Using EEG to Understand the Effects of Top-Down Processing on Speech Perception

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INTRODUCTION

Our research focused on assessing the influence of various top-down factors on the process of speech perception in the auditory modality.

Previous research has shown that we use top-down processing when perceiving language, with more recent studies verifying this idea using the event-related potential (ERP) technique (Getz & Toscano, 2019; Noe & Fischer-Baum, 2020; Sarret et al., 2020). A few of the key features of language (for example: lexical status, frequency, neighborhood density) that affect speech perception in a way that signifies top-down processing have been explored separately by many researchers over the years (Ganong, 1980; Mutter & Hashtroudi, 1987; Connine et al., 1993; Vitevitch & Luce, 1998).

To expand upon previous research, we designed a **word identification experiment** with two original facets:

1. We used **auditory** stimuli for both the primes and the target words with the intention of making our results generalizable, as engaging in verbal speech in day-to-day life is how most people experience the process of speech perception
2. We considered the variables of lexical status, frequency, neighborhood density, and context at the **same time**
    - **Lexical status**: Minimal pairs (bark/park) vs. Ganong pairs (botato/potato)
    - **Frequency**: High (pen) vs. Low (doll)
    - **Density**: High (toe) vs. Low (temple)
    - **Context**: Association (*amusement* park) vs. Neutral (*finger* park)

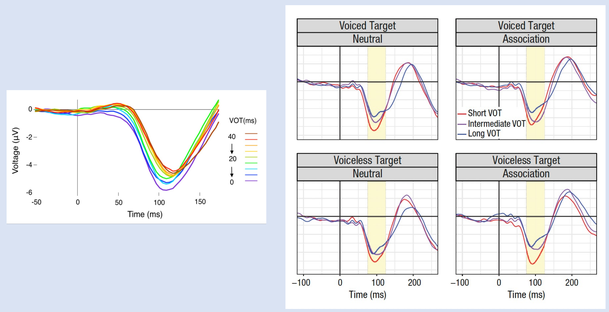
METHODOLOGY

Participants (*N* = 31 for Experiment 1; *N* = 5 for Experiment 2) responded to a **4AFC task** to decide between which phoneme they believe the target word started with.

- **Auditory Stimuli:** Word pairs (consisting of a prime and a target) were heard through headphones. The target words were manually manipulated by the researchers along a voice onset time (VOT) continuum, with the first phoneme having either a 10ms, 25ms, or 40ms VOT.
- **Design:** Participants completed 4 blocks of 168 trials
    - 28 prime-target word pairs (**14 voiced, 14 voiceless**)
    - Each word set was presented with an **Association and Neutral** prime
    - Each target word was presented at **three VOTs** (10, 25, 40)

PREDICTED RESULTS

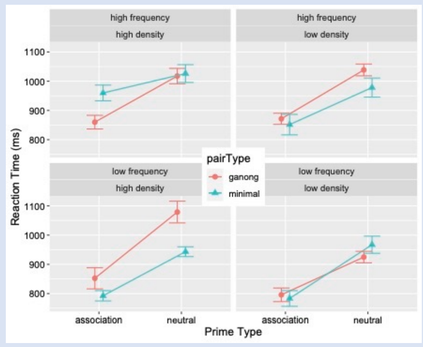
We predicted that the ERP data collected would indicate a greater negative N100 amplitude for shorter VOTs (Toscano et al., 2010).

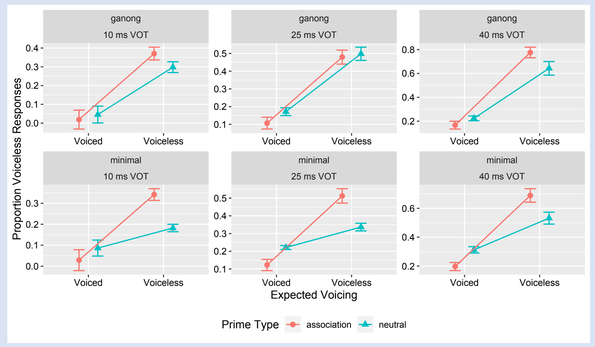


We predicted that N1 amplitude with an ambiguous VOT accompanied by an associated prime would rely more heavily on top-down processes; this is because the amplitude would differ based on expected voicing predicted by the prime (Getz & Toscano, 2019). Data will be analyzed to further investigate the interaction between prime context and frequency, density, and lexical status.

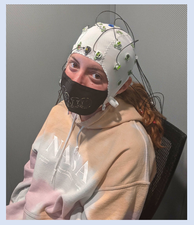
RESULTS

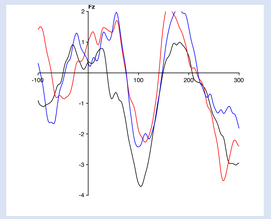
Experiment 1



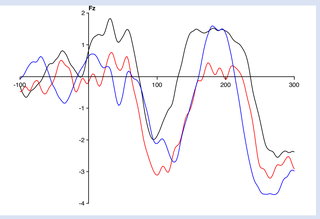


Experiment 2

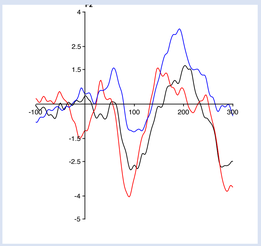




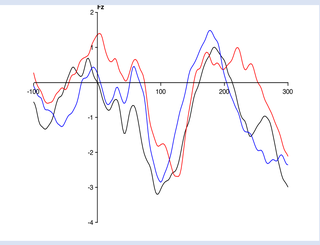
Neutral Prime / Voiced Target



Association Prime / Voiced Target



Neutral Prime / Voiceless Target



Association Prime / Voiceless Target

Key: **Black** = VOT of 10ms; Red = VOT of 25ms; Blue = VOT of 40ms

CONCLUSION

Results suggest that top-down processing does have an effect on the process of perceiving auditory stimuli, and these results support an interactive model of the process of speech perception.

References

Connine, C. M., Titone, D., & Wang, J. (1993). Auditory word recognition: Extrinsic and intrinsic effects of word frequency. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19*(1), 81–94.

Ganong, W. F. (1980). Phonetic categorization in auditory word perception. *Journal of Experimental Psychology: HumanPerception and Performance, 6*(1), 110-125.

Getz, L. M., & Toscano, J. C. (2019). Electrophysiological evidence for top-down lexical influences on early speech perception. *Psychological Science, 30*(6), 830-841.

Mutter, S. A., & Hashtroudi, S. (1987). Cognitive effort and the word frequency effect in recognition and lexical decision. *The American Journal of Psychology, 100*(1), 93–116.

Noe, C., & Fischer-Baum, S. (2020). Early lexical influences on sublexical processing in speech perception: Evidence from electrophysiology. *Cognition, 197*, 104162.

Sarrett, M. E., McMurray, B., & Kapnoula, E. C. (2020). Dynamic EEG analysis during language comprehension revealsinteractive cascades between perceptual processing and sentential expectations. *Brain and Language, 211*, 104875.

Toscano, J. C., McMurray, B., Dennhardt, J., & Luck, S. J. (2010). Continuous perception and graded categorization: electrophysiological evidence for a linear relationship between the acoustic signal and perceptual encoding of speech. *Psychological Science, 21*(10), 1532-1540.

Vitevitch, M. S., & Luce, P. A. (1998). When words compete: Levels of processing in perception of spoken words. *Psychological Science, 9*(4), 325–329.

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