Processing Nasality: Lexical Access or Phonological Inference

Yongqing Ye[1] and Karthik Durvasula[2]

[1,2]Michigan State University
[1]*yeyongqi@msu.edu* [2]*durvasul@msu.edu*

Introduction: The ongoing debate on lexical effects in perception centers around the question of how lexical information is used during perception. Theories with an interactivist view argue for a top-down effect of lexical knowledge on earlier stages of processing (Cutler and Norris 1979; Elman and McClelland 1988; McClelland and Elman 1986; McClelland et al. 2006), whereas theories that oppose an interactive effect claim that lexical information is not necessary in prelexical processes involving acoustic signals and phoneme identification (Norris 1994; Norris and McQueen 2008; Norris et al. 2000). This research sets out to answer this question with two perceptual experiments. Specifically, it focuses on the perception of anticipatory nasalization, which has been argued to be dependent on the listener's knowledge of nasalization in the corresponding languages (Beddor and Krakow 1999; Lahiri and W. D. Marslen-Wilson 1992; Ohala and Ohala 1993; Ohala and Ohala 1991, 1992) and is sensitive to coarticulation patterns in the language (Fowler and Brown 2000; Krakow et al. 1988; Zellou 2017). The study provides cross-linguistic evidence that listeners rely on phonological inference in processing vowel nasalization in perception. Previous work on the perception of gradient phonetic information related to nasalisation either tacitly assumed without evidence that lexical representations are the source of the perception, or cannot address this question as the experiments typically involved only real words stimuli. For example, Beddor et al. (2018, 2013) used a visual eye-tracking paradigm to examine the perception of nasalization with all real word stimuli, thus introducing lexical effects into the experiment with an assumption that the perception of nasalization is mediated by lexical information. Lahiri and W. Marslen-Wilson (1991) and Lahiri and W. D. Marslen-Wilson (1992) claimed that the phonological processing of nasalization is contingent on the underspecified phonological presentation of lexical forms. Ohala and Ohala (1995) argued against such a claim by suggesting that it is not accurate to assume only underlying lexical representation plays a distinct role in speech perception, and phonetic cues in derived surface structures are sufficient in segment identification in perception. The current study intends to show that phoneme identification can be reached with phonological inference. Specifically, native listeners rely on phonological inference in processing nasality in nonce words, and lexical module is not necessary to understand the incremental perception observed in previous research.

Experimental Design: This study discusses two perceptual experiments in PsychoPy (Peirce et al. 2019) using the gating paradigm (Grosjean 1980) in Mandarin Chinese and in Mainstream American English (henceforth MAE) (Schneider et al. 2004). The first experiment was conducted with 11 native speakers of Mandarin. It included a forced choice lexical identification task with real words and a segment identification task with both real words and nonce words. The gated stimuli were constructed using a Praat script that spliced each vowel into equal parts from the onset to the offset of the vowel.n Participants were asked to choose between two options by pressing '1' and '0' on the keyboard upon hearing the gated segment. The second experiment, conducted with native speakers of MAE, consisted of two identical separate sessions (number of participants = 39 and 34 respectively) conducted roughly a week apart. The second experiment mirrored the forced choice segment identification task in the first experiment, and used gated nonce word segments in MAE as stimuli. the participants listened to gated segments consisting of nine pairs of nonce word in [əCVN] and [əCVC] sequences. They were told that they would hear a series of words and the final sounds of these words had been shortened in many cases. The objective of the participants was to guess the final sound of each nonce word and respond on the keyboard, indicating whether they heard a nasal or an oral segment with the same place of articulation,

e.g. ‘n’ v.s ‘d’. Participants responses were modeled in R using mixed-effects logistic regression models (Baayen 2012; Baayen et al. 2008).

Results: In the first experiment, participants performed equally well in nasal identification for both real and nonce words, and were able to accurately identify oral and nasal segments early in the vowel. Real word identification shares the same pattern of incremental processing in the lexical identification task (Figure 1) as that in the segment identification task (Figure 2). The trend lines in both of tasks show the split between oral and nasal identification at the point of Gate 3. Compared to real words, the split in nasal identification is earlier for nonce words, which would be surprising if lexical information aided nasal identification. The analysis of nasal identification patterns in the second experiment found that there was a significant effect of the type of segment (nasal consonant [CVN] v.s. oral consonant [CVC]) on participant’s nasal responses from the very beginning. The pattern can also be seen with a visual inspection of the trend lines in Figure 3 and 4. In other words, participants were able to correctly infer the upcoming oral and nasal consonants based on a minimal amount of acoustic cues in nonce words, which obey the phonetic, prosodic, and phonotactic rules of the language but arguably do not have lexical representations. The results in both experiments showed that native listeners relied on phonological inference in processing nasality, which supports the hypothesis that fine-grained gradient activation of phonemic segments can be achieved without feedback from the lexicon, and native listeners are not identifying phonemes based on enriched lexical representations from memory.

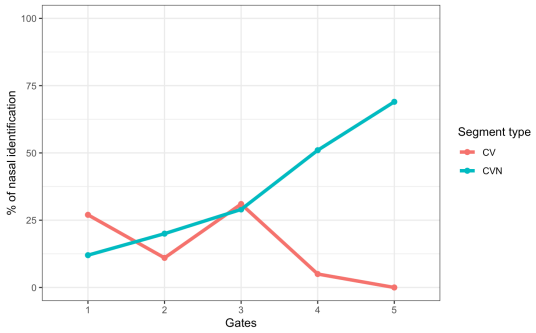

Figure 1. Exp. 1 Nasal identification rates for Mandarin real words in the lexical identification task

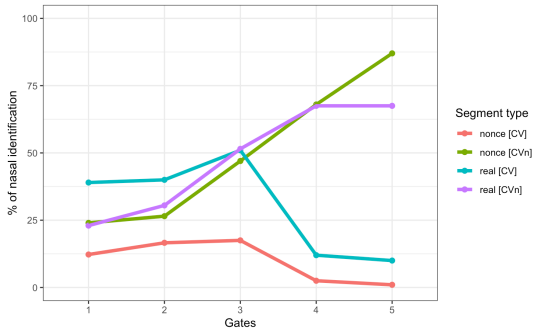

Figure 2. Exp. 1 Nasal identification rates for Mandarin real and nonce words in the segment identification task

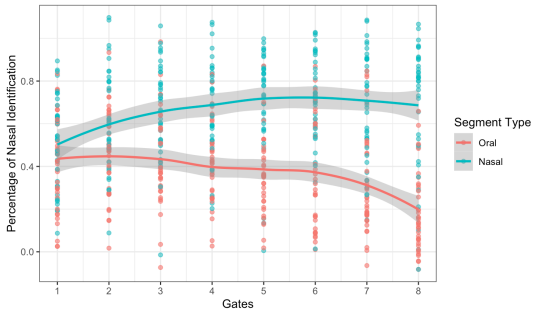

Figure 3. Exp. 2 Nasal identification rates for nasal and oral segments in MAE, Session 1

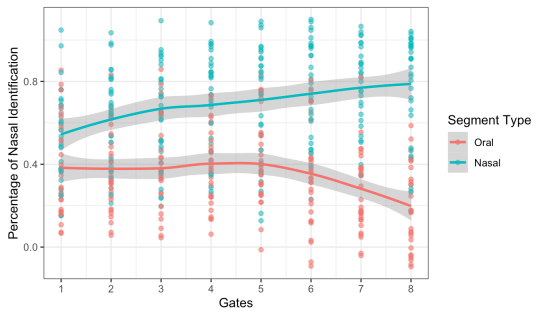

Figure 4. Exp. 2 Nasal identification rates for nasal and oral segments in MAE, Session 2

Implications: This study helps us gain a better understanding of the processing mechanism behind speech perception in general and the perception of vowel nasalization in particular. The pattern found in this research provides evidence that adds to the theoretical discussion on modularity in perception. The results imply that we can still get the same perceptual effect without having a lexical module interacting with pre-lexical perceptual representations in a feedback loop in perception. That is lexical module is not necessary to to understand the incremental perception observed in previous research. In addition, in line with recent recommendations (Mack 2019; Spruyt et al. 2004; Stemberger 1992) of the importance of replicability of phonological experiments, the results in the second experiment were directly replicated in a second session of the experiment, which thereby lends further credence to the results and the inference stemming from them.

Selected References

Beddor, P.S., Coetzee, A.W. & Styler, W. (2018). The time course of individuals' perception of coarticulatory information is linked to their production: Implications for sound change. *Language, 94*(4), 931-968.

Lahiri, A. & Marslen-Wilson, W. (1991). The mental representation of lexical forms: a phonological approach to the recognition lexicon. *Cognition 38*m, 245-294.

McClelland, J. L. and Elman, J. L. (1986). "The TRACE model of speech perception". *Cognitive psychology 18*(1), 186.

Norris, D. and McQueen, J. M. (2008). "Shortlist B: a Bayesian model of continuous speech recognition." *Psychological review 115*(2), 357.

Norris, D., McQueen, J. M., Cutler, A. (2000). Merging information in speech recognition: Feedback is never necessary. *Behavioral and Brain Sciences, 23*(3), 299-370.

Zellou, G. (2017). Individual differences in the production of nasal coarticulation and perceptual compensation. *Journal of Phonetics 61*, 1329.