Effect of Vowels on Consonants in Nasalence

[1]Gopi Sankar R. & [2]Pushpavathi M.

Abstract

The present study investigated the mean nasalence value of three isolated vowels and explored the nasalence value across CV combinations based on various place of articulation of consonants. The subjects consisted of fifty (21 males, 29 females) normal young adults in the age range of 18 to 27 years. The subjects were instructed to repeat the isolated vowels and CV combinations. The mean nasalence value was calculated. Repeated measures of ANOVA were used to find the significant difference in within and across the condition (CV combination). The results indicated significant difference across vowels with the high nasalence value for the high front vowel / i / followed by / a/ and /u/. Unvoiced bilabial and retroflex stop consonants with / i / had high nasalence value followed by /u/ and /a/. This results support the finding that high front vowel have significantly higher nasalence value than other vowels. This result also aids the speech pathologists to develop the stimuli for assessing the Velopharyngeal closure.

Key words: Nasalence, Vowels, Consonant vowel combination, Vowel effects.

Speech is a fleeting event. Researchers and clinicians strive to capture the speech signals and to analyze the same using the sophisticated methods. There is considerable information available concerning the acoustic characteristics of abnormal and normal resonance, as well as clinical assessment and management of resonance impairments. Nasalence is intended to be a measure of the acoustic energy that occurs primarily on vowels, glides and liquids. Traditionally, clinicians have used long passages, such as the Zoo Passage, rainbow passage to assess nasalance with the Nasometer. Shorter stimuli have been proposed (MacKay and Kummer, 1994; Watterson T, Hinton J & McFarlane S 1996; Awan, 1998) to measure the nasalence. But short stimuli create the potential for vowel and consonant content to have a weighting effect on the nasalance value (Karnell, 1995; Watterson T, Lewis KE & Foley-Homan N 1999). Because the Nasometer is designed primarily to measure the acoustic energy in vowels, the vowel content of the short stimulus would be of particular concern (Fletcher SG, Adams LE, & McCutcheon MJ. 1989). Most of the studies in nasalence measurement are focused on measuring and comparing the nasalence for high pressure and low pressure consonants.

In recent years, growing evidence has evolved concerning the relation between nasalence measurement and velopharyngeal closure specifically on vowels. Variation in the nasalence during the nasal airflow is closely related to the velar height and velopharyngeal closure. Carney and Sherman (1971) studied the effects of three speech tasks upon the perception of nasality for 10 normal subjects and 10 subjects with cleft palate. The three speech tasks consisted of the production of five isolated vowels, same vowels in consonant-vowel-consonant (CVC) syllables and same CVC in connected speech passage. The results indicated that for both groups, CVC syllables from a connected speech are judged to be less nasal than either isolated vowels or isolated CVC syllables. The variations in results were attributed to co-articulatory influences. Subjects with cleft palate are more nasal on high vowel than on low vowels, while subjects without cleft palate were more nasal on low vowels than on high vowels. MacKay and Kummer (1994) provided data that supported the contention that nasalance values from short stimuli may be markedly influenced by vowel content. For the Simplified Nasometric Assessment Procedures Test (SNAP Test), MacKay and Kummer (1994)

[1]Research officer, Dept. of Clinical Services, All India Institute of Speech and Hearing, Manasagangothri, Mysore-570006, email:sankaj2002@yahoo.co.in, [2]Reader in Speech Pathology, All India Institute of Speech and Hearing, Manasagangothri, Mysore- 570 006, email: pushpa19@yahoo.co.in.

provided mean nasalance data for normal subjects using a variety of stimuli. The syllable repetition subtest requires subjects to repeat a CV syllable 6 to 10 times (e.g., ti-ti-ti), and data were provided for CV stimuli that differ only with respect to the vowel. The data showed that nasalence values for stimuli with the high front vowel /i/ were markedly higher than nasalance values obtained from stimuli with the low back vowel /a/. According to the authors, individual consonant environments (i.e., voicing, manner, and place) exerted different influences from vowel to vowel, where voicing produced the greatest effects on nasal perception. Vowels in voiced environments, and fricative environments were found to be longer in duration, lower in fundamental frequency, and greater in intensity than vowels in voiceless or plosive environments. The perception of nasality increased when these acoustic correlates (i.e., longer duration, lower fundamental frequency, and higher intensity) accompanied the phonetic context. Results indicated that perception of nasality followed this progression from least to most: (a) voiceless plosive environments /p, t/, (b) voiceless fricative /s, f/ and voiced plosive environments /g, d/, and (c) voiced fricative environments /v, z/. Overall, tongue height and voicing were found to have the most significant influence on the perception of nasality (Lintz & Sherman, 1961). In another study, Watterson T, Lewis KE & Foley-Homan N (1999) compared nasalance values for 17-syllable passage, 6-syllable sentence, and 2-syllable word from a standard 44- syllable passage. The results showed that the longer the stimulus, the stronger the association with the standard passage. The shortest stimulus (two-syllable word) had insufficient criterion validity to warrant its use in clinical applications; however, the authors expressed concern that the vowel content might unduly influence the nasalance value in such a short stimulus. Kerry, L, Watterson, T, & Terasa ,Q (2000) compared the nasalence values with nine different speech stimuli with vowel content controlled. The subjects were 19 normal children and 19 children with velopharyngeal dysfunction. The stimuli consisted of nine speech stimuli which included four vowels in isolation and five sentences which were loaded with high front, high back, low front and low back vowels and one sentence with a mixture of vowel types, five sentences and four sustained vowels. The result showed that high vowels were associated with significantly higher nasalence values than low vowels for both sentence and sustained vowels. For the velopharyngeal dysfunction (VPD) group, nasalence values for high vowel sentences and mixed vowel sentences were significantly higher than the nasalence value for the low vowel sentences. In both groups, nasalence values for sustained vowels were significantly higher for the high front vowel /i/ than for the other vowel .Difference was evident among front / back vowel contrasts. Nandurkar (2002) studied the Nasalance measures in Marathi consonant-vowel-consonant syllables with pressure consonants produced by children with and without cleft lip and palate. The results indicated differences between groups. As the nasalence value may be markedly affected by the vowel, it is necessary to determine the specific influence of various vowels in CV combination. Hence the present study investigated the mean nasalence value of the three isolated vowels and explored the nasalence value across CV combinations.

Method

Subjects: Fifty (21 males, 29 females) normal young adults with age range of 18 to 27 years (mean 19) participated in the study. All participants were judged by the investigators to possess speech and hearing within normal limits and reportedly were free from upper respiratory infection. None of the participants had a history of craniofacial anomalies or velopharyngeal impairment.

Instrumentation: Nasometer model 6400 (Kay Elemetrics, New Jersey) was used to measure resonance using a lightweight headset made up of a harness that holds a (oral/nasal) separation plate. The separation plate was firmly fitted against the area between the nose and the upper lip and had two directional microphones mounted on either side of it, which collected the separated acoustic signals. The signals were transmitted to the computer database where they were calculated and analyzed by the Nasometer software. The resultant acoustic values were a ratio of nasal to nasal-plus-oral acoustic energy, which was multiplied by 100, and expressed as a “nasalance.” Prior to testing, the Nasometer was calibrated and disinfected in accordance with the procedures outlined in the instruction manual.

Stimuli: The stimuli consisted of vowels /a/, /i/, and /u/, and CV syllables in which /p, t, k/ was paired.

Procedure: Subjects were tested individually. They were seated comfortably in a chair. The Nasometer headset was positioned perpendicular to the facial plane and seated firmly against the upper lip. Subjects were instructed to sustain vowels and nasal consonants in isolation. For CV combination, the subjects were instructed to repeat a CV syllables 3 times (e.g., pa-pa-pa) at a normal speed. A single mean nasalance percentage or nasalance values for 3 repeated stimuli was computed. Repeated measures ANOVA were used to find the significant difference between conditions and CV combination.

Results and Discussion

a. Mean nasalence value for vowels in isolation: Results showed that high front vowel /i/ had the highest nasalence followed by low mid vowel /a/ and high back vowel /u/. Table 1 depicts the mean and SD of nasalence.

	Mean	S.D
/a/	25.56	14.17
/ I /	36.84	20.25
/u /	19.70	17.62

Table 1: Mean and SD for vowels.

Results of the repeated measures of ANOVA indicated significant difference between vowels. Vowel /a/ had significant lower nasalence scores compared to vowel /i/. (F (2, 98) =28.371, p<0.001).

b. Nasalence value for the oral consonants across the vowels: results indicated higher nasalence value for /p/, /t/ and /k/ when followed by vowel /i/ compared to when followed by other vowels. Figure 1 shows the mean nasalence value for unvoiced stop consonants combined with vowels. Consonant /k/ had higher nasalence values compared to /t/ and /p/. That is, the nasalence value decreased as the place of articulation moved forward the oral tract.

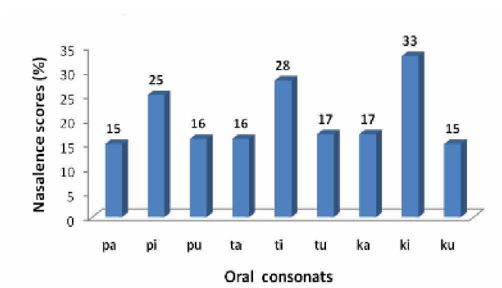

Figure 1: Mean scores for CV combination.

Consonants	Mean
/k/	21.67
/t/	20.33
/p/	18.67

Table 2: Mean values for consonants.

Results of repeated measures of ANOVA indicated significant difference between CV combinations. Table 3 shows F and p values for across the vowel and consonant combinations.

Across the vowel			Across the consonants		
	F value	P value		F value	P value
/pa/-/pi/	F(2,98)= 27.345	<0.001	/pa/-/ta/	F(2,98) =2.481	>0.05
/pa/-/pu/			/pa/-/ka/		
/pi/-/pu/			/ta/-/ka/		
/ta/-/ti/	F(2,98)= 34.808	<0.001	/pi/-/ti/	F(2,98) =24.203	<0.001
/ta/-/tu/			/pi/-/ti/		
/ti/-/tu/			/ti/-/ki/		
/ka/-/ki/	F(2,98)= 72	<0.001	/pu/-/tu/	F(2,98) =3.125	>0.05
/ka/-/ku/			/pu/-/ku/		
/ki/-/ku/			/tu/-/ku/		

Table 3: F values on repeated measures of ANOVA.

The results indicated that front high vowel /i/ had significantly higher nasalence value compared to low mid vowel /a/ and high back vowel /u/. This supports the findings of Neumann and Dalston (2001), who reported the similar findings. This may be due to the articulatory postures assumed during the production of these vowels. The low mid vowel /a / is a open vowel which creates relatively little resistance to airflow out of the mouth. Therefore the maximum energy is transmitted through the oral cavity. But high vowels /i/ and /u / impose relatively high resistance to airflow. However, during the production of the /u/ the tongue is placed in close proximity to the velum. This placement may tend to dampen the velar oscillations and thereby reduce acoustic transfer.

The results also support the findings of Moore and Sommers (1973) who reported the greater degree of nasality on high vowels as the high vowels make greater demand upon the valving function i.e higher points of posterior pharyngeal wall/ velar contacts, tighter velopharyngeal seals and greater velar excursion.

Kendrick (2004) provided a physiological explanation for higher nasalence value on vowel /i/. He has suggested a strong effect of horizontal position of the tongue on the nasalance of vowels. Back vowels are reported to have lower nasalance values because some of the muscles that pull the body of the tongue back also pull the velum down securing a tight closure between the two structures. To keep the velum from lowering during vowel production, the muscles that elevate the velum may be more active during back vowel production than front vowel production to counteract the downward force of the muscles pulling the tongue back. The production of the higher vowel requires the positioning of the velum in high position making the tight velopharyngeal closure. This is a feature of normal speech production.

Mc Donald and Baker (1951) suggested that the correlation might be due the speaker's efforts to maintain a "characteristic balance or ratio between oral and nasal resonance." This resonance ratio presumably depends on the relative sizes of the velopharyngeal port and the posterior opening into the oral tract. Hence, when the speaker intends to produce no audible nasal output, a lower velum is tolerated for an open vowel than for a close vowel.

However, the results do not partially support the findings of Lintz and Sherman (1961) who found that the perception of nasality increased as tongue height decreased during sustained vowel production (i.e., low vowels were perceived as more nasal than high vowels for normal speakers). This may be due to methodological difference as they used perceptual judgment and the subjects were children whereas the present study used an objective evaluation and the subjects were adults.

The present study is the first attempt to explore the co articulation effect based on nasalence measures in consonant- vowel context. Most of the studies which are cited in the literature are based on perceptual measurement are measuring only in sentences or words. Since coarticulation effects allied with perceptual phenomena operating both forward and backward in time are known to cause interactions between adjacent phones, it is possible that a similar interaction could also be observed in consonant-vowel syllables. Bell-Berti, F., Baer, T, Harris, K. S and Niimi, S (1979) have shown that the effects of vowel height on velar height extend into adjacent consonants. Alternatively, as Ackerman (1935) have suggested, movements of the larynx and pharynx may determine velar position through connections provided by the palatopharyngeus muscles. From the results of this study it can be speculated that tongue position had the greatest influence on nasalance values during sustained vowel production. If the tongue was in an elevated and retracted position, as was on the vowel / u /, the velum achieved increased velar elevation and tighter VP closure, resulting in lower nasalence values for the normal speaker. The palatoglossus muscle, which is involved in tongue and velar functions, is active in achieving a front tongue position and at the same time pulls downward on the velum. This would result in less velar elevation, loose VP closure, and in turn higher nasalence values. Previous research has demonstrated that tongue height during vowel production significantly influenced nasalence, and the results from this study were in agreement with the findings of MacKay & Kummer (1994), Kuehn & Moon (1998), Lintz & Sherman, (1961).The results of the present study indicated that unvoiced consonants do not influence the nasalence value. However, vowels play a major role in nasalence values.

Conclusions

The results of the study showed that nasalence values are vowel dependent. High front vowels had significantly higher nasalence value than other vowels. This data also helps the speech pathologists to develop the stimuli for assessing the Velopharyngeal closure which is very important for determining the nasalence value.

References

Ackerman, E. L. (1935). Action of the velum palatinum on the velar sounds /k/and /g/, Vox 31, 2-9. Cited in ArthurS, Abramson, Patrick W. Nye, Janette B. Henderson and CharlesW. Marshall (1981).Vowel height and the perception of consonantal nasality. *Journal of the Acoustic Society of America,* 70(2), 329-339.

Aparna Nandurkar (2002).Nasalance measures in Marathi consonant-vowel-consonant syllables with pressure consonants produced by children with and without cleft lip and palate. *The Cleft palate-Cranofacial Journal*, 39(1), 59-65.

Awan SN(1998). Analysis of nasalance: NasalView (the nasalance acquisition system). In Zigler W, Deger K, eds. *Clinical Phonetics and Linguistics.* London:Whurr, 519–527.

Bell-Berti, F., Baer, T, Harris, K. S and Niimi, S (1979). Coarticulatery effects of vowel quality on velarfunction, *phonetica*, 36, 187-193.

Carney & Sherman (1971).sevearity of nasality in three selected speech tasks. *Journal of Speech and Hearing Research*, 14,396-407.

Fletcher SG, Adams LE, & McCutcheon MJ. Cleft palate speech assessment through oral nasal acoustic measures. In: Bzoch KR, ed. *CommunicativeDisorders Related to Cleft Lip and Palate.* Boston: Little Brown; 1989:246–257.

Karnell M P(1995). Nasometric discrimination of hypernasality and turbulent nasal airflow. *The Cleft palate-Craniofacial Journal,* 32,145–148.

Kendrick K.R (2004). *Nasalance Protocol Standardization*. Unpublished Master Thesis Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College.

Kerry,L, Watterson ,T, & Terasa ,Q (2000). The Effect of vowels on nasalence Values. *The Cleft palate-Cranofacial Journal*, 37(6), 584-589.

Kuehn & Moon, (1998) Velopharyngeal Closure Force and Levator Veli Palatini Activation Levels in Varying Phonetic Contexts,*Journal of Speech Language Hearing Research,* 41, 51-62.

Lintz LB & Sherman D (1961). Phonetic elements and perception of nasality. *Journal of Speech and Hearing Resarch,* 4,381–396.

MacKay IR & Kummer A.W (1994). *Simplified Nasometric Assessment Procedures*. Lincoln Park, Kay Elemetrics, NJ.

Mc Donald & Baker (1951) nasal air flow and nasal sound pressure level. In jhon hajek(Eds)universals of sound change in nasalization,pp.127-129.Boston:Blackwell.

Moore & Sommers (1973) .Phonetic contexts: their effect on perceived nasality in cleft palate speakers. *The Cleft palate-Craniofacial Journal,* 10, 72-83.

Neumann & Dalston (2001). Nasalence Values in noncleft individuals: Why not zero? *The Cleft palate-Craniofacial Journal*, 38(2), 106-117.

Watterson T, Hinton J & McFarlane S(1996). Novel stimuli for obtaining nasalance measures from young children. *The Cleft palate-Craniofacial Journal.* 33 ,67–73.

Watterson T, Lewis KE & Foley-Homan N (1999). Effect of stimulus length on nasalance values. *The Cleft palate-Craniofacial Journal,* 36, 243–247.