Normative Nasalance Values in a Population of French-Speaking Children

Normalisation des scores de nasalance recueillis au sein d'une population d'enfants francophones

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KEYWORDS
HYPERNASALITY
NASALANCE
NASOMETER
EUROPEAN FRENCH

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Editor-in-Chief:
David H. McFarland

Abstract

Normative nasalance scores are essential for diagnosis and clinical follow-up. This research was conducted to establish a European French language protocol for nasometry and determine normative nasalance values for European French-speaking children. One hundred and seven French-speaking children aged 5–14 years (mean age, 9 years) with normal speech were included in this prospective study. Participants were asked to repeat different oral and nasal sounds (phonemes, words, sentences, and logatomes) and speech samples were recorded using a Nasometer II model. Normative nasalance values were measured with the Nasometer II model, including differences due to age, gender, context, and first language. Mean nasalance scores were 17% (95% CI, 6–39) for oral words, 13% (5–29) for oral sentences, 71% (50–84) for nasal words, and 63% (37–80) for nasal sentences. A significant effect of age on nasalance ($p < .05$) was observed with the highest scores in the youngest children, aged 5–6 years. There was no significant gender or mother tongue effect on nasalance scores. Nasalance values of oral speech samples were comparable with those reported for other languages. Findings indicated that our protocol is a simple and rapid-to-use tool that is applicable for French-speaking children in order to determine normative nasalance values. It can be recommended as an evaluation tool, as well as a quality control, following surgery and/or speech therapy.

Abrégé

La normalisation des scores de nasalance est essentielle pour le diagnostic et le suivi clinique. Les objectifs de la présente étude étaient de développer un protocole de nasométrie pour le français européen et d'établir des normes pour les scores de nasalance y étant recueillis auprès d'un échantillon d'enfants européens francophones. Cent sept enfants francophones âgés de 5 à 14 ans (âge moyen = 9 ans) et ayant une parole normale ont été inclus dans la présente étude prospective. Il leur a été demandé de répéter différents sons oraux et nasaux (phonèmes, mots, phrases, logatomes) et des échantillons de leur voix ont été enregistrés à l'aide d'un nasomètre (modèle II). Les normes pour les scores de nasalance ont été établies en tenant compte des différences dues à l'âge, au sexe, au type de son (oral ou nasal) et à la langue maternelle. Les scores moyens de nasalance étaient de 17 % (intervalle de confiance à 95 % = 6 %–39 %) pour les mots ne contenant que des phonèmes oraux, 13 % (intervalle de confiance à 95 % = 5 %–29 %) pour les phrases ne contenant que des phonèmes oraux, 71 % (intervalle de confiance à 95 % = 50 %–84 %) pour les mots contenant une proportion élevée de phonèmes nasaux et 63 % (intervalle de confiance à 95 % = 37 %–80 %) pour les phrases contenant une proportion élevée de phonèmes nasaux. Un effet significatif de l'âge a été observé sur les scores de nasalance ($p < 0,05$), les scores les plus élevés étant été observés chez les enfants plus jeunes (c.-à-d. chez les enfants âgés de 5 à 6 ans). Aucun effet significatif du sexe ou de la langue maternelle n'a été observé sur les scores de nasalance. Les scores de nasalance obtenus pour les mots ou phrases ne contenant que des phonèmes oraux étaient comparables à ceux obtenus dans d'autres langues. Les résultats indiquent que le protocole présenté dans la présente étude est simple et rapide et qu'il est applicable auprès d'enfants francophones pour déterminer les scores de nasalance. Il s'agit d'un outil pouvant être recommandé pour évaluer et faire un suivi de la qualité de la parole des enfants en contexte postopératoire et en orthophonie.

Hypernasality, also referred to as hypernasal speech, hyperrhinolalia, or *Rhinolalia aperta*, is an abnormal proportion of sound energy emerging from the nasal resonators as the consequence of congenital or acquired velopharyngeal dysfunction (VPD). Hypernasality accompanies oral vowels and consonants and gives rise to an abnormal nasalized voice quality and low volume in speech production. In contrast to hypernasality, hyponasality implies a diminished sound energy emerging through the nose during the production of nasal phonemes. Mixed resonance, hypernasal and hyponasal, is a combination of nasal obstruction and VPD (Kummer, 2011; Leuchter, 2015). Resonance disorders may be associated with articulation disorders and loss of intelligibility (Delvaux, 2009).

The assessment of hypernasality is the key task and most challenging aspect of the evaluation of VPD patients. As with the evaluation of voice disorders, acoustic-perceptual assessment is essential and remains the gold standard evaluation method. However, perceptual assessment has its limitations and may be a source of error, e.g., due to expertise of the judges, different internal standards of listeners (Kreiman et al., 1993), or confounding effects such as misarticulations or delayed language development (Keuning et al., 2002). There is consensus in the literature about the necessity of both objective tests and subjective assessment techniques for the evaluation of nasality (Bettens et al., 2018; Hirschberg, 1983). Nasality is a complex phenomenon, and its measure is not linearly related with velopharyngeal opening or even with perceived hypernasality (Hirschberg & Van Demark, 1997). It is influenced by various factors that can be speaker-related or due to technical specificities (Henningsson et al., 2008; Lewis et al., 2000).

There are simple clinical tests to observe nasal air loss during phonation, such as the Glatzel mirror test and the Gutzmann test (Gutzmann, 1913). The latter is simple to perform: The patient is asked to produce held vowels such as /a/ and /i/, with and without pinching the nose. A difference in sound perceived between the two conditions is an indicator of poor velopharyngeal closure. Instrumental evaluation of nasalance includes mainly nasofibroscopy, videofluoroscopy, aerophonometry, and nasometry (de Stadler & Hersh, 2015; Leuchter, 2015;). Nasofibroscopy allows, by means of a flexible optical fibre, the physician to observe the closure of the velopharynx directly from the nasopharynx (Glade & Deal, 2016). Videofluoroscopy is a radiologic exam that allows visualization of the velopharynx in different three-dimensional planes at rest or when closing (Lipira et al., 2011). Aerophonometry is an aerodynamic measurement of nasality allowing clinicians to calculate a ratio of nasal and oral airflows.

In 1970, Fletcher and Bishop introduced The Oral Nasal Radiometer (TONAR), an acoustic device measuring nasal resonance. Its successors, the Nasometer 6200, 6400, and 6450 (KayPentax), have been commercialized since 1986. The Nasometer consists of a metal plate placed perpendicular to the face at the level of the philtrum, between the base of the nose and the border of the upper lip. Two one-directional microphones separately pick up the nasal and oral acoustic energy within a specified frequency band. The acoustic signal is transmitted to a microprocessor, analyzed by a computer, and visualized on a monitor. The device computes a score, named "nasalance" (Fletcher & Daly, 1976), that reflects the relative amount of nasal acoustic energy in speech. Nasalance is expressed as a percentage and defined as

$$\text{Nasalance (\%)} = \frac{\text{nasal sound energy (dB)}}{(\text{nasal sound energy (dB)} + \text{oral sound energy (dB)})} \times 100$$

Thus, high nasalance scores can be expected in VPD patients, while low scores are measured in patients with obstruction of the nasopharynx or nasal tract. Nasalance scores depend naturally on the phonetic composition of speech samples. Fletcher et al.'s (1989) measurements of two different speech samples in typical American children illustrated this fact: Nasalance scores were 35.69% for the Rainbow Passage with an equilibrated distribution of nasal consonants and 15.53% for the Zoo Passage that is free of nasal consonants. Importantly, the protocol must be adapted to the patient's language to be correctly used in clinical practice.

Two similar instruments have been developed: NasalView (Tiger Electronics) and OroNasal System (Glottal Enterprises; Bressmann et al., 2006). The OroNasal System measures nasalance in a manner comparable to the Nasometer and NasalView but its microphones are sensitive to the airflow coming from the mouth and the nose, creating artefacts. The three systems measure nasalance in different ways and provide nasalance scores that are not interchangeable (Bressmann, 2005). In the literature, the Nasometer remains the gold standard in the evaluation of nasalance: Several advantages have been described: (a) it is an objective noninvasive measure that provides numerical values (Seaver et al., 1991); (b) users can obtain fast results in real time, even with small children (van der Heijden et al., 2011a; Sweeney et al., 2004); (c) it is a tool in speech therapy for visual feedback (van der Heijden et al., 2011a); (d) it allows for objectifying a patient's progress; and (e) it has significant correlation with perceptual evaluation (Hirschberg et al., 2006).

However, nasometry has its limitations. In a study where Dalston et al. (1991) assessed 514 patients aged 3 to 56 years perceptually (clinical evaluation of hypernasality by an experimenter) and instrumentally (nasometric evaluation), they suggested that nasometry reaches its optimal clinical utility when used in conjunction with clinical judgment; its utility decreases when used as a single method. Further, Vallino-Napoli and Montgomery (1997) pointed out that the scoring of nasalance has limitations when comparing different languages, concluding that the Nasometer should always be used as a complement to clinical evaluation. Finally, although the Nasometer is a useful tool for evaluation of hypernasality, there are still controversies over its usefulness for other nasal resonance problems such as hyponasality (Anderson, 1996).

The aims of this study were to establish a protocol for nasometry adapted in French and to determine normative nasalance values for European French-speaking children as measured with the Nasometer II model, including differences due to age, gender, context, and first language.

Method

The Institutional Review Board at the University Hospital Geneva approved our research on May 14, 2014 (ethical number: 80514).

Participants

We recruited 111 children from Geneva, the French part of Switzerland, aged 5 to 14 years, selected among three school levels and three age categories: 5–6 years (Grade 2), 8–10 years (Grade 6), and 12–14 years (Grade 10). Sample size was based on the recommendations of the International Federation of Clinical Chemistry to determine the range of normality for the values, defined between 0.025 and 0.975 percentiles (Poulsen et al., 1997). Parents of all children completed informed consent and an inclusion questionnaire with medical and demographic data. Inclusion criteria included European French-speaking children schooled in Switzerland with normal speech according to teachers' evaluation. Exclusion criteria were hypernasality or hyponasality, non-French speakers, speech and language disorders, previous surgery for cleft palate or facial malformation, syndromic diseases and craniofacial malformations, acute infection of the upper airway, or hearing impairment. Eleven patients had simple otolaryngologic surgeries: adenoidectomy (n = 5), tonsillectomy (n = 4), transtympanic drains (n = 2)—and were excluded. A first language different from French was not an exclusion criterion.

To exclude VPD participants, we performed the Gutzmann test (Gutzmann, 1913) as a first screening test; that is, each participant was asked to produce a series of /a/ and /i/ alternately with the nares opened and closed. A change in sound quality when the nares were closed indicated the existence of hypernasality. A recording of the voice counting from 1 to 10 was then conducted and later evaluated by a phoniatrician and speech-language therapist to exclude hypernasal or hyponasal speech.

Nasometry Assessment Protocol

Following acoustic-perceptual assessment, nasometry was performed using a Nasometer II model, version 3.3.3, which was installed on a laptop. A Nasometer consists of a metal plate slightly curved with two microphones, one on the upper side and another on the lower side. The plate is positioned against the participant's upper lip and is maintained by a helmet which must be adjusted on the head. Sidebars that connect the helmet to the plate were adjusted for each child so that the latter remained perpendicular to the vertical half of the face. We calibrated the Nasometer according to the manual's (Kay Pentax) recommendations. The upper microphone recorded a nasal sound wave and the lower microphone recorded an oral sound wave. Recordings were done in a quiet room in a seated position. Children were verbally instructed to repeat the sounds (phonemes, words, sentences, logatomes) the examiner pronounced. The audio recording and nasometric measures were done simultaneously, always with the same recorder distance (30–40 cm) and a natural speaking intensity. Recordings were completed successfully in 5 to 10 minutes. When an error occurred, the experimenter repeated the complete item. The same experimenter always evaluated the repeated session.

Data processing was done using the Nasometer software. Each item was associated with an acoustic signal represented by a curve as a function of time (on the x-axis) and of the percentage of nasalance (on the y-axis). Each item of our protocol was treated individually, with the same procedure. First, we selected the most stable part of the signal to analyze. We used the statistics function on the laptop to get numeric values and entered data in an SPSS file: mean nasalance (mean), minimal nasalance (min), maximal nasalance (max), duration of the selected signal (time range), precise moment of the start of the signal selected in seconds (start), and precise moment of the end of the signal (end).

Speech samples used in the protocol are known to influence nasalance results and their selection is particularly important in cross-language studies (Lewis et al., 2000; Watterson et al., 2005). Three types of stimuli are generally used to assess nasalance: oral sentences or texts which avoid nasal coarticulation (Lee & Browne, 2013; Mishima et al., 2008; Seaver et al., 1991); nasal sentences or texts which allow closed rhinolalia evaluation (Lee & Browne, 2013; Seaver et al., 1991); and mixed sentences or mixed texts (containing both oral and nasal phonemes) which are representative of conversational speech, but provide no additional clinical information compared to other contexts (Dalston & Seaver, 1992). In English, three short texts usually serve as a standard protocol: the Zoo Passage which is devoid of nasal phonemes (oral text), the Rainbow Passage which contains 11.5% nasal phonemes (mixed text), and nasal phrases which contain 35% nasal phonemes (nasal text; Mayo & Mayo, 2011).

We designed our protocol based on those described in the literature (Abou-Elsaad et al., 2012; Anderson, 1996; Brunnegård & van Doorn, 2009; Falé & Hub Faria, 2008; Hirschberg et al., 2006; Lee & Browne, 2013; Lehes et al., 2018; Nichols, 1999; Okalidou et al., 2011; Putnam Rochet et al., 1998; Sweeney et al., 2004; van der Heijden et al., 2011b; Van Lierde et al., 2001; Whitehill, 2001). We followed specific principles for constructing speech samples to facilitate comparison across languages. To find the most appropriate speech materials, we based our protocol on Henningson et al.'s (2008) speech sampling guidelines. Specifically, single words containing only one vowel and both high and low vowels were sampled, all test words contained only one type of target pressure consonant per word and were sampled in different positions of occurrence in French, and words did not contain nasal consonants. Sentences included all vowel types relevant for European French, focusing on one pressure consonant target only, with at least one consonant from each of the pressure consonant categories. French has 38 phonemes: 16 vowels, 19 consonants, and three semi-vowels. A majority of phonemes are oral: 12 vowels (/a, ɑ, ə, ø, œ, e, ɛ, i, o, ɔ, y, u/) and 15 consonants (/b, s, k, d, f, g, ʒ, l, p, ʁ, t, v, z, ʃ, h/). Only eight are nasal phonemes: four vowels (/ɑ̃, ɔ̃, ɛ, œ̃/) and four consonants (/m, n, ɲ, ŋ/). Our protocol was designed to take into consideration the characteristics and peculiarities of French with phonetically well-balanced verbal stimuli, summarized in **Table 1**: five isolated oral vowels; three isolated nasal vowels, 14 oral words with a target consonant (/p, t, k, b, d, g, f, s, ʃ, v, z, ʒ, l, ʁ/), and two nasal words with a target consonant (/m, n/). We designed our sentences in three ways: oral (containing only oral phonemes), mixed (with oral and nasal phonemes in same proportion), and nasal (with high proportion of nasal phonemes). Our protocol involved seven oral sentences (0% of nasal phonemes); two nasal sentences (45.8% of nasal phonemes); one mixed sentence (11.76% of nasal phonemes); and three logatomes. Logatomes were designed including occlusives /p, t, k/ and fricatives /f, s, ʃ/ and /v, z, ʒ/. Finally, children were asked to repeat oral and nasal vowels in an alternating manner: /a/–/ã/, /e/–/ɛ̃/, and /o/–/õ/. The phonetic content of stimuli was carefully matched by the distribution of oral and nasal vowels. One passage was carried out with each participant.

Statistical Analyses

All data were analyzed with the Nasometer's software to obtain mean nasalance scores. Descriptive statistics were presented as the mean rate of nasalance, with the 95% confidence interval (CI) corresponding to the minimal and maximal values. Data were transcribed in an Excel table. We analyzed four variables which could influence nasalance scores: age, gender, context, and first language. Children were stratified into three age groups with a balanced number of participants. Statistical analyses were performed using SPSS software, v. 22.0. An analysis of variance test

Table 1

Design and Illustration of Verbal Stimuli Used in Our Protocol

Speech stimuli	Number	Illustration
Oral vowels	5	/a/, /e/, /i/, /o/, /u/
Nasal vowels	3	/ã/, /ɛ̃/, /õ/
Oral words	14	"papier," "tatou," "cacao," "baobab," "dodu," "gaga," "foufou," "saucisse," "chou-chou," "vive," "zazou," "joujou," "lilas," "arrière"
Nasal words	2	"mamie" et "nana"
Oral sentences	7	t'es pas cap, boule de glace, elle se fâcha, je vais au zoo, alors relis-le, le coq fait cocorico, apporte le petit pot
Nasal sentences	2	une nuit en montagne, un grand pain rond
Mixed sentences	1	Pierre a mangé tout le gâteau
Logatome	3	Pa-ta-ka, fa-sa-cha, vi-zi-ji

was performed to assess the impact of the age factor. An independent samples *t*–test was carried out to compare the mean nasalance scores for oral and nasal words according to gender. A two-factor analysis of variance test was then performed to compare nasalance scores as a function of the context (oral versus nasal) and gender (boys versus girls). An independent samples *t*–test was performed to compare nasalance scores of all items combined according to the child's first language (French versus other languages). The significance level was set at $p = .05$.

Results

We analyzed recordings from 111 children (48 boys and 63 girls). Four participants were excluded after perceptive analysis: two presented with slightly hypernasal speech, one had an acute nose obstruction, and one had data that was not interpretable. Thus, 107 children (mean age = 9 years) were included for the nasalance measures. Demographic data are summarized in **Table 2**. Thirty (28%) children were in Grade 2, 42 (39%) in Grade 6, and 35 (33%) in Grade 10. Among our group, 74% of the children had European French as their first language and 26% had another mother tongue: Portuguese ($n = 8$), Spanish ($n = 5$), Arabic ($n = 5$), Albanian ($n = 3$), Italian ($n = 2$), English ($n = 1$), Swedish ($n = 1$), Serbo-Croatian ($n = 1$), Thai ($n = 1$), Chinese ($n = 1$), and Japanese ($n = 1$). Regarding the language spoken at home, 94% spoke European French and 63% spoke a second language other than French: Spanish ($n = 14$), Italian ($n = 14$), Portuguese ($n = 13$), Arabic ($n = 8$), English ($n = 4$), Albanian ($n = 3$), German ($n = 2$), Serbo-Croatian ($n = 2$), Lingala ($n = 1$), Creole ($n = 1$), Swedish ($n = 1$), Thai ($n = 1$), Vietnamese ($n = 1$), Chinese ($n = 1$), and Japanese ($n = 1$).

Our results showed mean nasalance scores of 16% (3–46) for oral vowels, 69% (40–96) for nasal vowels, 17% (6–39) for oral words, 13% (5–9) for oral sentences, 71% (50–84) for nasal words, and 63% (37–80) for nasal sentences. Nasalance scores with their mean and CIs are summarized in **Table 3**. We observed a significant effect of age and school grade level on nasalance ($p < .05$), with the highest scores in children in Grade 2 (5–6 years; $M = 19\%$) compared to those in Grade 6 (8–10 years; $M = 15\%$). The effect of age was mostly present for isolated oral vowels. Gender nasalance scores were not significantly different ($p = .394$). The context of nasality and first language ($p = .764$) did not influence nasalance scores.

Discussion

Our findings showed a mean nasalance score of 13% for oral sentences and 14.5% for computed oral vowels, words, sentences, and logatomes. The nasalance values of oral speech samples were comparable with those reported for other languages, such as English, Finnish, Greek, and Swedish (Haapanen, 1991; Kavanagh et al., 1994; Van Doorn & Purcell, 1998), but scores for the nasal words and sentences were much higher due to the high proportion of nasal phonemes in the chosen samples. We found significantly higher nasalance scores for oral stimuli in the group of youngest children. The age effect could be due to acoustic factors. Young children have a high fundamental frequency that can sometimes be close to the lower end of the acoustic filters used by the Nasometer (Delvaux, 2012). Mayo and Mayo (2011) attributed this difference to a change in the neuromuscular control of the velum resulting in the enlargement of the vocal tract during growth. Indeed, growth and involution of adenoids over the years influence vocal resonance. However, other studies have observed no significant effect of age on nasalance scores (Brunnegård & van Doorn, 2009; Mayo & Mayo, 2011). We found no effect of gender for each of the age categories tested, which is consistent with the literature (Litzaw & Dalston, 1992). With regard to the first language , there was no significant effect on nasalance scores, which could suggest that our measures are applicable even in children with French as a second language.

One limitation of our study is that a variety of first languages other than French were combined into the same group. In clinical practice, we cannot affirm that a child with a first language different from French could be expected to perform within the norms established here. Nasalance scores have been reported to vary with speaker regional dialect when the same reading passage is used. Leeper et al. (1992) described the presence of regional dialectal variations for nasalance among speakers of Canadian English. Seaver et al. (1991) studied the influence of dialect on nasalance in English-speaking participants from four different geographic regions of the United States and Canada (Illinois, North Carolina, Alabama, and Ontario); he concluded that

Table 2

Demographic Data and Distribution of Participants

Variables	Values
Male:female ratio	46:61
Mean age (years)	9

Table 3

Summary of Mean Nasalance Scores With Confidence Interval

Verbal stimuli	Mean nasalance in % (95% CI)
Oral vowels	16 (3–46)
/a/	11 (3–33)
/e/	16 (5–44)
/i/	30 (14–55)
/o/	9 (2–28)
/u/	16 (5–36)
Nasal vowels	69 (40–96)
/ã/	55 (39–75)
/ɛ̃/	65 (49–91)
/õ/	82 (54–96)
Oral words	17 (6–39)
Nasal words	71 (50–84)
Oral sentences	13 (5–29)
Nasal sentences	63 (37–80)
Mixed sentences	26 (15–37)
Oral logatomes	15 (4–38)

participants from North Carolina had a higher nasalance score when compared to other regions. According to Kummer (2011), dialect differences mainly concern vowels. Mayo et al. (1996) hypothesized that differences between dialects are explained by difference in closing time of the soft palate during the transition between nasal consonants and vowels. Finally, several studies in the literature suggested that differences in nasalance scores according to dialect were not clinically significant (Mayo & Mayo, 2011; Mayo et al., 1996; Putnam Rochet et al., 1998; Seaver et al., 1991).

We performed measurements in only one passage. According to several studies, there was no significant difference between two successive passages for children without language disorders, which was the case with our cohort. For children with language disorders, a difference of up to 5% has been reported (Watterson et al., 2005).

Nasometry is a popular tool and easy to use, even with small children. The usefulness of this instrumental assessment depends on correlation with acoustic-perceptual evaluation of nasality. Several authors have reported good or moderate correlation between instrumental and perceptual assessment (Fletcher & Bishop, 1970; Hirschberg et al., 2006). Even though the Nasometer is considered the gold standard for the clinical diagnosis of VPD, there is variation in nasalance scores attributed to intraspeaker variability and variability in successive recording conditions (Sweeney et al., 2004, Watterson et al., 2005). With the introduction of new models of the Nasometer, there is also a between-machine variation (Kummer, 2011; Watterson et al., 2005).

Nasometry Normative Data

To the best of our knowledge, this is the first nasalance standard established in a large population of European French-speaking children. A previous study reported normative values of nasalance in a mixed-age Canadian French speaking population (Putnam Rochet et al., 1998). There is a significant difference in nasalance norms among languages including speaker-specific factors (idiosyncrasies), age-related and gender-related factors, and linguistics and dialectal factors. Nasalance scores are also a function of the linguistic material included in the protocol, which can vary across studies investigating the same linguistic community. A number of studies in different languages have been conducted to determine the normative values of nasalance in normal speakers (Abou-Elsaad et al., 2012; Anderson, 1996; Brunnegård & van Doorn, 2009; Falé & Hub Faria, 2008; Hirschberg et al., 2006; Lee & Browne, 2013; Lehes et al., 2018; Nichols, 1999; Okalidou et al., 2011; Putnam Rochet et al., 1998; Sweeney et al., 2004; van der Heijden et al., 2011b; Van Lierde et al., 2001; Whitehill, 2001) and are summarized in **Table 4**.

The first conclusion to be drawn from these studies is that nasalance scores depend on the speaker's native language. This may be explained by the different proportion

Table 4

Means for Nasalance Scores in French and Other Languages

Language	Author	Year published	*N*	Age (years)	Gender	Mean nasalance (in %): Oral	Mean nasalance (in %): Mixed	Mean nasalance (in %): Nasal
English USA	Seaver et al.	1991	148	16–63	Both	16 (T)	36 (T)	62 (S)
English Canada	Kavanagh et al.	1994	52	18–33	Both	13.4 (T)	37.1 (T)	65.4 (S)
English Canada	Putnam Rochet et al.	1998	315	9–85	Both	11.3/11.5 (T)	32.9/34.5 (T)	61.6/62.7 (T)
French Canada	Putnam Rochet et al.	1998	153	9–85	Both	11.5/12.4 (T)	26/28.3 (T)	35.5/38.5 (T)
English Ireland	Sweeney et al.	2004	70	4–13	Both	14 (S)	16 (S)	51 (S)
English Ireland	Lee and Brown	2013	60	18–28	Both	11.5 (T)	29.6 (T)	47.6 (S)
Australian	Van Doorn and Purcell	1998	245	4–9	Both	13.1 (T)	–	59.6 (T)
Cantonese	Whitehill	2001	141	21	Both	16.79 (S)/13.68 (T)	35.46 (T)	55.67 (S)
Finnish	Haapanen	1991	58	21	Both	13.6 (T)	–	69.4 (S)
Japanese	Tachimura	2000	100	24	Both	9.1 (S)	–	–
Japanese	Mishima et al.	2008	68	23.5	Both	10.3/15.6 (T)	–	–
Spanish (Puerto Rican)	Anderson et al.	1996	40	21–43	Both	21.95 (T)	36.02 (T)	62.07 (S)
Spanish (Mexican)	Nichols	1999	152	8–40	Both	17.02 (S)	–	55.28 (S)
Swedish	Brunnegård and van Doorn	2009	220	9	Both	12.7 (S)	29.5 (S)	56.5 (S)
Thai	Prathanee	2003	188	9.5	Both	14.3 (T)	35.6 (T)	51,1 (T)
Flemish	Van Lierde	2001	58	19–27	Both	10.9 (T)	33.8 (T)	55.8 (T)
Dutch	Van der Heijden	2011b	55	4–6	Both	11(T)	27 (T)	–
Hungarian	Hirschberg	2006	30	5–25	Both	11(S)	31.7 (S)	–
Portuguese	Falé and Hub Faria	2008	25	19–27	Both	10 (T)	–	44(T)
Arabic	Abou-Elsaad et al.	2012	300	3–54	Both	29/33 (S)	–	77/75 (S)
Greek	Okalidou et al.	2011	80	18–34	Both	12.4 (T)	25.5 (T)	42 (T)
French (European)	**Our data**	**2022**	**107**	**5–14**	**Both**	**13 (S)**	**26 (S)**	**63 (S)**

Note. T = text; S = sentences; USA = United States of America of phonemes in each language and by the presence of nasalized vowels in some languages, as in French /ã, ɛ̃, õ/. It follows therefore that standard passages should be developed for each language. In addition, studies show that not only different languages, but also regional dialects (Brunnegård & van Doorn, 2009; Kavanagh et al., 1994) may influence nasalance scores. Nasalance norms must then be determined for each language and each region.

Our study aimed to establish nasalance norms for European French and had some limitations. First, in our protocol for recordings, children were instructed to keep the recommended distance and the same experimenter did the evaluation. Nevertheless, no external control of intensity was performed. Also, children were evaluated on a single passage. Although other studies have found that a second passage does not result in different values, multiple repetitions would have been a better approach. The size of our sample (*N* = 107) is a respectable number in comparison with other previous studies; however, it seems quite limited to really assess the effect of age, gender, and bilingualism.

Future Directions and Clinical Implications

The main use of nasalance scores is to evaluate the quality of surgical or conservative treatment in cleft palate patients and its progress over time (Vallino-Napoli & Montgomery, 1997). However, nasometry measures are useful for supplementing the speech-language therapist's perception of hypernasal resonance in patients with VPD (Dalston et al., 1991). Nasalance scores and perceptual ratings of nasality are complementary and should be used together for a better reproducibility of results over time (Sweeney & Sell, 2008). Nasometry is considered an acoustic-instrumental assessment of hypernasality and may be used as a diagnostic or monitoring tool after surgery or speech therapy. It may also be useful to compare results from one centre to another or to help clinicians in borderline cases. For all these uses, the determination of cut-off scores is essential to applying the Nasometer in medical practice and decide when nasalance is normal or abnormal. However, as Dalston et al. (1991) highlighted, any treatment decision should be based upon cumulative evidence gathered from various sources, including instrumental assessment and clinical perceptual evaluation.

Conclusion

Nasometry implies normative nasalance scores specific to every language. In the present study, we report a nasometric protocol that is simple, rapid-to-use, and applicable for all children, irrespective of their first language. This protocol can be recommended as an evaluation tool, as well as a quality control following surgery and/or speech therapy. The evaluation of VPD, particularly resonance and speech assessment, remains challenging and the choice of therapy will essentially depend on the type and severity of the clinical manifestations and patient expectations. Instrumental assessment of nasality by nasometry is one of the cornerstones of this evaluation.

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Disclosures

No conflicts of interest, financial or otherwise, are declared by the authors.