Phonetic Contexts: Their Effects on Perceived Nasality in Cleft Palate Speakers

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Among the factors found related to cleft palate speech by a number of investigators, those dealing with the phonemic distinction of nasalized/non-nasalized appears as one of the major speech problems of cleft palate speakers. A consistent trend in the literature has revealed the articulatory skills of cleft palate speakers to be influenced to a considerable degree by the presence of perceived nasality (*2, 4, 8, 9, 12, 14, 15, 16, 17, 19*). Phonetic contexts have also been shown to influence the perceived defectiveness of phonemes in cleft palate speakers (*11, 18*). Carney and Sherman (*3*) demonstrated that isolated vowels, isolated CVC syllables, and CVC syllables in a connected speech passage were judged as more nasal on high vowels than on low vowels for cleft palate speakers. These findings appear to be commensurate with the finding that misarticulations are inconsistent in cleft palate speakers. The inconsistent misarticulations may thus be a function of the phonetic context in which the phoneme is tested since nasal distortion may influence judgements of articulatory defectiveness.

Other factors related to cleft palate speech are those of intraoral breath pressure and air flow. Phonemes requiring greater intraoral breath pressure and air flow (*1, 7*) are preceived as being more defective than others (*6*).

The most likely explanation for the occurrence of greater degrees of nasality is that some consonants in conjunction with high vowels make greater demands upon the valving function, i.e., higher points of posterior pharyngeal wall/velar contacts, tighter velopharyngeal seals, and greater velar excursion.

The present study was designed to investigate the extent to which various types of consonants would interact with high and low vowels to affect perceived nasality. Specific information of this type has not been reported by other investigators. It was hypothesized that a hierarchial order of nasality could be identified using VCV syllables, and that less nasality would be perceived in VCV syllables which utilize low vowels as

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compared to high vowels. Further, that the interaction between vowel height and consonants will allow one to identify the postulated hierarchy. Finally, that those consonant sounds found to be most frequently in error in cleft palate speakers will tend to be perceived as more nasal.

Method

SUBJECTS. Sixteen subjects with repaired cleft palate or cleft palate and lip served as the experimental subjects. Fourteen were males and two were females. These subjects were judged by the senior experimenter to demonstrate nasality in their spontaneous speech prior to testing. Oral manometer ratios with bleed were obtained for each of the subjects. The mean for the distribution of ratios was .66, the median .765, the standard deviation .60 and the range .23–.94. The Iowa Pressure Test was also administered. Judgements of perceived nasality (scaling procedure reported below), on a seven point equal-appearing intervals scale, yielded a mean of 5.89, median of 6.215, standard deviation of 3.77 and a range of 3.91–6.89. No individual with an obturator or pharyngeal flap was included in the experimental sample. Subjects ranged in age from 4.8–13.5 years with a mean age of 9 years and median age of 7 years.

EXPERIMENTAL TASKS. In the first speech task each subject imitated the examiner's production of the following vowels: /ɑ/, /ɔ/, /u/, /æ/, /ɛ/, and /i/. Following this the 43 Item Iowa Pressure Test (*12*) was administered to each subject. In the third speech task each subject imitated the production of VCV syllables utilizing the same vowel in the initial and final positions. The following vowels were employed: /ɑ/, /æ/, /ɔ/, /ɛ/, /u/, and /i/. These vowels were used to produce VCV syllables with the consonants in the following order: /l/, /w/, /r/, /j/, /h/, /g/, /d/, /b/, /k/, /t/, /p/, /dʒ/, /tʃ/, /v/, /ð/, /ʒ/, /z/, /f/, /θ/, /ʃ/, and /s/. The production of VCV syllables was counterbalanced so that half of the experimental subjects produced VCV syllables progressing from low to high vowels while half of the subjects produced the VCV syllables progressing from high to low vowels. The order of the consonants was held constant for each vowel context.

All speech tasks were tape recorded. An Ampex tape recorder, Model 602-1, and a RCA microphone, Model BK-6-B, were used to record the subjects' responses at 7½ ips. The experimenter's voice was dubbed out of the tapes for judgement purposes. These tapes were utilized for judgements of perceived nasality with the following speech tasks for each subject: isolation task, Iowa Pressure Test, and six VCV sequences with 21 responses for each vowel environment.

SCALING PROCEDURE. The tapes of the 16 subjects' responses were judged by two speech pathologists neither of whom were acquainted with the hypotheses under investigation. A training session was conducted to familiarize the judges with the task and improve their reliability of judging perceived nasality. Judgements of severity were rated on a seven point equal-appearing intervals scale with one representing lack of perceived nasality and seven representing severe perceived nasality. The intraclass correlation (*20*) between the average ratings of the first and second judges was .99 on the first task, .85 on the second task, and .90 on the VCV syllables.

Results

Inferential statistical procedures were employed to analyze the obtained raw data. Analyses of variance, *a posteriori* mean comparisons and contrasts, tests of linear trend, and correlational procedures were utilized. Mean scale values of perceived nasality constituted the raw data.

VOWELS IN ISOLATION. To test the differences between the mean scale values of perceived nasality for vowels in isolation, a one-way analysis of variance for repeated measures was employed (*20*). This analysis revealed a significant main effect for vowels ($F = 8.04$, $df = 5{,}75$) beyond the .001 level of confidence. Figure 1 illustrates the mean scale values for each of the six vowels tested in isolation.

The Scheffé procedure for contrasts (*5*) revealed the average mean scale value of 2.34 for /ɑ/, /ɔ/, /æ/, and /ɛ/ to be significantly different from the average mean scale value of 3.36 for /u/ and /i/ beyond the .01 level of confidence (absolute mean scale value of -5.00 compared to critical value of 4.02). The average mean scale value of 2.38 for the back vowels /ɑ/, /ɔ/, and /u/ was not found to be significantly different from the average mean scale value of 2.98 for the front vowels /æ/, /ɛ/, and /i/ when this contrast was tested at the .05 level of confidence (absolute ratio value of -3.12 compared to critical value of 3.41).

VCV SYLLABLES. A two factor analysis of variance for repeated measurements (*20*) of the vowel and consonant mean scale values of perceived nasality was completed. This analysis yielded a significant main effect for vowels, $F(5{,}75) = 9.28$, $p < .001$; a significant main effect for consonants, $F(20{,}300) = 15.51$, $p < .001$; and a significant vowel x consonant interaction effect, $F(100{,}1500) = 2.08$, $p < .001$.

Vowels in VCV syllables: The means for the six vowels utilized are presented in Figure 1. As indicated, the order of perceived nasality, from least to most severe, was: /ɔ/, /ɑ/, /ɛ/, /æ/, /u/, and /i/. To analyze this significant main effect *a posteriori* mean comparisons of the combinations of the six vowel environments were made. The Newman-Keuls procedure, described by Winer (*20*), was employed to test the differences between the ordered means. The mean scale differences between /ɔ/, /ɑ/, /ɛ/, and /æ/ were not significantly different when tested at the .05 level of confidence. Both the low and low-mid back vowels /ɑ/ and /ɔ/ were found to be significantly less nasal then the two high vowels /u/ and /i/ beyond the .01 level of confidence. The high-low and low-mid front vowels /æ/ and /ɛ/ were not found to be significantly less nasal then the high-back vowel /u/ ($p > .05$), but were significantly less nasal then the high-front

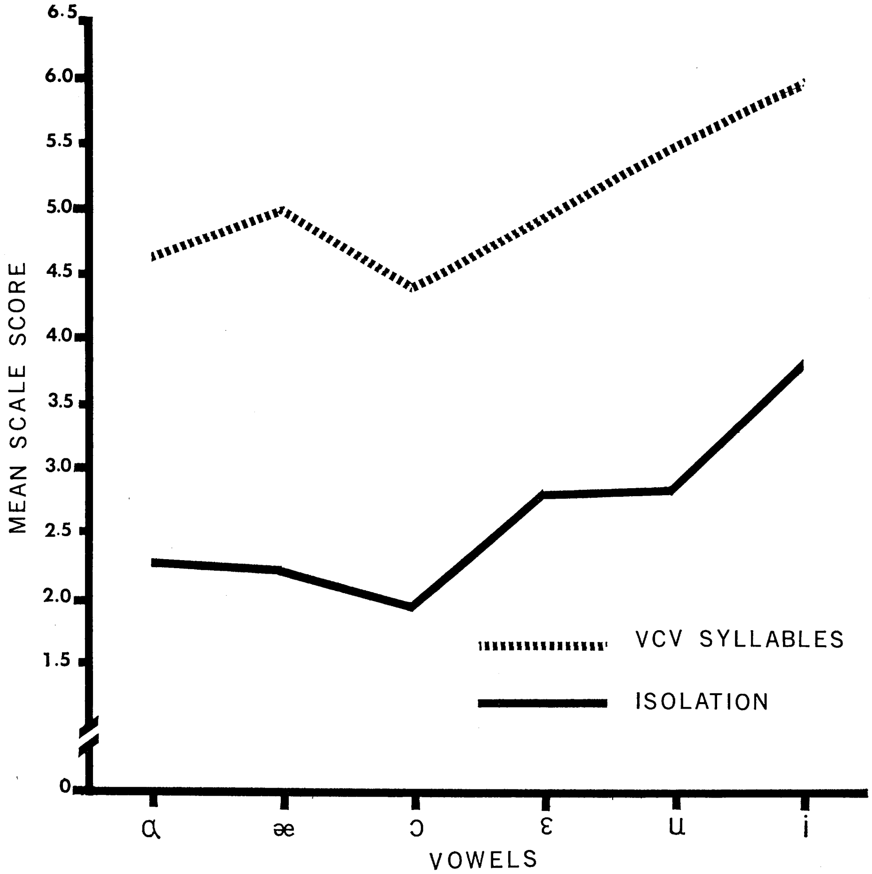

FIGURE 1. Mean scale scores of perceived nasality for each vowel context and vowels in isolation.

vowel /i/ when tested at the .01 level of confidence. The high-back vowel /u/ was significantly less nasal then the high front vowel /i/ as well ($p <$ .05).

Since mean comparisons appeared to indicate a trend between both low and high vowels and front and back vowels in VCV syllables, contrasts were made between the average differences between these combinations. The Scheffé method (*5*) was employed to make these contrasts. This procedure revealed that the average mean scale value of 4.77 for /ɑ/, /ɔ/, /æ/, and /ɛ/ contexts was significantly different from the average mean scale value of 5.80 for /u/ and /i/ contexts beyond the .01 level of confidence (absolute ratio value of −7.37 compared to critical value of 4.52). However, the average mean scale value of 4.86 for the back vowel contexts /ɑ/, /ɔ/, and /u/ was not significantly different from the average mean scale value of 5.36 for the front vowel contexts /æ/, /ɛ/, and /i/ when this contrast was tested at the .05 level of confidence (absolute ratio value of

-3.11 compared to critical value of 3.32). Although smaller mean scale values were observed for vowels in isolation, these tests of contrasts revealed the same trend in perceived nasality as in VCV syllables.

A test of linearity on the ordered totals of the vowel contexts from least to most severe yielded a linear mean square of 575.75 which is significant beyond the .001 level of confidence (F = 43.50, df = 1,75). The total variation between vowels was 614.12. Of this total 575.75 or 93.75 per cent is accounted for by the linear trend.

Consonants in VCV syllables: The mean scale values for the consonants are represented in Figure 2. Inspection of the mean data appeared to indicate a trend for the consonants by manner of production. To delineate this apparent trend, contrasts were made between the combinations of the glides and glottal fricative /h/, plosives, and fricatives/affricatives employing the Scheffé method (*5*).

The average mean scale value of 4.01 for the glides and glottal fricative /h/ was found to be significantly different then the average mean scale value of 4.88 for the plosives (absolute ratio value of -6.58 compared to the critical value of 6.13) beyond the .01 level of confidence. This average mean scale value of 4.01 was also found to be significantly different from the average mean scale value of 5.82 for the fricatives/affricatives (absolute ratio value of -15.62 compared to critical value of 6.74) beyond the .001 level of confidence. Contrasting the average mean scale value of 4.88 for the plosives with the average mean scale value of 5.82 for the fricatives/affricatives revealed a significant difference (absolute ratio value of -8.87 compared to critical value of 6.74) beyond the .001 level of confidence as well. This statistical procedure revealed the following order of perceived nasality for the consonants: glides and the glottal fricative /h/, plosives, and fricatives/affricatives.

A test of linearity on the ordered totals of the consonants from least to most severe yielded a linear mean square of 1343.10, which is significant beyond the .001 level of confidence (F = 304.07, df = 1,300). The total variation between consonants is 1370.48. Of this total, 1343.10 or 98 per cent is accounted for by the linear trend.

Vowel x consonant interaction: Although a significant interaction effect (F = 2.08, df = 100,1500) was revealed by the analysis of variance, the large degrees of freedom with which the F-ratio was tested may account for this statistically significant interaction and in reality the relationship may be weak (with df = 100,1500 a F-ratio of 1.24 is statistically significant beyond the .05 level of confidence; whereas a theoretical F-ratio of 1.00 would be expected when the variance estimate for interaction is zero in the mean square interaction term).

A second analysis of variance was employed to analyze the interaction effect of vowel x manner of consonant production (glides and the glottal fricative /h/, plosives, and fricatives/affricatives). This analysis revealed a non-significant vowel x manner interaction effect (F = .67, df = 10,150,

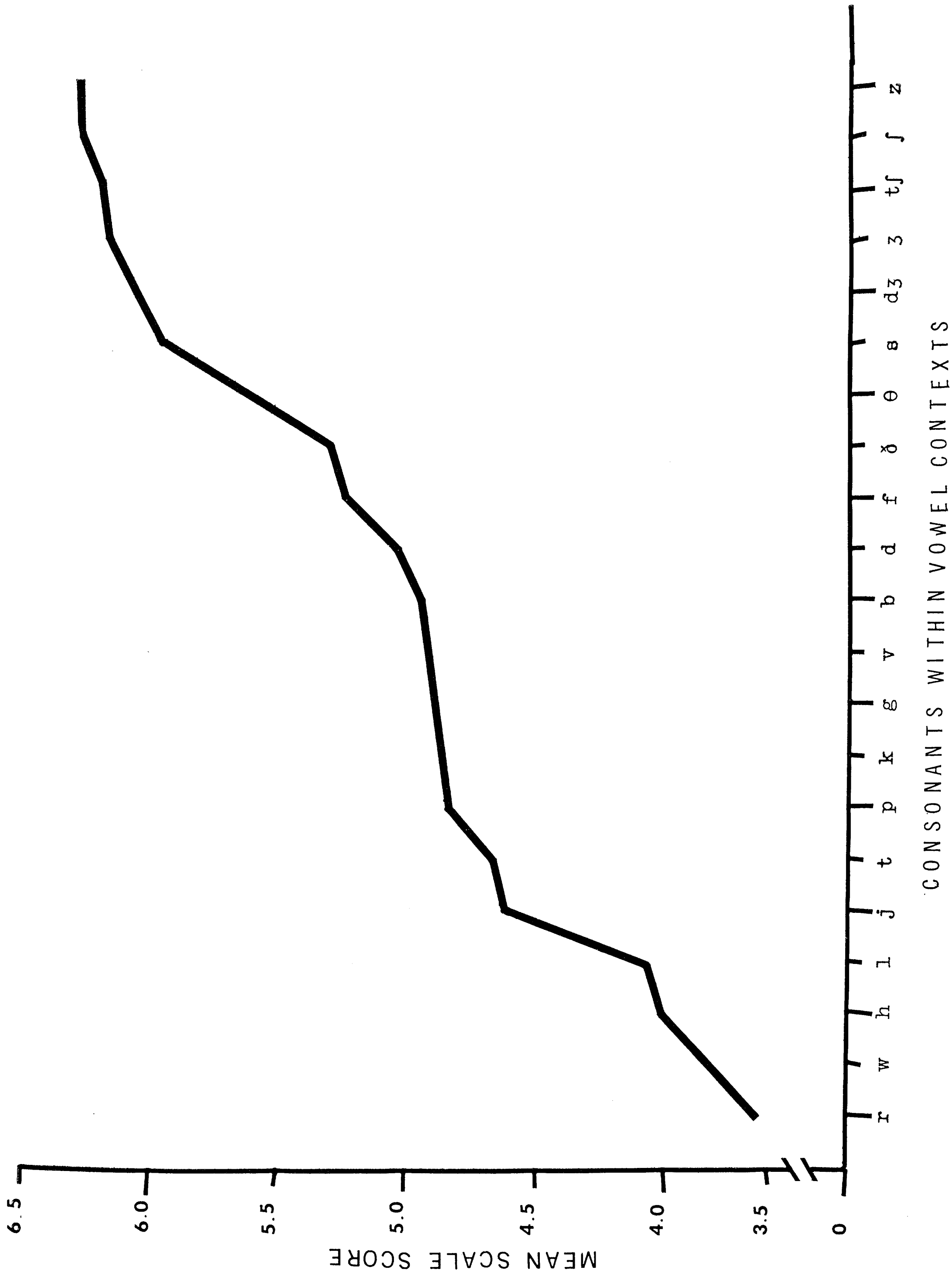

FIGURE 2. Mean scale scores of perceived nasality for consonants within vowel contexts.

p > .75). This analysis substantiated the findings that perceived nasality varies as a function of vowel context and manner of consonant production as reported above. Figure 3 represents the mean scale values for the vowel x manner of consonant production interaction.

CORRELATIONAL ANALYSIS. The mean scale values of perceived nasality of the following independent variables were analyzed employing Personian correlational procedures: vowels in isolation; Iowa Pressure Test; vowel contexts; and consonants in vowel contexts.

Vowel contexts: Vowels produced in isolation were found to be correlated with three vowel contexts: /æ/, /ɛ/, and /u/ (Table 1). The Iowa Pressure Test was found to be correlated with vowels in isolation and all vowel contexts with the exception of /i/ contexts. Commensurate with the means comparisons test reported above, /i/ contexts were not found to be correlated with any of the other vowel contexts, vowels in isolation, or the Iowa Pressure Test.

Contexts containing /ɔ/ were found to be correlated with more variables than any other vowel context. Other significant correlations between vowel contexts are reported in Table 1.

Consonants in vowel contexts: Significant correlations between the Iowa Pressure Test, vowels in isolation, and consonants in vowel contexts are reported in Table 2. As revealed in this table, fricatives/affricatives in /i/ contexts were found to be significantly correlated with fricatives/affrica-

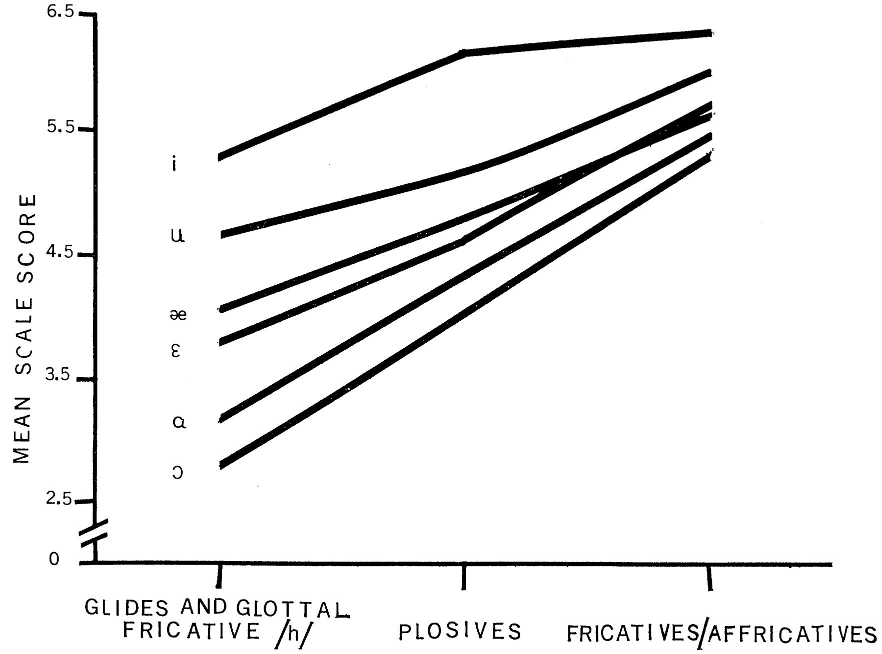

FIGURE 3. Mean scale scores of perceived nasality for consonant manner of production within vowel contexts.

TABLE 1. Correlation matrix for vowel environments, Iowa pressure test and isolated vowels only significant correlations are reported.

	Iowa press. test	*isolat. vowels*	*vowel environments*					
			/ɑ/	/æ/	/ɔ/	/ɛ/	/u/	/i/
Iowa Press. test	—	.57	.70	.90	.82	.81	.72	
isolat. vowels		—		.57		.53	.58	
/ɑ/			—	.62	.82	.52		
/æ/				—	.85	.88	.60	
/ɔ/					—	.81	.71	
/ɛ/						—	.65	
/u/							—	
/i/								—

Critical value of r at the .01 level of confidence = .62 (n = 16).
Critical value of r at the .05 level of confidence = .50 (n = 16).

tives in all other vowel contexts as well as a number of other independent variables. These relationships were not revealed when the data were analyzed across vowel contexts. Glides and the glottal fricative /h/ in /ɑ/ contexts were not found to be correlated with any of the other 20 variables.

Fricatives/affricatives in /ɔ/ environments appeared to be the best single predictor of perceived nasality in VCV syllables, being correlated with 13 of the 17 VCV contexts, vowels in isolation, and scores from the Iowa Pressure Test. This is of particular importance since fricatives/affricatives were perceived as significantly more nasal than any other consonant classification while /ɔ/ contexts were perceived as the least nasal of the vowel contexts.

Discussion

Results from the statistical analyses confirm the existence of a hierarchial order of perceived nasality in VCV syllables for cleft palate speakers. Consonants, both between and within vowel contexts, were found to increase in perceived nasality in the following order: glides and glottal fricative /h/, plosives, and fricatives/affricatives. Tests of linear trend revealed a linear progression across vowel contexts. Perceived nasality between vowel contexts increased from low to high vowel contexts. A linear progression was also demonstrated between vowel contexts.

Previous research findings indicating that the degree of perceived nasality of cleft palate speakers is greater on high vowels then low vowels (*3*, *15*, *19*) were confirmed in the present investigation. Our data show this for both vowels produced in isolation and vowels produced in VCV syllables. Vowel height was found to be a more critical variable in the perception of nasality then front or back vowel classification. If the Minifie et al. (*10*) finding that lateral pharyngeal wall movement is greater for low vowels compared to high vowels is confirmed by other researchers, it may serve to assist in

TABLE 2. Correlation matrix for consonants within vowel environments, Iowa pressure test and isolated vowels. Only significant correlations are reported. (G = glides and /h/, P = plosives, F = fricatives/affricatives).

	Iowa press. test	isolat. vowels	VCV syllables																	
			/ɑ/			/æ/			/ɔ/			/ɛ/			/u/			/i/		
			G	P	F	G	P	F	G	P	F	G	P	F	G	P	F	G	P	F
Iowa press. test	—	.57		.54	.74	.83	.77	.90		.63	.92	.67	.63	.84		.59	.83		.53	.70
isolat. vowels		—				.78					.54	.58				.57				
/ɑ/ G			—																	
/ɑ/ P				—	.58	.53	.60	.50	.62	.74	.60		.53			.63		−.58		
/ɑ/ F					—	.65	.58	.65		.62	.89	.54		.66		.60	.70			.58
/æ/ G						—	.67	.84			.75	.76	.60	.68		.53	.59			.50
/æ/ P							—	.80		.87	.78	.56	.89	.77		.70	.63			
/æ/ F								—		.61	.84	.68	.66	.83			.66			.57
/ɔ/ G									—			.60				.52				
/ɔ/ P										—	.68		.82	.59		.72				
/ɔ/ F											—	.62	.58	.86		.65	.84		.51	.66
/ɛ/ G												—	.59	.73		.53	.60			.59
/ɛ/ P													—	.71		.61	.52			
/ɛ/ F														—			.89			.73
/u/ G															—	.63				
/u/ P																—	.59			
/u/ F																	—			.69
/i/ G																		—		
/i/ P																			—	.72
/i/ F																				—

Critical value of r at the .01 level of confidence = .62 (n = 16).
Critical value of r at the .05 level of confidence = .50 (n = 16).

explaining the present finding of the importance of tongue height on perceived nasality.

The interaction between tongue height and lateral wall movement may also play a critical role in the perception of nasality. A tentative conception of the nature of this complex interaction of events might suggest that as the aperture between the pharyngeal and oral cavities is decreased relative to increasing tongue height, lateral pharyngeal wall movement may also be decreasing, thus decreasing the resistance between the pharyngeal and nasal cavities. This interaction may result in more complete coupling of the pharyngeal and nasal cavities when high vowels are produced resulting in a greater degree of perceived nasality. Data from radiographic techniques are needed to confirm this speculation.

The order of perceived nasality for consonants found in the present study agrees well with findings reported by others (*4*, *9*, *14*). Perceived nasality, within and between vowel contexts, from least to most severe was observed in the following order: glides and the glottal fricative /h/, plosives, fricatives/affricatives. In general, this same order of severity has been reported for judgements of articulatory ability in cleft palate speakers. This finding supports Perkins' (*13*) statement that nasality is more than an undesired resonance characteristic and represents an inability to make articulatory distinctions.

Correlational Analysis: Correlational procedures revealed the Iowa Pressure Test to be significantly correlated with VCV contexts except for /i/ contexts when the data were collapsed across consonants. Significant correlations were obtained when the data were analyzed by manner of production for all vowel contexts containing plosives and fricatives/affricatives. Indeed, the Iowa Pressure Test contains phonemic elements (plosives and fricatives/affricatives) which are most defective in cleft palate speakers. Our results appear to support the validity of this test in assessing perceived nasality on these elements. However, only two vowel environments, /æ/ and /ɛ/, containing glides and the glottal fricative /h/ were found to be significantly correlated with the Iowa Pressure Test (r's = .83 and .67, p's $< .01$). The non-inclusion of glides and the glottal fricative /h/ necessarily makes the Iowa Pressure Test insensitive to those consonants which are perceived as least nasal in cleft palate speakers. It would appear that this added information has diagnostic and therapeutic value to the clinician in planning a program of speech habilitation with cleft palate speakers, and it is not currently obtainable from the Iowa Pressure Test in its' present form.

As indicated in the correlational analysis, fricatives/affricatives in /ɔ/ contexts were significantly correlated with more speech tasks than any other single VCV context. This context was found to be correlated with vowels in isolation, the Iowa Pressure Test, and 13 of the possible 17 VCV contexts.

Summary

The effects of phonetic contexts (VCV syllables) on judgements of perceived nasality in cleft palate speakers were investigated. Statistical analyses confirmed the existence of a hierarchial order of perceived nasality in VCV syllables for cleft palate speakers. Nasality between and within vowel environments was judged as less severe in low vowel contexts as compared to high vowel contexts. Tests of linear trend for perceived nasality demonstrated a significant linear trend for vowel contexts and consonants within vowel contexts. The present data showed vowel height to be a more critical variable in judgements of perceived nasality then front or back vowel classification both for vowels produced in isolation and vowels produced in VCV syllables. The interaction of tongue height and lateral pharyngeal wall movement is discussed as a possible explanation for the current findings and trends for perceived nasality.

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