10-1-2018

Hypernasal Speech is Perceived as More Monotonous Than Typical Speech

Monique Tardif
University of Toronto

Larissa Cristina Berti
Universidade Estadual Paulista Julio de Mesquita Filho

Viviane Cristina De Castro Marino
Universidade Estadual Paulista Júlio de Mesquita Filho

Jennifer Pardo
Montclair State University, pardoj@montclair.edu

Tim Bressmann
University of Toronto

Original Paper

Folia Phoniatrica et Logopaedica

Folia Phoniatr Logop 2018;70:183–190
DOI: 10.1159/000492385

Published online: September 5, 2018

Hypernasal Speech Is Perceived as More Monotonous than Typical Speech

Monique Tardif[a] Larissa Cristina Berti[b] Viviane Cristina de Castro Marino[b] Jennifer Pardo[c] Tim Bressmann[a]

[a]University of Toronto, Toronto, ON, Canada; [b]São Paulo State University, Marília, Brazil; [c]Montclair State University, Montclair, NJ, USA

Keywords

Hypernasality · Intonation · Perception of speech · Ratings of speech · Instrumental measures · Auditory-perceptual evaluations

Abstract

Background/Purpose: Anecdotal clinical reports have stated that hypernasal speech sounds monotonous. However, the relationship between the perception of intonation (i.e., the fundamental frequency variation across an utterance) and hypernasality (excessive nasal resonance during the production of non-nasal sounds) has not been investigated in research. We hypothesized that auditory-perceptual ratings of intonation would be significantly lower for more hypernasal stimuli. ***Methods:*** One male and one female voice actor simulated 3 levels of intonation (monotone, normal, and exaggerated) at 4 different levels of hypernasality (normal, mild, moderate, and severe). Thirty participants listened to the simulations and rated the intonation on a visual analogue scale from 0 (monotone) to 100 (exaggerated). ***Results:*** A mixed-effects ANOVA revealed main effects of intonation ($F_2 = 236.46$, $p < 0.001$), and hypernasality ($F_3 = 159.89$, $p < 0.001$), as well as an interaction between the two ($F_6 = 28.35$, $p < 0.001$). Post hoc analyses found that speech was rated as more monotonous as hypernasality increased. ***Summary/Implications:*** The presence of hypernasality in speech can lead listeners to perceive speech as more monotonous. Instrumental measures should be used to corroborate auditory-perceptual evaluations of speech features like intonation.

Introduction

The term intonation describes the linguistically motivated changes in fundamental frequency during speech. Intonation is a part of the more global concept of prosody [1]. Prosody encompasses the rhythm, stress, and intonation occurring during speech. The present study focuses on intonation, i.e., the fundamental frequency variation across an utterance. Speakers use pitch variation to convey linguistic information [2]. Intonation is important for communicating speaker emotions and intentions [2, 3]. The same statement with two different intonation patterns can have different meanings. For example, in English, a statement can become a question if the end of the

KARGER

E-Mail karger@karger.com
www.karger.com/fpl

Tim Bressmann
160-500 University Avenue
Toronto, ON M5G 1V7 (Canada)
E-Mail tim.bressmann@utoronto.ca

utterance is spoken with rising intonation [1, 4]. On the other hand, novel or unexpected intonation patterns can impede listeners' processing of tasks such as word-monitoring, lexical decision, or semantic categorization [5]. Intonation can be affected by a variety of speech disorders [6, 7].

Hypernasality is a speech disorder that is characterized by excessive sound resonating in the nasal cavity during non-nasal sounds [8]. Hypernasality can result from structural defects of the palate in cleft palate and craniofacial syndromes [8], neurogenic dysarthria or palatal paralysis [9], or palatal resections in head and neck cancer patients [10]. In hypernasal patients, the velum does not adequately close off the nasal cavity during speech. This results in excessive unwanted nasal resonance during the production of oral vowels and consonants. Acoustically, nasalization of speech results in a low-frequency nasal murmur (around 200–300 Hz) [11]. This acoustic parameter may overlay the fundamental frequency of the speaker.

The relationship between hypernasality and the perception of intonation has not been investigated systematically. However, it has been observed anecdotally that speech of hypernasal patients with cleft palate may be perceived as monotonous by clinicians [8, 10]. It is possible that the increase in spectral energy in the low frequencies interferes with the perception of the fundamental frequency (the acoustic correlate for intonation). Since the accurate auditory-perceptual diagnosis of speech disorders informs further treatment decisions [10, 12], it is of importance to understand how these two aspects of speech production may relate to each other. The purpose of this study was to investigate how the presence of hypernasality affects listeners' perception of intonation. Based on the empirical clinical impression that hypernasal speech can sometimes be perceived as more monotonous [8, 10], the research hypothesis was that auditory-perceptual ratings of intonation would be significantly lower for more hypernasal stimuli.

Methods

Preparation of Listening Stimuli

Speech samples produced by one male and one female voice actor were recorded (26 and 23 years old) in a sound-insulated recording booth. They spoke Brazilian Portuguese with the accent common to the Midwestern region of São Paulo state. The actors did not report nasal congestion on the day of the recordings. Speech samples were recorded using a Sennheiser 855 microphone (Sennheiser, Hannover, Germany) positioned on a stand approximately 20 cm from the actors' mouth. The microphone signal was recorded using a Marantz PMD660 (Marantz, Kanagawa, Japan) digital recorder. Additionally, nasalance scores were recorded with a Nasometer II 6400 (KayPentax, Lincoln Park, NJ, USA). Two phonetically mixed sentences with oral and nasal consonants were used in order to elicit normally occurring nasal murmur in the bilabial nasal /m/, the alveolar nasal /n/, and the palatal nasal /ɲ/ (written orthographically as "nh") as well as to include a variety of oral sounds to permit for the perception of hypernasality. They were designed to be syntactically and semantically simple and easily pronounceable. The two sentences were "Belinha gosta de banana" (Little Isabella likes bananas) and "Camilla pega a manga" (Camilla takes a mango). The rate of speech was controlled with a 90-bpm metronome click presented through a set of headphones. Speakers produced the strong syllables from the sentences synchronously with the metronome clicks, for example "Be**lin**ha **gos**ta de ba**na**na" (strong syllables are written in bold). Actors were asked to produce three levels of intonation (monotone, normal, exaggerated). Additionally, the actors were asked to simulate four levels of hypernasality (none, mild, moderate, and severe) in combination with the three levels of intonation. They were trained by a speech-language pathologist (the third author) specialized in hypernasal speech disorders. During the training, auditory examples were provided, and during the recordings, the speakers had visual feedback from the Nasometer's software. One actor was recorded at a time. The first recordings were the normal condition, followed by the exaggerated, then monotonous speech. This order of intonation level was repeated for each level of hypernasality from least severe to most severe (mild, moderate, and severe). In total, 48 recordings were produced (2 actors × 2 sentences × 4 levels of hypernasality × 3 levels of intonation).

Analysis of Listening Stimuli

Perceptually, the stimuli showed the intended acoustic effects, as verified by the first, second, and third authors during the recording sessions with the actors. Since changes in fundamental frequency (F_0) are the principal acoustic feature of intonation, the variability of the F_0 can be used to quantify the variability of a speaker's intonation [3, 13]. To corroborate the online auditory-perceptual evaluation of the speech stimuli, the standard deviation of the fundamental frequency was used to assess intonation variability, based on Nakai et al. [3]. The standard deviation of the average pitch was measured in Praat [14]. In the monotonous condition, the standard deviation was expected to be smaller than in the normal condition, and both normal and monotonous were expected to have smaller standard deviations than the exaggerated condition. The levels of hypernasality were measured using nasalance scores, recorded with a Nasometer 6400 (KayPentax, Lincoln Park, NJ, USA). Actors' nasalance scores were expected to increase with the levels of simulated hypernasality. Average scores for the different levels of intonation and hypernasality can be found in Figures 1 and 2.

Paired *t* tests were run to determine whether the two sentences were different across pitch or nasalance scores. No differences of means between the two sentences were found for F_0 standard deviation ($t_{1.59} = -0.21$, $p = 0.86$) or nasalance ($t_{1.36} = -0.68$, $p = 0.59$). Paired *t* tests were also run to determine whether the two actors showed differences for F_0 standard deviation or nasalance scores. No differences of means were found between the actors for the F_0 standard deviation ($t_{1.15} = -4.52$, $p = 0.11$) or nasalance scores

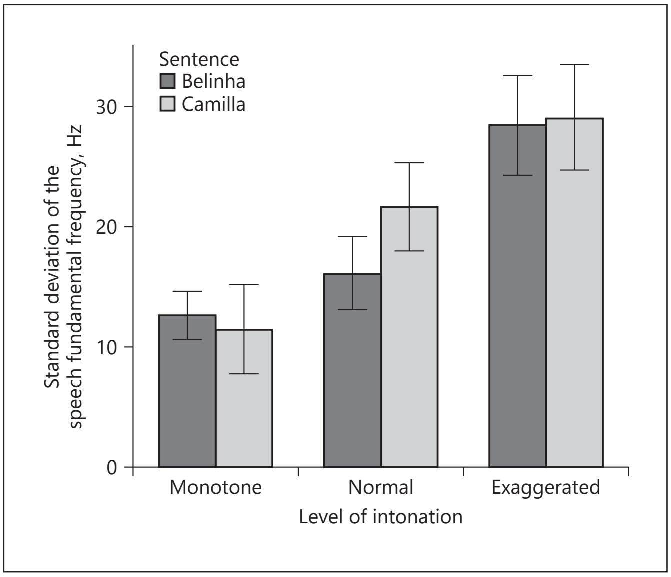

Fig. 1. Standard error bar graph of pitch variability by level of intonation.

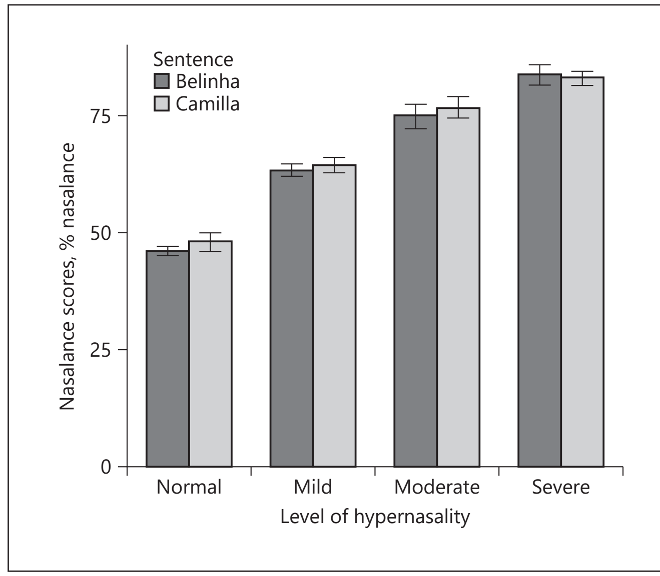

Fig. 2. Standard error bar graph of nasalance score by level of hypernasality.

($t_{1.20} = 0.50$, $p = 0.69$). The data for the two sentences and the two actors were therefore combined in all further analyses.

A repeated-measures ANOVA was run to determine if the F_0 standard deviation was significantly different at the different intonation levels (monotone, normal, and exaggerated). There was a main effect of intonation level ($F_2 = 79.09$, $p = 0.012$). There was no effect of hypernasality ($F_3 = 0.82$, $p = 0.56$), and no interaction between intonation level and hypernasality level ($F_6 = 0.64$, $p = 0.70$). Visually some differences in intonation were visible between levels of intonation, as depicted in Figure 3. However, the ANOVA indicated that the F_0 standard deviations differed as intended for the levels of intonation and not for the levels of hypernasality.

Similarly, a repeated-measures ANOVA was used to determine whether nasalance scores were significantly different at the different levels of hypernasality. There was a main effect of level of hypernasality ($F_3 = 1{,}382.85$, $p < 0.001$). There was no effect intonation level ($F_2 = 2.12$, $p = 0.32$), and no interaction between intonation level and hypernasality level ($F_6 = 2.06$, $p = 0.20$). These results indicated that the levels of hypernasality represented different severity levels of hypernasality.

Participants

Thirty-one participants (16 males, 15 females) were recruited from the student and staff population of the Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP) in Marília, SP, Brazil. All participants were between the ages of 18–35 (mean = 22.84, standard deviation = 5.39) with the exception of one male participant. This individual self-identified as older than 35 years of age after completing the experiment. Since this exceeded the stated upper age limit for the study, his data were not included in the analysis. The data from the remaining 30 participants were included in the analysis. All of the 15 female, but none of the 15 male, participants recruited were students of the speech-language pathology and audiology program at UNESP. The female students of speech-language pathology had

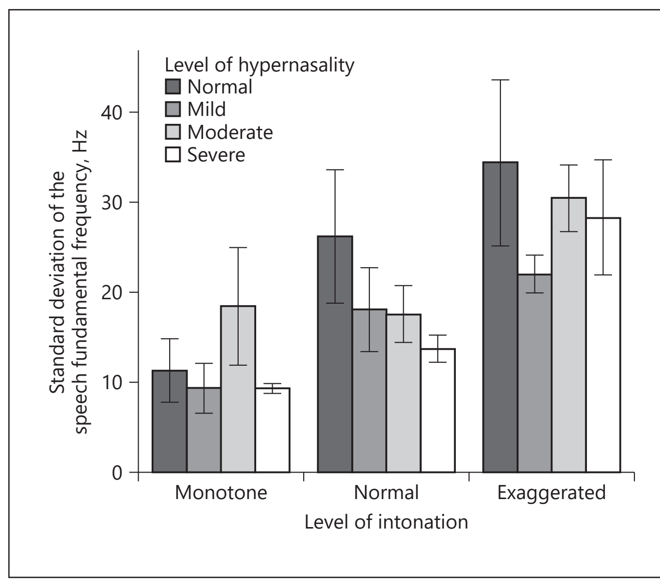

Fig. 3. Standard error bar graph of pitch variability by level of intonation.

all been exposed to different speech and language disorders as part of their academic and clinical training. The male participants were students or graduates of degree programs other than speech-language pathology. Since the two groups differed by both gender and previous knowledge about speech disorders and their assessment, they will be referred to as the female experienced and the male inexperienced groups in the presentation of the results and the discussion. All participants spoke Brazilian Portuguese as their native lan-

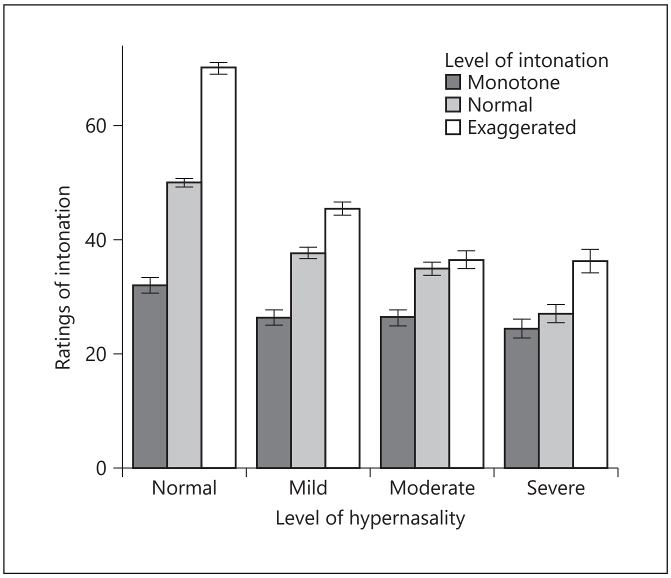

Fig. 4. Standard error bar graph of ratings of intonation in the presence of hypernasality. Ratings of intonation: from 0 (monotonous) to 100 (exaggerated).

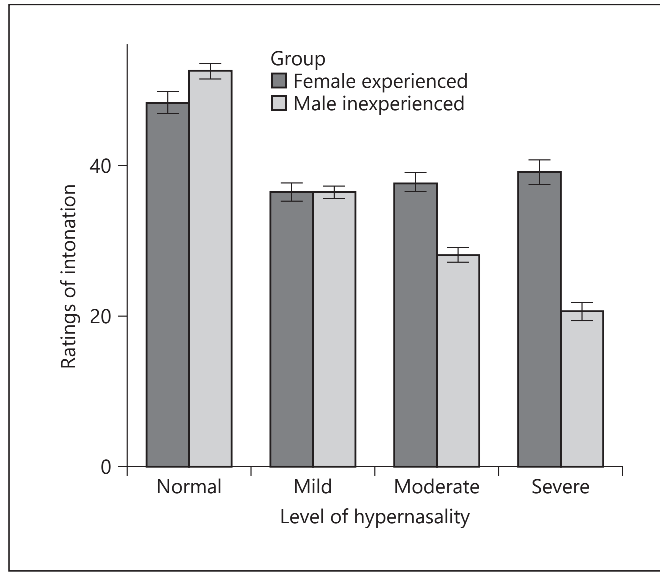

Fig. 5. Standard error bar graph of ratings of intonation in the presence of hypernasality for the female experienced and the male inexperienced groups. Ratings of intonation: from 0 (monotonous) to 100 (exaggerated).

guage with the accent typical of the Midwestern region of São Paulo state. The participants reported normal hearing and no history of speech or language disorders. All participants provided informed consent in writing. The research procedures were reviewed and approved by the Research Ethics Board at the UNESP Marília as well as by the University of Toronto Research Ethics Board.

Procedure

The experiment was run on a MacBook Air laptop computer (Mac OS Sierra 10.12.6). Stimuli were presented and ratings were obtained using a custom computer program running in OpenSesame 3 [15]. Participants worked on the task individually. They were seated at a desk in a quiet room and listened to the stimuli on SHL3060bk/28 Philips headphones (Philips, Amsterdam, the Netherlands). The order of the presentation of the stimuli was randomized by the computer program for every participant. The participants listened only once to each recording. They were then prompted to rate the intonation of each individual speech recording on a visual analog scale from 0 (monotone) to 100 (exaggerated) using the trackpad of the computer. The participants judged each recording twice in the same session, so they made a total of 96 ratings based on 48 auditory stimuli. The rationale for repeating the ratings was to reduce possible effects of statistical outliers on the data. The experiment took approximately 15 min to complete.

Analysis

The Number Cruncher Statistical Software Version 8 (NCSS LLC, Kaysville, UT, USA) was used for the statistical analyses. A mixed-models ANOVA was used to determine the impact of hypernasality on the perception of intonation. Bonferroni-adjusted *F* tests were used as post hoc measures.

Results

The mean ratings of intonation for levels of pitch showed an increase from monotone (mean = 27.20, SD = 22.64) to normal (mean = 37.31, SD = 19.66) to exaggerated (mean = 47.06, SD = 27.07). The mean ratings of intonation at different levels of hypernasality showed a decrease from normal resonance (mean = 50.61, SD = 23.06) to mild (mean = 36.46, SD = 19.62) to moderate (mean = 32.52, SD = 21.68) to severe (mean = 29.17, SD = 28.03). When the mean ratings for intonation were analyzed by group, the mean ratings of the female experienced participants (mean = 40.40, SD = 25.84) were higher than those of the male inexperienced participants (mean = 34.39, SD = 23.28). Figure 4 shows an error bar plot of the different categories of intonation and hypernasality.

To investigate the impact of increasing levels of hypernasality on the listener ratings of intonation, a mixed-model ANOVA was run. The dependent variable was participants' intonation ratings. The three independent variables included three levels for intonation (monotone, normal, and exaggerated), four levels for hypernasality (none, mild, moderate, and severe), and two levels of listener group (female experienced and male inexperienced). Main effects were found for intonation (F_2 = 236.46, $p < 0.001$), hypernasality (F_3 = 159.89, $p < 0.001$),

Folia Phoniatr Logop 2018;70:183–190
DOI: 10.1159/000492385

and group ($F_1 = 4.36$, $p = 0.046$). Furthermore, there was a significant interaction in raters' perception of intonation between levels of intonation and hypernasality ($F_6 = 26.27$, $p < 0.001$). Additionally, there were interactions between listener group and level of intonation ($F_2 = 38.81$, $p < 0.001$), as well as between listener group and level of hypernasality ($F_3 = 47.10$, $p < 0.001$). There was a three-way interaction between group, level of intonation, and hypernasality ($F_6 = 2.90$, $p = 0.008$).

The main effect for group showed that average ratings for female experienced listeners were significantly higher than those for male inexperienced listeners. Bonferroni-adjusted post hoc comparison tests were used to clarify the other main effects for intonation and hypernasality. The post hoc comparisons for intonation indicated that all levels of intonation were rated differently from one another, with highest ratings for stimuli with exaggerated and lowest ratings for stimuli with monotonous intonation (all $p < 0.001$). Similarly, the post hoc comparisons for hypernasality indicated that higher levels of hypernasality were rated as more monotonous (all $p < 0.001$).

More Bonferroni-adjusted post hoc tests were used to explore the interactions. Differences of listener's ratings were found between levels of hypernasality for every level of intonation ($p < 0.05$). Additionally, differences were found between ratings at every level of intonation for every level of hypernasality ($p < 0.001$) with one exception. There was no significant difference between monotonous and normal intonation when hypernasality was severe ($p = 1.00$). The interaction between group and level of intonation was only significant in the exaggerated condition ($F_1 = 24.12$, $p < 0.001$). Significant interactions between group and levels of hypernasality were only found for the moderate ($F_1 = 7.73$, $p = 0.033$), and severe ($F_1 = 37.18$, $p < 0.001$) levels of hypernasality.

The three-way interaction between group, level of intonation, and hypernasality was interpreted based on the two-way interactions between the different fixed factors of the model. The difference between the female experienced and male inexperienced participants is visualized in Figure 5, which shows that female experienced participants rated items with moderate and severe hypernasality as less monotonous than the male inexperienced participants.

Discussion

The present study evaluated the effect of hypernasality on the perception of intonation. Simulations from trained actors were used to enable the creation of listening stimuli with clear differentiation between levels of severity of intonation and hypernasality. This was preferable over the alternative of using clinical patient recordings because of the limited control patients have over the severity of their speech disorder. Additionally, clinical speech disorders may present with co-occurring features in different subsystems of speech production [9]. Conceivably, this would make it more difficult to assess speech intonation independently of auditory-perceptual features of speech other than hypernasality.

The analysis of the stimuli confirmed that they were appropriate for the study purposes. No significant differences were found between the two actors or the two sentences. Nasalance scores were found to increase with higher levels of simulated hypernasality. Similarly, pitch standard deviations were found to be different corresponding to the simulations of different levels of intonation. Inspection of the data revealed that the simulations of the different levels of hypernasality had more clear-cut results than the simulations of the different levels of intonation. Based on visual inspection of the results, the standard deviation of the fundamental frequency for the monotonous intonation at moderate hypernasality was closer to the normal intonation, compared to other levels of hypernasality. Despite their best efforts, the actors were limited in their abilities to produce perfectly differentiated levels of severity of intonation when they had to simultaneously simulate hypernasality. However, this limitation did not appear to affect the overall study results.

The hypothesis motivating the research stated that speech would be rated as more monotonous as hypernasality increases. The results from the study provided evidence to support this hypothesis. The mean ratings of intonation for levels of pitch showed an increase from monotonous to exaggerated which indicated that listeners were differentiating between the levels of intonation. The mean ratings of intonation at different levels of hypernasality showed a decrease from normal to severe hypernasality, indicating that listeners perceived intonation to be more monotonous as the level of hypernasality increased. These observations were confirmed by the mixed-model ANOVA, which demonstrated significant main effects of intonation, hypernasality, and listener group. There were also significant two-way interactions between all independent variables as well as a significant three-way interaction. The Bonferroni-adjusted post hoc comparison tests for intonation showed that all levels of intonation were rated differently from one another, confirming that raters were able to differentiate all the levels of intonation. The post hoc comparisons for hypernasality indicated

DOI: 10.1159/000492385

that intonation ratings were lower (i.e., more monotonous) as hypernasality increased. The interaction between the levels of intonation and hypernasality further corroborated the significant decrease in intonation ratings across levels of intonation and hypernasality, lending support to the research hypothesis that hypernasal speech is perceived as more monotonous [8–10].

The study results revealed interactions between group and level of intonation, as well as group and level of hypernasality. There was also a three-way interaction between group and levels of intonation and hypernasality. These interactions were explained by the post hoc statistics, which demonstrated female experienced listeners' significantly higher ratings for exaggerated intonation as well as higher ratings for moderate and severe levels of hypernasality. The groups differed in terms of both gender and previous experience with speech disorders. Previous research has demonstrated potential effects of both factors on auditory-perceptual assessment, but the findings have not been unequivocal.

Systematic gender differences in auditory-perceptual ratings were first described for fluency disorders, with males rating stuttering as more severe than females [16]. However, Patterson and Pring [17] were not able to replicate this finding. Williams and Dietrich [18] did not find gender differences but the same authors found that males perceived communication disorders as more severe in a later study [19]. Other researchers were not able to show gender effects for the perception of different speech disorders such as stuttering [20, 21], dysarthria [22] and simulated speech and language disorders [23].

All of the female listeners recruited in this study were speech-language pathology and audiology students. This discrepancy in expertise between the two groups could be another possible driver of the apparent differences between the groups. In general, naïve listeners are able to identify features of disordered speech [24], particularly as the severity of the disorder increases [25]. Speech-language pathologists have been found to rate the acceptability of disordered speech lower than naïve listeners [24, 26–28]. However, the opposite effect has also been observed [29]. Finally, some studies reported no differences in ratings of severity or vocal effort between individuals with dysphonia, naïve listeners, and expert raters [30, 31].

Based on the available literature, it is not possible to draw firm conclusions whether the differences in rating patterns by the two groups were spurious or could be attributed to differences in gender or experience. These findings notwithstanding, the differences observed between listener groups did not detract from the main finding that the presence of hypernasality affected the perception of intonation. However, more research is needed to better understand possible effects of gender and expertise on the perception of intonation.

The results of the present study are important for speech-language pathologists because the auditory-perceptual evaluation of speech features such as voice quality and intonation is a core area of their practice. There are different schemes for auditory-perceptual voice analysis [32, 33], and often, these may be the only tool available [34, 35]. However, listeners may base their auditory-perceptual evaluations on different individual internal standards, which can detract from interrater reliability [36]. When multiple disordered features are present in a complex case, it becomes more difficult for listeners to isolate individual auditory-perceptual features with any accuracy [37].

Like voice quality, hypernasality is usually assessed auditory-perceptually [10, 38]. Auditory-perceptual ratings of hypernasality can show variable agreement and be quite unreliable [39, 40]. The variability has been attributed to the types of rating scales used [41] or to listeners' experience [42, 43]. Studies about listener training have shown improved interrater agreement [44–46]. However, it is largely unknown how listeners perform when there are co-occurring pathologies in more than one perceptual dimension, which is often the case in clinical practice. In a first foray into this uncharted territory, Dattilo [47] demonstrated that the presence of more severe articulation disorders in speech samples of children with cleft palate resulted in higher ratings of the severity of hypernasality. In a similar vein, the present study demonstrated how increasing levels of hypernasality affected listener ratings of speech intonation. Such cross-contamination effects of auditory-perceptual dimensions should be investigated in future research.

Since auditory-perceptual assessment of speech disorders appears not to be a very exact science, it may be advisable to clinicians to corroborate the auditory-perceptual assessment with instrumental measures, such as nasalance scores for hypernasality [12, 38] or fundamental frequency measurements for intonation [32, 48]. Future research should investigate whether such acoustic measures could help anchor speech-language pathologists' auditory-perceptual evaluations. Another interesting next step would be to reverse the experimental paradigm and investigate influence of intonation on the auditory-perceptual rating of hypernasality.

The present study had a number of limitations. The simulations of disordered speech may not be representative of real clinical populations. However, using clinical patients to record the speech stimuli required for this experiment would not have allowed creating the required carefully balanced levels of severity. Another limitation was the inclusion of only two model speakers, although this also had the advantage of minimizing possible speaker effects. While the model speakers' nasalance scores and rate of speech were carefully monitored during the recordings, the speakers' intensity contours and speaking loudness were only monitored auditory-perceptually online by the first three authors. Changes in speaking loudness can affect the production of lexical stress [49]. This should be considered in future research. It should also be noted that the two participant groups differed in both gender and the extent of their previous experience with speech disorders. This made it impossible to disentangle the separate effects that both gender and experience may have had on the results for the two groups. In future research, the possible effects of gender and experience should be investigated in more detail. Finally, the research was carried out with speakers of Brazilian Portuguese, which is characterized by a comparatively extensive set of vowel contrasts (8 oral vowels, 5 nasalized vowels as well as a variety of diphthongs). Multisyllabic words in Brazilian Portuguese have a regular stress pattern with emphasis on the penultimate syllable [50]. Further research is needed to demonstrate whether the results of the present study can be transferred to languages with different vowel systems and intonation patterns [50].

Conclusion

The present study demonstrated that the presence of hypernasality affected listeners' auditory-perceptual ratings of intonation. It is important for speech-language pathologist to understand that there may be cross-contamination between different auditory-perceptual dimensions and that this may influence their ratings. Whenever possible, speech-language pathologists should use available acoustic measures to corroborate their perceptual impressions. More research is needed to better understand how different auditory-perceptual qualities may influence listeners' ratings of symptom severity.

Acknowledgment

Ms. Tardif's three months' visit to the UNESP Marília was supported by a MITACS GlobaLink Research Award (reference IT09603). Ms. Tardif was also funded by a Social Sciences and Humanities Council Research Insight Development Grant (grant number 430-2016-00253) to the fourth and fifth authors.

Disclosure Statement

The authors have no conflict of interest to declare.

References

1 Cruttenden A. Intonation. 2nd ed. Cambridge: Cambridge University Press; 1997.
2 Hart JT, Collier R, Cohen A. A Perceptual Study of Intonation: An Experimental-Phonetic Approach to Speech Melody. Cambridge: Cambridge University Press; 1990.
3 Nakai Y, Takashima R, Takiguchi T, Takada S. Speech intonation in children with autism spectrum disorder. Brain Dev. 2014 Jun; 36(6):516–22.
4 Gibbon D, Richter H, editors. Intonation, accent and rhythm: Studies in discourse phonology. Berlin, New York: W. de Gruyter; 1984.
5 Braun B, Dainora A, Ernestus M. An unfamiliar intonation contour slows down online speech comprehension. Lang Cogn Process. 2011;26(3):350–75.
6 Kent RD, Rosenbek JC. Prosodic disturbance and neurologic lesion. Brain Lang. 1982 Mar; 15(2):259–91.
7 Shriberg LD, Campbell TF, Karlsson HB, Brown RL, McSweeny JL, Nadler CJ. A diagnostic marker for childhood apraxia of speech: the lexical stress ratio. Clin Linguist Phon. 2003 Oct-Nov;17(7):549–74.
8 Zajac DJ, Vallino LD. Evaluation and management of cleft lip and palate: A developmental perspective. San Diego: Plural Publishing Inc; 2017.
9 Darley FL, Aronson AE, Brown JR. Motor Speech Disorders. Philadelphia: Saunders; 1975.
10 Peterson-Falzone SJ, Hardin-Jones MA, Karnell MP. Cleft Lip and Palate. 3rd ed. St. Louis: Mosby; 2001.
11 Fujimura O, Lindqvist J. Sweep-tone measurements of vocal-tract characteristics. J Acoust Soc Am. 1971 Feb;49(2):Suppl 2:541+.
12 Kummer AW. Cleft palate and craniofacial anomalies: the effects on speech and resonance. 2nd ed. Clifton Park: Delmar Cengage Learning; 2008.
13 Meister H, Landwehr M, Pyschny V, Walger M, von Wedel H. The perception of prosody and speaker gender in normal-hearing listeners and cochlear implant recipients. Int J Audiol. 2009 Jan;48(1):38–48.
14 Boersma P, Weenink D. Praat: doing phonetics by computer. Version 5.3.63 [software]. 2017 May 26. Available from: http://www.fon.hum.uva.nl/praat/
15 Mathôt S, Schreij D, Theeuwes J. OpenSesame: an open-source, graphical experiment builder for the social sciences. Behav Res Methods. 2012 Jun;44(2):314–24.
16 Burley PM, Rinaldi W. Effects of sex of listener and of stutterer on ratings of stuttering speakers. J Fluency Disord. 1986;11(4): 329–33.
17 Patterson J, Pring T. Listeners attitudes to stuttering speakers: no evidence for a gender difference. J Fluency Disord. 1991;16(4): 201–5.

18 Williams DF, Dietrich S. Effects of speech and language disorders on raters' perceptions. J Commun Disord. 1996 Jan-Feb;29(1):1–12.
19 Williams DF, Dietrich S. Perceptions of communicative disorders: verification and specification of rater variables. J Commun Disord. 2001 Jul-Aug;34(4):355–66.
20 Valente AR, St Louis KO, Leahy M, Hall A, Jesus LM. A country-wide probability sample of public attitudes toward stuttering in Portugal. J Fluency Disord. 2017 Jun;52:37–52.
21 St Louis KO. Male versus female attitudes toward stuttering. J Commun Disord. 2012 May-Jun;45(3):246–53.
22 Walshe M, Miller N, Leahy M, Murray A. Intelligibility of dysarthric speech: perceptions of speakers and listeners. Int J Lang Commun Disord. 2008 Nov-Dec;43(6):633–48.
23 Allard ER, Williams DF. Listeners' perceptions of speech and language disorders. J Commun Disord. 2008 Mar-Apr;41(2):108–23.
24 Brunnegård K, Lohmander A, van Doorn J. Untrained listeners' ratings of speech disorders in a group with cleft palate: a comparison with speech and language pathologists' ratings. Int J Lang Commun Disord. 2009 Sep-Oct;44(5):656–74.
25 Rabinov CR, Kreiman J, Gerratt BR, Bielamowicz S. Comparing reliability of perceptual ratings of roughness and acoustic measure of jitter. J Speech Hear Res. 1995 Feb;38(1):26–32.
26 Dagenais PA, Watts CR, Turnage LM, Kennedy S. Intelligibility and acceptability of moderately dysarthric speech by three types of listeners. J Med Speech-Lang Pathol. 1999;7(2):91–5.
27 Finizia C, Lindström J, Dotevall H. Intelligibility and perceptual ratings after treatment for laryngeal cancer: laryngectomy versus radiotherapy. Laryngoscope. 1998 Jan;108(1 Pt 1):138–43.
28 Damrose JF, Goldman SN, Groessl EJ, Orloff LA. The impact of long-term botulinum toxin injections on symptom severity in patients with spasmodic dysphonia. J Voice. 2004 Sep;18(3):415–22.
29 Laczi E, Sussman JE, Stathopoulos ET, Huber J. Perceptual evaluation of hypernasality compared to HONC measures: the role of experience. Cleft Palate Craniofac J. 2005 Mar;42(2):202–11.
30 Eadie TL, Nicolici C, Baylor C, Almand K, Waugh P, Maronian N. Effect of experience on judgments of adductor spasmodic dysphonia. Ann Otol Rhinol Laryngol. 2007;116(9):695–701.
31 Eadie TL, Van Boven L, Stubbs K, Giannini E. The effect of musical background on judgments of dysphonia. J Voice. 2010 Jan;24(1):93–101.
32 Oates J. Auditory-perceptual evaluation of disordered voice quality: pros, cons and future directions. Folia Phoniatr Logop. 2009;61(1):49–56.
33 Karnell MP, Melton SD, Childes JM, Coleman TC, Dailey SA, Hoffman HT. Reliability of clinician-based (GRBAS and CAPE-V) and patient-based (V-RQOL and IPVI) documentation of voice disorders. J Voice. 2007 Sep;21(5):576–90.
34 Behrman A. Common practices of voice therapists in the evaluation of patients. J Voice. 2005 Sep;19(3):454–69.
35 Kent RD. Hearing and believing: some limits to the auditory-perceptual assessment of speech and voice disorders. Am J Speech Lang Pathol. 1996;5(3):7–23.
36 Kreiman J, Gerratt BR, Kempster GB, Erman A, Berke GS. Perceptual evaluation of voice quality: review, tutorial, and a framework for future research. J Speech Hear Res. 1993 Feb;36(1):21–40.
37 Kreiman J, Gerratt BR. Sources of listener disagreement in voice quality assessment. J Acoust Soc Am. 2000 Oct;108(4):1867–76.
38 Kuehn DP, Moller KT. Speech and language issues in the cleft palate population: the state of the art. Cleft Palate Craniofac J. 2000;37(4):348–382.
39 Keuning KH, Wieneke GH, Dejonckere PH. Correlation between the perceptual rating of speech in Dutch patients with velopharyngeal insufficiency and composite measures derived from mean nasalance scores. Folia Phoniatr Logop. 2004 May-Jun;56(3):157–64.
40 Whitehill TL, Lee AS. Instrumental analysis of resonance in speech impairment. In: Ball MJ, Perkins MR, Müller N, Howard S, editors. The Handbook of Clinical Linguistics. Cambridge: Blackwell; 2009. p. 332–43.
41 Whitehill TL, Lee AS, Chun JC. Direct magnitude estimation and interval scaling of hypernasality. J Speech Lang Hear Res. 2002 Feb;45(1):80–8.
42 Brunnegård K, Lohmander A, van Doorn J. Comparison between perceptual assessments of nasality and nasalance scores. Int J Lang Commun Disord. 2012 Sep-Oct;47(5):556–66.
43 Lewis BA, Freebairn L, Heeger S, Cassidy SB. Speech and language skills of individuals with Prader-Willi syndrome. Am J Speech Lang Pathol. 2002; 11(3):285–94.
44 John A, Sell D, Sweeney T, Harding-Bell A, Williams A. The cleft audit protocol for speech-augmented: A validated and reliable measure for auditing cleft speech. Cleft Palate Craniofac J. 2006 May;43(3):272–88.
45 Lee A, Whitehill TL, Ciocca V. Effect of listener training on perceptual judgement of hypernasality. Clin Linguist Phon. 2009 May;23(5):319–34.
46 Chapman KL, Baylis A, Trost-Cardamone J, Cordero KN, Dixon A, Dobbelsteyn C, et al. The americleft speech project: A training and reliability study. Cleft Palate Craniofac J. 2016 Jan;53(1):93–108.
47 Dattilo KL. The effects of articulation errors on perceived nasality in speakers with repaired cleft lip and/or palate [Master's thesis]. Ioway city: The University of Iowa; 2016.
48 Barsties B, De Bodt M. Assessment of voice quality: current state-of-the-art. Auris Nasus Larynx. 2015 Jun;42(3):183–8.
49 Arciuli J, Simpson BS, Vogel AP, Ballard KJ. Acoustic changes in the production of lexical stress during Lombard speech. Lang Speech. 2014 Jun;57(Pt 2):149–62.
50 Cagliari LC. Elementos de fonética do português brasileiro. São Paulo: Paulistana; 2009.