Tracking lexical garden-path resolution with MEG: Phonological commitment and sensitivity to subphonemic detail are independent

Laura Gwilliams1,3, Tal Linzen1, Kyriaki Neophytou3, David Poeppel1,4 & Alec Marantz1,2,3
New York University Psychology1 and Linguistics2 Department; NYU Abu Dhabi3; Max-Planck-Institute4

Introduction

- Speech is inherently noisy and ambiguous
- Comprehension fluency is achieved by integrating top-down information with bottom-up acoustic input
- Sensitivity to phonological categories found ~100 ms after onset for unambiguous tokens, but not yet uncovered responses to ambiguous sounds
- Behavioural studies have used sensitivity to subphonemic variation to approximate the size of the integration window, with inconclusive results

How does the auditory system reflect and resolve phoneme ambiguity?

Methods

Experiment 1: Syllable Continua
- Extracted the first syllable from natural spoken words
- Eleven-step continua of syllables between two unambiguous end-points. Voice onset time (VOT): t-d, p-b, k-g; place of articulation (PoA): t-p, p-k
- 2AFC task: choice between two letters presented on-screen
- Neurophysiological responses of 24 participants measured concurrently with a 208-channel KIT-MEG system

Experiment 2: Lexical Garden Paths
- Selected 5 continua steps of spoken words, based on the psychometric functions of Experiment 1
- 65 word pairs, with identical speech stream until divergence point (also see McMurray et al., 2009)
- Match/mismatch task: written words presented 500 ms after speech offset; 22 participants' responses measured with MEG

Results: Time-locked to Syllable/Word Onset

1. Responses in left (but not right) Heschl's Gyrus are modulated by phoneme ambiguity ~50 ms after onset.
2. Sensitivity to PoA and VOT is bilateral at 100 ms. Replicated across syllable and word contexts.

Results: Time-locked to Point of Disambiguation (POD)

3. Ambiguity effect re-surfaces at POD, regardless of latency.
4. Cohort activation is weighted by subphonemic detail until the system commits to a phoneme category ~450 ms.

Conclusion

- Sensitivity to phoneme categories is apparent from ~50 ms after onset: Tracks difficulty of classification and is not driven by acoustic properties
- If disambiguation comes too late (> 450 ms after word onset), listeners preemptively commit to a phonological interpretation
- Subphonemic detail is maintained across long time-scales in Heschl's Gyrus; phonological commitment resolves earlier in superior temporal gyrus
- Acoustic-phonetic and phonological processing are independent and computed in parallel

References


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Contact: laura.gwilliams@nyu.edu