | 1 |
| EF 2 | S | | +1 | -4 | - | 1 |
| EF 3 | R | | +1 | -4 | - | 1 |
| EF 4 | R/S | | +1 | -4 | - | 1 |
| EF 5 | R | | +2 | -3 | - | 1 |
| EJ 1 | R | | +1 | -4 | - | 1 |
| EJ 2 | To | | +1 | -4 | - | 1 |
| EJ 3 | R | | +1 | -4 | - | 1 |
| EJ 4 | To | | +1 | -4 | + | 1 |
| EJ 5 | R | | +1 | -4 | + | 1 |
| EJ 6 | To | | +1 | -4 | + | 1 |
| EJ 7 | To | | +1 | -4 | + | 1 |
| EJ 2' | R | | +1 | -4 | + | 1 |
| EJ 8 | Ta | 0.93 | +2 | -4 | + | 2 |
| EJ 9 | Ta | 0.82 | +2 | -4 | + | 2 |
| EJ 3' | R | 0.78 | +2 | -4 | + | 2 |
| EJ 10 | Ta | 0.82 | +2 | -4 | + | 2 |
| EJ 11 | R | 0.78 | +2 | -4 | + | 2 |
| EJ 12 | Ta | 0.92 | +2 | -4 | + | 2 |
| EJ 11' | Ta | 0.96 | +2 | -4 | + | 2 |
| EJ 13 | R | 0.63 | +2 | -4 | + | 2 |
| EJ 14 | R | 0.89 | +2 | -4 | + | 2 |
| EJ 15 | Ta | 0.89 | +2 | -4 | + | 2 |
| EJ 16 | N | 0.98 | +2 | -4 | + | 2 |
| EJ 17 | N | 0.94 | +2 | -4 | + | 1 |
| EJ 18 | R | 0.83 | +2 | -4 | + | 2 |
| EJJ 1 | A | 0.52 | +2 | -4 | (+) | 2 |
| EJJ 2 | A | 0.60 | +2 | -4 | (+) | 2 |
| EJJ 3 | N | 0.88 | +2 | -4 | (+) | 1 |
| EJJ 4 | S | 0.67 | +2 | -4 | + | 2 |
| EJJ 5 | S | 0.62 | +2 | -4 | + | 2 |
| EJJ 6 | S | 0.68 | +2 | -4 | + | 2 |
| EJJ 7 | S | 0.78 | +2 | -4 | + | 2 |
| EJJ 8 | S | 0.68 | +2 | -4 | + | 2 |
| EJJ 9 | S | 0.76 | +2 | -4 | + | 2 |

column of the evaluator.

(4) The blank in the column for AVERAGE s/c shows that the student's test record was not subject to the post-session analysis programs.

(5) The sign + in the column for DISPLAY shows that the display system was utilized (i. e. the phonetic symbols were presented to the students through the oscilloscope), and the - sign that the system was not utilized. The + signs enclosed in parentheses (as found in EJJ1, EJJ2, and EJJ3) indicate that those students could read only a small number of phonetic symbols although they were provided with the display.

(6) The numbers 1 and 2 in the rightmost column indicate the number of session divisions, viz. whether the test was divided into two subsessions or was run continuously in one stretch in a single day. In most cases with two session divisions, the interval between the two was a week, but the shortest interval was two days, and the longest one six weeks.

## 3. ANALYSES OF THE TEST RECORDS

### 3. 1 Preparatory remarks on the analyses

Not all the tests we have conducted will be analyzed here. We have excluded from our consideration, the test results of the test sessions EJ2, EJ4, EJ6, and EJ7 in order to avoid the possible dialectal problems since the evaluator of these sessions was a native speaker of British English while the test material was given in General American. The EF tests are also excluded from the analysis here.

The remaining tests may be subcategorized according to various factors such as the selected values of the upper and lower thresholds, the use or non-use of the display, the evaluator, and the number of subdivisions of the test. The major bifurcation falls between the group consisting of EJ 8-18 and the group consisting of EJJ 1-9, which we shall henceforth refer to as the 'EJ group' and the 'EJJ group', respectively. These two groups are characterized by their average grades and lengths of experience with the target language.

#### 3. 1. 1 State as a measure of the student's performance on a WF

In the design of the system, the WF states were employed as a measure of the student's performance on individual WF's. If we employ the states directly in the evaluation and analysis of the test results, some ob-

vious difficulties arise. Consider, for example, a case where a WF, by some reason once obtains a positive value of state s. This value remains positive throughout the test session, however many times this WF actually causes NO-judgments of words containing it. Consequently, another measure is called for to represent the student's grade in this WF. An alternative is the value s/c.

3.1.2 State/count as the measure

In the present study, all the analyses from now on are based on the value s/c for each WF at the end of the session, which we assume to be an approximate representation of the student's grade for the WF. We will explicate the underlying assumption and the algorithm for determining this value, before we describe the results of the analyses.

We assume that the student's competence in pronunciation of a WF in any word is predictably good if the s/c-value of the WF has a sufficiently positive value. The states and counts are updated within a test according to the following principles.

(1) When the student's repetition of a presented word is evaluated as OK, the states of all WF's in the word are given an increment of +1, and the counts of all WF's are also given +1. Therefore, in an extreme case, where every word gets OK whenever it is presented to the student, the s/c for each WF is 1, which is the highest value of this measure in our grading system.

(2) When the student's repetition of a presented word is evaluated as NO, the update of s/c is made in a somewhat complex manner. We have the following four different situations as regards the states of the pertinent WF's for the word just before its presentation.

  (i) The states of all WF's in the word are positive, i.e. these WF's have already been tested and judged as OK for the student.

  (ii) Only one WF in the word has a non-positive state, others being all positive.

  (iii) Only one WF in the word has a positive state, all others having values of either zero or negative.

  (iv) The states of all WF's in the word are non-positive.

Let us examine some typical cases and the possible problems involved therein. In case (2)-(i), the states remain unchanged and only the counts

receive an increment of +1 each. For instance, suppose we present to the student a word X which consists of three WF's, A, B, and C, whose values of s/c are 2/3, 1/4, and 4/5 respectively. The resultant values will be 2/4, 1/5, and 4/6 respectively. Our motivation for doing this is that we can't conclude, from the observation of his failure on this word X, which WF has caused the failure. On the other hand, it is clear that at least one of the WF's in X must have been pronounced wrong. Therefore, it seems justified that the s/c of each WF is decreased by a fraction of 1.

In case (ii), it is not too difficult to determine the WF which is most probably responsible for the failure on the word; it is the WF whose s is non-positive. In this case, the s-value of this WF is decreased by 1 and the c-value is increased by 1. But in effect, we also decrease the s/c of other WF's by giving an increment of 1 to c but none to s, and this may be justified by the fact that these WF's may possibly have also served as the trouble spot.

In case (iii), just as in case (i), we cannot uniquely identify the trouble spot. Here again our system does not attempt to hypothesize plausible sources of failure, but simply updates the counts, not the states of relevant WF's, resulting in minor and somewhat arbitrary changes in the s/c values. In case (iv) too, we cannot but follow the same principle since there is no way to uniquely specify the trouble spot.

Thus we find that even though neither s nor s/c serves as a true measure of a student's competence in a WF, it is clear that the s/c serves as a better measure of competence than s does, and in fact it makes a reasonably reliable first approximation to the true measure. We could perhaps arrive at a better justified system if we adopted an entirely different and substantially more complex task of the evaluator, for example judging and recording the trouble spot of the student's performance on each test word, rather than to record the overall acceptability. However, this would be essentially against the principle of the present T-T system, where we claim that any good native speaker of the target language can serve as the evaluator performing a simple and comprehensible task, all the professional knowledge and experience in the foreign language teaching being taken care of by the computer, and also that the test can be performed as efficiently as possible under objectively reproducible conditions.

3. 1. 3 Saturation of the s-value at +9

As noted in footnote ** in section 1. 1, an s-value ranges from M to +9. The saturation at +9 which was introduced to save the computer memory space, causes some difficulty in determining the grade (i. e. the value s/c) in certain cases, in particular in the case of vowels, each of which occurs typically many more times than 9 in the entire session as contexts to different consonantal WF's. Since there is no way to assess the exact s beyond 9 for the post-session analyses, we make s/c equal to 1 whenever the final s is 9, regardless of c. This tends to result in a contrary-to-fact conclusion that most students can perfectly pronounce English vowels. In view of such considerations, for the time being we will omit vowels from the subsequent analyses.

3. 1. 4 Characterization of the groups under analyses

The groups subject to the analyses here are the EJ and the EJJ groups. The reason for separating these subjects in two groups is that the proficiency in terms of the average s/c's for the groups are significantly difficult, namely 0. 68 for EJJ, and 0. 86 for EJ. The range of the average s/c for individual test sessions for Group EJ was 0. 78 to 0. 98 (including a second time test session which indicated a significant improvement over the first session of the same student) except one case with an average s/c = 0. 63. For Group EJJ, the average s/c ranged from 0. 52 to 0. 78 except one student with a score of 0. 88. The average s/c's are given in Chart 3.

3. 2 Description and results of the post-session analyses

3. 2. 1 Post-session analysis programs

We made the following hypotheses at the start of our project:

(i) Each WF has its own level of difficulty.

(ii) A consonant cluster (i. e. a phonemic string consisting of more than one consonant) functions as an independent unit. The difficulty of a consonant cluster may not be predicted from the difficulty levels of the constituent consonants by any known algorithm.

We have been testing these hypotheses by analyzing the test records by means of the post-session analysis programs, a description of which follows below. * We have two post-session analysis programs, a LEVEL IMPROVE-

* The attempt along this line is explained in Smith et al., 1970.

MENT and a WORD FEATURE COMPONENT RESEARCH, in particular relevance to hypotheses (i) and (ii), respectively.

3. 2. 1. 1 Level Improvement

The aim of this program is to modify the difficulty level assignment for each WF based on the test records in order to reflect its actual degree of difficulty as assessed by this objective method. We process the test records by a TOSBAC 3400 computer in the format shown in Chart 4.

The format consists of maximally 16 columns. The two columns at the extreme left identify the WF's and their levels assigned originally. In the rightmost column are given the average s/c values represented in percent (referred to as AVERAGE hereafter) for the group of students for individual WF's. The columns in the middle display the s/c values for each of the students, maximally 13 of them, and when either the s-value is +9 or the c-value is +1, an asterisk is put in front of the s/c value.

The WF's have been reordered according to their AVERAGES, and new level values have, for the present, been optimally assigned as follows: LEVEL 1 to WF's whose AVERAGE was 100, LEVEL 2 85-100, LEVEL 3 70-85, LEVEL 4 50-70, and LEVEL 5 to WF's with an AVERAGE under 50. The reassignment of these new levels will be given automatically whenever it is considered necessary for any group of students by the same computer program. Automatic rearrangements of the word samples on the test tape, which would be necessary for an optimal use of the effect of the level reassignment, requires some new technical devices that are not provided by our present computer system.

Besides this semi-automatic reassignment of levels, the limited number of WF's originally classified as LEVEL 6 are to be eliminated from our WF list, since we have found these WF's are in general too complex even for a native speaker to pronounce naturally as they are prescribed in dictionaries. A native speaker typically omits one or two consonants in these WF's in natural speech, which means he is actually pronouncing WF's which belong to a lower level. In attempting to pronounce the clusters as prescribed, he tends to break them down into separate units.

3. 2. 1. 2 Word feature component research

The aim of this program is to examine the possible correlations

CHART 4

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | -NGKTH | 1.00 | 1.00 | 0.50 | 0. * | 1.00 | 1.00 | 75.000 |
| 3 | -LD | 1.00 | 0.50 | 0.50 | 1.00 | 0.50 | 1.00 | 75.000 |
| 3 | -RL | 1.00 | 1.00 | 1.00 | 0.50 | 0. | 1.00 | 75.000 |
| 3 | -RPS | 0.50 | 1.00 | 1.00 | 0. | 1.00 | 1.00 | 75.000 |
| 4 | -DTH | 1.00 | 0.50 | 0. * | 1.00 * | 1.00 | 1.00 | 75.000 |
| 3 | -LTH | 0.50 | 0.66 | 1.00 | 1.00 | 0.66 | 0.66 | 74.999 |
| 4 | -R | 0.50 | 0.83 | 1.00 | 0.50 | 1.00 | 0.66 | 74.999 |
| 2 | -Z | 0.45 | 0.88 | 1.00 | 0.55 | 0.71 | 0.85 | 74.506 |
| 1 | -NS | 1.00 | 0.50 | 0.50 | 1.00 | 0.66 | 0.79 | 74.444 |
| 5 | SPL- | 1.00 | 1.00 | 0.40 | 1.00 | 0.66 | 0.40 | 74.444 |
| 3 | DJ- | 0.50 | 0.66 | 0.66 | 1.00 | 1.00 | 0.62 | 74.305 |
| 3 | SW- | 0.66 | 0.50 | 0.83 | 0.62 | 1.00 | 0.83 | 74.305 |
| 2 | -RM | 0.50 | 0.40 | 1.00 | 0.50 | 1.00 | 1.00 | 73.333 |
| 2 | -N | 0.44 | 0.62 | 0.75 | 1.00 | 0.71 | 0.85 | 73.181 |
| 1 | -TS | 0.62 | 0.71 | 0.66 | 0.71 | 0.66 | 1.00 | 73.115 |
| 5 | -SPT | 0.50 | 0.66 | 0.19 | 1.00 | 1.00 | 1.00 | 72.777 |
| 2 | SN- | 0.63 | 0.72 | 0.58 | 0.72 | 0.66 | 1.00 | 72.348 |
| 3 | -RMZ | 0.33 | 0.33 | 1.00 | 1.00 | 0.66 | 1.00 | 72.222 |
| 4 | -LDJD | 1.00 | 1.00 | 0.66 | -0.33 | 1.00 | 1.00 | 72.222 |
| 2 | PY- | 0.66 | 0.33 | 1.00 | 1.00 | 1.00 | 0.33 | 72.222 |
| 2 | -MPT | 0.33 | 1.00 | 1.00 | 0.66 | 0.66 | 0.66 | 72.222 |
| 1 | -NTS | 1.00 | 0.59 | 0.22 | 1.00 | 0.50 | 1.00 | 72.037 |
| 4 | SKR- | 1.00 | 0.57 | 0.75 | 1.00 | 0.28 | 0.66 | 71.230 |
| 4 | -ES | 0.40 | 0.66 | 0.50 | 1.00 | 1.00 | 0.66 | 70.555 |
| 5 | -LD | 1.00 | 0.66 | 0.16 | 1.00 | 1.00 | 0.40 | 70.555 |
| 5 | -NDJD | 0.33 | 0.50 | 1.00 | 1.00 | 1.00 | 0.40 | 70.555 |
| 1 | -NDZ | 1.00 | 0.71 | 0.59 | 0.66 | 0.79 | 0.42 | 70.158 |
| 4 | -BD | 1.00 | 0.33 | 0.40 | 1.00 | 1.00 | 0.40 | 68.888 |
| 4 | -V | 0.40 | 1.00 | 0.50 | 1.00 | 0.66 | 0.50 | 67.777 |
| 2 | -RS | 0.33 | 0.66 | 0.40 | 1.00 | 0.66 | 1.00 | 67.777 |
| 4 | -SPS | 0.33 | 0.66 | 0.40 | 1.00 | 1.00 | 0.66 | 67.777 |
| 3 | SL- | 0.83 | 0.77 | 0.66 | 0.42 | 0.35 | 1.00 | 67.724 |
| 2 | -RST | -1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 66.666 |
| 4 | VY- | * 1.00 | * 1.00 | * 1.00 | * 1.00 | *-1.00 | * 1.00 | 66.666 |
| 4 | -ZD | 1.00 | -0.50 | 1.00 | 0.50 | 1.00 | 1.00 | 66.666 |
| 4 | -PTS | * 1.00 | * 1.00 | * 1.00 | * 1.00 | *-1.00 | * 1.00 | 66.666 |
| 4 | -FTH | * 1.00 | * 1.00 | *-1.00 | * 1.00 | * 1.00 | * 1.00 | 66.666 |
| 4 | -TTH | * 1.00 | *-1.00 | * 1.00 | * 1.00 | * 1.00 | * 1.00 | 66.666 |
| 4 | -RVZ | 0.50 | 0.50 | 1.00 | 0.50 | 1.00 | 0.50 | 66.666 |
| 4 | -NGKST | * 1.00 | *-1.00 | * 1.00 | * 1.00 | * 1.00 | * 1.00 | 66.666 |
| 4 | -MPST | * 1.00 | *-1.00 | * 1.00 | * 1.00 | * 1.00 | * 1.00 | 66.666 |
| 5 | -LVD | 1.00 | 0.50 | 1.00 | -0.50 | 1.00 | 1.00 | 66.666 |
| 6 | -KSTHS | * 1.00 | * 1.00 | *-1.00 | * 1.00 | * 1.00 | * 1.00 | 66.666 |
| 4 | -PST | 0.66 | 0.33 | 0.33 | 0.66 | 1.00 | 1.00 | 66.666 |
| 2 | -RDZ | 1.00 | 1.00 | -0.42 | 1.00 | 1.00 | 0.40 | 66.190 |
| 5 | PR- | 1.00 | 0.66 | 0.33 | 0.66 | 0.59 | 0.66 | 65.555 |
| 4 | -KT | 0.18 | 1.00 | 0.50 | 1.00 | 1.00 | 0.22 | 65.067 |
| 4 | -TH | 0.50 | 0.66 | 1.00 | 0.33 | 1.00 | 0.40 | 64.999 |
| 4 | HW- | 0.50 | 0.69 | 0.77 | 0.66 | 0.85 | 0.36 | 64.420 |
| 3 | -LM | 1.00 | -0.50 | 1.00 | 1.00 | 1.00 | 0.33 | 63.888 |
| 4 | SF- | 0.50 | 0.33 | 1.00 | 0. | 1.00 | 1.00 | 63.888 |
| 3 | KW- | 0.57 | 0.37 | 0.50 | 0.50 | 0.87 | 1.00 | 63.690 |
| 3 | -MZ | 0.50 | 1.00 | 0.28 | 0.50 | 1.00 | 0.50 | 63.095 |
| 3 | SKW- | 0.66 | 0.28 | 1.00 | 0.75 | 1.00 | 0.06 | 62.817 |

between some structurally related WF's, or in other words, interactions of their various constituents when they form WF's. * For instance, in the case of the WF -NGKTHS, we can compare the grade of this WF with the grades of the constituent WF's, viz. -NGKTH, -NGK, -NG, -KTHS, -THS, and -S, which are obtained by dropping all possible strings of sound segments on either side, i. e. by eliminating in the WF above -S, -THS, -KTHS, -NG, -NGK, and -NGKTH, respectively. ** We call a part to be thus suppressed for comparison of a pair of WF's the FOCUS, and the WF composed by the remaining segment string plus the hyphen as in the original WF REMAINDER In the computer program we can input specifications of any focus segments (string of segments) and automatically search through all existing comparisons of WF's.

In the present research, however, we have used this program only for the following two specific purposes:

(1) to see whether it is in fact the case that a longer consonant cluster is more difficult than shorter ones consisting of their substrings.

(2) to see whether morphological endings such as the third-person-singular-present marker, the plural ending, the past-tense marker, etc., contribute any additional difficulty to a final consonantal WF.

The format consists of maximally 22 columns. An example is given in Chart 5, in which the segment Z# is specified as the FOCUS. The first two columns identify the pertinent WF's and their levels, the third column gives the corresponding REMAINDERS, and the fourth their levels. The next maximally 12 columns display the DIFFERENCE (s/c of the WF minus s/c of its REMAINDER in respect to the FOCUS, in this case Z#, in percent) for each of the students. The following column (AV) gives the average of the DIFFERENCE's over different students. The last five columns show the percentage of students whose DIFFERENCE values fall in each of five fixed ranges: under -10, -10 to 0, 0, 0 to 10, and above +10, in this case.

The results of these analyses are summarized in Charts 6 and 7. Chart 6 illustrates the case with WF's with and without morphological endings, and Chart 7 some of the other kinds of cases. The value in the column

* See Smith, et al., 1970.

** The hyphen indicates that there will be an adjacent vocalic syllable nucleus on this side of the WF when a word is formed.

Chart 5

RIGHT FOCUS Z

| | WF | WFR | | | | | | | | | | AV | -M | M-O | O | O-P | P- |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -NDZ | -ND | 1 | -27 | -17 | -35 | * 33 | * 50 | * 0 | | | 1 | 50 | 0 | 17 | 0 | 33 |
| 2 | -RDZ | -RD | 2 | * -67 | 17 | -35 | *-167 | * -84 | * 67 | | | -45 | 67 | 0 | 0 | 0 | 33 |
| 2 | -NZ | -N | 2 | 0 | * 0 | 0 | * 0 | 0 | 0 | | | 0 | 0 | 0 | 100 | 0 | 0 |
| 2 | -RZ | -R | 4 | -25 | * 0 | * 0 | -9 | -75 | -67 | | | -29 | 50 | 17 | 33 | 0 | 0 |
| 2 | -LNZ | -LN | 3 | * 0 | * 0 | * 0 | *-200 | * 0 | * 0 | | | -33 | 17 | 0 | 83 | 0 | 0 |
| 2 | -RNZ | -RN | 2 | * 0 | * 86 | -121 | *-100 | -34 | * 0 | | | -28 | 50 | 0 | 33 | 0 | 17 |
| 3 | -LDZ | -LD | 3 | * -67 | * -67 | -17 | * -86 | * -67 | * 0 | | | -51 | 83 | 0 | 17 | 0 | 0 |
| 3 | -LZ | -L | 4 | 0 | 0 | 67 | 0 | 0 | 0 | | | 11 | 0 | 0 | 83 | 0 | 17 |
| 3 | -MZ | -M | 1 | * 11 | * 11 | * 14 | * 13 | -43 | * 14 | | | 3 | 17 | 0 | 0 | 0 | 83 |
| 3 | -LMZ | -LM | 3 | -67 | * 0 | * -67 | * 0 | 33 | * 0 | | | -17 | 33 | 0 | 50 | 0 | 17 |
| 3 | -RLZ | -RL | 3 | 0 | 0 | * 100 | * 0 | * 100 | * 0 | | | 33 | 0 | 0 | 67 | 0 | 33 |
| 3 | -RMZ | -RM | 2 | * 67 | * 0 | 20 | * -67 | * 80 | * 0 | | | 17 | 17 | 0 | 33 | 0 | 50 |
| 4 | -DZ | -D | 2 | -36 | -200 | * 38 | * 33 | * 0 | * 0 | | | -27 | 33 | 0 | 33 | 0 | 33 |
| 4 | -BZ | -B | 2 | * 67 | 0 | -89 | * 80 | -25 | * 0 | | | 6 | 33 | 0 | 33 | 0 | 33 |
| 4 | -GZ | -G | 2 | * 0 | * 0 | * 0 | * 67 | * -67 | * 0 | | | 0 | 17 | 0 | 67 | 0 | 17 |
| 4 | -NGZ | -NG | 4 | -10 | * 200 | * -67 | * -75 | * 0 | * 0 | | | 8 | 33 | 17 | 33 | 0 | 17 |
| 4 | -VZ | -V | 4 | * 0 | * 0 | 0 | -6 | * 67 | * -67 | | | -1 | 17 | 17 | 50 | 0 | 17 |
| 4 | -LBZ | -LB | 4 | * 0 | * 0 | * 0 | *-100 | * 0 | * 0 | | | -17 | 17 | 0 | 83 | 0 | 0 |
| 4 | -LVZ | -LV | 4 | *-200 | * 0 | -67 | * 0 | * 0 | *-100 | | | -61 | 50 | 0 | 50 | 0 | 0 |
| 4 | -RBZ | -RB | 2 | 83 | -9 | -34 | *-100 | * 0 | * 0 | | | -10 | 33 | 17 | 33 | 0 | 17 |
| 4 | -RVZ | -RV | 2 | * 0 | -134 | * 0 | * 67 | * 0 | * 0 | | | -11 | 17 | 0 | 67 | 0 | 17 |
| 5 | -DHZ | -DH | 4 | * 0 | * 0 | -20 | * 140 | * -81 | * 67 | | | 18 | 33 | 0 | 33 | 0 | 33 |
| | TOTAL | | | -271 | -113 | -313 | -477 | -146 | -86 | | | | | | | | |
| | AVERAGE | | | -12 | -5 | -14 | -21 | -6 | -3 | | | | | | | | |

for "WFR is more difficult" represents the number of WF's in percentage where the grade of a WF is better than that of its WFR, i. e. the WFR is more difficult than the WF in pronunciation, among the WF's which contain the FOCUS specified. On the other hand, the value in the column for "WF is more difficult", represents the number of WF's in percentage where the grade of a WF is worse than that of its WFR, i. e. the WF is more difficult than the WFR in pronunciation. Chart 7 indicates that in general, longer WF's without morpheme boundaries are equal to or harder than shorter ones, although there are exceptions, such as FOCUS -S, for the EJ group and FOCUS P# for the EJJ group. *

CHART 6

| FOCUS | | EJ GROUP | | | EJJ GROUP | | |
|---|---|---|---|---|---|---|---|
| | The No. of WF's which contain the FOCUS | WFR is more difficult % | Comparison | WF is more difficult % | WFR is more difficult % | Comparison | WF is more difficult % |
| S# | 38 | 57. 9 | > | 42. 1 | 18. 4 | < | 81. 6 |
| Z# | 22 | 36. 4 | < | 63. 6 | 36. 4 | < | 63. 6 |
| T# | 31 | 64. 5 | > | 35. 5 | 38. 7 | < | 61. 3 |
| D# | 26 | 53. 8 | ≥ | 46. 2 | 53. 8 | ≥ | 46. 2 |
| SUM | 117 | 54. 7 | ≥ | 45. 3 | 35. 0 | < | 65. 0 |

CHART 7

| FOCUS | | EJ GROUP | | | EJJ GROUP | | |
|---|---|---|---|---|---|---|---|
| | The No. of WF's which contain the FOCUS | WFR is more difficult % | Comparison | WF is more difficult % | WFR is more difficult % | Comparison | WF is more difficult % |
| #S | 14 | 35. 7 | < | 64. 3 | 35. 7 | < | 64. 3 |
| -S | 8 | 75 | > | 25 | 37. 5 | < | 62. 5 |
| -D | 5 | 20 | < | 80 | 40 | < | 60 |
| P# | 4 | 50 | = | 50 | 75 | > | 25 |
| -P | 6 | 50 | = | 50 | 33. 3 | < | 66. 7 |
| SUM | 37 | 45. 9 | ≤ | 54. 1 | 40. 5 | < | 59. 5 |

* The # indicates that the word boundary will be here when a word is formed.

This, however, does not necessarily hold for WF's with morphological endings S#, Z#, T#, D#, as seen in Chart 6. The addition of these endings does not contribute to the additional difficulty for the EJ group, although it does in the case of the EJJ group. More precisely, for the EJ group, the difficulty of the WF is hardly affected by addition of such morphological endings. This could be explained by the fact that members of the EJ group have already acquired sufficient knowledge of rules of English grammar to realize that these WF's are in fact not wholly new unit but combinations of the stem and suffix, the latter at least being known, whereas members of the EJJ group, being still in their earliest stage of English learning cannot fully utilize such knowledge.

Some improvements of the testing system based on the results discussed above are underway, in connection with the preparation of a revised version of magnetic tapes for test words. A separate project is also being carried out dealing with the problem of semi-automatization of pronunciation-hearing training, and a first study with use of somewhat detailed analyses of a preliminary set of personal teaching sessions for the EJJ group based on the results of their tests described above, was actually conducted. (See Sato, this issue)

## References


1) O. Fujimura, "Technological Developments for Language Learning," Annual Bulletin (Research Institute of Logopedics and Phoniatrics, University of Tokyo) No. 3, 81-110 (1969).

2) O. Fujimura, H. Ishida, K. Ito, K. Saito, and D. Smith, "Haiburrido Jikiteepu Sochi o Tsukkata Hatsuon Chyoshu Shisutemu (Pronunciation Hearing Test System Using Hybrid Magnetic Tape Unit)" Preprint of the Annual Meeting of the Information Processing Society of Japan, 113-114 (December, 1970).

3) S. L. Hanauer, "Computer-Assisted Instruction in the Pronunciation of Foreign Languages," Annual Bulletin (Research Institute of Logopedics and Phoniatrics, University of Tokyo) No. 4, 103-109 (1970).

4) H. Ishida, "An Audio-Digital Hybrid Magnetic Transport, "Annual Bulletin (Research Institute of Logopedics and Phoniatrics, University of Tokyo) No. 3, 67-68 (1969).

5) D. Jones, An English Pronouncing Dictionary, J. M. Dent, 1956.

6) J. S. Kenyon, and T. A. Knott, A Pronouncing Dictionary of American English, G. & C. Merriam Co., 1953.

7) K. Saito, Pronunciation-Hearing Test System Using On-Line Computer (In Japanese), Unpublished B. A. Thesis, University of Electro-Communications, 1961.

8) C. Sato, A Computer-Assisted Experiment of Pronunciation Test-Training, Unpublished M. A. Thesis, International Christian University, 1971.

9) D. Smith, K. Ito, C. Sato, H. Ishida, and O. Fujimura, "The Pronunciation-Hearing Test Using a Hybrid Magnetic Tape System," Annual Bulletin (Research Institute of Logopedics and Phoniatrics, University of Tokyo) No. 4, 111-113 (1970).