Nasalence Value for Rainbow Passage: Normative Data for Non-Native Speakers

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Abstract

The development of normal speech is the most important goals of a clinician. The speech disorders associated with cleft lip and palate include abnormal consonant production, abnormal nasality, nasal air emission, nasal turbulence, and unintelligible speech. Nasality is measured subjectively and objectively. The ratio of acoustic energy output from the oral and nasal cavities of the speaker is called "Nasalence". Most normative data available for assessing resonance through instrumentation have been on English speaking population. The nasalance is influenced by several parameters such as age, language, dialect, speech stimuli and gender. Hence the present study investigated nasalence values in Non- native English speakers using RAINBOW passage. Mean nasalence scores were obtained from 45 normal males and 70 normal females. The results indicated higher nasalence percent and variability in females compared to males. The mean nasalence value was 31.39 for females and 27.93 for males. A comparison of the nasalence values for Rainbow passage across various studies reveal significant differences except Hutchinson etal. (1978). this difference is due to the difference across subjects, age and the instrumentation.

Key words: Nasometer, Nasalence, Rainbow passage, Non-native English speaker.

Nasality is a common problem in subjects with repaired / unrepaired cleft palate, which affects the speech intelligibility. Nasal resonance is not only seen in disordered speech, it is also seen at certain extent in normal speech. Nasality can be assessed by subjective as well as objective methods. Judgment of nasality is done using various rating scales. Instrumentation provides explicit information with respect to certain ranges of nasal resonance that was particularly difficult for listeners to resolve. Earlier studies indicated that nasalance values vary across languages. (Anderson, 1996; Van Doorn and Purcell, 1998; Van Lierde, 2001; Whitehill, 2001; Van Lierde, Wuyts, De Bodt, and Van Cauwenberge, 2001: Van Lierde, Wuyts, Bodt, and Cauwenberge, 2003; Sweeney and O'Regan, 2004: Mahesh and Pushpavathi, 2008)

An initial step towards refining the use of nasometry as an objective measure of perceived nasal acoustic energy involves manipulating the speech sample used. Several speech samples and reading materials are included in the nasometry package for use in assessment of resonance disorders. Three standard stimuli for data collection were recommended by Fletcher (1978) - Rainbow passage (a passage in which the occurrence of phonemes is similar to the occurrence in English conversational speech), Zoo passage (which has only oral sounds) and a set of nasal sentences. Most of the studies used speech stimuli developed in their own languages and are comparable to Standard English passages. Nasalence data has been published for normal speakers (Hutchinson, Robinson and Nerbonne, 1978: Seaver, Dalston and Leeper, 1991: Leeper, Rochet and MacKay, 1992) as well as in clinical groups (Fletcher, 1978).

Nasalence value also varies with reference to the gender. Gender related differences in nasalance value can possibly be related to basic structural and functional differences across gender. The resonance of voice is influenced by the size, shape and surface of infraglottal and supraglottal resonating structures and cavities. Previous studies found that female speakers have

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significantly higher nasalance values compared to male speakers on passage containing nasal consonants (Seaver, Dalston, and Leeper, 1991; Van Lierde, Wuyts, De Bodt and Van Cauwenberge, 2001; Fletcher, 1978; Hutchinson, Robinson, and Nerbonne, 1978).

Seaver, Dalston and Leeper (1991) compared the nasalence values of 148 normal adult subjects speaking four dialects of American English using Rainbow passage, Zoo passage and a set of nasal sentences. The mid atlantic speakers were found to have significantly higher nasalence value in all three stimuli. The female subjects had significantly higher nasalence value on the nasal sentences. They also found significant difference across dialects. Post hoc comparison revealed significant difference among the values of Mid Atlantic and Mid Western speakers, Mid Atlantic and Ontario speakers, Mid Atlantic and southern speakers. Correlations of moderately high strength were found between nasalence values of Rainbow passage readings with Zoo passage readings probably due to predominance of oral consonants and vowels, even though it does contain some nasal consonants. Correlations of moderately high strength were also found between nasalence values of Rainbow passage readings with nasal passage readings probably due to both passages contain nasal consonants hence the instrument would respond accordingly.

There is very limited data on nasometric values in non-native English speakers using rainbow passage. Normative data are available for English speakers, as most of the studies have been conducted in native English speakers. These data in turn indicate that not all native English speakers obtain the same nasalence values. Factors such as English dialect spoken and gender of the subject appear to affect nasalence value which suggest cross dialect differences. These results stress the importance of developing normative data for various subgroups in the general population using the standard rainbow passage. Speech pathology clinics in India are using the Nasometer to confirm the perceptual judgment of abnormal levels of speech nasality. In particular, it is being used to assess the velopharyngeal dysfunction and to evaluate its treatment in clients with cleft palate. Normative nasalence measures will provide the database for future investigation on clinical population in India. In this context, the present study developed normative data on nasalence for non-native English speakers.

Method

Subjects: Forty five males and seventy females in the age range of 18 to 30 years served as subjects in the present study. All the subjects had normal structure and function of the oral mechanism. The subjects considered were from different parts of India. Subject had learnt English as a second language. Table 1 shows the subject details considered in the present study.

Subjects	Age range	Language (Mother tongue)				
		Kannada	Malayalam	Tamil	Telugu	Hindi
Males (N=45)	18-30 yrs	12	8	7	3	15
Females (N=70)	18-30 yrs	30	15	6	2	22

Table 1: Details of the subjects.

Instrumentation and Material: The Nasometer Model 6400 (Kay Elemetrics, New Jersy) was used in the present study. The oral and nasal components of the subject's speech are sensed by microphones on either side of a sound separator that rests on the patient's upper lip. Nasometer computes a ratio of the nasal to nasal –plus- oral acoustic energy from the digitized signals. Nasalence is expressed as a percentage value computed from that ratio (nasalence= nasal/{oral + nasal}X100. Prior to data collection, the nasometer was calibrated as prescribed by the manufacturer. One of standard passage, "Rainbow passage" provided in the manufacturer's manual was used as stimuli in this study. The "Rainbow passage" contains a mixture of oral and nasal consonants in the approximate proportion found in everyday speech (Fairbank, 1960). It contains about 11% of nasal phonemes and the nasal sentences are 35%.

Procedure and analysis: Subjects were seated in a quiet setting with the Nasometer headgear adjusted so the separation plate rested comfortably but firmly on the subject's upper lip and perpendicular to the plane of the face. Each subject read the Rainbow passage displayed on the monitor. Once the subject completed the task, the mean nasalence value was computed using the software package. For each subject's production, data on mean nasalence value, standard deviation, maximum and minimum nasalence value were collected using nasometer software. Independent 't' tests was computed to determine significant differences in nasalence values across gender and to compare with other studies.

Results and Discussion

Mean Nasalence value across gender

The nasalence value ranged from 16% to 35% and the mean was 27.93 (SD 4.17) in males. In females the range was 20 % to 56% and the mean was 31.39 (SD-7.31). Table 2 shows the mean nasalence value and standard deviation of nasalence.

Gender	Rainbow passage		
	N	Mean	SD
Male	45	27.93	4.17
Female	70	31.39	7.31
Total	115	30.04	6.48

Table 2: Mean nasalence value for Rainbow passage.

Results of Independent "t" test showed significant difference across gender (t= 2.85, $p<0.01$) with females having higher nasalence percent compared to males. Also, the standard deviation was higher in females compared to males indicating higher variability among females.This result supports the findings of Seaver et al., 1991; Van Lierde et al., 2001; Fletcher, 1978; Hutchinson et al, 1978, who reported that female speakers have significantly higher nasalance values than male speaker on passage containing nasal consonants. Gender related differences in nasalance value can possibly be related to basic structural and functional differences. The resonance of voice is influenced by the size, shape and surface of infraglottal and supraglottal resonating structures and cavities.

Two subject variables could be associated with increased nasal flow rate in female speakers, increased respiratory effort and increased nasal cross sectional area. Since females have longer nasal cross sectional area than males such a difference could be seen (Liu,1990). Mc Kearns and Bzoch (1970) discovered different patterns of velopharyngeal closure for females as determined by cineradiographic analysis. They suggested that different velopharygeal muscle insertions occur across gender, which may arise from differences in the relationship of the skull and cervical column or differences in vocal tract dimensions.

Thompson and Hixon (1979) studied 112 normal children and adults and found that females produced more coarticulatory anticipation of nasal consonants and had greater degree of nasal air flow during production of nasal consonants than males. The nature of measurement procedure dictates that degree of nasalence in speech will be proportional to the acoustic energy of the signal as it exits from nasal and oral chambers. This proportion is controlled by the physical characteristics of the oral and nasal chambers, integrity of velopharygeal valve, postures of lips and tongue and by the phonetic demands of the sounds spoken.

The present study does not support the findings of Fletcher (1978) who found that males had higher mean nasalence value than females for nasal sentences. The present study also does not support the notion that there is no significant difference in nasalence value across gender (Litzaw and Dalston, 1992; Kavanagh, Fee and Kalinowski, 1994).

Comparison of nasalence value for Rainbow passage across studies

The normative data for sentences using "Rainbow Passage" across various studies are presented in Table 2. Single sample "t" test was used to compare the present study with earlier studies using Rainbow passage and is presented in table 3. Table 4 shows the results of single sample "t" test.

Author (Year)	Language	N	Subjects	Mean	S.D
Fletcher et al. (1989)	American	117	Children	35.6	5.20
Seaver etal(1991)	American	140	Adult male	35.0	6.0
			Adult female	36.0	6.0
Hutchinson etal (1978)	North west American	30	Geriatric male	23.5	5.1
	North west American	30	Geriatric female	32.0	10.7
Litzaw & Dalston (1992)	Mid Atlantic	15	Adult male	36.0	4.0
	Mid Atlantic	15	Adult female	37.0	4.0
Present study (2008)	Indian	45	Adult male	27.9	4.1
		70	Adult female	31.3	7.3

Table 3: The normative data for Rainbow passage across various studies.

Sl No.	Author (Year)	Subjects	"t" value	"p" value	Interpretation
1	Fletcher et al. (1989)	Children	9.25	<0.001	Significant difference
2	Seaver etal(1991)	Males	11.23	<0.001	Significant difference
		Females	5.23	<0.001	Significant difference
3	Hutchinson etal (1978)	Males	7.04	<0.001	Significant difference
		Females	0.69	>0.05	No significant difference
4	Litzaw & Dalston (1992)	Males	12.82	<0.001	Significant difference
		Females	6.36	<0.001	Significant difference
		Total	9.76	<0.001	Significant difference

Table 4: Results of single sample "t" test.

The above table depicts the mean nasalence value across studies and across age. The mean value ranges from 23 % to 37%. This difference is due to the difference across subjects, age and the instrumentation. A comparison of the nasalence values for Rainbow passage across various studies reveal significant differences except Hutchinson etal. (1978). They measured nasalence on elderly subjects in the age range of 50-80 years using TONAR II instrument. A nasalence mean value of 23.5 and 32.0 in geriatric males and geriatric females, respectively was found in the study. There was significant difference across mean nasalence value in males ($p<0.01$) when compared to the present study. The probable difference could be attributed to the age and the instrument used.

Aging is accompanied by degeneration of receptor cells, decline in number of nerve fibres in associated neural tracts, loss of brain cells in corresponding projection areas, decrease in muscular strength, slowness, lack of fine coordination of movement, cognitive slowing and deterioration in neural density and general delay in synaptic transmission (Corso, 1975; Botwinick, 1973; Crossman and Szafran 1956; Griew, 1963). The present results permit the general conclusion that where relatively continuous demands for velopharyngeal closure are required, older subjects exhibit notably less competence than normal young adults.

There was no significant difference across mean nasalence value in females when compared to the present study. Seaver etal. (1991) reported that nasometer performance was not significantly influenced by age. Warren and collegues, (1990) has indicated that nasal cross sectional areas is not affected by age after the age of 18.

On theoretical grounds, one might imagine that Rainbow passage would be particularly useful in sampling the acoustic consequences of velopharyngeal behaviour since the frequency of occurrence of phonemes in this passage roughly mirrors that found in conversational speech. Eleven percent of the phonetic elements are nasal consonants. The effect of these nasal consonants is not limited to the moment of their utterance, however rather a coarticulatory "spread of nasalization" is found in which the nasal consonants are anticipated by opening of the velopharyngeal valve prior to the onset of the nasal element in the speech output (Fletcher 1989). On other hand , this passage is much longer than Zoo passage. Moreover, it is syntactically more complex and contains a number of words that are difficult for very young children (Dalston and Seaver, 1992). Fletcher, (1978) determined that Nasalence values for the rainbow passage were consistently higher than the Zoo passage.

Litzaw and Dalston, (1992) measured nasalence on adults in the age range of above 18 years with mid atlantic dialect using Nasometer 6200 instrument. A nasalence mean value of 36.0 and 37.0 in adult males and adult females, respectively, was found in the study. Though the subjects taken up in both the studies were adults there was significant difference across the values. Seaver etal.(1991) also measured nasalence in the age range of 16 years to 63 years belonging to four geographic regions using Nasometer 6200 instrument. A nasalence mean value of 35.0 and 36.0 in males and females respectively was found in the study. There was significant difference across mean nasalence value in males and females ($p<0.01$) when compared to the present study. These differences could be attributed to significant cross dialectal (English) and cross linguistic differences in nasometric values (Seaver et al., 1991; Leeper, Rochet, and MacKay, 1992).

Fletcher et al. (1989) measured nasalence in Children in the age range of 5 years to 12 years using Nasometer 6200 instrument. A nasalence mean value of 35.69 was found in the study. There was significant difference across mean nasalence value in children ($p<0.01$) when compared to the present study. These differences could be attributed to subjects taken up in both the studies, as the present study included only adults.

Differences in these values are difficult to interpret because there were methodological differences in the studies. However, the extent of the differences may indicate that there is need to control for dialect, age, and gender before meaningful across study comparisons can be made.

Research has reported significant cross dialectal and cross linguistic differences in nasometric values (Seaver et al., 1991; Leeper et al., 1992). Normative data for nasalence values and clinically determined cutoff values have both been found to be sensitive to dialectal differences in different regions of North America. Differences in mean Nasalence values across languages may be explained by different use of vowels, oral and nasal consonants across languages (Leeper et al., 1992; Anderson, 1996).

Furthermore, even in bilingual speakers, differences in nasometric values across languages are significant (Leeper et al., 1992). Thus it is essential that for establishing normative data for nasometer, issues pertaining to dialect and language need to be considered. Mean nasometric values obtained for a specific linguistic group may not be valid for use with other groups, even though they may speak the same language. Hence the normative data for different dialectal and linguistic populations are necessary.

Conclusions

Very few Indian studies have been done on developing a normative data in Indian context using "Rainbow passage" as the standard stimuli using Nasometer 6400. The primary purpose of this present study has been to provide speech and language pathologists with instrumental verification of their perceptual judgements concerning the diagnostic evaluations. There are no Indian studies reported on nasalence value using the Nasometer II 6400. Most of the earlier studies used TONAR system and Nasometer 6200 to measure nasalence. The nasometer instrumentation differs substantially from the earlier Tonar system. The reported normative nasalance data provide important reference information for the assessment of nasality disorders in adults on using Nasometer II 6400 with "Rainbow passage" as the speech stimuli. The performance on "Rainbow passage" would provide information over and above that available from the values of Nasal and Zoo passage. The provision for rapid, accurate, biometric feedback provides opportunity to probe the modifiability of nasalence systematically. However, study by Dalston and Seaver, 1992 reported, that "Rainbow passage contains a number of words that are difficult to produce for very young children to pronounce.

Establishing the cut off values for clinically significant abnormalities is important in many areas of medical epidemiology. It can be approached from a clinical or statistical perspective (Barker and Rose, 1984). For the Nasometer, the issue of determining cut off nasalance value for clinical populations has been approached from both statistical and clinical perspective. Clinically the normative data reported in the present study may help identifying adults with resonance disorders. Nasalence may also be a sensitive indicator of the presence and progress of neuromuscular disease (Fletcher and Bishop, 1970). Speech pathologists, Otolaryngologists, and Plastic surgeons can use the data to help objectify and supplement their diagnostic, follow-up testing, and treatment protocols.

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Acknowledgements

The authors wish to thank Dr. Vijayalakshmi Basavaraj, Director, AIISH for her encouragement and all the support provided to conduct this study. The authors also wish to thank all the subjects who volunteered to serve as subjects in this study.