Nasal coarticulation in Lombard speech: An articulatory and acoustic study

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Keywords: Coarticulation; Nasality; Lombard speech; Vocal effort

Introduction

Coarticulatory phenomena have long been seen as potentially useful parameters for speaker discrimination. Nasal coarticulation, in particular, has shown promises of speaker idiosyncrasy (Amino & Osanai, 2012; Su et al., 1974). Yet, the production of coarticulation in forensically relevant conditions remains not well understood. While communicative scenarios demanding enhanced clarity and intelligibility typically lead to less coarticulation (e.g., Guo & Smiljanic, 2023), the evidence for nasal coarticulation across a range of contexts involving real and imagined interlocutors has been conflicting (Cohn & Zellou, 2023; Scarborough & Zellou, 2013). Here we investigate how changes in vocal effort in Lombard speech impact nasal coarticulation. Given well-known issues associated with acoustic correlates of nasality (Carignan 2021), we address our aims primarily through the technique of nasometry and secondarily explore how well any variation is reflected in A1-P0, an acoustic correlate widely used and considered robust (Chen 1997; Styler 2017a).

Methods

11 male speakers of Southern British English completed a communicative task, with 176 target words embedded in CVC, CVN, NVC and NVN contexts. In each of two sessions, they completed the task in a *quiet* environment and two noisy conditions: *Lombard*, where they were played white noise at 70 dB SPL through headphones; and simulated *phone* conversation, with 300-3400 Hz bandpass filtered noise played and the experimenter out of view. A handheld nasometer was used to record their nasal and oral output on separate channels, from which we extracted amplitudes at 9 equidistant points across each target vowel to calculate trajectories of proportional nasal amplitude (nasalance). We derived the magnitude of anticipatory/carryover coarticulation by normalising each CVN/NVC trajectory with respect to the corresponding mean CVC and NVN trajectories from the same speaker, vowel and condition. A1-P0 measurements were extracted (Styler 2017b) at corresponding timepoints and treated in an analogous manner. We then fitted separate linear mixed effects models to the magnitudes of coarticulation in anticipatory and carryover directions, with the fixed effects of condition, vowel category and session, by-speaker random intercepts and condition-by-speaker random slopes.

Results & Discussion

Overall, nasalance trajectories were highest in the quiet condition, with a slightly stronger downward shift in the phone condition than in the Lombard condition (Fig. 1). A1-P0 trajectories displayed broadly similar trends. However, acoustic nasality increased towards target vowel offset regardless of following context and displayed comparatively greater fluctuations within individual speakers. There was also variation between speakers in the degree to which A1-P0 mirrored nasalance. Interestingly, while the results here echo previous findings of lowered vowel nasality in hyperarticulated styles, we found little to no effect of condition on either nasalance-based or acoustic magnitude of coarticulation, suggesting that speakers generally did not vary their use of coarticulation across levels of vocal effort. In addition to the effects of condition, we further examine within-speaker variability of nasal coarticulation due to session and vowel category. By comparing the findings from A1-P0 with those from nasalance, we discuss the implications for the use of acoustic correlates of vowel nasality in forensic voice comparison.

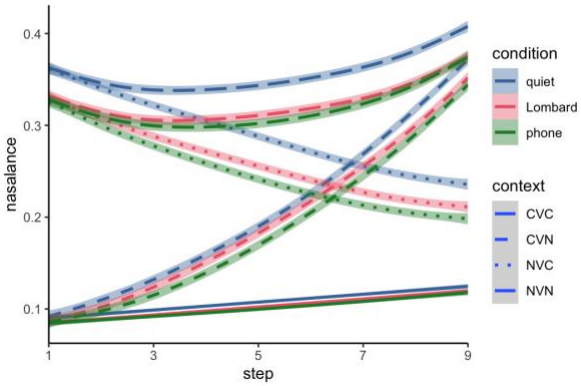

Figure 1. Overall nasalance trajectories by phonological context and experimental condition.

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