Characteristics of Nasalance in Speakers of Western Canadian English and French

Caractéristiques de la nasalité des anglophones et des francophones de l'ouest du Canada

by • par

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ABSTRACT

Nasalance data collected via a Nasometer are reported for 468 normal native speakers of western dialects of Canadian English and Canadian French, aged 9 - 85 years. Three hundred and fifteen anglophones and 153 francophones read aloud three standard passages constructed for each language: one containing no nasal phonemes, one saturated with nasal phonemes, and one reflecting the natural proportion of nasal phonemes in everyday speech. Data were analyzed within each language for differences across age groups and between sexes. The analyses revealed that nasalance scores tended to increase with age; and that the scores of children and teens were significantly lower than those of adult speakers in both languages. Nasalance values for females typically exceeded those of their male cohorts for the same passage in both data sets, though this difference was not significant for the non-nasal passage in either language. These results for western Canada are compared with nasalance data reported for other regions.

ABRÉGÉ

Cette étude a pour but d'établir le degré normal de nasalité (rapport entre l'énergie acoustique nasale et la somme de l'énergie nasale et de l'énergie orale) pour 468 personnes, âgées de 9 à 85 ans et dont la langue maternelle est l'anglais ou le français parlé dans l'ouest du Canada. Trois cent quinze sujets de langue anglaise et 153 sujets de langue française ont lu dans leur langue maternelle trois passages standardisés. Un de ces passages ne contient aucune nasale, un autre en contient une grande quantité, et le troisième reflète la fréquence normale des nasales dans le langage courant. L'analyse des données révèle que dans les deux langues il existe des différences de nasalité entre les sexes et les groupes d'âge. La nasalité augmente avec l'âge: Les valeurs observées pour les enfants et les adolescents sont moins élevées que pour les adultes. On observe des valeurs plus élevées pour les sujets féminins, mais la différence n'est pas significative dans le cas du passage qui ne contient pas de nasales. Les valeurs de nasalité obtenues dans cette étude pour l'ouest du Canada sont comparées avec celles déjà publiées pour d'autres régions.

KEY WORDS
nasalance scores • nasalité • western Canada • French • English • age differences • sex differences

Nasalance refers to the relative amounts of oral and nasal acoustic energy in speech [(nasal energy)/(nasal + oral energy)] as measured by the Nasometer (Kay Elemetrics, Inc., Lincoln Park, NJ, USA). Nasalance is affected by the amount of phonemic, as well as assimilation nasality in an utterance. Under normal speaking circumstances, nasal resonance increases in English with the production of nasal consonants, and in French with a nasal consonant or nasal vowel. As well, the influence of nasal phonemes tends to "spill over" to neighboring vocalic elements as the natural phenomenon of assimilation nasality. Thus, a certain amount of nasalance is normal in languages where nasal phonemes are part of the speech sound repertoire, but there are limits to what is perceived as normal, both within and across languages. Because nasalance also has been shown to correlate with listener judgements of too little or too much nasality, the measurement of nasalance has evolved as a clinical procedure that complements perceptual judgements of the resonance disorders known as hypo- and hypernasality.

To facilitate the valid and reliable use of nasalance data in the clinical practice of speech-language pathology, collaborative efforts among centres in North America have begun to accumulate language- and region-specific databases for nasalance in native speakers of English and French using standardized procedures, identical instrumentation, and comparable spoken materials (Kavanagh, Fee, Kalinowski, Doyle, & Leeper, 1994; Leeper, Rochet, & MacKay, 1992; Seaver, Dalston, Leeper, & Adams, 1991). Healthy, literate males and females aged 8-85+ years have been included so that the effects of spoken-language history, regional dialect, sex, and age on nasalance may be studied, and appropriate normal ranges determined for clinical practice.

The earliest results of this effort to accumulate nasalance data for "prairie" versions of French and English were reported by Leeper et al. (1992) along with data for eastern and southern regions in Ontario. Their data reflected the existence of regional dialectal variation for nasalance within the two official languages in Canada. Variation also has been documented among dialects of English spoken in the United States (Seaver et al., 1991). Kavanagh et al. (1994) have contributed normative nasalance data for anglophones in several regions within Atlantic Canada, though no significant differences among the nasalance values for speakers from those regions were observed.

Variations in nasalance with age and sex also have been cited in the literature. An increase in nasalance with age has been documented in several reports (Hutchinson, Robinson, & Nerbonne, 1978; Leeper et al., 1992; Seaver et al., 1991). Differences in nasalance between males and females also have been reported (Fletcher, 1978; Hutchinson et al., 1978; Leeper et al., 1992; Seaver et al., 1991), although they are not always consistent or significant (Kavanagh et al., 1994; Litzaw & Dalston, 1992).

The work reported here was undertaken to collect data that represent western dialects of Canadian French and Canadian English for contribution to the North American database on nasalance. It includes analyses for the effects of sex and age and compares the mean values of these nasalance data for residents of the prairie provinces with those published for other regions of Canada.

Method

Participants

Data are reported for 468 participants (315 native anglophones & 153 native francophones), aged 9 to 85 years, who were recruited from schools, health units and seniors' centres in rural and urban communities in Northern Alberta (see Table 1). Among the anglophones, 166 were female, and 149 male. The francophone sample includes 93 females and 60 males. Participants were native speakers of either French or English and either native to the prairie provinces (Manitoba, Saskatchewan, & Alberta) or residents there for at least 25 years. Potential participants who were not native speakers but claimed near-native proficiency in one language or the other on the basis of immersion schooling or some other second-language acquisition process were not included. All participants filled out a short form that solicited information about their language and health histories and the regions of Canada where they had lived, and for how long. All rated their health as "good" at the time of recording. Self-ratings of health have been reported to have face-validity,

Table 1. Mean ages for participant groups according to language and sex.

	Sex (number)	Mean age (years; months)
English		
9-13	M (30)	10;11
	F (31)	11;8
14-19	M (37)	17;5
	F (37)	18;0
20-44	M (31)	26;5
	F (32)	25;7
45-64	M (28)	51;5
	F (35)	51;0
65-85	M (23)	72;8
	F (31)	71;3
French		
9-19	M (27)	12;8
	F (32)	13;5
20-44	M (21)	31;7
	F (35)	29;8
45-85	M (12)	62;1
	F (26)	60;1

as well as concurrent validity with physicians' ratings of their patients' conditions (Maddox & Douglass, 1973). All participants were screened to exclude those with histories of neurological, respiratory, laryngeal, or craniofacial disorders, sudden or congenital hearing loss, and more than age-appropriate presbycusis. It was expected that some presbycusis would be present in many of the participants in the oldest age group (65-85 years) and that speakers with a moderate-to-severe hearing loss might have an associated resonance distortion that could skew the normal limits of the sample (Ysunza & Vazquez, 1993). Rather than rely on pure-tone hearing screening results to assess hearing status for elders, the experimenters chose to use the *Hearing Handicap Inventory* (HHI; Ventry & Weinstein, 1982) to screen elders who were potential participants. This tool assesses the degree to which a hearing impairment affects the emotional and social well-being of elders for everyday communication situations. Seniors who perceive that they are limited severely tend to have high scores on this questionnaire, and those who are coping well (with or without amplification) tend to have low scores. Almost all anglophones who were 65 and older were asked to fill out the HHI which was presented to them in large, easy-to-read print. Elder francophones were ques-

tioned about their hearing by the examiners, as no printed French translation of the HHI was available for use with them. The HHI cut-off score for participation in this study was ≤20 out of a total possible score of 100, a result comparable to a mildly impaired (26-40 dB) hearing level category (Ventry & Weinstein, 1982).

Reading Materials

The participants read aloud three short passages constructed for their native language, French or English. Those for anglophones, "Rainbow," "Zoo," and "Nasal Sentences," have been used in clinical practice since their introduction by Fairbanks (1960; "Rainbow Passage") and Fletcher (1972; "Zoo" & "Nasal Sentences"). Those for francophones, "Le petit prince," "La peur du tigre," and "Blanche Neige," were constructed in the early 1990s (Leeper et al., 1992) so that Canadian French could be included in the North American database for nasalance. One passage for each language contains no nasal phonemes ("Zoo"; "La peur du tigre"), one reflects the natural proportion of nasal phonemes in everyday speech for each language ("Rainbow" & "Le petit prince," ~14% nasal elements), and one is saturated with nasal phonemes ("Nasal Sentences" ~31% nasal consonants, & "Blanche Neige" ~28% nasal consonants & vowels). The nasally loaded passages have proved valuable in the perceptual and nasometric assessment of hypo- or denasality (Dalston, Warren, & Dalston, 1991a) and nasal airway impairment (Dalston, Warren, & Dalston, 1991b), while the non-nasal passages provide a connected-speech context in which to assess velopharyngeal closure competence without the confounding presence of nasal elements and assimilation nasality (Dalston, Warren, & Dalston, 1991c; Watterson, McFarlane, & Wright, 1993). Dalston and Seaver (1992) have suggested that the phonemically balanced passages contribute no unique information to the clinical assessment of resonance balance that cannot be provided by the nasally loaded or non-nasal materials. Data were collected for all three passages in this work to complement the existing nasalance database for North America.

Instrumentation

Participants' reading performances were sampled and analyzed by means of a Nasometer (model 6200) supported by a microcomputer (Zenith 286AT). The Nasometer was calibrated at the outset of every data collection session according to the manufacturer's specifications. Participants read aloud while wearing the Nasometer headset, which samples the oral and nasal components of the speech signal simultaneously by means of two unidirectional microphones positioned in front of a speaker's mouth and nose and separated by a metal plate. The metal plate rests firmly on the speaker's upper lip under the nose and serves as an acoustical barrier between the two microphones. The plate is covered with a removeable plastic guard that distributes the pressure of the plate against the speaker's lip; this guard was removed, cleaned and sterilized after each person's use. The intermicrophone attenuation of the metal plate is 25 dB. The microphone signals are preamplified and conditioned by a 300 Hz bandpass filter with a center frequency of 500 Hz, 3 dB down points at 350 and 650 Hz, and a filter roll-off characteristic of 80dB/decade.

Data Collection

All participants were encouraged and given time to rehearse the reading materials aloud to reduce the likelihood of misreadings and dysfluencies during data collection. They were also encouraged to read aloud at habitual pitch and loudness levels and rates. Ten percent of the participants read the passages three times each to provide intra-speaker reliability data for nasalance measures. For these participants, the first nasalance score obtained for each passage was entered into the group data for analysis; the within-speaker reliability data across the three readings of each passage were analyzed separately. The order in which the passages were read was randomized across the data collection for all participants. The recording process took no more than 15-30 minutes per speaker, including instances when participants were asked to read each passage three times, or when dysfluencies required that a speaker re-read a particular passage. The investigator supervising the data collection for every participant was a native speaker of French or English, or fluently bilingual. The information, history and consent forms that were given to participants had been prepared in both languages, so that francophones read and completed forms in French, and anglophones in English. As well, prior to and during the data recording process, the supervising investigator interacted with each participant in that person's native language. This preliminary work and face-to-face interaction in the language of interest put each speaker in the "language set" of his/her native tongue and allowed additional perceptual confirmation by the investigator that the speaker had a native command of that language, exhibited normal articulation and could read aloud fluently. Having a native speaker supervising the recording process also ensured that instances of misreading would be identified accurately and immediately, so that the participant could be cued to stop and re-read the material.

Data Analysis

For purposes of analysis, the data were grouped by na-

tive language, age, and sex (see Table 1). For the anglophone data set, five age groups were identified: children (9-13years), adolescents (14-19 years), young adults (20-44 years), middle-aged adults (45-65 years), and old adults (65-85 years). Because the francophone data set was less complete than that for the anglophones, especially for adolescents and old adults, only three age subdivisions were used: children and teens (9-19 years), young adults (20-44 years), and adults (45-85). The mean ages for the participant groups according to native language and sex are shown in Table 1.

A three-factor analysis of variance (age by passage by sex), with repeated measures on one factor (passage) and a significance level of .05 was used to analyze the data for each language. For English, a 5x3x2 factorial model was used: The factor of age had five levels; reading passage had three which were the repeated measures, and sex had two levels. For French, a 3x3x2 factorial model was used, reflecting the use of only three levels for the factor of age in that data set. The dependent variable, percent nasalance for each utterance sample, was computed by the Nasometer software (version 1.7) according to the formula, % Nasalance = [(nasal sound energy)/(oral+nasal sound energy)] x 100.

A 2-factor analysis of variance (passage by trial) with repeated measures on one factor (trial) was applied to the intra-speaker reliability data for each language. Pairwise Pearson correlational analyses were computed across nasalance scores for the three passages within each language to assess the degree of relationship among the passages and between a speaker's nasalance score on one passage and his/her scores on the other two. Interlanguage statistical analyses were not performed.

Table 2. Mean percent nasalance values (±1 SD) according to language, age group, sex, and reading passage. The *non-nasal* passages are "Zoo" for English and "La peur du tigre" for French. The *balanced* passages are "Rainbow" and "Le petit prince." The *nasal* passages are "Nasal Sentences" and "Blanche Neige."

	Sex (#)	Non-nasal	Balanced	Nasal
English				
9-13	M (30)	9.3 (3.2)	31.0 (4.2)	59.5 (5.7)
	F (31)	10.0 (2.8)	33.2 (3.7)	62.0 (5.2)
14-19	M (37)	10.8 (5.0)	32.9 (4.5)	62.1 (6.4)
	F (37)	10.7 (4.1)	34.6 (4.3)	63.0 (5.7)
20-44	M (31)	11.9 (6.0)	33.6 (6.0)	62.8 (7.4)
	F (32)	10.1 (3.4)	34.0 (3.3)	61.2 (5.1)
45-64	M (28)	12.6 (5.1)	34.1 (5.7)	62.4 (6.6)
	F (35)	12.9 (5.1)	35.3 (5.4)	63.7 (7.0)
65-85	M (23)	12.6 (4.6)	33.0 (6.0)	60.7 (7.2)
	F (31)	13.7 (5.0)	35.4 (5.6)	63.5 (7.6)
French				
9-19	M (27)	9.2 (4.1)	24.0 (4.4)	33.4 (6.1)
	F (32)	8.8 (2.3)	25.3 (3.5)	35.6 (5.5)
20-44	M (21)	13.9 (5.3)	28.3 (5.5)	38.6 (7.0)
	F (35)	14.5 (5.8)	30.1 (6.0)	40.3 (6.8)
45-85	M (12)	12.4 (4.8)	26.0 (5.1)	35.0 (6.0)
	F (26)	14.1 (4.6)	29.7 (5.2)	39.5 (6.6)

Results

Mean percent nasalance data (± 1 SD) for all participants in both languages are summarized in Table 2. The results of the statistical analyses of the data by language are presented.

English

Statistical analyses revealed significant main effects for passage [$F(2,309) = 21884.6$; $p = .0001$] and age [$F(4, 309) = 2.974$; $p = .0196$]. Significant interactions were found between age and passage [$F(8, 618) = 2.104$; $p = .0335$], and sex and passage [$F(2, 618) = 5.357$; $p = .0049$].

The main effects reflect significant differences among the reading passages, and between the nasalance scores for young and old participants. Post hoc analyses of the interactions between age and passage, and sex and passage were conducted using Scheffe's S test at a significance level of .05. The interaction between age and passage was significant only for the Zoo ($p = .0001$) and Rainbow passages ($p = .0386$). The nasalance scores of the English-speaking children and teens were significantly lower than those of the middle-aged and old adults for these passages. The interaction between sex and passage revealed a significant difference between females and males only for the Rainbow passage ($p = .0044$); nasalance scores for females were significantly higher than those for males for this passage.

French

Statistical analyses revealed significant main effects for passage [$F(2,149) = 3535.8$; $p = .0001$], age [$F(2, 149) = 15.079$; $p = .0001$], and sex [$F(1, 149) = 4.098$; $p = .0447$]. A significant interaction was found between sex and passage [$F(2, 298) = 6.790$; $p = .0013$].

The main effects in the French data reflect significant differences among the reading passages and between the nasalance scores for young and old participants, and males and females. Post hoc analyses of the main effect for age

and the interaction between sex and passage used Scheffe's S test at the .05 level. Analysis of the main effect for age identified the nasalance scores of the French-speaking children and teens as significantly lower than those of both the adult groups in the sample. The interaction between sex and passage was significant only for the two passages that contained nasal elements, "Le petit prince" (p = .0075) and "Blanche Neige" (p = .0088). The nasalance scores of the French-speaking females were significantly higher than those of the males for these passages.

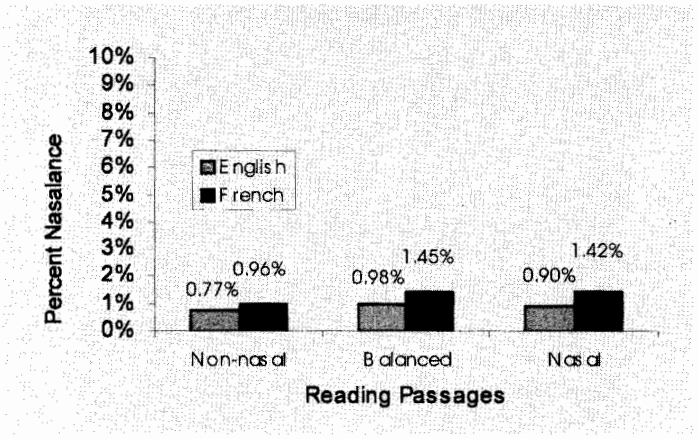
Correlations among Nasalance Scores

Significant (p = .0001) positive Pearson Product Moment correlation coefficients were obtained between nasalance scores across the three passages in each language. Among the francophones, the correlations between the non-nasal passage and the phonemically balanced and nasally loaded passages were r = .85 and r = .75, respectively; the correlation between the two passages containing nasal elements was r = .89. For the anglophones, the correlations between the non-nasal passage and the phonemically balanced and nasally loaded passages were r = .71 and r = .56, respectively; the correlation between the two passages containing nasal elements was r = .82.

Intraspeaker Reliability

Analysis of the intraspeaker reliability data revealed no significant differences (p > .05) among the nasalance scores for three readings of each passage by 10% of the speaker sample in either French or English. Figure 1 displays the average deviations in percent nasalance for the repeated measures. Variation in nasalance scores ranged from 0.77 to 0.98% for anglophones' repeated readings, and from 0.96 to 1.45% for francophones' repetitions.

Figure 1. Average variation in percent nasalance across repeated reading of the same passage by 10% of the participant sample for each language



Discussion

The purpose of this study was to obtain data from normal native speakers of western dialects of Canadian French and Canadian English for contribution to the North American database for nasalance. It was hoped that these data could serve as normative references for the clinical practice of speech-language pathology and as samples for sociolinguistic and acoustic phonetic interests.

Table 3 compares the data of other studies with those presented here. All the data displayed were collected using standardized procedures, identical instrumentation, and comparable spoken materials. Among the results shown, the data for Ontario reported by Seaver et al. (1991) and those reported here for western dialects of Canadian French and English tend to exhibit the lowest values.

A survey of the data specific to the western Canadian sample in Table 2 reveals several trends. First, a tendency for nasalance values for females to exceed those of their male cohorts for the same passage is noticeable in both data sets, though it is not significant for the non-nasal passage in either language. Second, a tendency for nasalance scores to increase with age also is apparent in both data sets; the scores of children and teens are significantly lower than those of adult speakers in both languages. Third, as expected, the three passages within each language are distinctly different from one another in their mean nasalance values, a finding that is statistically robust and consistent with the phonemic construction of the passages. Finally, although a cross-language comparison was not the intent of this work, it is interesting to note that the mean nasalance values for the non-nasal passages in both languages ("La peur du tigre" & "Zoo") are quite similar, while the average nasalance values for the phonemically balanced and nasally loaded passages in French ("Le petit prince" & "Blanche Neige") are noticeably lower than the average scores for the comparable passages in English ("Rainbow" & "Nasal Sentences").

Sex Differences in Nasalance Scores

The tendency for the mean nasalance scores of females to exceed those of male cohorts has been reported by other investigators, though the difference is not always consistent or significant (Fletcher,1978; Hutchinson et al.,1978; Kavanagh et al.,1994; Leeper et al.,1992; Litzaw & Dalston,1992; Seaver et al., 1991). In the present study, the tendency for the nasalance scores of females to ex-

Table 3. Results according to language, region, sex, and reading passage among studies that have contributed nasalance data for dialects of Canadian English and French to the North American database.

Language	Passage	Seaver, Dalston, Leeper, & Adams, 1991 Toronto	Leeper, Rochet, & MacKay, 1992 Sudbury	Leeper, Rochet, & MacKay, 1992 Ottawa	Kavanagh, Fee, Kalinowski, Doyle, & Leeper, 1994 Atlantic Canada	Rochet, Rochet, Sovis, & Mielke (present study) Western Canada
CANADIAN ENGLISH						
Males	*Zoo*	11.0 (5.0)	13.6 (9.2)	14.5 (5.7)	11.9 (5.4)	11.3 (5.0)
	Rainbow	33.0 (8.0)	34.0 (9.8)	33.3 (6.2)	35.8 (5.9)	32.9 (5.3)
	Nasal sent's	57.0 (6.0)	61.5 (9.4)	62.2 (7.6)	63.7 (6.2)	61.6 (6.7)
Females	*Zoo*	12.0 (6.0)	14.2 (8.0)	13.6 (5.1)	14.0 (7.2)	11.5 (4.4)
	Rainbow	36.0 (6.0)	37.2 (10.0)	35.6 (6.4)	37.7 (5.7)	34.5 (4.6)
	Nasal sent's	62.0 (7.0)	63.7 (9.2)	62.5 (7.9)	66.2 (5.7)	62.7 (6.2)
CANADIAN FRENCH						
Males	*Peur du Tigre*		15.2 (8.5)	15.6 (5.8)		11.5 (5.1)
	Petit Prince		28.9 (7.1)	29.4 (7.4)		26.0 (5.2)
	Blanche Neige		37.0 (9.4)	39.1 (9.1)		35.5 (6.7)
Females	*Peur du Tigre*		14.4 (6.4)	14.4 (6.4)		12.4 (5.2)
	Petit Prince		28.7 (5.9)	31.0 (7.0)		28.3 (5.5)
	Blanche Neige		38.4 (8.8)	42.2 (8.4)		38.5 (6.6)

ceed those of males is apparent in almost all the cells of Table 2. This difference is significant, however, only for the phonemically balanced ("Le petit prince") and nasally loaded ("Blanche Neige") passages in French, and the phonemically balanced ("Rainbow") passage in English. It is not significant for the non-nasal passage in either language ("Zoo" & "La peur du tigre"), and Table 2 illustrates that the trend is reversed in the non-nasal data for English-speaking adolescents and young adults, and for the male and female members of the youngest French group. Such a reversal also occurs for the young adults on the nasally loaded passage in English. In these cases, the average male nasalance scores exceed slightly those of females.

Physiological and acoustical explanations for the small sex difference observed repeatedly in nasalance data sets from normal speakers have yet to be substantiated unequivocally. Natural differences between males and females in velar length and velopharyngeal closure patterns (Kuehn, 1976; McKerns & Bzoch, 1970), and sexual dimorphism in nasal cross sectional areas (Seaver et al., 1991) have been cited as possible influential factors, but reliable evidence that they affect oral-nasal resonance balance has been difficult to obtain. Litzaw and Dalston (1992) found no difference in nasal cross-sectional area between males and females, and no correlation between nasal cross-sectional area and nasalance scores in their speakers of either sex. In a study of normal nasal airflow characteristics during speech, Thompson and Hixon (1979) observed that female speakers exhibited transnasal airflow in anticipation of nasal consonants earlier than male speakers for the initial /i/ in the utterance /ini/. These authors suggested that the differences in velopharyngeal configuration and closure patterns documented by McKerns and Bzoch (1970) might reflect biomechanical differences in the velopharyngeal mechanism between the sexes that allow more extensive anticipatory nasal assimilation in female speakers. Aeromechanical and temporal data published recently by Zajac and Mayo (1996) for the utterance "hamper" did not document a sex difference for nasal coarticulation in anticipation of the /m/, but the female participants in their study were slower to achieve peak intraoral pressure on the subsequent /p/. Considering their results in the context of reports by Kuehn (1976), McKerns and Bzoch (1970) and Thompson and Hixon (1979), Zajac and Mayo (1996) conjectured that females may require more time to achieve velopharyngeal closure, a functional difference that could also be influential in the measurement of nasalance, especially when an utterance includes nasal elements.

Acoustical explanations for the small but persistent sex difference in nasalance scores include the suggestion that the band-pass filter characteristics of the Nasometer may interact with the source-filter characteristics of men and women differently to capture, or perhaps to introduce, a measureable difference in nasalance (Leeper et al., 1992; Seaver et al., 1991; Zajac, Lutz & Mayo, 1996). The rela-

tionship between formant frequency and nasalance has yet to be explored directly. Litzaw and Dalston (1992) examined the relationship between modal pitch and nasalance scores in their adult speakers and found no significant correlation between these two parameters that would support assumptions of a differential interaction between the vocal source and the Nasometer hardware that could influence nasalance scores. More recently, Zajac et al. (1996) assessed the effect of the response characteristics of the Nasometer filter on nasalance across a range of frequencies (105 - 330 Hz) pertinent to the voices of adults and children. Their results indicated that the filter characteristics of the Nasometer did not affect nasalance scores. The second part of their investigation indicated, however, that sensitivity differences in the frequency response of the two microphones on the Nasometer headset may be a potential source of variation in nasalance scores within and across speakers and might explain the small differences between the scores of males and females that have been reported in some studies.

In summary, the sex difference that appears in these data sets for anglophones and francophones in western Canada has been noted in nasalance data collected by others from normal speakers in a variety of regions. Notwithstanding its persistence, the difference is small and not always statistically significant, and when it is significant, it is more often so on the standard passages containing nasal elements. Furthermore, it has not yet been reported to be perceptible (Seaver, et al., 1991) and has yet to exceed the within-speaker variation associated with repeated utterance of the same passages (Litzaw & Dalston, 1992). Finally, though physiological and acoustical explanations have been offered for it, none has been substantiated unequivocally. Thus, its clinical significance remains unknown until such time as it can be identified as a real difference associated with some reliable structural, physiological, acoustical or instrumental phenomenon that influences the clinical evaluation of resonance balance using nasometry.

Age Effects on Nasalance Scores

Also of interest in these data is the small but consistent increase in nasalance scores with age that is noticeable in Table 2 for all passages in both languages. The nasalance scores for children and teens are significantly lower than those for both groups of adults in the francophone sample. Among the anglophones, the children's data are significantly lower than the middle-aged and older adults. These age differences are consistent with those reported by others who have compared nasalance across age groups (Hutchinson et al., 1978; Leeper et al., 1992; Seaver et al., 1991). Two phenomena have been suggested as possible explanations for this age effect: (a) structural differences associated with age that may influence the acoustical impedance of natural sound barriers among the resonating chambers of the head, and (b) physiological changes with age that may influence the maintenance of neuromuscular control of the velopharyngeal sphincter across the continuous demands for VP closure during non-nasal connected utterance, and the rapid dynamic demands for VP orifice control during speech that includes nasal components.

Structural explanations for the effect of age on nasalance are based on the premise that the soft and hard tissues of the mouth, jaws, palates, nose, sinuses, and cranium change considerably across the life span in ways that could influence the acoustic characteristics of resonance, of which nasalance would be a component (Weismer & Liss, 1991). The supralaryngeal vocal tracts of speakers in the 9-13 and the 14-19 age groups are more or less crowded with the lymphatic tissues of the tonsils and adenoids that are notorious for altering oral and nasal resonance in the hyponasal direction. These tissues atrophy in most speakers by early adulthood. At this same threshold, the volume of the craniofacial sinuses increases remarkably and continues to do so, albeit at a slower rate, throughout adulthood (Norton, 1988). Later, as speakers approach and enter senescence, they begin to experience loss of bone and changes in the density and mechanical integrity of the skeletal frame, including alveolar bone resorption and remodeling of the mandible (Norton, 1988). The soft tissues of the oropharyngeal region also change with age. Some regions of the mucosal epithelium tend to thin and dry (Heeneman & Brown, 1986), nonmuscular connective tissues tend to stiffen (Weismer & Liss, 1991), and the supralaryngeal muscles may atrophy and become fibrotic (Kahane, 1981; Sonies, 1991; Weismer & Liss, 1991). Reductions in bone density and soft tissue mass, stiffening of connective tissues and pneumatization of the maxillary and frontal sinuses together could reduce the natural acoustical impedance of the palatal shelf and other parts of the maxillofacial complex and modify the dimensions of the vocal tract (Weismer & Liss, 1991). This, in turn, may alter the natural relative acoustical impedances of the mouth and nose during speech such that nasalance increases slightly with age.

Physiological explanations for the effect of age on nasalance are based on the premise that inevitable, nonpathological changes in sensorimotor structures and functions occur with age, including some reduction in motor neuron numbers, decrease in nerve conduction velocities, a decrease in the number and diameter of voluntary muscle fibers, as well as changes in the sensory end-organs, afferent networks, and neurotransmitter systems that sup-

port the performance of rapid, skilled movements (Hutchinson et al., 1978; Weismer & Liss, 1991). Such natural changes could influence the operation of the velopharyngeal sphincter for rapid dynamic control during speech, allowing it to fall behind momentarily or to weaken progressively across the duration of connected utterance. Hutchinson et al. (1978) suggested that a slower reading rate, which has been documented as a natural phenomenon in elders reading aloud (Ramig, 1983; Ryan, 1972; Smith, Wasowicz & Preston, 1987), also may encourage discontinuities in velopharyngeal closure patterns and increase the opportunity for speech segments with higher nasalance as the velopharynx is in transition between open and closed states. Hoit et al. (1994) attempted to test the physiological hypothesis for higher nasalance scores among elders with aeromechanical evaluation techniques which are well-suited to illustrating if and when the velopharyngeal sphincter may have trouble keeping up with the other articulators or fatigues across connected utterance. They studied 80 men and women from 20 to 80+ years and found no aeromechanical signs of deficiency in VP control in older compared to younger adults.

The fact that a small age effect is apparent in the data for both languages across all passages in the present study could provide support for either a structural or physiological hypothesis. In the final analysis, however, the differences in mean nasalance noted across the age span in the anglophone and francophone data reported here are hardly radical. The group differences are rarely beyond one standard deviation of each other, their ranges overlap extensively, and it is not known if the differences have any perceptual reality. Research by Ryan and Burk (1974) demonstrated that "hypernasality" was a relatively insignificant predictor variable in the ability of listeners to accurately estimate the age of older men when hypernasality was used in multiple regression analysis. It remains to be determined whether the difference in nasalance recorded here and by others between children and adults is perceptually or clinically significant.

Stimulus Considerations and Nasalance Scores

Figure 1 illustrates that the average deviations in percent nasalance for participants' repeated readings of the same passage were small. This is consistent with the reports of others who have included repeated measures in their investigations (Litzaw & Dalston, 1992; Seaver et al., 1991). Figure 1 also reveals that nasalance scores varied least across speakers' repetitions of the non-nasal passages, and most for the passages containing nasal elements. It is possible that passages with nasal elements provide more opportunity for variation in nasalance across repeated utterance than non-nasal passages do. Under normal speaking conditions, utterance of the non-nasal passages requires that velopharyngeal closure simply be maintained across breath groups. The primary opportunities for individual variation in nasalance on the non-nasal passages, then, would be natural differences among the acoustic characteristics of each speaker's vocal tract and craniofacial resonating chambers, and individual differences in velopharyngeal sphincter closing and opening behaviors at breath-group onset and offset. Utterance of passages with nasal elements, however, introduces the need for velopharyngeal sphincter adjustments within breath groups and thus creates more opportunity for individual variation in the realization of nasal segments, within and across speakers. Thus, it is not surprising that more intraspeaker variability occurs on the passages containing nasal elements.

The results of Pearson pairwise correlational analyses among participants' nasalance scores for the three passages within a language are consistent with those reported by Seaver et al. (1991), Singbeil (1991), and Dalston and Seaver (1992). They reflect the strongest correlations between the passages containing nasal elements. These data also suggest that a speaker's nasalance score relative to the group performance on one passage tended to be consistent with his/her score relative to the group mean on the other passages. This consistency in speakers' nasalance patterns across the different reading passages, as well as the tendency for speakers' nasalance scores to be reliable across several readings of the same passage are opportune in clinical practice when behavioral or time restrictions may limit data collection to only one or two of the standard passages, depending on the focus of the assessment and the clinician's concerns about resonance balance and velopharyngeal control.

Also of interest in the results of studies that have sampled both Canadian French and English is the comparability of the values for the non-nasal passages in the two languages and the noticeable difference in the overall mean nasalance values for the passages that include nasal elements in roughly the same proportions (~14% for the balanced passages, and ~30% for the nasally loaded passages). This difference has been identified as significant in earlier work (Leeper et al., 1992). Explanations for the differences between the French and English passages with nasal elements may be related to constraints governing the phonemic profile of the passages as well as phonological phenomena governing their utterance (Leeper et al., 1992). Mean overall nasalance associated with the "Rainbow" and "Nasal Sentences" passages is a function of the presence of nasal consonants whose acoustic energy is emitted primarily via the nose, because the mouth is closed and the velopharynx open. The nasalance in "Le Petit

Prince" and "Blanche Neige," however, is a function of the presence of nasal consonants and nasal vowels. French nasal vowels emit both oral and nasal energy, because both the mouth and the velopharynx are open during their production. Thus, a nasal vowel will not achieve as high a nasalance value as a nasal consonant, because nasalance as measured by the Nasometer reflects the proportion of sound energy influencing the nasal microphone out of the total acoustic energy influencing both the oral and nasal microphones. Therefore, the overall nasalance scores for "Le Petit Prince" and "Blanche Neige" tend to be lower than the scores for their English counterparts ("Rainbow" & "Nasal Sentences"), because the construction of the French passages must include both nasal vowels and consonants to achieve the target phonemic "load" for nasal elements. An additional factor that may contribute to the differences in mean overall nasalance scores for the comparable passages in French and English is that francophones exhibit less assimilation nasality on vowels in the neighborhood of nasal consonants than anglophones for the same utterance context regardless of vowel height (Rochet & Rochet, 1991). This, too, may relate to the existence of phonemic nasal vowels in French and the francophone's need to realize an acoustical target that ensures a perceptual distinction between a nasal vowel and a phonemically non-nasal vowel contiguous with a nasal consonant.

Participant Sample Limitations

Both samples contain data from speakers native primarily to Alberta and Saskatchewan collected in urban and rural centres around Edmonton, Alberta. Although some data were collected in community centres, parishes, hospitals and health units beyond the university community and the metropolitan centre, there likely is an urban bias in the sampling, as well as the preferential selection of literate individuals who could read the information about the research, read and understand the consent form, and read the passages aloud fluently in their native tongue. Clinicians are encouraged to keep these sampling limitations in mind when applying the data from this study in clinical practice. Norms such as these also cannot be applied to pre-literate or illiterate persons, or to conversational speech. Standard stimulus materials for the assessment of nasalance in young children are available from Watterson, Hinton and McFarlane (1996) and MacKay and Kummer (1994).

Summary and Conclusion

This study reports mean nasalance data for 468 healthy, normal speakers of Canadian English (n = 315) and Canadian French (n = 153) in western Canada. As a part of the North American database for nasalance, these two data sets reflect the dialectal characteristics of Canada's two languages as they are spoken by persons native to the Prairie Provinces. Clinicians will note that mean nasalance values in these two data sets tend to be slightly lower than comparable values sampled in parts of eastern Canada and the Atlantic provinces, especially for the phonemically balanced and nasally loaded reading materials. The data sets also reflect a tendency for females to exhibit slightly higher nasalance scores than male cohorts for the same passage in both languages. Finally, the data exhibit a small increase in mean nasalance scores with age across the range of the two samples (9-85 years). These trends are consistent with those reported by others contributing to this database, though their clinical significance has yet to be identified or delimited.

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