Influence of Voice Focus on Oral-Nasal Balance in Speech

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Summary: Objectives. The concept of voice focus describes the relationship of the vocal tract length on the perceived brightness or darkness of the speaker's voice. The present study explored the impact of adjustments of the voice focus on oral-nasal balance. The vocal tract settings in question were backward focus (retracted tongue, wide pharynx, and lowered larynx) and forward focus (fronted tongue, constricted pharynx, and raised larynx). The backward focus condition was expected to decrease nasalance scores and the forward focus condition was expected to increase nasalance scores.

Study design. Experimental repeated-measures study.

Methods. Sixteen females aged 23.78 (standard deviation 1.99) produced oral and nasal test sentences with a backward focus and a forward focus. Audio recordings and nasometry measurements were made. Nine of the participants completed the task successfully.

Results. In a repeated-measures analysis of variance, the nasalance scores were compared across stimuli, speaking condition, and repetition. There was a main effect for stimuli ($F = 109.37$, $P < 0.0001$). In a follow-up analysis of variance we found a condition effect for the nasal stimulus ($F = 17.91$, $P < 0.0001$). For the nasal stimulus, the nasalance scores of the backward focus were lower, and the nasalance scores of the forward focus were higher than in the normal condition.

Conclusions. Changing the voice focus influenced oral-nasal balance more when the velopharyngeal port was open. Future studies should explore the possible treatment potential of voice focus for patients with hypernasality.

Key Words: Voice focus–Nasalance–Hypernasality–Oral-nasal balance–Vocal tract settings.

INTRODUCTION

The concept of voice focus describes the influence of the settings of the tongue, pharynx, and tongue on the perceived sound of the voice.[1] Physiologically, a forward focus results from a raised larynx together with a forward tongue carriage and a narrowed pharynx, resulting in a shortened and narrowed vocal tract. The sound is described as thin and juvenile. A backward focus results from a lowered larynx, a posterior tongue carriage, and a widened pharynx, resulting in a lengthened and widened vocal tract. The corresponding sound is described as a dark and throaty "country bumpkin voice."[2] Vocal focus is an important concept in singing pedagogy. Tongue positioning plays a central part in singing teaching. A more forward tongue position is associated with a more anterior singing focus, whereas classical bel canto singing has a more central focus.[3,4] Sundberg and Nordström[5] demonstrated how altering the length of the vocal tract by raising or lowering the larynx respectively increased or decreased vowel formants, in particular the second formant, and changed the characteristics of the long-term averaged spectrum (LTAS). The purpose of the present study was to investigate how the speaking focus of the voice influences oral-nasal balance in speech.

Accepted for publication August 31, 2015.
Presented at the Voice Foundation's 44th Annual Symposium, May 28 (May 26–31) 2015, Philadelphia, Pennsylvania.
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Journal of Voice, Vol. ■■, No. ■■, pp. ■■-■■
0892-1997

http://dx.doi.org/10.1016/j.jvoice.2015.08.021

The oral-nasal balance of a speaker is regulated by the velopharyngeal mechanism. This mechanism is complex and comprises a number of pharyngeal muscles.[6,7] If the velopharyngeal sphincter cannot close completely because of a structural or neurological disorder, too much air and sound will be emitted through the nose, leading to hypernasal speech. Hypernasality can affect the intelligibility and acceptability of speech and can lead to social prejudice toward the speaker.[8] Velopharyngeal closure is a variable and task-dynamic process, and it has been found that speakers use different closure patterns.[9] It is difficult for a speaker to appreciate how the velum and pharynx are moving because they offer little to no proprioception.[10] As a result, there are few effective speech therapy exercises that can help a hypernasal patient develop better velopharyngeal closure.[8,11]

Although it is difficult for speakers to lift the velum or approximate the pharyngeal wall on command,[12] it may be possible to influence oral-nasal balance in speech by changing global vocal tract settings, such as the voice focus.[2,8] However, the specific impact of forward or backward voice focus on oral-nasal balance in speech has yet to be investigated. The voice focus and the acoustics of speech are the direct product of vocal tract settings, such as lip rounding, tongue position, mandibular opening, pharyngeal width, and larynx height.[13] Vocal tract settings are altered and adapted when a speaker switches languages,[14,15] speaks with the mouth full,[16] or voluntarily contorts the tongue for a specific effect.[17] Speech perturbation experiments have shown how quickly speakers adapt their speech movements when a bite block is inserted between the teeth,[18] lip rounding is changed with a tube,[19] or the jaw is suddenly pulled down during speech.[20] It is probably the speaker's auditory monitoring that allows him or her to adjust the vocal tract settings quickly.[21,22]

Oral-nasal balance is commonly assessed with an instrument called the nasometer.[23] The nasometer uses a sound separation plate to make separate recordings from the speaker's nose and mouth. The nasal proportion of the total speech signal is quantified as a percentage, resulting in a measure called nasalance.[8] Nasalance scores are lower scores for oral sounds and higher for nasal sounds. High scores for oral stimuli are associated with hypernasality and low scores for nasal stimuli are associated with hyponasality.[8] It has been observed that vowel height influences nasalance scores.[24] Stimuli with high front vowels have higher nasalance scores than those with low back vowels.[24–27] The increase in scores with high vowels may be due in part to transpalatal sound transmission.[26] Based on computer modeling, it has also been speculated that an expanded pharynx and a more anterior tongue position may reduce the perception of hypernasality for the vowel /i/.[28] On the other hand, Bressmann et al[29] described the case of a speaker who reduced her perceived hypernasality and her nasalance scores by speaking with an extreme forward focus (raised larynx and constricted pharynx). Here, the drop in hypernasality and nasalance scores may have been due to a constriction of the pharynx, which may have improved velopharyngeal closure.

To date, there has been no research on nasalance values for forward or backward speaking foci in normal speakers. Based on the model by Rong and Kuehn[28] and what is known about the effect of vowel type on nasalance scores,[24–27] the first hypothesis was that the forward focus condition would yield higher nasalance scores than the normal speaking condition. The second hypothesis was that the backward focus condition would yield lower nasalance scores than the normal speaking condition.

Apart from the research hypotheses, there were other expectations for the data set, based on nasalance scores reported in the literature. These were included in the statistical analyses. The oral stimuli with high front vowels were expected to have higher scores than those with low back vowels.[24,27] It was also expected that the nasal stimulus would have higher scores than the oral stimuli.[25] Nasalance scores were expected to be consistent across repetitions.

METHODS

Participants

Sixteen female participants with a mean age of 23.78 (SD 1.99) were recruited from the student population of the University of Toronto. They reported normal hearing, no history of hyper- or hyponasality, and no nasal congestion at the time of data collection. All participants spoke English with the accent common to southern Ontario. The research procedures were reviewed and approved by the Research Ethics Board at the University of Toronto.

Sample size was determined as follows: Assuming a mean nasalance score of 12 (SD 3) for the zoo sentence in the normal speaking condition[30,31] and a score of 16 (SD 3) for the forward focus, we determined a sample size of seven to achieve a power of 0.8 and an alpha of $P = 0.05$ (one-sided). Because we could not be certain that all participants would be able to do the task correctly, we decided to enrol 16 participants to ensure a sufficient group size.

Participant training

The first author discussed the concept of vocal tract settings with each participant and demonstrated how to use the forward focus and backward focus in speech. The possible impact of focus on pitch was discussed, and the difference between simply changing pitch and adopting a forward or backward focus was demonstrated. For the forward focus, the participants were asked to bring their tongue forward, raise the larynx, and narrow the pharynx. To illustrate the elevation of the larynx, tactile feedback from the neck during a swallow was used. For the backward focus, the participants were asked to retract their tongue, lower the larynx, and widen the pharynx. This lower position was facilitated with a yawning maneuver. During the training phase, participants had the opportunity to use an ultrasound transducer (SeeMore 5.0 MHz USB ultrasound probe, National Ultrasound, Pleasanton, CA) to monitor the midsagittal shape and position of their tongue on a laptop computer (Acer Aspire One, Acer Canada, Mississauga, ON) running the Interson SeeMore imaging software (National Ultrasound).

Stimuli

The stimuli consisted of six sentences without nasal sounds and one sentence loaded with nasal consonants. The first oral stimulus consisted of the first two sentences of the zoo passage ("Look at this book with us, it's a story about a zoo") and the nasal stimulus was the first of the nasal sentences ("Mama made some lemon jam").[23] The remaining five oral sentences were loaded with different vowels.[24] These stimuli were chosen because they are commonly used in clinical nasalance assessments, and they are considered appropriate to assess changes in oral-nasal balance.

All seven stimuli were presented to the participants on a computer monitor. The order of the stimuli was randomized, and they were read twice for each speaking condition. The participants were asked to read the stimuli in the normal condition first. The order of the two remaining conditions (forward and backward focus) was randomized. If a participant made an error on a stimulus, they were asked to read it again. On occasion, participants indicated that they felt their productions were not good. In this case, they were given an opportunity to repeat a block of stimuli.

Recording procedures

All the recordings took place in a quiet room. The participants were seated with their forehead in a head stabilizer.[32] They wore the headset of the Nasometer II 6450 (KayPENTAX, Montvale, NJ). The nasometer was calibrated according to the manufacturer instructions on each day of recording. The nasometer was attached to a laptop (Asus model X53U, Asus Canada, Markham, ON). The nasalance sound recordings for each condition were saved to a hard disk and measured after the session. The mean nasalance scores for the different test items were recorded.

During the recording, the participants rested their chin on the ultrasound probe. The video feed of the participants' midsagittal tongue was converted to a National Television Systems Committee RS-170A signal (TV-PC85 converter, Sabrent, Chatsworth, CA) and recorded to a digital video disc (Sony DVDirect VRD-MC6, Sony Canada, Toronto, ON). The online ultrasound image allowed the experimenter to monitor during