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Acoustic Analysis of Nasal Consonants during Fast and Normal Speaking Rate in Malayalam Speaking Adults

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ABSTRACT: Nasal consonant are produced when the velum is lowered and the airstream is allowed to flow out through the nose to produce [m] and [n].the present study investigated the acoustic characteristic of nasal consonants across two different rate of speech i.e. normal and fast rate in 19-25 year old young adults. A total of 30 young adults participated in the study. These were native speakers of Malayalam with no history of speech, language and hearing problems. The subject was asked to repeat back the words presented in normal and fast speaking rates. The responses were recorded using PRAAT software. The acoustic parameters including mean pitch, jitter, shimmer, SNR and HNR were acoustically analyzed for normal and fast rate of speech.

Keyword: Nasal consonants, Malayalam language, Acoustical analysis.

I. INTRODUCTION

Nasalization is the production of a sound while the velum is lowered, so that some air escapes through the nose during the production of the sound by the mouth. When this happens, the oral cavity is still the major source of output but the sound gets a distinctively nasal characteristic. Nasality is one of the important parameters in the perception of normal as well as disordered speech. The concept of "Nasalance" introduced by Fletcher et al. (1978) An archetypal nasal sound is /n/.In most languages vowels that are adjacent to nasal consonant are produced partially or fully with a lowered velum in a natural process of assimilation and are therefore technically nasal, though few speakers would notice. Kawabata and Nakamura (2000) examined the acoustic and perceptual properties of syllables in continuous speech as a function of speaking rate and suggested that individual syllables do not have enough phonetic information to be correctly identified especially for the fast speech. Malayalam is a Dravidian language spoken by around 35 million speakers of Kerala state in the south –west of India .All consonant involve a modification of the airstream, ranging from mild in the case of approximants to severe in the case of plosives. Overveiw of acoustic characteristics of consonant is organized in terms of manner of articulation, beginning with those of approximants, since they are most similar to those of vowels and ending with those of plosives. In a study by Kerry, Watterson and Terasa (2000) high vowels were associated with signifi- cantly higher nasalance values than the low vowels for both sentence and sustained vowels.

Nasality depends on several factors such as vowel type, length of the stimuli, context of the speech sound and rate of the speech. For the production of nasal stop consonant the oral airflow is temporarily blocked by means of a complete constriction in oral cavity. However the velum is lowered such that air can escape only through the nasal cavity. The resulting sound is known as nasal murmur. Nasals require the use of two resonance cavities, oral and nasal which are combined in a complex way. As a class nasal are characterized by several properties. Aoyama (2003) conducted a two experiment study in which she investigated the perception of syllable initial and syllable final nasal in English by Korean and Japanese listeners .In both Korean and English,/m/ and /n/ contrast syllable initially and /m/,/n./ and /N/ contrast. Nasal consonant are produced by an oral closure and a velopharyngeal opening (house 1957:stevens , 1998). Data provided by MacKay and Kummer (1994) supported the contention that nasalance values from short stimuli may be markedly influenced by the vowel content.

Regarding the production of nasal consonants and their acoustic characteristics, some relevant variables which have been considered by researches are stress syllable and vowel (fujimura, 1962; Krakow, 1995) .Malayalam language has different accents across Kerala and people uses normal and fast rate of speech which causes difficulty for perceiving speech by listeners.

II. Review of literature

Kuwabara and Nakamura (2000) examined the acoustic and perceptual properties of syllables in contiouns speech as a function of speaking rate and suggested that individual syllables do not have enough phonetic information to be correctly identified especially for the fast rate of speech.

Velayudhan (1975) studied the durational aspects of Malayalam vowel in isolation as well as in a variety of phonetics contexts. The results revealed that short and long vowel tend to keep their ratio in the range of 1:2. System can accommodate for alterations due to rate of speech.

Kurowski and Blumstein (1987) carried out two experiments in order to determine whether the acoustic properties of articulation of nasals could be derived for English labial and alveolar nasal consonants and to determine whether they remain stable across vowel context, speakers, and syllable positions. As stated by Kurowski and Blumstein (1995, p.199), studies have shown that vowel context influences the perception of the place of articulation of nasal consonants. Zee (1981, cited in Kurowski & Blumstein, 1996, 199) investigated the effect of vowel quality on the perception of post-vocalic nasal consonants (labial, alveolars and velars) in white noise (ie., noise within a wide range of random frequencies of uniform intensity, inserted to make the task more difficult) by native speakers of English.

As regards perception of non- native nasal consonants, few studies have been carried out. Harnsberger(2000,2001) carried out cross language studies in which he investigated the perception(discrimination and /or identification) of non native nasal consonants by native speakers of Malayalam, Marathi, Punjabi, Tamil, Oriya, Bengali, and American English. Results of the identification test (Harnsberger, 2000) showed that labeling and rating of non native stimuli were conditioned by a degree of language- specific phonetic detail that corresponds to perceptually relevant cues to native language contrasts.

The effect of linguistic experience on perceptual similarity among nasal consonant; a multi- dimensional scaling analysis by Hansberger (1999)

And demonstrate that description of the native perceptual categories of listeners must be made at the level of the individual acoustic cues.

Nasalance is the proportion of nasal energy to the total acoustic energy in a speech signal. The study done by chandan r narayan in 2007 on the topic the acoustic –perceptual salience of nasal place contrats and suggest that the role of the acoustic perceptual salience in the distribution of nasal place in the world language.

Malayalam has got more nasal resonance than any other languages. The phonetic implement of geminates in Malayalam nouns by john and simpson and he conclude that the articulatory and durational aspect of utterance extending over a number of syllables.

Nasality can be assessed by subjective as well as objective methods. Perceptual judgment of nasality is done using various rating scales. Research done by kawahara and garney on 2014 in nasal place assimilation and the perceptibility of place contrast and conclude that the asymmetry in place assimilation may result from a difference in the perceptibility of the place contrasts. Previous studies found that female speakers have significantly higher nasalance scores than male speaker on passage containing nasal consonants .Fletcher reported higher nasal value for normal men on nasal sentences. But Hutchinson (1978) reported higher nasal value for women on three reading passages

According to menon and allen 2009 a psychoacoustic methods to find the perceptual cues of stop consonant in natural speech and conclude that the robustness of a consonant sound to noise is determined by the intensity of the dominant cue.

Acoustic analyasis of singleton and geminate nasal in Italian by matti and benedetto 2008 came with that for stops, fricatives ,nasal and consonant also exhibited a significantly larger energy than there singleton counter parts.

Normal speech production depends, in part, on the ability to rapidly couple and decouple the nasal cavity from the oral cavity. Nasal speech sounds require oral nasal coupling, oral sounds require oral nasal decoupling. According to shwartz 2012 the acoustic of normal and nasal vowel production, comparative normal nasal spectrum envelops are derived for each of several vowel and explanation are offered to account for each of each of the prominent within vowel difference Acoustic analysis of speech.

Many studies reported that a significant difference was not evident in nasalance scores across gender. Validation studies by white and strak 2009 and concluded that the acoustic recognition of faults in articulation by the spectrograph is more reliable than that of defects in voice quality.

According to singhall and pradip 2013 they studied the acoustic properties of nasal and non nasal vowels in temporal domain and the result shows significant difference between nasalized and non nasalized vowel /a/.

In English, nasal sounds include the consonants /m/ (bilabial), /n/ (alveolar) and /ŋ/ (velar). In order to properly produce these sounds, the velum must assume a lowered position in order for proper nasal resonance to be achieved. All other sounds in English are considered non nasal. Acoustical analysis of nasal resonance patterns in speech by anne and rochet 1990 and conclude that the

data not only illustrate the difference assimilation nasality pattern within each language as a function of vowel height. Studies on speaking rate have been reported in Malayalam language. Malayalam language has different accent across Kerala and people uses normal and fast rate of speech which cause difficulty for perceiving speech by listeners. Hence an attempt has been made to study the acoustic characteristic of stops during normal and fast rate of speech in typically developing Malayalam speaking children.

The above review indicates limited studies on objective analysis of nasal consonant in fast rate and normal rate in Malayalam language This study was taken up due to lack of studies which objectively document the effect of nasal consonants in fast and normal rate of speech in Malayalam language.

III. Aim

The present study investigated the acoustic characteristic of stop consonants during normal and fast rate of speech of 19 -25 years of Malayalam speaking adult with following objectives:

- To investigate the acoustic characteristics of nasals (n and m) in normal rate of speech.
- To investigate the acoustic characteristics of nasal (n and m) in fast rate of speech.
- To compare the acoustic characteristics of nasal consonants in normal and fast rate of speech.
- To compare the acoustic characteristic of nasal consonants in normal and fast rate of speech between the genders.

IV. Methodology

Subject selection

30 Malayalam speaking adult in age range 19-25 years participated in the present study. (15 male and 15 female).

Stimulus preparation

Words were formulated using nasals such as /m / and /n/. Selected words consisted of nasals in initial, medial and final position.

Stimulus

- The acoustic characteristics of nasal sounds were done between the genders i.e.15 males and 15 females
- Mean pitch, jitter, shimmer, SNR, HNR were analyzed in initial medial and final position.
- t- Test was used to see the significance difference between normal and fast rate of speech.

V. Result and Discussion

Table 1.1 shows the nasal consonant /n/ in final, medial and initial position at fast and normal rate of speech.

comparison between male and female

Parameter	Parameter	Rate		Mannwhitney test Z value	p	
/na/	FINAL	Normal	MEAN PITCH (Hz)	-4.666	.000	*
			JITTER(%)	-1.183	.237	
			SHIMMER(db)	-2.261	.024	*
			HNR(db)	-1.307	.191	
			SNR(db)	-1.265	.206	
		Fast	MEAN PITCH (Hz)	-4.666	.000	*
			JITTER(%)	-2.137	.033	*
			SHIMMER(db)	-2.717	.007	*
			HNR(db)	-.311	.756	
			SNR(db)	-.850	.395	
	INITIAL	Normal	MEAN PITCH (Hz)	-4.666	.000	*
			JITTER(%)	-1.182	.237	
			SHIMMER(db)	-2.136	.033	*
			HNR(db)	-2.053	.040	*
			SNR(db)	-1.058	.290	
		Fast	MEAN PITCH (Hz)	-4.666	.000	*
			JITTER(%)	-.830	.407	
			SHIMMER(db)	-.353	.724	
			HNR(db)	-1.556	.120	
			SNR(db)	-1.804	.071	
	MEDIAL	Normal	MEAN PITCH (Hz)	-4.666	.000	*
			JITTER(%)	-2.054	.040	*
			SHIMMER(db)	-1.141	.254	
			HNR(db)	-1.182	.237	
			SNR(db)	-2.717	.007	*
		Fast	MEAN PITCH (Hz)	-4.666	.000	*
			JITTER(%)	-.892	.372	
			SHIMMER(db)	-1.743	.081	
			HNR(db)	-1.183	.237	
			SNR(db)	-3.257	.001	*

In final position of normal rate of speech shimmer and mean pitch shows high significance were as jitter, HNR and SNR shows less significance and in fast rate of Speech mean pitch and jitter and shimmer shows high sigh significance and HNR and SNR has less significance.

In initial position of normal rate of speech shimmer HNR and mean pitch shows high significance and jitter SNR has no significance at all .and in fast rate of speech only mean pitch shows a significance.

In medial position of normal rate mean pitch, jitter and SNR shows high significance and in fast rate only the mean pitch and SNR shows high significance.

Table 1.2 shows the nasal consonant /m/ in final, medial and initial position at fast and normal rate of speech.

/ma/	FINAL	Normal	MEAN PITCH (Hz)	-4.666	.000	*
			JITTER(%)	-1.244	.213	.
			SHIMMER(db)	-1.472	.141	.
			HNR(db)	-.767	.443	.
			SNR(db)	-.311	.756	.
		Fast	MEAN PITCH (Hz)	-4.666	.000	*
			JITTER(%)	-.166	.868	.
			SHIMMER(db)	-2.427	.015	*
			HNR(db)	-1.182	.237	.
			SNR(db)	-.850	.395	.
	INITIAL	Normal	MEAN PITCH (Hz)	-4.666	.000	*
			JITTER(%)	-2.053	.040	*
			SHIMMER(db)	-1.887	.059	.
			HNR(db)	-.477	.633	.
			SNR(db)	-.892	.373	.
		Fast	MEAN PITCH (Hz)	-4.667	.000	*
			JITTER(%)	-.518	.604	.
			SHIMMER(db)	-1.680	.093	.
			HNR(db)	-2.178	.029	*
			SNR(db)	-1.597	.110	.
	MEDIAL	Normal	MEAN PITCH (Hz)	-4.666	.000	*
			JITTER(%)	-.062	.950	.
			SHIMMER(db)	-2.634	.008	*
			HNR(db)	-.892	.373	.
			SNR(db)	-.311	.756	.
		Fast	MEAN PITCH (Hz)	-4.666	.000	*
			JITTER(%)	-.021	.983	.
			SHIMMER(db)	-1.348	.178	.
			HNR(db)	-.187	.852	.
			SNR(db)	-.062	.950	.

b. Grouping Variable: gender

- In final position of normal rate of speech only mean pitch shows high significance.
- In initial position and fast rate of speech only mean pitch and jitter shows high significance.
- In initial position of normal rate of speech only mean pitch and shimmer shows high significance and in fast rate of speech mean pitch and HNR shows high significance.
- Medial position of normal rate of speech mean pitch and shimmer shows high significance and in fast rate of speech only mean pitch shows high significance.
- Comparison between males and females.

Table 1.3 showing the comparison between males and females in normal and fast rate speech for /na/ in initial, medial and final positions

Parameter		Parameter	gender	Z	p	
/na/	MEAN PITCH (Hz)	FINAL	Male	-1.141	.254	
			Female	-.062	.950	
		INITIAL	Male	-1.514	.130	
			Female	-1.431	.152	
		MEDIAL	Male	-.933	.351	
			Female	-.021	.983	
	JITTER(%)	FINAL	Male	-3.340	.001	*
			Female	-2.426	.015	*
		INITIAL	Male	-.394	.694	
			Female	-.685	.493	
		MEDIAL	Male	-1.804	.071	
			Female	-2.366	.018	*
	SHIMMER(db)	FINAL	Male	-1.721	.085	
			Female	-1.639	.101	
		INITIAL	Male	-2.465	.014	*
			Female	-.954	.340	
		MEDIAL	Male	-2.219	.026	*
			Female	-.602	.547	
	HNR(db)	FINAL	Male	-2.344	.019	*
			Female	-2.406	.016	*
		INITIAL	Male	-1.099	.272	
			Female	-1.369	.171	
		MEDIAL	Male	-1.846	.065	
			Female	-.457	.648	
	SNR(db)	FINAL	Male	-2.800	.005	*
			Female	-2.178	.029	*
		INITIAL	Male	-2.178	.029	*
			Female	-1.120	.263	
		MEDIAL	Male	-2.344	.019	*
			Female	-.353	.724	

- Mean pitch: there is no significance at all in the positions in both males and females
- Jitter; both males and females shows high significance in the final position
- And females shows high significance in the medial position
- Shimmer in initial and medial position males shows high significance
- HNR; both males and females showing significance only in the final position
- SNR; both males and females shows high significance in final position and only males shows significance in medial and initial positions.

Comparison of /ma/ in males and females

Table 1.4 showing the comparison between males and females in normal and fast rate of speech for/ma/ in initial, medial and final positions.

/ma/	MEAN PITCH (Hz)	FINAL	Male	-1.472	.141	.
			Female	-1.638	.101	.
		INITIAL	Male	-1.348	.178	.
			Female	-1.224	.221	.
		MEDIAL	Male	-1.472	.141	.
			Female	-.809	.419	.
	JITTER(%)	FINAL	Male	-.249	.803	.
			Female	-1.265	.206	.
		INITIAL	Male	-1.929	.054	.
			Female	-2.303	.021	*
		MEDIAL	Male	-1.763	.078	.
			Female	-2.096	.036	*
	SHIMMER(db)	FINAL	Male	-.643	.520	.
			Female	-.726	.468	.
		INITIAL	Male	-.809	.419	.
			Female	-.353	.724	.
		MEDIAL	Male	-2.966	.003	*
			Female	-1.079	.281	.
	HNR(db)	FINAL	Male	-1.307	.191	.
			Female	-.601	.548	.
		INITIAL	Male	-2.302	.021	*
			Female	-.850	.395	.
		MEDIAL	Male	-2.012	.044	*
			Female	-2.219	.026	*
	SNR(db)	FINAL	Male	-2.592	.010	*
			Female	-.933	.351	.
		INITIAL	Male	-2.426	.015	*
			Female	-1.141	.254	.
		MEDIAL	Male	-2.758	.006	*
			Female	-2.012	.044	*

- Mean pitch there is not any significance between males and females in all the three positions.
- Jitter- in initial and medial for females there is high significance whereas I other positions there is not any significance for males
- Shimmer-males shows high significance in any positions
- HNR-males shows high significance in initial and medial positions whereas females shows significance in the medial position.

Summary and conclusion

The study geared to understand the acoustic characteristics of nasal consonants across 2 different rate of speech i.e. normal and fast rate in 19-25 years typically developing Malayalam speaking children. A total of 30 subjects participated in the study. These subjects were native speakers of Malayalam with no history of speech, language, and hearing problems. The subjects were asked to repeat back the words presented in normal and fast speaking rate. The response was recorded using PRAAT software. The acoustic parameters including mean pitch, jitter, shimmer, SNR and HNR were acoustically analyzed for normal and fast rate of speech. The results indicated that there is no significant difference for acoustic characteristics of stop consonants during normal and fast rate of speech

Limitation

- The number of sample words was limited due to paucity of time
- Perceptual comparison was not done
- The contained data was recorded in a more artificial set up compared to speech, which occur in more natural setting.
- Future directions
- Similar studies on other types of consonants can be continued.
- Rate of speech can be better controlled for other sample preparation.
- Study can be conducted for other Indian languages
- Can compare across various age group
- Effect of socio economic status can be considered

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