Effects of Certain Variables on Speech of Cleft Palate Persons

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Stress, rate, and rhythm are speech variables which conceivably might affect certain aspects of speech effectiveness of cleft palate speakers. Among methods for remediation of speech problems among cleft palate speakers, the writer (*8*) has suggested careful training in coarticulation of CV combinations in unstressed and less stressed syllabic environments. He has observed that cleft palate speakers tend to articulate affricates, fricatives, and plosives better in stressed syllables than in syllables of reduced stress. However, there has been no objective evidence that would support or refute this impression. The writer (*8*) has also suggested reduction in speaking rate of cleft palate speakers. Although this variable has been studied (*10*), its effect on ratings of any parameter of speech defectiveness of such speakers has not been reported in the literature. In a comparative study of rate characteristics in cleft palate and noncleft palate adult male speakers, Lass and Noll (*10*) reported differences in oral reading, impromptu speaking, and rate alteration between the two groups of subjects. All these differences indicated slower mean rates of speaking among the cleft palate subjects. Tarlow and Saxman (*20*) reported that their young (7–9 year old) cleft palate subjects had smaller word per minute reading rate (105.4 wpm; range of 60.6 to 166.8 wpm) than their matched noncleft palate control subjects (164.8 wpm; range of 123.0 to 212.4 wpm). (*8*) From the findings of Lass and Noll (*10*) and Tarlow and Saxman (*20*), one might infer that cleft palate speakers generally sense a need to speak more slowly to achieve more proficient articulation, greater intelligibility, and possibly even improved voice quality. In terms of information theory (*15*, p. 156), improvement in the speech of the speaker, as well as more effective reception of information by the listener, should occur at slower speaking rates among speakers who are generally characterized by articulatory inaccuracy and intelligibility loss. In the encoding and decoding of General American speech, rhythm appears to be a means of contributing to meaning. Although four basic rhythms—iambic, trochaic, anapestic, and dactylic—are most discernible in poetic literature,

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This research was supported by a JAC/UAC faculty research fellowship-grant in aid award through the Research Foundation of the State University of New York. It was conducted in conjunction with the Fifth Annual Day Care-Residential Summer Cleft Palate Speech Program at the State University College at Buffalo.

it seems reasonable that these basic rhythms and their combinations are subtly yet inextricably interwoven into the linguistic code. Review of the literature failed to discover any study of the possible effect of rhythm on any parameter of speech proficiency or defectiveness.

The purpose of this study was to determine the relative effects of stress, rate, rhythm, and phonemic type on various parameters of perceived speech proficiency among cleft palate speakers. The perceptible variables under study were articulatory proficiency, intelligibility, and nasality. Phonemic type was included for study principally to complete the intended design. Relative ability of cleft palate speakers to articulate various patterns of phonemes (e.g., affricates, fricatives, and plosives) has been sufficiently reported. (*1, 13, 14, 16, 18, 22*) Fricative, plosive, and distortion-nasal errors have been reported as correlating more highly with rated nasality than errors on other types of consonants. (*22*) There may be question, however, as to whether affricates and fricatives, as compared with plosives, might differentially affect ratings of nasality.

Procedure

Overall Design. Twenty cleft palate speakers were trained to utter test sentences on signal. These sentences representd two rhythm patterns (iambic and trochaic) and two conditions of syllabic rate (fast and slow). Two general types of consonantal phonemes (plosives and fricatives-affricatives) constituted the sentence loading factor under conditions that allowed CV coarticulation in either stressed syllables or syllables of less stress or unstress. The subjects were trained and tape recorded in groups of five. Within each training group sentences were tape recorded in a randomized sequence for speaker, rhythm, rate, phoneme type and syllabic stress. The recorded tape samples were rearranged in a rotational procedure that insured probability of each subject appearing once every 20 playback sentences. No two consecutive sentences were from the same subject. The rearranged tapes were played back for auditor judgments of articulatory proficiency, intelligibility, and nasality.

Subjects. Twenty subjects, all receiving speech therapy in the annual Day Care-Residential Summer Cleft Palate Speech Program at the State University College at Buffalo, were employed in the study. They ranged in age from seven to 19 years, with a mean age of 11.25 years. Fourteen were males. Nineteen subjects had postoperative cleft of the lip and palate or palate only. Three had prostheses and three had undergone velopharyngoplasty to achieve secondary velopharyngeal restoration. One subject had velopharyngeal incompetency that was believed to be related to a maxillofacial growth problem. All subjects had better ear thresholds in the 250–4000 Hz range (re: ASA 1951 standard) no poorer than 25 dB, and the pure tone average loss for the better ear in this range was no poorer than 17 dB.

Test Conditions. Eight sentences were fashioned to represent the two

rhythm patterns, the two conditions of rate, the two types of consonantal phonemic loading, and the two conditions of syllabic stress. The eight sentences are: (1) I carry Paula too. (2) I hit a rocky loop. (3) I feel a sorry chill. (4) Aloof, alas, I itch. (5) Perry tore a collar. (6) Lighter limpy walk, Al. (7) Follow Sally, Charley. (8) Watch a ruffian wrestle.

Sentences 1–4 were designed to represent iambic rhythm (–/–/–/), whereas sentences 5–8 appeared to fit a trochaic (/–/–/–) rhythm pattern. For phonemic loading, sentences 1, 2, 5, and 6 were designed to include the /p/, /t/, and /k/ phonemes; sentences 3, 4, 7, and 8 were loaded with /f/, /s/, and /tʃ/ phonemes. For these phonemes coarticulation occurs in a stressed syllabic environment in sentences 1, 3, 5, and 7. The other sentences allow CV coarticulation of these phonemes in less stressed or unstressed syllables. In the less stressed or unstressed syllabic condition it was necessary to allow the phoneme to close the syllable at the end of the sentence (see sentences 2 and 4) to maintain the proper rhythm pattern. In sentence 8, /f/ also coarticulates with /j/.

To achieve sentence balance otherwise, a representative sampling of vowels, high to low and front to back, was provided. It seemed necessary to preclude differential effect of vowels on perception of nasality, since it had been determined in previous studies (*7*, *17*) that vowels affect the perception of nasality among cleft palate speakers in terms of high-to-low and front-to-back tongue positions. Where possible, other CV coarticulatory combinations were designed to include glides like /l/, /r/, and /j/, since such sounds have been found to have less effect on the perception of nasality. (*22*) They also tend to be articulated comparatively well by cleft palate speakers. (*1*, *3*, *13*, *16*, *22*) In one sentence (see sentence 2) the /h/ phoneme was also employed.

The test sentences were replicated in two conditions of speaking rate, 3.33 syllables per second and 5.00 syllables per second. These speaking rates were chosen to approximate roughly the extremes of the Fairbanks (*5*, p. 115) rate scale.

Training and Recording Subjects. Prior to the final training and recording session, all subjects had been trained by their clinicians to follow various rhythm patterns and rates in sample sentences. The final training and recording was done in a quiet room (as measured on a Bruel and Kjær sound level meter, Model 2203, linear and C-scale readings were 67 dB and 66 dB, respectively).

To avoid confusion the subjects were trained and recorded in groups of five. Prior to training and recording, the 80 sentences, representing 16 test conditions for each of five subjects, were randomized, with the additional provision that no given subject would follow himself in the resulting sequence. Each sentence was first demonstrated for the subject at the appropriate metronomic rate, using a Seth Thomas metronome and the stimulus speech of the experimenter. After sufficient training, which varied from one to three subject trials, the tape recorder was turned on, the num-

ber of the test sentence was announced, and the recording was made. Where necessary, the sentence was rerecorded. Five seconds of silence was allowed to elapse to permit time for future auditor judgments. The tape recorder was stopped, another subject was trained for his sentence under its prescribed conditions, and so on.

After all 20 subjects had been trained and tape recorded in this fashion, the test sentences from the four reels (one for each training session) were rotated as follows. The first five test sentences from the first reel were spliced to the sixth through tenth sentences from the second reel. To these were added the eleventh through fifteenth sentences from the third reel, then the sixteenth through twentieth sentences from the fourth reel, and so on. In this manner the 320 test sentences were reassembled in a randomized and rotational sequence.

Recording and Playback Equipment. The tape recorder employed for recording and playback (at 7½ in. per sec) was a SONY Tape Recorder, Model TC-105. According to the manufacturer's specifications, this instrument, with a crystal microphone, has a frequency response of unspecified intensity variation for the 40–18000 Hz range. Playback for auditor judgments was directly from the tape recorder speaker in a quiet room (as measured on the B and K sound level meter, linear and C-scale readings of 56 dB and 50 dB were obtained). This arrangement for auditor judging seemed preferable to the use of a soundproof suite, since the room had the advantage of being air conditioned during rest periods. Carpeting and drapes enhanced its acoustic properties. The conditions for auditor judgment were very good, since the college was not in session at the time, and the listening was done in the evening hours. In the opinion of the judges, the fidelity of recordings in playback conditions was excellent.

Rating Scales. For judging *articulatory proficiency*, a discrete numerical scale, ranging from *one* to *seven*, was used. The judges were asked to judge only three consonants in each test sentence, and to ignore the rest of the sentence. The consonants to be judged were either /p/, /t/, and /k/ (occurring in half the sentences), or /f/, /s/, and /tʃ/ (in the remaining sentences). For each sentence judged the sentence appeared on the rating sheet, with each of the three appropriate consonants underlined. A rating of *one* was assignable to correct articulation on all three consonant sounds, regardless of other possible errors or perception of nasality. For perceptible nasal emission, slighting, or slight distortion on any one of the three consonants, a value of *one* was to be added. Thus if there were nasal emission, slighting, or slight distortion on all three consonant sounds, the assigned rating would be *four* (*one* plus *three*). However, where any one of the three consonants was clearly in error because of loss of phonemic entity (omission, glottal substitution, velar or pharyngeal articulation, lateral distortion, General American substitution, etc.) a value of *two* was to be added. Therefore if glottal or pharyngeal articulation characterized all three consonants, or if they otherwise lost phonemic entity

in the opinion of the judges, the assigned rating would be *seven* (*one* plus *six*). In this manner of discrete rating, it was possible to have ratings of articulatory proficiency ranging from *one* to *seven*. This rating procedure was necessary to focus judgments of articulatory proficiency on those consonant types representing test conditions.

The ratings of *intelligibility* and *nasality* employed seven point equal-appearing-intervals rating scales, as suggested by Thurstone and Chave. (*21*) For *intelligibility*, the judges were asked to make their ratings in terms of how intelligible the sentence, devoid of any other context, would probably be to a layman. A rating of *one* was assignable if the judges considered the sentence to be completely intelligible, with all the words completely understood even by casual listening. A rating of *seven* represented complete unintelligibility, with failure to be understood even by careful listening. For *nasality*, a rating of *one* represented extremely mild or no nasality (including denasality if discernible), and a rating of seven represented extremely severe nasality.

Rating Procedures. Four judges, all of whom possess master's degrees in speech pathology and experience with cleft palate children, were employed. Each of the variables under judgment was dealt with in separate listening sessions. Prior to each listening session five samples of extremes and the midpoint of the continuum for the variable under judgment were presented for training purposes. Following every 40 judgments, approximately 20 sentences were replayed to allow the judges to compare their respective judgments. The 15 training samples were then replayed for retraining to insure stabilization of judgment. This procedure for intermittent training was carried out after every 40 judgments for each of the three judging sessions.

Results

Reliability Measures. The criterion measure for comparison was the median rating of the four judges of the variable under consideration. Reliability for 40 repeated measures was evaluated by Pearson r and t test of significance of mean difference. The r's for articulatory proficiency, intelligibility, and nasality were .91, .93, and .85, respectively. The repeated judgments of intelligibility and nasality yielded respective t's of .83 and .60, which are nonsignificant. The t for repeated judgments of articulatory proficiency, 2.00, was barely significant at the .05 level. However, the actual mean difference was only .14 scale value, and it is felt that the procedure for pretraining and periodic retraining kept judgments of this variable stable. The analysis of covariance between articulatory proficiency and intelligibility for the 320 measures was significant at the .0001 level, with a Pearson r of .80. Articulatory proficiency also correlated with nasality for the total speech sample with an r of .75. These findings suggest that the ratings of articulatory proficiency were rather stable.

Establishing reliability with regard to dispersion of ratings was not in-

tended since only four judges were employed. Although Counihan and Cullinan (*4*) correctly point out that confidence in reliability of Q data above 1.00 for a seven point scale should be constrained, they refer to date based on nine or more judges. For four judges the Q values in the present study are rather low if not significantly so: 1.14 for articulatory proficiency, 1.11 for intelligibility, and 1.26 for nasality. These measures represent one-half the mean range of dispersion of the present judges. Although the restricted ranges of judgment of the present four judges are not statistically assessable (*25*), they are fairly low: .71 for articulatory proficiency, .69 for intelligibility, and .73 for nasality.

METHOD of ANALYSIS. The 320 measures for each of the three variables under study were analyzed in a complete factorial analysis of variance procedure, with rhythm, rate, phoneme type, and syllabic stress in a 2^4 design. (*11*, pp. 254–257)

EFFECTS ON JUDGED ARTICULATORY PROFICIENCY. Phoneme type ($P < .0002$) and syllabic stress ($P < .0001$) were significant main effects on judgments of articulatory proficiency (see Table 1). As shown in Table 2, comparison of means for these factors reveals better articulation (as judged) on plosives than on fricative-affricate consonants. Table 2 also shows that articulation was judged more favorably in those conditions where CV coarticulation occurred in a stressed syllable, as contrasted with a less stressed or unstressed syllable. As seen in Table 1, rhythm ($P < .64$) and rate ($P < .28$) failed to exert significant effects on judged articulatory proficiency. None of the interactions was significant.

TABLE 1. Summary of analysis of variance evaluating effects of rhythm, rate, phonemic type, and syllabic stress on median ratings of articulatory proficiency.

source	*df*	*ms*	*F**	*P less than*
rhythm (Rh)	1	.7508	.210	.64
rate (R)	1	3.9383	1.1591	.28
phonemic type (PT)	1	50.0070	14.7181	.0002
syllabic stress (SS)	1	62.5695	18.4155	.0001
Rh × R	1	.6570	.1934	.66
Rh × PT	1	.0633	.0186	.89
Rh × SS	1	1.0695	.3148	.58
R × PT	1	.0383	.0113	.92
R × SS	1	2.0320	.5981	.44
PT × SS	1	6.7570	1.9887	.16
Rh × R × PT	1	.7508	.2210	.64
Rh × R × SS	1	3.1008	.9126	.34
Rh × PT × SS	1	.4133	.1216	.73
R × PT × SS	1	.2258	.0665	.80
Rh × R × PT × SS	1	.0633	.0186	.89
(within cells)	304	3.3977		
total	319			

* All tests of F are for 1 and 304 degrees of freedom.

EFFECTS ON INTELLIGIBILITY RATINGS. Syllabic stress ($P < .02$) was the only significant main effect on ratings of intelligibility (see Table 3). The other three factors—rhythm, rate, and phoneme type—were insignificant in their effect. None of the interactions was significant. As shown in

TABLE 2. Mean judgments of articulatory proficiency, intelligibility, and nasality under experimental conditions.

experimental conditions	*mean judgments*		
	artic. prof.	*intell.*	*nasality*
rhythm			
iambic	3.77	3.32	4.25
trochaic	3.68	3.57	4.37
rate			
fast	3.84	3.53	4.35
slow	3.62	3.35	4.27
phoneme type			
stop—plosive	3.33	3.37	4.31
fricative—affricate	4.12	3.52	4.31
syllabic stress			
stress	3.28	3.21	4.27
reduced stress	4.17	3.67	4.36
(general means)	3.72	3.44	4.31

TABLE 3. Summary of analysis of variance evaluating effects of rhythm, rate, phonemic type, and syllabic stress on median ratings of intelligibility.

source	*df*	*ms*	*F**	*P less than*
rhythm (Rh)	1	5.0000	1.6988	.19
rate (R)	1	2.8125	.9556	.33
phonemic type (PT)	1	1.8000	.6116	.43
syllabic stress (SS)	1	17.1125	5.8143	.02
Rh × R	1	.2531	.0860	.77
Rh × PT	1	.0031	.0011	.97
Rh × SS	1	.0031	.0011	.97
R × PT	1	.1531	.0520	.82
R × SS	1	.9031	.3069	.58
PT × SS	1	3.4031	1.1536	.28
Rh × R × PT	1	.3125	.1062	.74
Rh × R × SS	1	2.8125	.9556	.33
Rh × PT × SS	1	3.2000	1.0873	.30
R × PT × SS	1	.0000	.0000	1.00
Rh × R × P × SS	1	.3781	.1285	.72
(within cells)	304	2.9432		
total	319			

* All tests of F are for 1 and 304 degrees of freedom.

TABLE 4. Summary of analysis of variance evaluating effects of rhythm, rate, phonemic type, and syllabic stress on median ratings of nasality.

source	*df*	*ms*	*F**	*P less than*
rhythm (Rh)	1	1.0695	.3697	.54
rate (R)	1	.5695	.1969	.66
phonemic type (PT)	1	.0008	.0003	.99
syllabic stress (SS)	1	.6570	.2271	.63
Rh × R	1	1.8758	.6484	.42
Rh × PT	1	.0008	.0003	.99
Rh × SS	1	.9570	.3308	.57
R × PT	1	.0633	.0219	.88
R × SS	1	.5695	.1969	.66
PT × SS	1	3.9383	1.3613	.24
Rh × R × PT	1	.1758	.0608	.81
Rh × R × SS	1	3.7195	1.2857	.26
Rh × PT × SS	1	.0070	.0024	.96
R × PT × SS	1	.6570	.2271	.63
Rh × R × PT × SS	1	.0633	.0219	.88
(within cells)	304	2.8931		
total	319			

* All tests of F are for 1 and 304 degrees of freedom.

Table 2, speech was judged as more intelligible in those conditions where CV coarticulation took place in the stressed syllabic environment. In this regard the effect was similar to that for articulatory proficiency.

Effects on Nasality Ratings. Table 4 indicates that none of the main effects exerted a significant effect on the ratings of nasality. No significant interactions were found.

Discussion

Rhythm. There is no precedent for expectation of any particular effect of rhythm, as delimited in this study, on any of the variables of speech proficiency that were included in the analysis. Thus the lack of significant effect is hardly remarkable. Further research may indicate the relative effect, if any, of anapestic and dactylic rhythms on judged articulatory proficiency, intelligibility, and nasality of cleft palate speakers.

Rate. Lack of significant effect of speech rate on any of the speech variables studied is somewhat surprising, since it is not what might be expected from clinical observation. The respective instructed rates for the present subjects were 3.33 and 5.00 syllables per second, for slow and fast rates. Transposition of these respective syllabic rates to words per minute, using the Rainbow Passage and an estimated syllable/word ratio of 1.5, yields comparable figures of 133 wpm and 200 wpm. According to Fairbanks (*5,* p. 115), these figures represent approximately the second and 96th percentiles for speaking rate, based on several studies. By the

same method of transposition, the present rates are approximately one-half syllable per second slower than the respective rates perceived as 'slow' and 'fast' by normal adult subjects studied by Johnson. (*9*) The speaking rates employed in this study also are closely comparable to the range in mean overall syllabic rates for standard speaking tasks among adult cleft palate speakers studied by Lass and Noll. (*10*) The impromptu speech of the slowest speaking cleft palate speaker in that study (*10*) was almost identical to the present 'slow' rate. However, the fastest impromptu cleft palate speaker in their study (*10*) spoke nearly one syllable per second faster than the rate employed in the present study as a 'fast' rate. There was no objective verification that the subjects in the present study performed at a speaking rate exactly as instructed. It was solely a matter of the experimenter's judgment. There might be merit in further study of the effect of speaking rate, objectively determined, of cleft palate speakers on speech proficiency in several parameters. This seems supportable by the suggestion of a trend for more favorable judgments of articulatory proficiency and intelligibility at the slower test condition employed in this study.

PHONEME TYPE. Finding of significant difference in judged articulatory proficiency between the two phoneme groupings tends to corroborate the results of Subtelny and Subtelny (*18*), found significantly greater incidence of fricative errors than plosive errors. Other studies of young cleft palate children (*1, 16*) and adolescent and adult cleft palate speakers (*3, 13*) consistently report higher incidence of articulatory errors for the affricate and fricative consonants than for the plosives.

Failure of phoneme type to be differentiable in terms of judged intelligibility is not readily interpretable. It is possible that these negative findings may have been partially influenced by the instructions for judging intelligibility. However, it seems more probable that the judges' ability to decode the errors on fricatives, affricates, and plosives may have overridden the instructions for judging this variable. The singular misarticulations of many cleft palate speakers, particularly glottal and pharyngeal articulation, may serve a dual purpose. They may obviate velopharyngeal closure in articulation, and they may be uniquely intelligible to most listeners. Moreover, speech with an overlay of nasal emission usually is rather intelligible. Initially in the judging procedure, one of the judges insisted that he heard pharyngeal articulation on sibilant sounds as 'correct' articulation. Only after considerable training and listening, he judged that he was able to detect the subtle acoustic cues that identify pharyngeal hissing from correct sibilant articulation. If the differentiation of relative articulatory proficiency exists on such fragile lines, one might well understand how easily intelligible pharyngeal (and possibly glottal) articulation tends to be.

Lack of differential effect of phoneme type on perceived nasality in the present study suggests that there was a preponderance of all those

phonemic errors, irrespective of phonemic grouping as tested, among those cleft palate speakers with more nasal voice quality. Likewise, there probably was relatively uniform ability to articulate affricates, fricatives and plosives among those subjects whose voices were judged to be less nasal. This interpretation seems to be borne out by other results in the present study. The correlations between articulatory proficiency and nasality (.75) and intelligibility and nasality (.76) are rather high. These measures are somewhat higher than a comparable measure reported by Subtelny *et al* (*19*), whose findings for intelligibility and nasality (.42) were based on nonsense syllables. The present correlations approximate correlation data reported by McWilliams (*12*), Falck (*6*), and Van Hattum (*23*). Like the present study, these studies are based totally or partly on a connected speech sample.

Syllabic Stress. Present findings of significant effect of syllabic stress on judged articulatory proficiency and intelligibility tend to support the observations of the writer (*8*) concerning the importance of this factor in diagnosis and articulatory therapy with cleft palate speakers. Clinical observation indicates that many cleft palate speakers tend to habituate patterns of consonantal articulation more proficiently in syllabic environments where the consonant combines with the vowel in syllables of relatively greater stress. Conversely, their articulation tends to be poorer in syllables where CV coarticulation involves less stress or lack of stress.

The implications of these findings are fairly obvious from diagnostic and therapeutic viewpoints. The effective identification of misarticulations, probably even patterns of misarticulations, of cleft palate speakers (*1, 2, 24*) might utilize connected speech tasks that require coarticulation in less stressed and unstressed syllables. It is in these syllables that such misarticulations should most commonly occur, according to the present findings. Future research should demonstrate whether this implication is true for specific patterns of error (e.g., nasal emission, nasal snorting, glottal stop, pharyngeal articulation, velar articulation, lateral distortion, etc.)

These findings also suggest that clinicians should give more therapeutic attention to syllabic environments of less stress and unstress in their articulatory therapy. Those conditions most relating to diagnostic identification of symptomatology would also seem to be the conditions most needful of attention in speech therapy.

Summary

The effects of rhythm, rate, phoneme type, and syllabic stress on judged articulatory proficiency, intelligibility, and nasality of cleft palate speakers were studied. Twenty cleft palate speakers were instructed to utter test sentences at each of two rhythm patterns, two rates, two phonemic groupings, and two conditions of syllabic stress. From the tape recorded sentences auditor judgments of articulatory proficiency, intelli-

gibility, and nasality were obtained. The analysis of data indicated that articulatory proficiency was significantly affected by phoneme type and stress of CV coarticulatory environment. Plosive articulation was more favorably judged than a fricative-affricate grouping. Coarticulation of CV combinations in stressed syllabic environments was more favorably judged than such coarticulation in less stressed and unstressed syllables. The condition of stress also similarly affected judgments of intelligibility. That is, coarticulation of CV combinations in stressed syllables was judged as more intelligible than similar coarticulation in less stressed and unstressed syllables. No other effects were significant. Implications for diagnosis and speech therapy were suggested.

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