

Some Relationships Between Vocal Intensity and Rated Nasality

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The effect of intensity variations on the degree of nasality perceived by the listener is of interest to those concerned with the assessment and treatment of nasal voice. It is generally accepted (4, 6, 8) that one outcome of coupling the nasal to the vocal tract, assuming a constant input, is to reduce the overall intensity of the speech signal. There is also evidence that severely nasal subjects tend to speak at lower intensity levels than those with mild nasal quality. Weiss (12) reports, for example, a negative correlation ($r = -.57$) between measures of average overall sound pressure levels and nasality ratings. While nasal quality appears to be related to the mean vocal intensity of the speaker, there is relatively little data concerning changes in the perception of nasality that might occur when subjects produce speech at different vocal intensity levels.

In one of the few studies directly related to this topic, Hess (7) asked each of fifteen male cleft palate speakers to phonate each of six vowels at each of two pitch levels, an habitual pitch level and a pitch level 1.4 times higher, and at two intensity levels, 75 and 85 dB SPL. Nasality was rated along a seven-point scale. He found a lower mean nasality rating at the higher than at the lower intensity level. The difference between the means for the two intensity levels while statistically significant was relatively small, amounting to .25 scale value. Hess' findings are compatible with those of Williamson (13) who reports a decrease in nasality with increased vocal intensity in functionally nasal speakers.

There are correlative data that bear on this question. Studies utilizing the probe-tube microphone assembly (1, 3, 9, 12) with cleft palate and functionally-nasal speakers have shown that measures of the difference, in decibels, between nasal and oral (overall) intensity are positively correlated with nasality ratings. There is some evidence in studies of normal (11) and cleft palate (9) speakers that the size of the sound pressure difference varies as a function of overall vocal intensity. These studies indicate that the size of the sound pressure difference tends to decrease as

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overall intensity is increased. To the extent that the nasal—oral sound pressure difference is a reliable index of perceived nasality, one might predict a decrease in rated nasality with increased vocal intensity levels.

In spite of the importance of defining the relationship between vocal intensity and nasality, available data are scant. Such data would appear important to an understanding of nasality as a perceptual phenomenon and to the clinical management of cleft palate speakers. For this reason, the present study was undertaken.

Part I

Purpose. The purpose of this portion of the study was to investigate the relationship between nasality ratings for sustained isolated vowels and the intensity level at which the vowels are produced, when all vowels are played back to judges at a constant intensity level.

Procedure. Available from an earlier study (10) were 640 vowel samples. The samples consisted of four isolated vowels /i/, /u/, /ae/, and /ɑ/, each sustained for four seconds. Each vowel was produced at each of four intensity levels: 70, 75, 80, and 85 dB SPL at a mouth-to-microphone distance of eight inches. The speakers were 20 cleft palate persons, 10 male and 10 female, ranging in age from 15 to 53 years, with a mean age of 26.4 years, and 20 normal speakers matched to them in age and sex. All cleft palate subjects presented oral manometer ratios less than .75. No attempt was made to control for vocal pitch level. A detailed description of the method and procedures followed in obtaining these samples is presented elsewhere (10).

Of the 640 available vowel samples, 624¹ were dubbed onto new tapes at a constant (± 1 dB) intensity (i.e., equal VU level) using the tape recorder on which the samples were originally recorded (Ampex Model 354) and a second tape recorder (Ampex Model 440). These samples were then used to construct eight experimental tapes. Four tapes contained vowel samples for normal and cleft palate males and four, the vowel samples for cleft palate and normal females. Each of the four tapes for each sex consisted of a random arrangement of all samples of one of the four experimental vowels, all dubbed at a constant intensity level. Thus, one tape contained the randomized samples of /u/ produced by the male normal and cleft speakers; another, the randomized samples of /i/ by the female normal and cleft speakers; and so on. The recorded samples were reproduced for judgment of perceived nasality using a tape recorder (Ampex Model 440) and amplifier-speaker (Ampex Model 620). The judging was completed in two listening sessions, separated by four weeks. Four experimental tapes were rated in each of the two sessions. The judges, 11 graduate students in speech pathology, were seated in front of the loudspeaker in a sound treated room. The samples were played at a

¹ Four vowels, two normal male /u/'s, one cleft male /i/ and one cleft female /ɑ/, were omitted from analysis due to tape dubbing difficulties.

comfortable, uniform intensity level. A rating of the degree of nasality for each of the recorded samples was obtained from each of the judges using a seven-point scale of equal-appearing intervals, with 1 representing the mildest and 7 the most severe nasality. Prior to the presentation of each of the eight experimental tapes to the judges, two examples of that vowel showing greatest nasality and two showing least nasality were presented to the judges to provide them with a common scaling reference. These examples of greatest and least nasality were chosen by three judges in a prior rating of each tape. In addition, the first ten samples on each tape were used as practice items and were repeated in a different random order at the end of the tape; the second ratings of these samples were included in the data analyses.

Results. The intraclass correlation procedure for evaluating the inter-judge reliability of ratings as described by Ebel (5) was applied to each of the eight sets of ratings. Using the formula which adjusts for between-judge variance, estimated intraclass correlation coefficients for average ratings ranged from .88 for the female /a/ samples to .95 for male /i/ samples and for female /u/ samples, with a mean correlation coefficient for the eight sets of .92. In addition, the semi-interquartile range, Q , was computed for each of the 624 samples. The mean Q value for all the samples was .86. The mean reliability coefficient and Q value are similar to those obtained in other studies of nasality (2).

The median scale value of nasality was computed for each sample. A mean median scale value of nasality was then derived for each vowel at each production intensity level for each sex and speaker group. These means are presented in Table 1. The significance of differences among the mean median scale values for the four intensity levels was tested for each vowel within each sex and speaker group using the Friedman two-way analysis of variance procedure. Only two of the differences were significant ($P < .05$): /u/ produced by normal speaking females ($P < .01$) and /i/ produced by cleft palate males ($P < .02$). The former showed a steady decrease in mean median nasality rating as the production intensity increased from 70 to 85 dB. The latter showed a steady increase in nasality as the production intensity increased. All other 14 tests yielded nonsignificant results with only the male cleft /u/ and the female normal /ae/ samples yielding statistics with associated probabilities between .05 and .10. The differences between means for the four vowels were not tested for significance in that the vowels were rated separately and it is possible that the judges employed different subjective scales in rating each vowel.

Examination of the trends within these data is of interest. While the pattern varies to some extent for individual vowels, there is support for Hess' finding (7) that small decrements in mean nasality ratings may occur with increased vocal intensity in male cleft palate speakers. With the exception of means for /i/, normal males display a similar trend. Normal females, however, evidence a trend toward higher mean ratings at

TABLE 1. Mean median scale values of nasality for samples produced at four intensity levels (5 dB steps) but played back for judging at a constant intensity level.

group	n	vowel	production-intensity level in dB SPL			
			70	75	80	85
Males						
normals	10	i	2.32	2.53	2.39	2.80
	8	u	2.98	2.69	2.69	2.76
	10	ae	3.09	2.66	2.55	2.86
	10	α	2.92	2.19	2.18	2.20
clefts	9	i	6.00	5.42	5.19	5.19
	10	u	4.70	5.02	4.39	4.26
	10	ae	5.64	5.22	5.34	5.62
	10	α	5.39	4.98	4.86	4.92
Females						
normals	10	i	3.03	3.15	3.04	3.61
	10	u	2.26	2.48	2.78	3.14
	10	ae	3.03	3.01	2.87	3.79
	10	α	2.71	2.96	2.84	3.36
clefts	10	i	4.97	4.68	4.92	5.05
	10	u	4.32	4.20	4.55	4.16
	10	ae	4.53	4.31	4.22	4.72
	9	α	3.87	3.88	3.88	3.83

the highest than at the lowest intensity levels. Further, the decline in mean ratings with increased intensity seen in the cleft palate male group is not evident for the cleft females. It is possible that the relationship between nasality ratings and vocal intensity differs for the sexes and that the extrapolation of nasality findings from male to female cleft palate and normal samples should be made with caution.

It should be noted that, in rating vowel samples played back at a constant level, judges may still perceive physiologic and acoustic cues associated with increases in production intensity. It will be recalled that no attempt was made to control vocal pitch or vocal effort in the present study. It is quite possible, therefore, that the judges, unable to hear the original SPL differences among the vowel samples, responded to other intensity-associated cues in their ratings. In any event, it seems reasonable to conclude that, with playback intensity held constant, variations in production intensity did not result in consistent changes in the nasality of all vowels produced by either the cleft or normal groups.

Part II

Purpose. The purpose of this portion of the study was to investigate the relationship between ratings of nasality for sustained isolated vowels and

the intensity level at which they are produced, with playback as well as production intensities varying.

Procedure. The four experimental tapes used in Part I to obtain nasality ratings for the male and female /a/ and /u/ samples were redubbed, reintroducing the original 5 dB differences among the samples for each vowel. The samples were kept in the same random order. The tapes for these vowels were identical in construction to those used in Part I of this study, except that judges could now hear the original SPL differences among the recorded samples. The rating procedures were also the same as used in Part I. All ratings, however, were obtained in one listening session which followed the second rating session of Part I by approximately six months. The judges were 11 graduate students in speech pathology, some of whom participated in Part I.

Results. Estimated intraclass correlation coefficients for the average ratings of the 11 judges, with between-judge variance controlled, ranged from .91 for the female /a/ samples and for the male /u/ samples to .94 for the male /a/ samples. The mean correlation coefficient for the four sets of samples was .92.

The median scale value was computed for each sample. The mean median scale value of nasality was then obtained for each vowel at each production intensity for each sex and speaker group. These means are presented in Table 2. The significance of differences among the mean median scale values for the four intensities was tested for each vowel within each sex and speaker-group using the Friedman two-way analysis of variance. Four of the eight tests (female normal /u/, female cleft /u/, male normal /u/, and male cleft /a/, yielded significant ($P < .05$) results.

TABLE 2. Mean median scale values of nasality for samples produced and played back at four intensity levels (5 dB steps).

group	n	vowel	production-intensity level in dB SPL			
			70	75	80	85
Males						
normals	8	u	2.60	2.58	3.16	3.45
	10	α	2.88	2.25	3.24	2.97
clefts	10	u	3.87	4.33	4.85	4.98
	10	α	4.65	5.26	5.01	5.39
Females						
normals	10	u	2.08	2.68	2.91	3.12
	10	α	2.40	3.06	3.02	2.96
clefts	10	u	3.89	3.92	4.53	4.55
	9	α	3.19	3.46	4.03	4.03

Of the four remaining tests, two (male normal /a/ and male cleft /u/) yielded statistics with associated probabilities between .05 and .10.

Inspection of the means in Table 2 reveals a trend, for both vowels, toward increased mean nasality ratings as vocal intensity level is increased for both the male and female cleft palate groups. This trend is also seen for both male and female normals in /u/ and, although the pattern is irregular, to some extent in /a/ as well.

A comparison of the mean scale values obtained for /a/ and /u/ in Part I (constant-intensity playback condition, CIP) and in Part II (variable intensity playback condition, VIP) is made graphically in Figure 1. A direct comparison of the absolute scale values for the same vowel under the two playback conditions is not intended in the figure. Inspection of Figure 1 suggests that the pattern of changes in mean nasality ratings associated with changes in vocal intensity level differs for the two playback conditions. In the CIP condition, the nasality ratings for male normal and cleft palate subjects tend to decrease as production intensity increases. An opposite trend is seen, however, in the VIP condition for these subject groups. Further, the cleft females show little variation in nasality ratings as production intensity level is increased in the CIP condition, but an increased nasality at the more intense production levels in the VIP condition. Only for the normal female group, most notably in the vowel /u/, is there a similar relationship between production-intensity level and nasality ratings in the two playback conditions.

These data suggest that, when playback intensity is not held constant, increasing production intensity through the range used in this study did not result in reduction of nasality for these normal and cleft palate subjects. Instead, there was a tendency among the judges to assign more severe ratings to samples with higher than with lower production intensity. The data also suggest that the effect of vocal intensity changes on perceived nasality varies for the vowel samples and for the same vowel according to the sex of the subject. The differential effect of vocal intensity changes on the nasality of individual vowels was noted previously by Hess (7).

The findings of this study also suggest that variations in playback intensity may be an important factor in the assignment of nasality scale values, at least in studies of sustained isolated vowels. We can speculate, for example, that the acoustic cues which inclined the judges to rate vowels less nasal at the higher than at the lower production intensity levels in the CIP condition were overridden when judges were permitted to hear the original SPL differences among the vowel samples. It seems reasonable to assume that the differences in the results obtained in Part I and Part II of this study relate to loudness differences among the vowel samples. If judges tend to assign more severe nasality ratings to vowel signals they perceive to be louder, a contaminating variable may be intro-

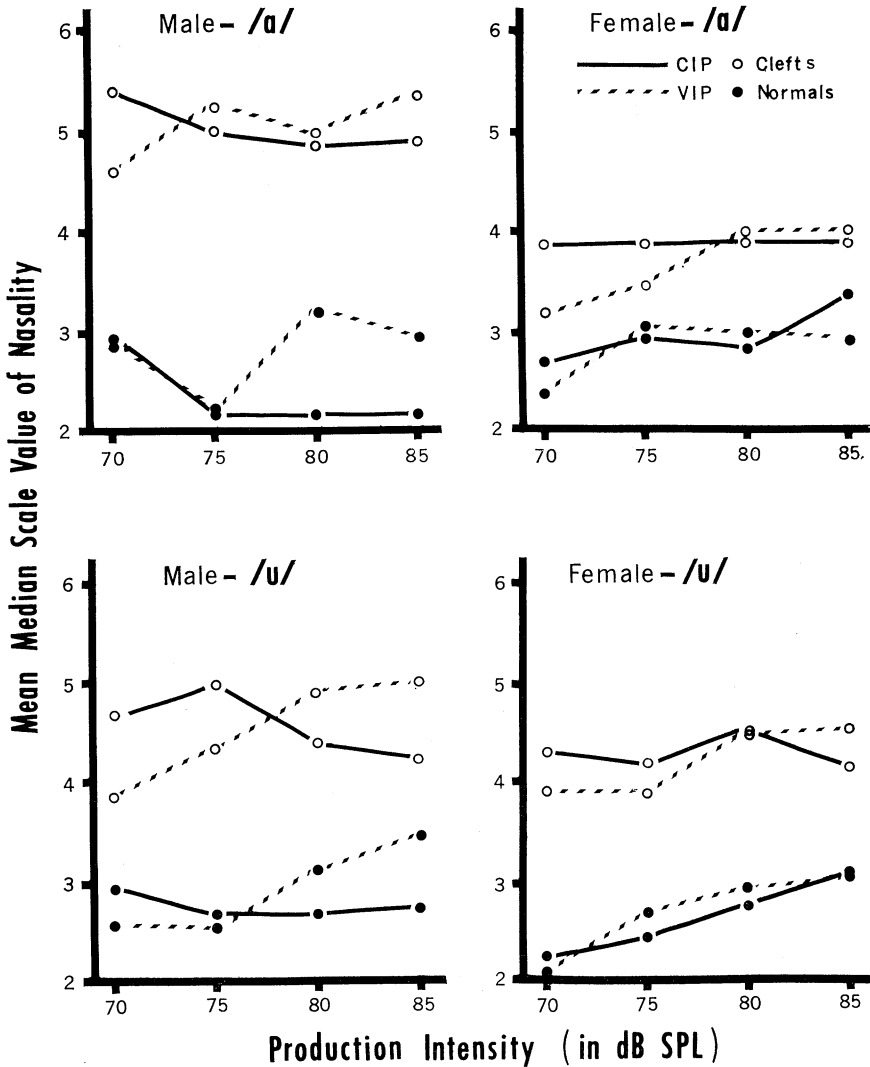


FIGURE 1. Mean median scale values of nasality for constant intensity (CIP) and variable intensity (VIP) playback conditions for vowels /a/ and /u/.

duced into nasality scaling sessions. This possibility deserves further study using a variety of speech sample types.

Summary

Nasality ratings of each of four sustained isolated vowels, each produced at each of four vocal intensity levels (70, 75, 80, and 85 dB SPL), were obtained for each of 20 cleft palate and 20 normal speakers. The ratings were obtained under two conditions: (1) when vowel samples are

played back to judges at a constant intensity level and (2) when judges are permitted to hear the original SPL differences among the vowel samples. Changes in average nasality ratings that occur as a function of variations in production and playback intensity are discussed.

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