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Nasalance scores for typical Irish English-speaking adults

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Abstract

To establish normative nasalance values for Irish English-speaking adults. Thirty men and 30 women with normal resonance read aloud 16 sentences from the Irish nasality assessment protocol (1), the Zoo passage, and the Rainbow passage. The speech samples were recorded using the Nasometer II 6400. Results of a mixed between-within subjects ANOVA indicated no significant gender effect on nasalance scores. The speakers showed significantly higher nasalance scores for high-pressure consonant sentences than low-pressure consonant sentences, and for the Rainbow passage than Total test sentences. There was no significant difference between high-pressure consonant sentences and the Zoo passage. Compared to previous studies, the Irish young adults had lower nasalance scores than Irish children and than young adults with North American dialects.

Keywords: nasalance, Nasometer, resonance, Irish English, normal adults, gender effect

Introduction

Nasometry is a non-invasive, computer-based procedure that quantifies acoustic consequences of velopharyngeal function by means of an index. It is the most frequently used instrumental technique in both research and clinical settings for assessing resonance disorders due to anatomical or physiological abnormalities of maxillofacial structures and for evaluating treatment outcome (2-4). Amongst the available systems, the Nasometer (KayPENTAX, Lincoln Park, NJ) is the most widely used (5). The Nasometer calculates a nasalance score, which is a ratio of nasal to nasal-plus-oral acoustic energy during speech. In principle, the higher the degree of nasality, the higher the nasalance score. Standardised speech stimuli for nasometric evaluation have been developed for various languages (see 6,7 for a review). There are three categories of stimuli: oral sentences or passage, which are devoid of nasal sounds, allow an examiner to assess for hypernasality as a result of inadequate velopharyngeal closure during speech; oronasal sentences or passage, which contain both nasal and non-nasal speech sounds, are useful for evaluating the impact of velopharyngeal dysfunction (VPD) in normal conversation; and nasal sentences or passage, which are heavily loaded with nasal speech sounds, are used to assess for hyponasality that is usually associated with nasal obstruction (6,7). The nasalance scores obtained from a patient are generally compared to published normative scores (8), hence, information on nasalance norms is important.

Normative nasalance data have been established for different languages and many studies have investigated the influence of language/dialect, age, gender, and phonetic content of speech stimuli on nasalance scores (5). Overall, the findings show that regional norms are necessary for nasometric evaluation because speakers of some

languages or dialects tend to show higher nasalance scores than others (6). For example, Van Lierde et al. (9) reported that adult speakers of Canadian English and North American English had significantly higher nasalance scores than Flemish and North Dutch speakers for oronasal and oral speech stimuli. Age may have an effect on the nasalance scores – generally speaking, children tend to have lower nasalance scores than young adults (10), who tend to have lower nasalance scores than older adults (11). Previous studies that have included children from a wide age range reported that younger children showed lower nasalance scores than older children on some speech stimuli (5,12). Speech stimuli that are loaded with a higher proportion of nasal speech sounds (13,14) or high vowels (15) are associated with higher nasalance scores. As for the effect of gender, mixed results have been reported. While a number of studies found negligible or no significant gender difference (1,5,16-21), other studies reported significantly higher nasalance scores for women than men (10,11,22-25), one reported significantly higher nasalance scores for school-aged boys than girls for oral speech stimuli (12), and one found significantly higher nasalance scores for women than men for a nasal sentence but significantly lower nasalance scores for women than men for an oral sentence (26).

To date, normative nasalance scores for Irish English-speaking children have been published (1) but there have not been published norms for Irish English-speaking adults. Sweeney et al. (1) reported the mean, standard deviation, and range of nasalance scores for four categories of speech stimuli collected from 70 typically developing children – 34 boys and 36 girls aged from 4 years 11 months to 13 years. The speech stimuli were 16 sentences adapted from the GOS.SP.ASS (Great Ormond Street Speech Assessment), which is widely used in the United Kingdom and Ireland with children

with cleft palate and VPD (27,28). Five of the sentences belonged to the High-Pressure Consonant Sentence category (oral sentences loaded with high-pressure consonants), two to the Low-Pressure Consonant Sentence Category (oral sentences devoid of high-pressure), and one to the Nasal Sentence Category (contains 55% nasal consonants). The rest of the sentences were mixed (oronasal) sentences and were included to ensure that the whole set of stimuli (i.e., the Total Sentence Category) contain 11% nasal consonants, which represents the frequency of occurrence of nasals in English (29). The stimuli were culturally appropriate for the Irish population and were intended for use in perceptual analysis of nasality, nasal airflow, and nasometric evaluation in Ireland (1). In their study, Sweeney et al. found no significant difference in nasalance scores between boys and girls across the different categories of stimuli. The nasalance scores of the nasal sentence were significantly higher than those of the Total Sentence Category and oral sentences. However, there was no significant difference between the high-pressure and low-pressure consonant sentences. The nasalance scores of the Irish English-speaking children were lower than those of the American English-speaking children, reported by Fletcher et al. (30) and Watterson et al. (14), by 6-10% for oronasal stimuli but there was no difference between the speakers of the two dialects for oral stimuli containing high-pressure consonants. For oral stimuli containing high-pressure consonants, the nasalance scores of the Irish speakers were higher than those of the Brazilian Portuguese-speaking children reported by Trindade et al. (31) by 6%.

As indicated above, normative nasalance data for both paediatric and adult populations are necessary for conducting nasometric evaluation with individuals with resonance disorders. Therefore, the primary aim of the present study was to establish nasalance norms for Irish English-speaking adults. In order to determine whether norms

should be reported separately for the male and female speakers, the effect of gender on nasalance scores was examined. Finally, the study investigated whether the findings on the influence of speech stimulus on nasalance scores reported for Irish children by Sweeney et al. (1) hold true for Irish adults. The speech stimuli developed by Sweeney et al. were used in this study. In order to make cross-dialect comparisons, the Zoo Passage (oral stimuli) (32) and the Rainbow Passage (oronasal stimuli) (29) were also included as they have often been used in previous nasometric studies for English-speaking adults.

Materials and methods

Sample size was calculated prior to data collection, based on the standardised difference which was derived from the standard deviations (SDs) reported in previous studies and the smallest true difference of nasalance scores (33). The SDs for the various speech stimuli reported in the studies by Sweeney et al. (1) and Seaver et al. (22) were used because the former employed Irish children and the latter was with adult speakers of English. The smallest true difference was defined as 6% nasalance score, as Watterson et al. (34) recommended that standard test-retest variability should be five nasalance points for typical speakers. The results of the calculation indicated that 30 participants per group was required to detect a difference of one standard deviation between the male and female speakers for all types of speech stimuli (detailed below) at a power of 0.9 and 5% significance level. Ethical approval was granted by the Clinical Research Ethics Committee of the Cork Teaching Hospital in January 2008, and written consent was obtained from each subject prior to data collection. Thus, 30 male (mean age = 21 years) and 30 female (mean age = 20 years) native speakers of Irish English between the ages of 18 and 28 years were recruited from University College Cork

(UCC) via email. In order to control for possible influence of dialect on the nasalance scores, only individuals from County Cork (south Ireland) were included. All subjects had normal hearing ability and no history of speech, language, voice, or hearing disorders and oro-craniofacial anomalies, according to self-report. They did not have a cold or nasal blockage on the day of data collection. Furthermore, they were judged to have normal resonance by the second author based on conversation.

The speech stimuli were the 16 sentences used in the nasometric study for Irish English-speaking children (1), the Zoo passage (32), and the first paragraph of the Rainbow passage (29). The subjects were instructed to read aloud the stimuli at their habitual level of loudness, pitch and rate. The speech samples were acquired using the Nasometer II Model 6400 (Kay Pentax, Lincoln Park, NJ) in a quiet room – the Phonetics Lab in the Department of Speech and Hearing Sciences, UCC. The Nasometer was calibrated according to the user manual at the start of each day before recording.

A mixed between-within subjects analysis of variance (ANOVA) was conducted using SPSS (version 16.0) to test the difference in nasalance scores between the male and female speakers across the six types of speech stimuli – High-pressure consonant sentence, Low-pressure consonant sentences, Nasal sentence, Total test sentences, the Rainbow passage, and the Zoo passage. A Bonferroni post hoc analysis was carried out to identify which speech stimuli showed significant differences ($p < 0.05$).

Results

The results of the mixed between-within subjects ANOVA indicated no significant main effect for gender ($F(1,58) = 0.053$, $p = 0.819$) but a significant effect for speech stimulus ($F(5,54) = 0.059$, $p = 0.000$). The interaction effect of gender and

stimuli was not significant ($F(5,54) = 0.401, p = 0.846$). Bonferroni post hoc analysis revealed significant differences between all types of speech stimuli ($p = 0.000$), except between the high-pressure consonant sentences and the Zoo passage ($p = 1.000$). Since there was no significant difference in nasalance scores between the male and female speakers, the results of all subjects were combined and they are summarised in Table I.

Insert Table 1 about here

Discussion

The present study aimed to establish normative nasalance values on a variety of standardised speech materials for Irish English-speaking adults and to examine possible differences in nasalance scores due to gender of speakers and speech stimulus type. The sample size was calculated before data collection in order to ensure the validity of the conclusions drawn from the results (35). Since, it was found that a total of 60 participants are required for detecting a difference of six nasalance points between two independent groups at a power of 0.9 and 5% significance level, the discussion that follows only compared the current results to past studies that had 30 or more speakers in each gender group.

First, this study found no significant gender effect for nasalance scores across the different categories of speech stimulus. This is consistent with the results reported by van Doorn and Purcell (19) with 122 boys and 123 girls of Australian English, Tachimura et al. (21) with 50 male and 50 female Japanese adult speakers, Sweeney et al. (1) with 34 boys and 36 girls of Irish English, and Brunnegård and van Doorn (5) with 104 boys and 71 girls of Swedish. However, significantly higher nasalance scores in the females than males were reported in studies conducted by Hutchinson et al. (11) with 30 men and 30 women (they found a difference of 10.6% for the Zoo passage,

8.5% for the Rainbow passage, 9.3% for the nasal sentences, and 7.4% for sustained vowel /a/), and Mishima et al. (25) with 31 men and 37 women (the difference ranged from 4.6% to 6.2% for four oral sentences and ranged from 7.1% to 13.7% for five oral vowels). There are a few studies that also reported significant gender effect on nasalance scores but the difference in mean nasalance scores between the male and female speakers was less than 6% – the smallest true difference. For example, Seaver et al. (22) found a difference of 2% for nasal sentences between 56 men and 92 women; Rochet et al. (24) reported a difference of 1.6% for the Rainbow passage between 149 male speakers and 166 female speakers of English, and a difference of 2.3% and 3% for a mixed passage and a nasal passage respectively between 60 male speakers and 93 female speakers of French. An unpublished study by Cafferky and Sweeney (36) with 32 male and 34 female Irish English-speaking adults found a difference of 3.25% for the Total test sentences. It is likely that the significant results reported in these study were due to large number of participants. Since the difference was less than 6%, Cafferky and Sweeney (36) did not consider this small difference as clinically significant.

Previous studies that found a significant gender effect have attributed the findings to the differences in the structure and/or function of speech production mechanism between men and women, particularly the differences in velopharyngeal valving mechanism (37) and velopharyngeal closure timing (38) during speech production (9,22). However, the findings of no significant gender effect in the current and some previous studies do not support this hypothesis. It might be argued that, in the studies that found no significant gender difference, the extent of structural and functional differences between the males and females was relatively less compared to those studies that have shown significant differences in nasalance scores. For example,

before puberty, boys and girls do not differ as much as men and women in terms of the structures and function of the larynx, velopharynx, and vocal tract (39) and, therefore, no significant gender difference on nasalance scores were found for school-aged children (1,5,19). However, it is uncertain whether this could also explain the results of the young adult males and females in this study and Tachimura et al.'s study (21).

Another possibility for the contrasting findings regarding gender effect on nasalance scores for typical adults is that those studies that found significant gender differences included subjects from a wider age range or from different regions of a country. For example, the speakers in Hutchinson et al.'s study (11) ranged in age from 50 to 80 years and those in Seaver et al.'s study (22) ranged from 16 to 63 years. The study by Cafferky and Sweeney (36) recruited participants from different parts of Ireland – Cork, Dublin, and Galway. Hence, the possible effect of confounding factors (i.e., age and dialect) should be taken into account.

The second finding of this study is that, regarding the difference in nasalance scores between different categories of speech stimuli, it was not surprising to find that nasalance scores were significantly higher for the sentence heavily loaded with nasal consonants, followed by stimuli with both oral and nasal speech sounds (i.e., the Total sentences and the Rainbow passage), and the stimuli that are devoid of nasal consonants (i.e., the sentences loaded with either high-pressure or low-pressure consonants and the Zoo passage) (14). It was also expected that the same type of stimuli would yield comparable nasalance scores but this is true for the high-pressure consonant sentences and the Zoo passage only. Although both Total Sentences and Rainbow passage contain the same proportion of nasal consonants (11%), the mean nasalance score for the Rainbow passage was significantly higher than that for the Total Sentences. This might

be due to the different proportion of high and low vowels, and voiced and voiceless consonants present in the two stimuli (7,15). Lewis et al. (15) found that sentences that contain high front vowels (/i/ and /ɪ/) were associated with significantly higher nasalance scores than sentences that contain low front (/ə/) or low back vowels (/a/). The relatively higher level of nasal resonance for high vowels is related to the high tongue position, which creates a higher acoustic impedance to sound transmission into the oral cavity. In contrast, the acoustic impedance is low for low vowels due to the low tongue position and, therefore, the oral resonance is more pronounced for this type of speech sounds (7,40). The findings of significant difference between the high-pressure and low-pressure consonant sentences contrasts with that reported by Sweeney et al. (1) and Watterson et al. (41). Sweeney et al. reported a mean nasalance score of 14% for the high-pressure consonant sentences and 16% for low-pressure consonant sentences for the Irish children; Watterson et al. found 30.28% and 28.98%, respectively, for 25 school-age American English-speaking children. Note that although the present study found significant difference between the two sentence types, the difference was small – about 3% on average. Typical speakers may show a difference of three to five nasalance points across repeated readings of the same stimulus within the same session (22,34). This means a difference in nasalance scores of around 5% between the two sentence types is expected in typical adults.

Thirdly, although not tested statistically, the young adults in this study showed lower nasalance scores than the children reported in Sweeney et al.'s (1) study for all stimuli. This contradicts with the results of Van Lierde and colleagues (10) that children had lower nasalance scores than young adults and the general findings that nasalance scores seem to increase with age (5,10-12). There are a few discrepancies between the

two Irish English studies – different versions of the Nasometer were used; different methods for eliciting the speech samples were used; and the speakers were recruited from different regions of Ireland. Sweeney et al. used model 6200, which is an older version of the Nasometer, compared to model 6400 used in this study. There are a number of differences between the two models in terms of the handling of the audio signal and calibration, which might lead to different nasalance results (24,34).

Watterson et al. (34) compared the nasalance scores obtained from 60 adults using the two models and found significantly higher mean nasalance scores with model 6400 for an oral passage and oronasal passage. However, the opposite was found in the present study. Model 6400 was used in Cafferky and Sweeney's (36) study with Irish English-speaking adults and the present scores compare favourably with their findings. Different methods were used for obtaining speech samples from the speakers in the two Irish English studies – in Sweeney et al.'s study, the children repeated the test sentences after the examiner; whereas in the present study, the adult speakers read aloud the sentences. However, it is uncertain whether the different methods could have an effect on the nasalance scores; further investigation of this area is warranted. A possible reason for the lower nasalance scores for Irish adults compared to Irish children is the different Irish accents spoken by the participants in the two studies. According to Sweeney (personal communication, February 25, 2010), the majority of children in their study had a south Dublin accent, while the young adults in this study had a Cork accent. To the best of our knowledge, there has not been published literature that compared the nasalisation in Dublin and Cork accents; further research on this issue is needed to support this hypothesis. Previous studies have shown that speakers from different parts of a country could speak with a different amount of nasality. For example, Seaver et al.

(22) found that Mid-Atlantic speakers showed significantly higher nasalance scores than speakers from the Mid-western and Southern part of the USA and Ontario in Canada.

Finally, the young adults of Irish English in this study showed lower nasalance scores than those with North American English accent. For example, Seaver et al. (22) reported an average of 16% for the Zoo passage and 36% for the Rainbow passage, while the speakers in this study had 11.5% and 29.6% respectively. This finding is consistent with Sweeney et al.'s (1) conclusion in comparing the mean nasalance scores of Irish children and children from North America reported in the studies by Fletcher et al. (30) and Watterson et al. (14). American dialects have been described as nasal by phoneticians (1,42,43) and this might be related to the increased anticipatory nasal coarticulation (44).

Conclusion

There was no significant difference in nasalance scores between the Irish English-speaking males and females for a variety of speech stimuli – high-pressure consonant sentences, low-pressure consonant sentences, mixed sentences, nasal sentence (1), the Zoo passage (an oral paragraph) (32) and the Rainbow passage (a mixed paragraph) (29). Perhaps due to different Irish dialects, the nasalance scores of the young adults in this study were lower than those reported for the Irish children (1), as oppose to the general findings that nasalance scores increase with the age of the speakers. Finally, the results of this study supported the hypothesis on dialectal difference on nasalance scores – young adults of North American dialects had higher nasalance scores than the Irish English-speaking young adults, possibly because of their increased nasal anticipatory coarticulation (44). The finding further highlights the need for regional norms (6). It is important to bear in mind that nasometry is a useful addition

to perceptual evaluation of resonance disorders and direct instrumental assessment of velopharyngeal dysfunction. Nasometric measure is useful for documenting progress or change, especially within an individual, but clinical decision, such as whether surgery is needed or not, should never be made on the basis of nasalance scores alone (7).

Furthermore, it is recommended that clinicians should use standardised speech stimuli for assessment and, if possible, to compare their patients' results to normative scores that have been collected from control speakers from a similar age range, using the same speech stimuli.

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Declaration of interests

The authors declare no conflicts of interest. The authors are responsible for the data collection and preparation of the manuscript.

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Table I. Mean, standard deviation (SD), and range of nasalance scores for each speech stimulus type for the 30 male and 30 female Irish English-speaking adults. There was no significant difference in nasalance scores between the high-pressure consonant sentences and the Zoo passage.

Speech stimulus	Mean (%)	SD (%)	Range (%)
High-pressure consonant sentences (n = 5)	11.6	4.0	6.0–31.0
Low-pressure consonant sentences (n = 2)	14.9	5.4	6.0–31.0
Nasal sentence (n = 1)	47.6	6.6	23.0–72.0
Total test sentences (n = 16)	22.2	4.0	12.0–32.0
Zoo passage (oral; no nasal consonants)	11.5	2.9	7.0–24.0
Rainbow passage (oronasal; mixed)	29.6	5.0	19.0–47.0