Research Article

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Interlocutor accommodation of gradually altered nasal signal levels in a model speaker

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Abstract: Background: Phonetic accommodation is observed when interacting speakers gradually converge (or diverge) on phonetic features over the course of a conversation. The present experiment investigated whether gradual changes in the nasal signal levels of a pre-recorded model speaker would lead to accommodation in the nasalance scores of the interlocutor in a speech-shadowing experiment. Methods: Twenty female speakers in two groups repeated sentences after a pre-recorded model speaker whose nasal signal level was gradually increased or decreased over the course of the experiment. Outcome measures were the mean nasalance scores at the initial baseline, maximum nasal signal level, minimum nasal signal level and final baseline conditions. The order of presentation of the maximum and minimum nasal signal levels was varied between the two groups. Results: The results showed a significant effect of condition in $F(3) = 2.86$, $p = 0.045$. Both groups of participants demonstrated lower nasalance scores in response to increased nasal signal levels in the model (phonetic divergence). The group that was first presented with the maximum nasal signal levels demonstrated lower nasalance scores for the minimum nasal signal level condition (phonetic convergence). Conclusion: Speakers showed a consistent divergent reaction to a more nasal-sounding model speaker, but their response to a less nasal-sounding model may depend on the order of presentation of the manipulations. More research is needed to investigate the effects of increased versus decreased nasality in the speech of an interlocutor.

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1 Background

The Communication Accommodation Theory (Giles 1973; Giles and Ogay 2007; Giles et al. 1991; Shepard et al. 2001) states that interlocutors in a conversation will often subconsciously converge in their speech patterns to facilitate the interaction. Conversely, they may also diverge to delineate their respective dominance or social prestige (Bilous and Krauss 1988; Bourhis and Giles 1977; Gregory and Webster 1996; Gregory et al. 1997; Labov 1974). The phenomenon of communication accommodation is also known under the names “coordination” (Clark 1996) or “alignment” (Pickering and Garrod 2004). Communication accommodation may involve linguistic aspects such as syntax and lexical choices (Labov 1974). Phonetically, researchers have identified convergence in features of speech production such as perceived accentedness, spectral covariation, and voice amplitude (e.g., Giles 1973; Gregory 1990; Natale 1975). Social and regional dialects can be particularly susceptible to acoustic-phonetic variability in conversation situations (Eckert 1989; Eckert and McConnell-Ginet 1992; Edwards 1985; Labov 1993; Trudgill 1983). If there are differences between talker dialects, speakers tend to converge more with models with dialects similar to their own (Kim et al. 2011). However, increased convergence can also occur when the speaker has a positive bias towards the interlocutor’s dialect (Babel (2010). Attentional effects, task difficulty and task setting may also influence the accommodation response (Belin et al. 2013; Pardo 2013; Pardo et al. 2010; Walker et al. 2018). However, convergence can sometimes even be observed when speakers have been instructed not to converge (Lewandowski 2012), underlining that there may also be an automatic subconscious component to the process (Cappella and Planalp 1981).

Much of the research on communication accommodation has been carried out with interacting speakers in reasonably naturalistic conversation situations. However, speakers even demonstrate phonetic convergence when they simply shadow a model speaker (i.e., repeat words or sentences after a model (Chen et al. 2016; Dias and Rosenblum 2016; Pardo et al. 2013, 2017; Walker and Campbell-Kibler 2015).

Sometimes, participants’ speech production may be influenced by unusual phonetic features. While Babel (2012) found that speakers converged more with model speakers with attractive voices (which was expected), she also described increased convergence with gender-atypical voices. The author interpreted this finding as an effect of novelty. Borrie and Liss (2014) investigated the effect of exposure to dysarthric speech on the speech of normal speakers. They found

phonetic convergence effects for speech rate and pitch variation. Speech accommodation can be a complex process, and it can sometimes be difficult to decide which specific phonetic features cause a research participant to accommodate. For experimental purposes, it would be useful if specific phonetic features could be dialed in and out at will so that their specific contribution to the overall effect on the research participants' speech could be better understood.

In speech compensation research, the methodological approach of gradually dialing different phonetic features in and out for research participants is well established. It has long been known from speech perturbation studies that auditory feedback of research subjects' own speech can influence their speech production. For example, when subjects hear themselves over headphones and their feedback volume is incrementally turned up or down, they tend to respond by lowering or increasing their speaking volume, respectively (Bauer et al. 2006; Lane and Tranel 1971; Siegel and Pick 1974). When a speaker hears him- or herself with an electronically altered pitch, this also tends to result in a compensatory adjustment in the opposite direction (Elman 1981; Larson et al. 2000; Niziolek and Guenther 2013). Similar effects have been shown for vowel formants (Houde and Jordan 1998; Purcell and Munhall 2006), and, more recently, for oral-nasal balance (de Boer and Bressmann 2017; Santoni et al. 2020). The compensation reaction is automatic, even when speakers are instructed not to compensate for the altered auditory feedback (Munhall et al. 2009).

In communication accommodation research, the phonetic convergence or divergence is elicited by pairing the research participant with an interlocutor or asking him or her to shadow a model speaker. In speech perturbation research, the compensation reaction is usually elicited with auditory feedback that is gradually changed after an initial set of baseline productions. Blending the approaches from these two lines of research offers a perspective for a new methodological approach for speech accommodation research: Gradual manipulation of specific aspects of the model's speech may allow researchers to investigate their effects with greater accuracy. This new approach might prove especially useful for speech accommodation research related to speakers with atypical productions. In order to test this new research paradigm, the current study focused on the regulation of oral-nasal balance when participants were confronted with a model speaker with gradually more or less nasal sounding speech.

An acoustic method for quantifying the amount of nasality in speech is the nasalance score. This score is based on separate sound pressure level measurements from the nose and mouth in connected speech. Nasalance is expressed as a percentage score that is calculated as the proportion of the nasal to the nasal plus oral sound pressure levels, multiplied by 100 (Fletcher 1976). Higher nasalance scores correspond to an increase and lower nasalance scores correspond to a decrease in perceived nasality.

Anatomically, the degree of nasalization of speech sounds, i.e., the oral-nasal balance, is determined by the opening and closing of the velopharyngeal sphincter (Kummer 2008). However, speakers have little conscious proprioception of the position and movement of their velopharyngeal structures (Hixon Weismer and Hoit 2008). De Boer and Bressmann (2017) demonstrated the importance of auditory feedback in the regulation of oral-nasal balance. The participants wore a headset with a metal separator plate that separated the oral and nasal sound signals. An audio mixer was used to change the signal level of the nasal signal level in the participants' headphones. As they continuously repeated a sentence, the participants' nasal signal level auditory feedback was gradually ramped up from baseline to the maximum, then returned to baseline, ramped down to the minimum, and returned to a final baseline. In a second group, the order of the maximum and minimum conditions was reversed. In both groups, speakers had significantly lower nasalance scores when they heard themselves over headphones with increased nasal signal level auditory feedback. Interestingly, the compensatory response to decreased nasal signal level auditory feedback was less pronounced. De Boer et al. (2019) replicated these findings in speakers of Brazilian Portuguese. Santoni et al. (2020) found similar results using a singing task. Srinivas and Bressmann (2019) found that the compensation was not affected by knowledge of the task, i.e., participants even compensated when instructed not to. While de Boer and Bressmann (2017) did not find that the order of the maximum and minimum nasal signal level feedback conditions had an effect on the results, Santoni et al. (2020) and Srinivas and Bressmann (2019) found that participants showed a following reaction (had lower nasalance scores) in response to decreased nasal signal levels when they were exposed to the maximum before the minimum nasal signal level auditory feedback condition.

The present study investigated the effect of a model speaker with gradually more or less nasal sounding speech on participants' nasalance scores. The research was carried out in two parts. In the first part of the study, the research findings of de Boer and Bressmann (2017), which had been based on a single stimulus sentence, were replicated with different sentences containing words with a mix of oral and nasal sounds. Speech perturbation research studies have tended to use simple syllables or short words (Houde and Jordan 1998; Larson et al. 2000; Purcell and Munhall 2006). De Boer and Bressmann (2017) employed the sentence "My hamper was damp, so the towels are smelly" as the stimulus material, and Santoni et al. (2020) used a short song with lyrics based on the same sentence. However, speech shadowing tasks usually employ different and phonetically varied speech stimuli. This results in lower phonetic predictability for the participant. Manker (2019) argued that stimulus items with lower predictability require speakers to direct more attention to the task, which was shown to result in

more pronounced phonetic accommodation. Therefore, the findings of de Boer and Bressmann (2017) were replicated using a set of phonetically varied sentences. After it had been demonstrated that the varied sentences could be used to elicit a compensation effect, they were used in the subsequent speech accommodation study. Separate research hypotheses were investigated in the two parts of the research study. The research hypothesis for the first experiment was as follows:

H1: The results from de Boer and Bressmann (2017) could be replicated using altered nasal signal level auditory feedback in a compensation experiment, but with different phonetically varied sentences.

For the second experiment, the following two hypotheses were formulated:

H2: Extending the methods from de Boer and Bressmann's (2017) speech compensation research to a phonetic accommodation experiment, speakers were expected to diverge from a model speaker with gradually increasing nasal signal levels to a degree that would be statistically significant.

H3: Extending the methods from de Boer and Bressmann's (2017) speech compensation research to a phonetic accommodation experiment and based on the results from Santoni et al. (2020) and Srinivas and Bressmann (2019), speakers were expected to show statistically significant phonetic convergence to a model speaker with gradually decreasing nasal signal levels.

2 Materials and methods

2.1 Participants

All research procedures were approved by the Office of Research Ethics at the University of Toronto. Two groups of 20 females were recruited. The 20 participants in the first experiment had a mean age of 22.95 years (SD 1.75; range 22–24 years), and the 20 participants for the second experiment had a mean age of 23.15 years (SD 1.5; range 21–28 years). All participants were students, and they were recruited on the campus of the University of Toronto. They spoke English with the accent common to Southern Ontario and had normal hearing, as per their self-report. Participants were told that the study was investigating the stability of speech production over time. They were not given information about the nature of the experiment until the debriefing afterwards.

2.2 Stimuli

The speech stimuli used were 10 phonetically varied sentences, containing words with nasal sounds, extracted from the Bamford-Kowal-Bench (BKB) Sentence Lists 1–8 (Bench et al. 1979). From these lists, the 10 sentences with the highest number of nasal sounds per sentence were chosen by the first author. The selected sentences had 6.2 syllables on average (SD 1.03) and were between 4 and 7 syllables long. Each of the BKB sentences contained 3–4 nasal sounds. It was important to use sentences with many nasal sounds so that the experimental increases or decreases in nasal signal level would lead to an appreciable change in the acoustic signal. A randomization procedure was used to order the BKB sentences for the different parts of the experiments. In addition, the 11-syllable sentence “My hamper was damp, so the towels are smelly” (hamper sentence; de Boer and Bressmann 2017) was used to make nasalance measurements during the baseline and maximum and minimum nasal signal level feedback conditions. Nasalance scores can be influenced by phonetic content, so it was important that the same stimulus sentence was used for all measurements.

2.3 Procedures for the speech compensation experiment

In the speech compensation experiment, the participants were seated in a sound booth and wore a Nasometer 6450 headset, which has separate oral and nasal microphones mounted on a baffle plate (Kay Pentax, Montvale, NJ; see Figure 1). The sound recordings from the Nasometer were measured and saved on an ASUS X53U laptop computer (ASUS Computer International Canada, Markham, ON). To obtain the nasalance measurements, the Nasometer’s oral and nasal microphone signals are bandpass-filtered with a 350–650 Hz window, so that the nasalance score is primarily based on the acoustic energy from voiced speech sounds such as vowels and nasal consonants. While the signal can be recorded and played back, no real-time auditory feedback can be obtained from the Nasometer. Therefore, two additional tie-clip microphones (ECM-CS3; Sony Canada, Toronto, ON) were attached to the oral and nasal sides of the baffle plate of the Nasometer headset, capturing oral and nasal sound separately. The signals from these additional microphones were boosted by a NasalView model T-02 stereo preamplifier (Tiger DRS, Seattle, WA). The preamplified signals were fed into a digital multi-track recorder (Tascam DP-008, TEAC America, Montebello, CA). The channels for the oral and nasal sound signals were set to the centre of the stereo panorama so that the participant perceived a single mono signal in a pair of Philips SHL3000RD headphones (Philips Canada, Mississauga, ON). The recording gain settings, the oral

Figure 1: Frontal and side view of the Nasometer headset. The positions of the additional microphones are indicated with white arrows.

channel level and the master output settings were held at constant settings. Only the nasal channel potentiometer was used to increase or decrease the nasal signal level in the mix. When the multi-track recorder was assessed in detail in a previous study (de Boer and Bressmann 2017), it was found that the maximum signal level was reached when the channel potentiometer was turned to 85%, and that the minimum was reached at 15%. Figure 2 illustrates the experimental setup.

Participants were divided into two groups, namely a high-to-low group (HL) of 10 participants and a low-to-high group (LH) of another 10 participants. The speech

Figure 2: Recording setups for the speech compensation experiment (indicated as Experiment 1 in the diagram) and the speech accommodation experiment (indicated as Experiment 2 in the diagram).

compensation experiment began with a first baseline recording with the nasal signal level at the 50% setting. In this first baseline recording, participants read seven BKB sentences, interspersed with three repetitions of the hamper sentence. This first baseline was followed by a first ramp phase with 16 BKB sentences. In the HL group, the nasal signal level in the participants' auditory feedback gradually increased in 5% increments every two sentences until the maximum of 100% nasal signal level was reached (with a potentiometer position of 90%). The nasal signal level adjustments were made manually by the experimenter. When the participants had reached the maximum, three repetitions of the hamper sentence were recorded. The participants' auditory feedback was then returned to the 50% nasal signal level setting, and they produced three additional hamper sentences for a second baseline recording. The participants in the HL group then took a short break from reading and were offered a drink of water. Then, the second round of recordings started. The third baseline recording was identical to the first baseline. The participants in the HL group were then gradually ramped down in 5% decrements to the minimum 0% nasal signal level setting (with a potentiometer position of 10%). When the minimum was reached, another three repetitions of the hamper sentence were recorded. The participants' auditory feedback was then returned to the 50% nasal signal level setting, and they produced three additional hamper sentences for the fourth and final baseline recording. The procedures for the LH group were identical, only the order of the auditory feedback manipulations was reversed, so this group was first ramped down to minimum nasal signal level feedback and then ramped up to maximum nasal signal level feedback. Figure 3 illustrates the experimental procedures.

Figure 3: Schematic overview of the speech compensation experiment.

2.4 Procedures for the speech accommodation experiment

The model recordings for the speech shadowing task were made by one female speaker with a typical Southern Ontario English accent. The Nasometer 6450 headset was used to record the oral and nasal speech signal to separate audio tracks on the Tascam DP-008 multi-track recorder. The model speaker recorded the 10 BKB sentences and the hamper sentence. The recordings were exported as .wav files with a sampling rate of 44.1 kHz and a signal resolution of 16 bit. Using the GoldWave 6.3 audio editing software (GoldWave Inc., St. John's, NL), the model speaker's recordings were arranged in the same order as in the speech compensation experiment. For the ramp phases, the nasal signal levels of the model speaker's speech were gradually changed in 5% increments or decrements every two sentences. For the maximum phase, the nasal signal level was increased to 100%, and for the minimum phase, the nasal signal level was reduced to 0%. The resulting sound recordings were saved as mono audio files.

As in the previous speech compensation experiment, the participants in the speech accommodation experiment were seated in a sound booth and wore a Nasometer headset connected to a laptop with the Nasometer measurement software. Additional tie clip microphones were attached to the Nasometer. The signals from these microphones were pre-amplified and connected to a digital multi-track recorder. The oral and nasal channels were both set to 50% signal volume and centered in the stereo panorama. This signal was then fed into an audio mixer (Xenyx 8, Behringer USA, Bothell, WA). The audio files with the model speaker were played back from a Hewlett-Packard 8470P Elite Book laptop computer (Hewlett-Packard Canada, Mississauga, ON), and the audio signal was fed into the audio mixer. The participants' headphones were connected to the audio mixer so that they could hear the model speaker and their own speech. The input and channel gain as well as the master output levels on the multi-track recorder and the mixer were held at constant settings. Figure 2 illustrates the experimental setup.

Participants were divided into two groups, namely a high-to-low group (HL) of 10 participants and a low-to-high group (LH) of another 10 participants. In the speech accommodation experiment, participants first listened to, and then repeated (shadowed), the sentences spoken by the model speaker. The stimulus presentation from the laptop was controlled by the first author. The speech accommodation experiment began with a first baseline recording with the model speaker's nasal signal level at the 50% setting. In this first baseline recording, participants read seven BKB sentences, interspersed with three repetitions of the hamper sentence. This first baseline was followed by a first ramp phase with 16 BKB sentences. In the HL group, the nasal signal level of the model speaker gradually

increased in 5% increments every two sentences until the maximum of 100% nasal signal level was reached. When the model speaker had reached the maximum, three repetitions of the hamper sentence were recorded. The model speaker's nasal signal levels were then returned to the 50% baseline setting, and the participants shadowed three additional hamper sentences for a second baseline recording. The participants in the HL group then took a short break and were offered a drink of water. Then, the second round of recordings started. The third baseline recording was identical to the first baseline. The participants in the HL group then shadowed the model speaker as she was gradually ramped down in 5% decrements to the minimum 0% nasal signal level setting. When the model speaker had reached the minimum, three repetitions of the hamper sentence were recorded. The model speaker's nasal signal levels were then returned to the 50% baseline setting, and the participants shadowed three additional hamper sentences for a fourth and final baseline recording. The procedures for the LH group were identical, only the order of the auditory feedback manipulations was reversed, so this group first shadowed the model speaker as she was ramped down to minimum nasal signal level feedback and then ramped up to maximum nasal signal level feedback.

2.5 Statistical analysis

The nasalance scores for each repetition of the hamper sentence were obtained using the Nasometer 6450 software. There were two experimental groups in this study, so half of the participants heard the increase in nasal signal level first while the others heard the decrease in nasal signal level first. For analysis purposes, measurements at the baselines 2 and 3 were removed because they followed and preceded different auditory manipulations.

The Number Cruncher Statistical Software 8 (NCSS, UT) was used to run one repeated-measures analysis of variance (ANOVA) per experiment. The between-subject variable was the group (high-low vs low-high). The within-subject variable was the condition (baseline 1, maximum nasal signal level, minimum nasal signal level, baseline 4). Greenhouse-Geisser adjustments were used to correct for sphericity violations in the within-subject repeated factor, as necessary. Fisher's Least Significant Difference (LSD) tests were used as the post-hoc statistic.

3 Results

The mean nasalance scores for the different speaking conditions in both experiments are shown in Table 1. The results for the speech compensation and accommodation experiments are shown in Figures 4 and 5, respectively.

Table 1: Mean nasalance scores from the two experiments, separated into high-to-low and low-to-high groups.

Compensation Experiment				Accommodation Experiment			
High-to-low group (HL; N = 10)	Nasalance Score			High-to-low group (HL; N = 10)	Nasalance Score		
	Mean	SD	SE		Mean	SD	SE
Baseline 1	32.83	9.48	1.73	Baseline 1	29.87	6.76	1.23
Maximum	30.03	9.41	1.72	Maximum	28.40	5.02	0.92
Baseline 2	31.63	9.77	1.78	Baseline 2	29.07	5.02	0.92
Baseline 3	32.33	10.38	1.90	Baseline 3	29.40	5.39	0.98
Minimum	33.37	9.71	1.77	Minimum	27.90	5.09	0.93
Baseline 4	32.97	9.38	1.71	Baseline 4	28.93	5.88	1.07

Low-to-high group (LH; N = 10)				Low-to-high group (LH; N = 10)			
Baseline 1	34.03	6.80	1.24	Baseline 1	29.53	3.46	0.63
Minimum	34.60	6.34	1.16	Minimum	28.57	3.43	0.63
Baseline 2	34.20	5.83	1.06	Baseline 2	29.50	4.02	0.73
Baseline 3	34.23	5.04	0.92	Baseline 3	28.90	4.20	0.77
Maximum	31.70	4.36	0.80	Maximum	30.10	4.02	0.73
Baseline 4	32.53	5.62	1.03	Baseline 4	30.93	2.82	0.51

Figure 4: Error-bar chart of the average nasalance scores and standard deviations in the different nasal signal level feedback conditions in the speech compensation experiment.

Figure 5: Error-bar chart of the average nasalance scores and standard deviations in the different nasal signal level feedback conditions in the speech accommodation experiment.

The repeated-measures ANOVA for the speech compensation experiment showed no effect for the HL vs. the LH group $F(1, 18) = 0.16, p = 0.069$. There was a significant Greenhouse–Geisser adjusted effect of condition $F(3, 54) = 11.84, p < 0.0001$, but no Greenhouse–Geisser adjusted group by condition interaction effect $F(3, 54) = 0.06, p = 0.092$. Post hoc analyses of the condition effect with Fisher’s LSD Multiple-Comparison Tests showed that the nasalance scores at maximum nasal signal level feedback were significantly lower (30.86, SD 7.72) than baseline 1 (33.53, SD 7.85), baseline 4 (33.58, SD 7.70) and minimum nasal signal level feedback (33.98, SD 8.08; all differences $p < 0.05$).

The repeated-measures ANOVA for the speech accommodation experiment showed no significance for group $F(1,18) = 0.28, p = 0.061$. There was a significant effect of condition $F(3,54) = 2.86, p = 0.045$, as well as trend towards a group by condition interaction $F(3, 54) = 2.67, p = 0.057$. Post hoc analyses of the condition effect with Fisher’s LSD Multiple Comparison Tests showed that the nasalance scores at the model’s maximum nasal signal levels were significantly lower (28.48, SD 5.02) than baseline 1 (29.7, SD 6.76) and baseline 4 (29.93, SD 5.88) (all differences $p < 0.05$). Visual inspection of the experiment data in Figure 5 and Table 1 shows that the trend towards the interaction effect was likely explained by the differences in the participants’ responses to the model’s minimum nasal signal levels. Compared to the baselines, speakers in the HL group had on average numerically lower nasalance scores, and speakers in the LH group had on average numerically higher nasalance scores in the minimum nasal signal level condition.

4 Discussion

The present study comprised two separate experiments with typical speakers. In the first speech compensation experiment, it was investigated whether a speech compensation effect for altered nasal signal level auditory feedback could be demonstrated using phonetically varied speech stimuli. The significant condition effect supported the first hypothesis and largely replicated the results of de Boer and Bressmann (2017). It was found that participants compensated for the maximum nasal signal level feedback with a significantly lower nasalance score. The compensation for the minimum nasal signal level feedback was less pronounced, which is in line with previous findings (de Boer and Bressmann 2017; de Boer et al. 2019; Santoni et al. 2020). Overall, this study corroborated the use of phonetically varied stimuli sentences and paved the way for the second speech accommodation study.

The second speech accommodation study investigated whether speakers would show phonetic divergence while shadowing a model speaker with gradually increasing nasal signal levels. The results showed that speakers, in both groups (HL and LH) demonstrated lower nasalance scores in response to increased nasal signal levels in the model speaker, supporting the second hypothesis. Post hoc tests of condition showed that the nasalance scores at the model's maximum nasal signal levels were significantly lower than at the baselines 1 and 4, indicating phonetic divergence from the model.

The third hypothesis was that the speakers would show statistically significant convergence with a model speaker with gradually decreasing nasal signal levels. This was not supported by results at the group level. However, there was a trend towards a group by condition interaction. While this interaction missed significance, Figure 5 indicates that the participants in the HL group showed a converging reaction with the lowered nasal signal levels in the model speaker. In two recent studies (Santoni et al. 2020; Srinivas and Bressmann 2019), following reactions were found when nasal signal levels were reduced. As in the present study, these following reactions appeared to occur when the participants were first exposed to increased and then to decreased nasal signal level feedback. In the HL group, 63.33% (19 out of 30) of the productions in the minimum nasal signal level condition were numerically lower than at the baseline, i.e., demonstrated convergence. In contrast, the participants in the LH group appeared to show a small divergent response, similar to the compensatory reaction found by de Boer and Bressmann (2017) and de Boer et al. (2019). In this group, only 30% (9 out of 30) productions were lower than the baseline in the minimum nasal signal level condition.

As found in previous speech compensation research (de Boer and Bressmann, 2017; de Boer et al. 2019; Santoni et al. 2020), there was a more consistent and statistically significant divergent reaction to increased nasal signal levels in the model speaker. Similar asymmetry in the convergence reaction was previously described by Nielsen (2011) who found convergence with increasing but not with decreasing voice onset times. Clinically, listeners appear to tolerate hyponasality better than hypernasality (Sphrintzen et al. 1979), and the findings of the present study indicate that this difference in perceptual tolerance may also apply to increased and decreased nasal signal levels. Hypernasality also affects listeners' impressions of speech intelligibility and acceptability (Blood and Hyman 1977; Lallh and Rochet 2000; Watterson et al. 2013). However, it should be noted that Zellou et al. (2016) demonstrated phonetic convergence to increased coarticulatory vowel nasality, which contrasts with the findings of the present study. The manipulation by Zellou et al. (2016) was specific and segmental while the manipulation in the present study was applied in a generalized fashion. More research will be needed to understand speakers' reaction to increased or decreased levels of nasality in speech.

In the present study, as in previous experiments (de Boer and Bressmann 2017; Srinivas and Bressmann 2019), only female speakers were recruited. The reasons for this were practical because female speakers were easier to access where the study was conducted (graduate school for rehabilitation sciences). While this was a limitation of the study, previous related research has not demonstrated differences between the sexes (Heller Murray et al. 2016; Santoni et al. 2020; Srinivas and Bressmann 2019). Speakers were required to speak English with the accent typical for Southern Ontario but it was not part of the study protocol to document whether they were proficient in other languages with different patterns of nasalization. However, de Boer et al. (2019) found that speakers of Brazilian Portuguese, which has different rules for nasalization than English, did not react differently to altered nasal signal level auditory feedback than English speakers in a previous study (de Boer and Bressmann 2017).

The present study is a first application of a new speech shadowing task that could be used for speech accommodation research. This approach should be replicated and corroborated by further research. While the present study only reported group effects to demonstrate that there may be value in this new approach, future research should also investigate the response patterns of individual speakers in detail.

5 Conclusion

The study presents results from the first application of a new shadowing task for speech accommodation research, characterized by gradually increasing or

decreasing a specific phonetic quality in a model speaker, such as increased or decreased nasal signal levels. Speakers showed a consistent divergent reaction to a more nasal-sounding model speaker but their response to a less nasal-sounding model depended on the order of the presentation of the manipulations. More research is needed to investigate interlocutor effects of increased versus decreased nasal signal levels in speech.

Author contributions: Telma Santos conducted the experiments and analyzed the results with the help of Jennifer Pardo and Tim Bressmann. Telma Santos and Tim Bressmann developed the first draft of the text, and all three authors contributed to the writing of the final manuscript and the revisions.

Statement of ethics: All research procedures were approved by the Office of Research Ethics at the University of Toronto (protocol number 00036807). Research participants gave their consent in writing and received a small remuneration for their time.

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