STATUS REPORT ON THE PRONUNCIATION TEST SYSTEM

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After the first series of experiments on the computer-assisted pronunciation-hearing test of English, [1] new difficulty levels, Level 1 to Level 5, were assigned automatically to all word features (henceforth WF's) except vowels [2] by applying the Level Improvement Program to the test results of six junior high school students. Following the new level assignment, the words were reordered and recorded by a native speaker of American English on the hybrid magnetic tape. This material is designed primarily for junior high school students who begin to study English in the first year. Eleven WF's, -ZJD, -DZD, -RTHT, -DTHS, -FTHS, -PTHS, -TTHS, -KSTHS, -LFTHS, -NGKTHS and -RMTHS, were excluded because these occur only in very limited cases. Using this second version of the testing material, we ran test sessions with five female junior high school students. The display of phonetic symbols on the oscilloscope surface, as described in a previous report, [3] was also employed in these sessions as before.

Results

The results obtained are notably dependent on the individual students, and it has been revealed that in some aspects it is difficult to obtain consistent results by our automatic level assignment procedure. There were 24 WF's assigned to the new Level 1 (where the average s/c value of a WF in

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percent is 100) when we processed the results of six junior high school students in the first series of experiments. In the results of the later five students, however, we find fourteen WF's whose average s/c percentage values are 100, but among these only -LB is a WF previously assigned to Level 1 (i. e. one of the 24 WF's mentioned above), and the other thirteen WF's were all expected to appear in Levels 2 to 5 (-MP and -LF were previously in Level 2; PY-, -TS, -RTJT and -NGKS in Level 3; -TH, -LN, -TJT, -RTJ and -RBD in Level 4; and -RTS and -RMTH in Level 5). As for the other 23 WF's previously assigned to Level 1, one WF belongs to Level 2 in this second version, seventeen to Level 3, and five to Level 4. This is not to say, of course, that the results are entirely sporadic. Clearly, there are some common points we can observe as general tendencies.

1. Consonantal WF's

Looking over the single consonants, we notice first that the s/c values for the final consonants vary between -1.00 and 1.00 both from student to student and from WF to WF and the range of values is much less for the initial consonants (cf. Figs. 1 and 2). Four students out of five got the best score (1.00) for -TS but relatively poor scores (from 0.22 to 0.67) for -DZ despite the fact that the only difference between -TS and -DZ is in voicing. Although obstruents occur only in syllable initial position in Japanese, this can be related to the fact that the fricative/affricate distinction is not used for voiced consonants. Almost the same correlation with voicing was observed for -TH and -DH, and -SJ and -ZJ. There is an exception, however. For NEJJ4 who got the best average score in percent (87), -DJ had the maximum s/c value (1.00) but -TJ had the minimum (-1.00). As for the initial consonants, the s/c value was low on the whole for Z-, TH-, DH- and SJ-. Of these, SJ- comes closest to occurring in Japanese; /z-/ is often affricated to [dz-]. A marked variation among students is seen in the grade for R-. The s/c value of R- ranges from -0.66 to 1.00; three students out of five got the maximum value (1.00). Among the WF's whose average s/c value (represented in percent) is around 50 or lower, R- (59), DH- (52), -R (50), -DZ (47), -G (47), Z- (47), -TJ (45), TH- (43), -DH (39) and -ZJ (0) are single consonants (cf. the discussion of obstruent-liquid clusters below). Half of them, i. e. TH-
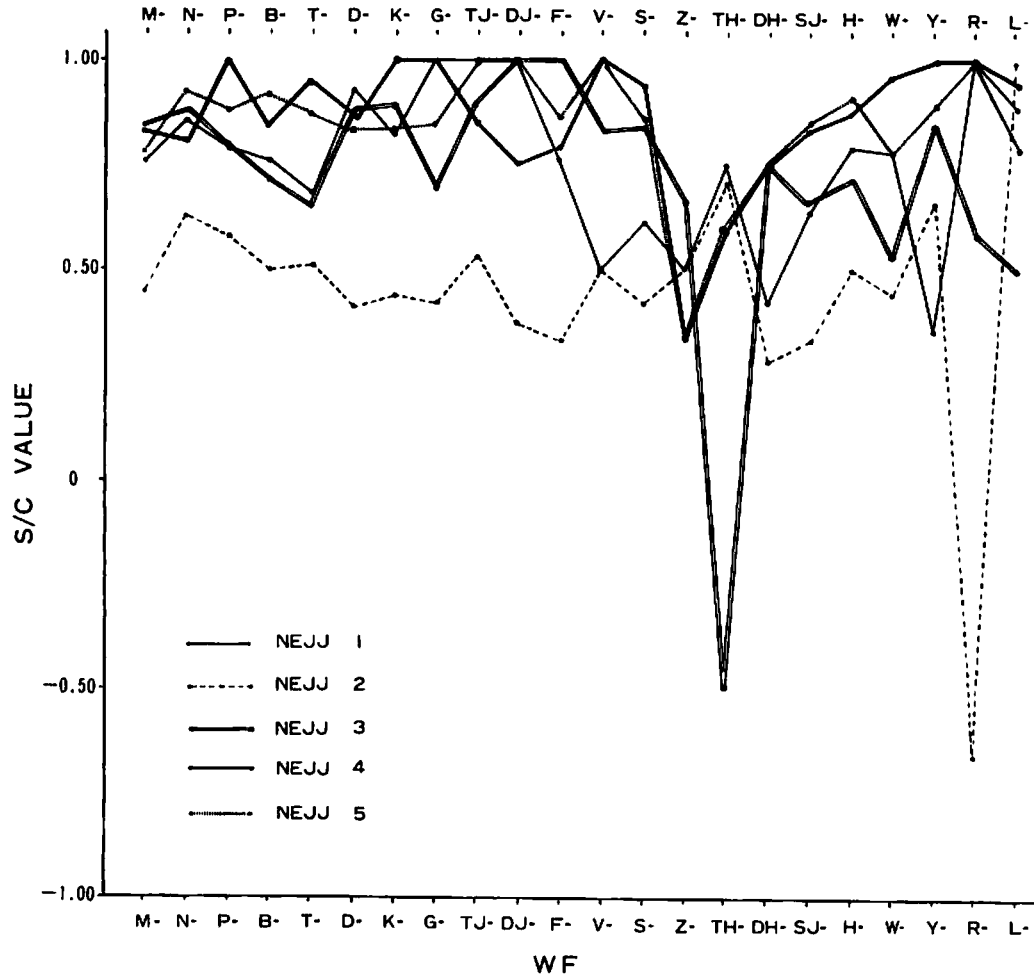
Fig. 1. The s/c values for single initial consonants (five students).
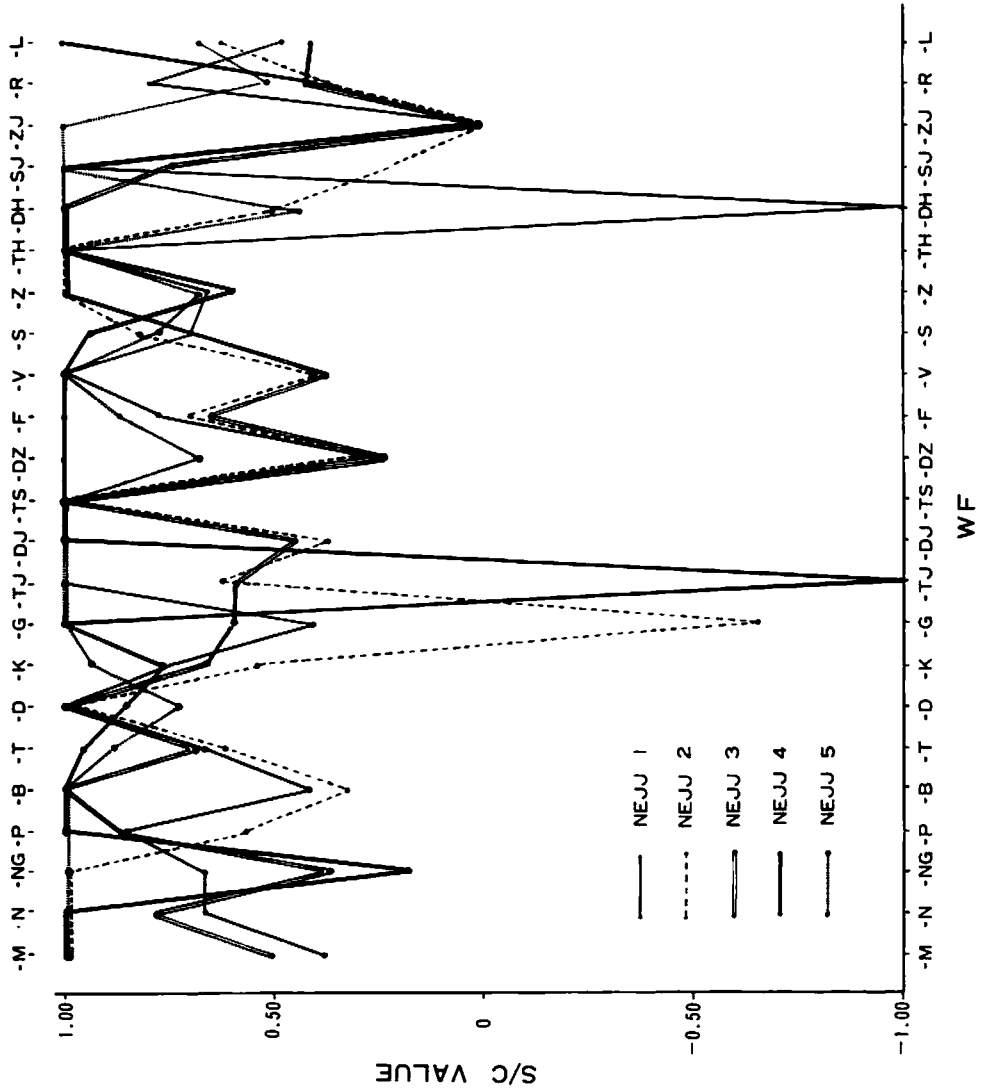
Fig. 2.   The s/c values for single final consonants (five students).

(52), R- (48), Z- (31) and -ZJ (0), were also found difficult in the test results of the six junior high school students who used the first version of the testing material.

Among these nine consonants, /r/ forms many consonant clusters. We shall here focus our attention on this consonant and see how it contributes to the difficulty in pronunciation of the different initial and final clusters having it as a constituent. There are 521 words containing R- or its associated WF's (i. e. C_i's (initial consonants or consonant clusters) containing the consonant /r/) recorded in the testing material, 225 words containing -R or its associated WF's, 375 words containing L- or its associated WF's, and 309 words containing -L or its associated WF's; although some words cover both /r/ and /l/. As is shown in Table 1, we notice that NEJJ2, getting the s/c scores of -0.66, 0.50, 0.58 and 0.33 for R-, B-, P- and F-, respectively, makes the good scores of 1.00, 0.75 and 1.00 for BR-, PR- and FR-, respectively. Those single consonants are difficult for this student when she pronounces each of them separately but they are much easier when combined with a labial or a labiodental consonant. NEJJ4, who got the maximum s/c (1.00) for R-, also obtained the maximum score for BR-, GR-, SPR-, SKR-, DR-, TR- and SJR- but did not have the same result for PR- (0.83), KR- (0.66) and FR- (0.40); the independent P-, K- and F- showed the grades of 1.00, 1.00 and 0.79, respectively. In NEJJ1 the s/c value of R- is maximum and those of almost all the single consonants (except D- and T-) and of SP-, SK- and ST- are relatively higher than those of consonant clusters formed with /r/. A similar phenomenon is seen for NEJJ3 although her s/c value of R- is 0.59, and F- and FR- show the maximum value. When R- is added to TH- (-0.50) for NEJJ3, the WF THR- becomes the most difficult for her (-1.00). NEJJ5, who got 1.00 for R- and 0.60 for TH-, has the best grade for THR- (1.00) among the five students. She scored perfectly not only in THR- but also in FR-, DR-, SJR-, STR-, SPR- and SKR-. However, she is not good in BR-, PR-, GR- and KR- though very good in the single consonants B-, P-, G- and K-. When /r/ is combined with a labial or a velar, it is difficult for her to pronounce it; but if /s/ is added to PR- and to KR-, it is easy for her. In contrast with R-, -R (for which the average s/c percentage value for the five students was 50) ranges from 0.38 to 0.80. as is shown in Table 2, and no one succeeded in getting a perfect score. But all five students were perfect in

Table 1. The s/c values of five students for R- and L- and for their associated consonantal WF's.

	R-	BR-	PR-	GR-	KR-	SPR-	SKR-	FR-	DR-	TR-	THR-	SJR-	STR-
NEJJ1	1.00	0.66	0.57	0.59	0.50	0.33	0.66	0.66	1.00	0.72	0.33	0.50	0.59
NEJJ2	-0.66	1.00	0.75	0.33	0.37	0.66	0.63	1.00	0.59	0.38	0.37	0.42	0.66
NEJJ3	0.59	0.66	0.77	0.42	0.59	0.75	0.66	1.00	0.42	0.33	-1.00	-0.33	0.28
NEJJ4	1.00	1.00	0.83	1.00	0.66	1.00	1.00	0.40	1.00	1.00	0.50	1.00	0.75
NEJJ5	1.00	0.67	0.80	0.67	0.60	1.00	1.00	1.00	1.00	1.00	0.87	1.00	1.00

	S-	B-	P-	G-	K-	SP-	SK-	F-	D-	T-	TH-	SJ-	ST-
NEJJ1	0.61	0.76	0.78	1.00	0.82	1.00	0.89	0.76	0.92	0.68	0.75	0.63	0.71
NEJJ2	0.42	0.50	0.58	0.42	0.44	1.00	0.69	0.33	0.41	0.51	0.71	0.33	0.75
NEJJ3	0.84	0.72	0.80	0.69	0.89	0.79	0.76	1.00	0.88	0.65	-0.50	0.66	0.83
NEJJ4	0.94	0.84	1.00	1.00	1.00	0.66	0.93	0.79	0.86	0.95	0.59	0.83	1.00
NEJJ5	0.86	0.92	0.88	0.85	0.83	1.00	0.89	0.86	0.83	0.87	0.60	0.85	1.00

	L-	BL-	PL-	GL-	KL-	SPL-	SKL-	FL-	SL-
NEJJ1	0.89	0.33	0.75	0.33	0.79	0.33	1.00	0.62	0.57
NEJJ2	1.00	0.50	-0.66	-0.66	0.69	0.66	0.50	0.28	0.38
NEJJ3	0.50	0.33	0.33	0.37	0.30	0.08	0.50	0.50	0.30
NEJJ4	0.94	0.72	1.00	1.00	1.00	1.00	0.50	0.79	0.79
NEJJ5	0.79	1.00	1.00	0.67	1.00	0.67	-1.00	0.67	0.75

Table 2. The s/c values of five students for -R and its associated single consonantal WF's.

	-R	-RM	-RN	-RP	-RB	-RT	-RD	-RK	-RTJ	-RDJ	-RTS	-RDZ	-RF	-RV
NEJJ1	0.80	1.00	1.00	0.50	1.00	1.00	1.00	1.00	1.00	0.67	1.00	0.50	1.00	0.50
NEJJ2	0.38	0.40	1.00	0.25	1.00	-1.00	0.75	0.67	1.00	0.50	1.00	-0.67	1.00·	0.50
NEJJ3	0.43	0.50	0.67	-0.33	1.00	0.50	0.20	0.67	1.00	0.50	1.00	0.40	0.00	0.00
NEJJ4	0.40	1.00	1.00	1.00	0.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NEJJ5	0.50	1.00	1.00	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

	-RS	-RZ	-RTH	-RSJ	-RL	-RST	-RFT	-RKT	-RPT	-RTJT	-RBD	-RDJD	*RLD
NEJJ1	0.67	1.00	0.20	0.50	1.00	0.50	0.67	0.67	1.00	1.00	1.00	1.00	-1.00
NEJJ2	1.00	0.50	0.50	0.00	1.00	-1.00	1.00	-0.50	-1.00	1.00	1.00	-1.00	-1.00
NEJJ3	1.00	0.29	0.67	1.00	1.00	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NEJJ4	1.00	1.00	0.50	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-1.00
NEJJ5	1.00	0.40	1.00	1.00	1.00	1.00	1.00	0.25	1.00	1.00	1.00	1.00	1.00

	-RMD	-RND	-RVD	-RFS	-RKS	-RPS	-RTHS	-RBZ	-RLZ	-RMZ	-RNZ	-RVZ	*RMTH
NEJJ1	1.00	0.50	1.00	1.00	1.00	0.50	0.33	1.00	1.00	1.00	1.00	1.00	1.00
NEJJ2	-1.00	1.00	0.50	0.00	0.00	1.00	0.33	0.00	0.00	0.33	0.00	0.67	1.00
NEJJ3	1.00	1.00	1.00	1.00	1.00	0.67	1.00	0.25	1.00	0.33	1.00	0.33	1.00
NEJJ4	0.50	1.00	1.00	1.00	1.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00
NEJJ5	0.00	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

	-M	-N	-P	-B	-T	-D	-K	-TJ	-DJ	-TS	-DZ	-F	-V
NEJJ1	0.38	0.67	0.87	0.40	0.67	1.00	0.75	1.00	1.00	1.00	0.22	0.78	1.00
NEJJ2	1.00	1.00	0.57	0.33	0.62	1.00	0.55	0.62	0.36	1.00	0.25	0.70	0.40
NEJJ3	0.50	0.80	0.87	1.00	0.69	1.00	0.67	0.60	0.44	1.00	0.22	0.67	0.38
NEJJ4	1.00	1.00	1.00	1.00	0.96	0.86	0.77	-1.00	1.00	1.00	1.00	1.00	1.00
NEJJ5	1.00	1.00	1.00	1.00	0.88	0.71	0.93	1.00	1.00	1.00	0.67	0.86	1.00

	-S	-Z	-TH	-SJ	-L
NEJJ1	0.71	0.67	1.00	1.00	0.47
NEJJ2	0.83	1.00	1.00	0.22	0.62
NEJJ3	0.70	1.00	1.00	0.75	0.42
NEJJ4	0.94	0.60	1.00	0.75	1.00
NEJJ5	0.78	0.67	1.00	1.00	0.67

* The count value of the WF is 1.

pronouncing some final consonant clusters involving /r/: -RTJ, -RTJT, -RTS and -RBD; and the relevant single consonants -TJ, -T, -TS, -B and -D were pronounced well except -B for NEJJ1 (0.40) and for NEJJ2 (0.33), and -TJ for NEJJ4 (-1.00). The five students got the maximum s/c for -TH, but only one student (NEJJ5) succeeded in 1.00 for -RTH and the other four had comparatively low grades, from 0.20 to 0.67, for -RTH. Another interesting result is that one student (NEJJ4) with the maximum s/c for -L, got zero for -RL and that the other four, with rather poor grades for -L (from 0.42 to 0.67), were perfect in -RL.

In a comparison of R- with the other liquid, L-, we find that the three students who had the highest s/c (1.00) for R- did not get 1.00 for L- but 0.89, 0.94 and 0.79, respectively, as is shown in Table 1. However, each of them was graded 1.00 in a cluster or clusters involving /l/ as a constituent. NEJJ1 reached 1.00 in SKL-; NEJJ4 in PL-, GL-, KL- and SPL-; and NEJJ5 in BL-, PL- and KL-. As for NEJJ4, her gardes on L-, BL-, PL- and KL- contrast notably (but not consistently) with her grades on R-, BR-, PR- and KR-. NEJJ3 scored 0.59 for R- and 0.50 for L-. NEJJ2, succeeding in L- 100%, is the one who scored the lowest s/c (-0.66) for R- among the five, but she is not good at all in consonant clusters that contain /l/. This is contrasted with the fact that she is very good in a few clusters with /r/, though lowest in R-. The significance of all these variations, both among students and among WF's, might be clearer if we had more extensive data.[4]

2. Component Additivity Test

In order to see generally how the difficulty of a consonant contributes to the difficulty of a consonant cluster containing it, the Component Additivity Test program was designed. Part of the results processed by this program are shown in Table 3.[5] The WF in the form of a cluster is listed in the second column and its difficulty level in the first column. The next column, "Word Feature Components (WFC), " consists of four sub-columns, in which

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4) A more detailed study of students' performance in perception of selected consonant pairs such as /r/ vs. /l/ is scheduled, using a new test-training program. See "Summary and Remarks on Further Study, " below.

5) This program was designed by Mmes. K. I.Harada and H. Gunji, but no use of this post-session program has been reported on.

Table 3. Part of the results processed by the Component Additivity Test program

WFL	WF	WORD FEATURE COMPONENTS (WFC)				S/C (PERCENTAGE)					WFC COUNT=1 WF				
		1	2	3	4	W-A	W-M	W	A	M	1	2	3	4	W
1	SK-	S- 85	K- 90	0	0	-11	-9	76	87	85					1
1	BL-	B- 72	L- 50	0	0	-28	-17	33	61	50					
1	BY-	H- 72	Y- 86	0	0	21	28	100	79	72					
1	FY-	F- 64	Y- 86	0	0	25	36	100	75	64					
1	-SK	-S 70	-K 67	0	0	-2	-1	66	68	67					
1	-LP	-L 42	-P 88	0	0	10	33	75	65	42					
1	-LR	-L 42	-B 100	0	0	29	58	100	71	42					
1	-KST	-K 67	-S 70	69	0	32	33	100	68	67			-1		
2	ST-	S- 85	T- 65	0	0	8	18	83	75	65					
2	SM-	S- 85	M- 85	0	0	-19	-19	66	85	85					
2	HY-	H- 72	Y- 86	0	0	-79	-72	0	79	72					
2	KY-	K- 90	Y- 86	0	0	12	14	100	88	86					
2	MY-	M- 85	Y- 86	0	0	15	15	100	85	85					
2	-SP	-S 70	-P 88	0	0	-54	-45	25	79	70					
2	-MP	-M 50	-P 88	0	0	31	50	100	69	50					
2	-LT	-L 42	-T 69	0	0	45	58	100	55	42					
2	-NT	-N 80	-T 69	0	0	-8	-3	66	74	69					
2	-PT	-P 88	-T 69	0	0	22	31	100	78	69					
2	-SJT	-SJ 75	-T 69	0	0	-22	-19	50	72	69					
2	-DHD	-DH 100	-D 56	0	0	22	44	100	78	56					
2	-DJD	-DJ 44	-D 56	0	0	0	6	50	50	44					
2	-GD	-G 60	-D 56	0	0	17	19	75	58	56					
2	-NGK	-NG 33	-K 67	0	0	-22	-5	28	50	33					
2	-RK	-R 43	-K 67	0	0	11	23	66	55	43					
2	-LTJ	-L 42	-TJ 60	0	0	-35	-26	16	51	42					
2	-LDJ	-L 42	-DJ 44	0	0	57	58	100	43	42					
2	-NDJ	-N 80	-DJ 44	0	0	38	56	100	62	44					
2	-LF	-L 42	-F 67	0	0	46	58	100	54	42					
2	-RV	-R 43	-V 38	0	0	-40	-38	0	40	38					
2	-KS	-K 67	-S 70	0	0	-18	-17	50	68	67					
2	-PS	-P 88	-S 70	0	0	21	30	100	79	70					

are listed WF components (henceforth WFc's) of the WF in the second column. If there are four WFc's forming the WF, four sub-columns are filled. If there are not more than two WFc's in the WF, the numeral "0" is written in the third and fourth sub-columns or in the fourth sub-column only (see for example the first line for SK- and the eighth line for -KST). The numerical value on the right side of a WFc indicates the s/c in percent of the WFc. There are five sub-columns in the column of "s/c (percentage)": W indicates the s/c value in percent of the WF listed in the second column; A, the average of the s/c values in percent of the WFc's of that WF; M, the minimal s/c value in percent for WFc's of the WF. W-A stands for W minus A, and W-M, W minus M. In the column "WFc Count = 1", the numerals 1, 2, 3 and 4 indicate sub-columns corresponding to the numerals in the third column; and each sub-column is filled in by the numeral 1 when the count of the WFc is 1. The last sub-column, "W", is filled in by 1 when the count of the WF in the second column is 1. When both W-A and W-M have negative values, for example, -11 and -9 for SK in the first line, we conclude that the difficulty of SK- is greater than the average difficulty of the WFc's, and than that of the most difficult of the WFc's (having the minimal s/c value): namely, SK is more difficult for this student than S- or K-, or the difficulty of SK- is not related to the individual difficulty of S- or K-. When both W-A and W-M have positive values, like 29 and 58 for -LB in the seventh line, this means that -LB is easier than the independent -L or -B, or -LB has become easier for this student when -L and -B are combined. When both W-A and W-M are zero, the difficulty of the WF and WFc's are the same. When W-A is negative or zero and W-M is zero or positive, the WF is a little more difficult than the average of the WFc's, or as difficult as the average, but the difficulty of the WF is equal to or lower than that of the most difficult WFc. -LDJ is shown to be much easier when -L and -DJ are combined (W-A: 57, W-M: 58), while the difficulty of -LTJ increased when -L and -TJ are combined (W-A: -35, W-M: -26).

This program makes it possible to see for example how the addition of morphological endings to a WF influences the difficulty in pronouncing the WF. [6] We have determined from the values of W-A and W-M that when mor-

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6) For some relevant discussions, see K. I. Harada, op. cit.

phological endings, -S, -Z, -T and -D, are added to a WF, they do not increase crucially the difficulty of the WF for four of the five students (especially for NEJJ4); they give additional difficulty to NEJJ2. Table 4 whos the number of the WF's in the form of a cluster, which are sorted into three categories according to the value of W-A or W-M. Apparently more than half of the WF's (perhaps except for NEJJ2) are simplified in pronunciation in comparison with the WFc's themselves.

Table 4. The number of WF's in the form of clusters, in three groups according to the value of W-A and W-M.

	W-A			W-M		
	-	0	+	-	0	+
NEJJ1	75	5	105	56	8	121
NEJJ2	101	0	84	90	3	92
NEJJ3	83	3	99	61	11	113
NEJJ4	40	16	129	35	18	132
NEJJ5	46	5	134	40	10	135

Four students (NEJJ1, NEJJ2, NEJJ3 and NEJJ5) did not succeed in -L. Their s/c values for -L are 0.47, 0.62, 0.42 and 0.67, respectively. As is shown in Table 5, except for NEJJ2 it is possible to say that the addition of one or more consonants does not always increase difficulty, but may help the student achieve acceptable pronunciation of a WF. The cluster -LV is more difficult for NEJJ1 than -L and -V averaged, but -LVZ is easier than -L, -V and -Z averaged. -LTH is made difficult for NEJJ3 by combining -L ith -TH, but her pronunciation improves with the addition of -S to -LTH. The value of W-A for -LDZ is negative for all five students. They had more difficulty in pronunciation of the combination of -L and -DZ than for -L and -DZ independently. The WF they all had less difficulty pronouncing as a cluster is -LT.

Table 5. The consonant clusters of -L sorted into three groups according to the average of W-A.

W-A < 0					W-A = 0					W-A > 0				
NEJJ1	NEJJ2	NEJJ3	NEJJ4	NEJJ5	NEJJ1	NEJJ2	NEJJ3	NEJJ4	NEJJ5	NEJJ1	NEJJ2	NEJJ3	NEJJ4	NEJJ5
								-LP		-LP	-LP	-LP		-LP
								-LB		-LB	-LB	-LB		-LB
										-LT	-LT	-LT	-LT	-LT
-LTJ		-LTJ									-LTJ		-LTJ	-LTJ
			-LDJ							-LDJ	-LDJ	-LDJ		-LDJ
								-LF		-LF	-LF	-LF		-LF
	-LST	-LST								-LST			-LST	-LST
		-LFT								-LFT	-LFT			-LFT
*RLD	*RLD											*RLD	*RLD	*RLD
-LKS											-LKS	-LKS		-LKS
-LPS	-LPS	-LPS											-LPS	-LPS
	-LVZ									-LVZ		-LVZ	-LVZ	-LVZ
		*LFTH						*LFTH		*LFTH	*LFTH			*LFTH
	-LM	-LM	-LM							-LM				-LM
-LD	-LD			-LD								-LD	-LD	
	-LK									-LK	-LK	-LK		
-LDZ	-LDZ	-LDZ	-LDZ	-LDZ										
-LV	-LV	-LV						-LV						-LV
		-LS								-LS	-LS		-LS	-LS
-LZ	-LZ	-LZ											-LZ	-LZ
		-LTH						-LTH		-LTH	-LTH			-LTH
*LSJT	*LSJT	*LSJT											*LSJT	*LSJT
-LMZ	-LMZ				-LMZ								-LMZ	-LMZ
								*LN		*LN	*LN	*LN		*LN
		*LSJ								*LSJ	*LSJ		*LSJ	*LSJ
			-RL							-RL	-RL	-RL		-RL
	-LKT									-LKT		-LKT	-LKT	-LKT
	-LPT									-LPT		-LPT	-LPT	-LPT
-LTJT	-LTJT	-LTJT											-LTJT	-LTJT
	-LBD		-LBD	-LBD						-LBD		-LBD		
	-LDJD									-LDJD		-LDJD		-LDJD
	-LVD		-LVD							-LVD		-LVD		-LVD
	-LFS									-LFS		-LFS	-LFS	-LFS
-LBZ	-LBZ	-LBZ											-LBZ	-LBZ
	-RLZ									-RLZ		-RLZ	-RLZ	-RLZ
-LMD	-LMD											-LMD	-LMD	-LMD
	-LTHS		-LTHS	-LTHS						-LTHS		-LTHS		
	*LNZ			*LNZ						*LNZ	*LNZ		*LNZ	

* The count value of the WF is 1.

3. Vocalic WF's

Since the saturation of the s-value at +9 was eliminated after the first series of experiments by modifying the testing program in this respect, we may be able to obtain some significant s/c value for fifteen vocalic WF's. as is shown in Table 6, and see how students perform on those vowels. Looking over the average s/c (in percent), we find that no WF reaches an s/c value of 85 or more. Eight WF's are to belong to Level 3, six to Level 4 and one to Level 5 if we follow the Level Improvement method mechanically. However, we should take some specific conditions concerning vocalic WF's into consideration. Vocalic WF's are presented many times in different contexts, with different consonants, during the test session. The average number of times a vocalic WF is presented (namely, the average count value) is 41 per test. However, E (which is assigned to Level 1) is presented from 138 to 159 times for the five students while UR(Level 5) is presented

Table 6. Vocalic WF's

Assigned level	WF	Expected average s/c in percent	Obtained average s/c in percent	average c
1	E	$\% = 100$	75	149
1	IJ		76	89
2	OJ	$85 \leq \% < 100$	74	24
2	UW		70	55
3	OA		75	71
3	AJ	$70 \leq \% < 85$	81	19
3	AW		76	18
3	OW		41	21
4	AE		66	31
4	A	$50 \leq \% < 70$	81	52
4	UA		81	35
4	EJ		68	10
5	I		60	31
5	UU	$\% < 50$	58	6
5	UR		64	4
			average	41

only from two to seven times. The number of counts (c) can be increased with the number of states (s) unchanged according to the algorithm[7] when we cannot determine which WF causes a student to fail in pronouncing the word (when it is judged as NO). For example, as is discussed in the previous report,[8] when the student is given a NO judgment on a word, we cannot identify the trouble spot of her pronunciation in case the states of all WF's in the word are positive or two of them negative, or in case the states of all WF's in the word are negative. Thus the "count" value increases, and the computer looks for the WF in another context to be tested. This procedure will be repeated until the s value of all WF's of a word reaches a threshold value of +2 or at least one WF of a word reaches a threshold value of -4 (the threshold value is set at the start of each test session). The more a WF appears in the test, the more the WF is exposed to the possibility of increasing its value without increasing s and the farther from the true grade s/c becomes. The vocalic WF's, especially E and IJ, tend to suffer this effect often. The lowest average s/c in percent obtained is 41 for OW. The reason for this value is that one student (NEJJ5) got a negative s/c of -0.5. This is the only negative value among the fifteen vocalic WF's in five students. We can think of one factor concerning this peculiarity: the evaluator for NEJJ5 was different from the one for NEJJ1 through NEJJ4, and the acceptability for a pa ticular WF might differ somewhat between evaluators.

Despite these problematic points, which should be considered in evaluating the results, we have obtained some general characteristics of the pronunciation of vowels. Taking the average c value of 41 into consideration, we regard first as an object of analysis E ([ɛ]), IJ ([i]), UW ([u]), OA ([ɔ]), and A ([ɑ]), each of which was tested more than 41 times ($c \geq 41$), which is the average number of times each vowel occurred. Since the s/c in percent of all the WF's except UW exceeds 70, we conclude that E, IJ, OA and A are comparatively easy for the five students. Following these five WF's, UA ([ʌ]), AE ([æ]) and I ([ɪ]), whose average c's are close to the value of

7) O. Fujimura, "Technological Developments for Language Learning, " Annual Bulletin No. 3, 81-110 (1969).
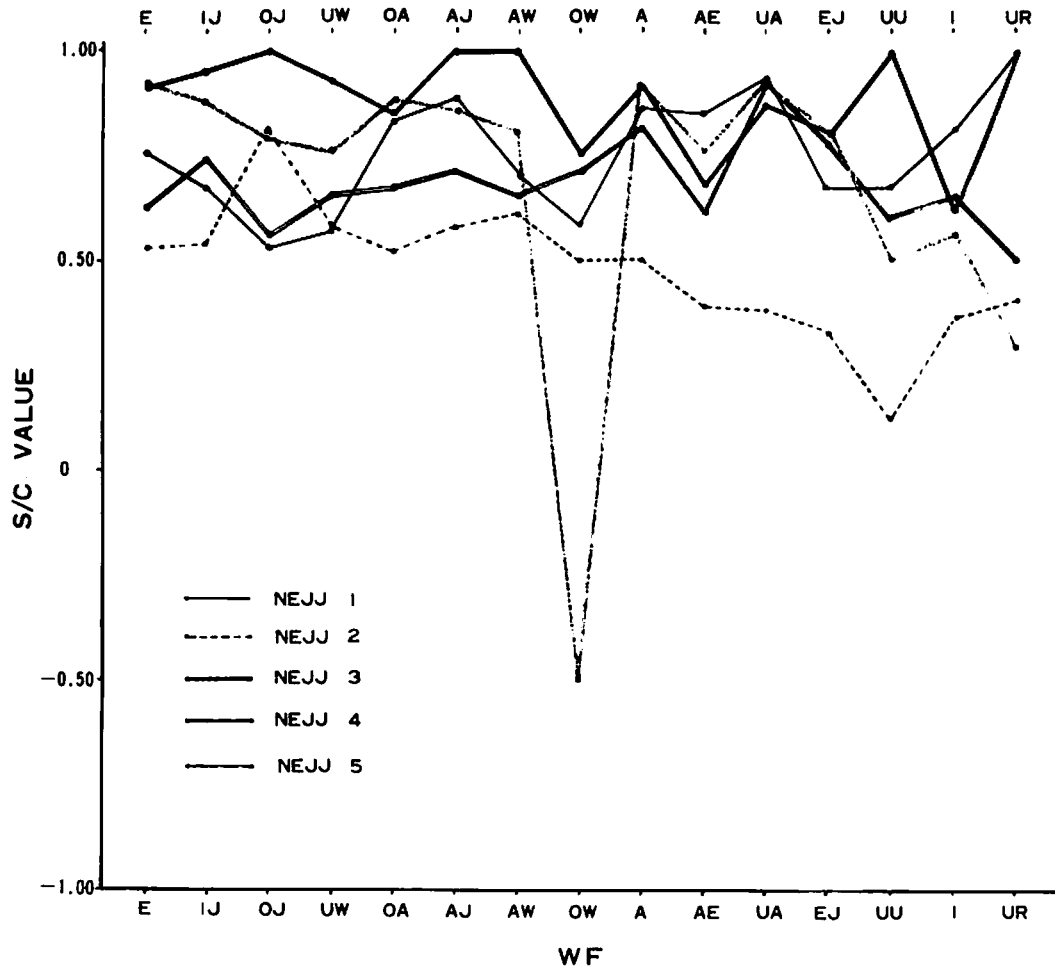
8) K. I. Harada, op. cit.

Fig. 3. The s/c values of vocalic WF's (five students).

41, are taken up. Among these three WF's UA has a good s/c in percent (81), and can be added to the first category with the four WF's. If the above-mentioned artifact were to be avoided on E and IJ, the s/c for the two WF's would be higher. NEJJ2's s/c value for A is put aside because her result is extraordinarily far away from the others, as is shown in Fig. 3; the s/c values of the other four students for A are very close to each other, varying from 0.82 to 0.93. The same is true of the s/c for UA except for NEJJ2: it ranges from 0.87 to 0.94. The distribution of the s/c value for UA is much smaller than that for A. Incidentally, from the viewpoint of distribution, the AE distribution (except for NEJJ2) is also relatively limited, 0.61 to 0.85, although the average s/c value in percent for AE is 66. Thus, except for NEJJ2, comparatively less variation among students is observed on lax vowels.

Summary and Remarks on Further Study

One of the main points of this second-stage experiment is that the vocalic WF's were subject to post-session analysis deriving relative difficulty levels among them. Also it was often observed that a student failed in a certain single consonant WF but she performed better in associated complex WF's; this seemed more often true than the contrary. The difficulty of a consonant cluster is relatively independent of that of each constituent consonant in the cluster, and it is quite understandable to experience the failure of a WF in a certain context and the success of the WF in another context. These findings lead us to the following conclusions:

(1) Each WF has its own level of difficulty

(2) A consonant cluster 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

which were our starting hypotheses in the design of this test-training system.

The difficulty of a WF in a certain context varies greatly from student to student. The present algorithm has an inherent limitation in that it would allow the s/c value of a WF, once it is established as positive, to remain positive through the test session, even if it were true that it eventually became the cause of failure in pronunciation. This situation, whose occurrence is difficult to avoid entirely, would immediately affect the significance

of our calculation of s/c values. We may need a better objective measure of students' ability.

As for the problem of discrimination of [r] and [l] which was discussed above, we made a list of 68 minimal pairs of the WF's R- and L- based on One-Syllable Words by Henry Moser and on A Pronouncing Dictionary of American English by Kenyon and Knott, and have recorded those pairs on hybrid magnetic tape. The WF's other than R- and L- and their associated WF's used in the list are five vocalic WF's (E, A, IJ, OW and UW) and a set of ten single initial consonants and seventeen single final consonants which are combined with /r/ and /l/ to form consonant clusters and monosyllabic words. In order to have a quick check on the ability in single consonants of students who will take this test, we placed 83 monosyllables made of those single consonants and the five vowels before the R-/L- minimal pairs. The number of the WF's included in these monosyllables is at least two. Part of the printout list is shown below (Fig. 4). The computer program for this

```
023002095000GUESS     GES      GES
019002088000BEG       BEG      BEG
021008083000DEEP      DIJP     DIJP
022002089000KETCH     KETJ     KETJ
029008098000SEETHE    SIJDH    SIJDH
000002084000EBB       EB       EB
000013087000AK        OWK      OWK
029008081000SCENE     SIJN     SIJN
020013086000TOAD      TOWD     TOWD
022013094000COVE      KOWV     KOWV
033014096000SHOES     SJUWZ    SJUWZ
018004085000POT       PAT      PAT

          :
          :

057002099000FRESH     FRESJ    FR
056002086000FLED      FLED     FL
038002088000LEG       LEG      L
037002081000WREN      REN      R
037002080000REM       REM      R
045002086000BLED      BLED     BL
038002080000LEM       LEM      L
038002086000LED       LED      L
046002086000BREAD     BRED     BR
038002081000LEN       LEN      L
056002099000FLESH     FLESJ    FL
037002088000REG       REG      R
```

Fig. 4. A list of words for concentrated testing on the /r/:/l/ distinction in different contexts.

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test is now being completed. This new test will be available in the labora-
tory in the near future so that any student can make use of the test by him-
self anytime for test-training for discrimination of R- and L-. Focusing on
another set of WF's, concerning e.g. /s/ vs. /θ/, we can have other test-
training material with use of the same program. It may be one of the prac-
tical tools for language learning.

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