Early and asymmetric sensitivity to phonological boundaries and within-category variation across hemispheres

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Introduction

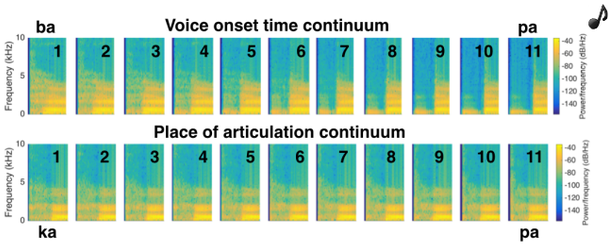
Speech processing requires mapping continuously varying acoustic signals to discrete phonological categories. Previous studies suggest that this is achieved through the identification of phonetic features and neutralisation of within-category variance by ~100ms after phoneme onset in the posterior superior temporal gyrus (pSTG: Chang et al., 2010; Mesgarani et al., 2014; Di Liberto et al., 2015).

How does the speech processing system <u>reflect</u> and <u>resolve</u> phoneme ambiguity

Methods

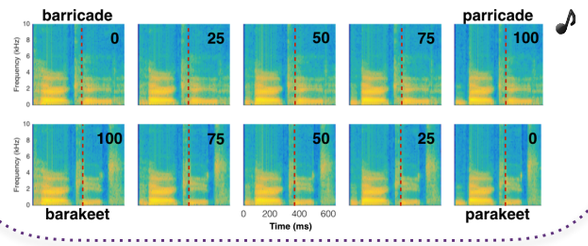
Experiment 1: Reflecting Ambiguity

- Extracted the first syllable from natural spoken words
- Eleven-step continua of syllables between two unambiguous end-points. VOT: t-d, p-b, k-g; PoA: t-p, p-k
- 2AFC task: choice between two letters presented on-screen
- Neurophysiological responses of <u>24 participants</u> measured concurrently with a 208-channel KIT-MEG system



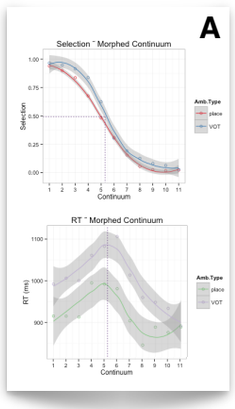
Experiment 2: Resolving Ambiguity

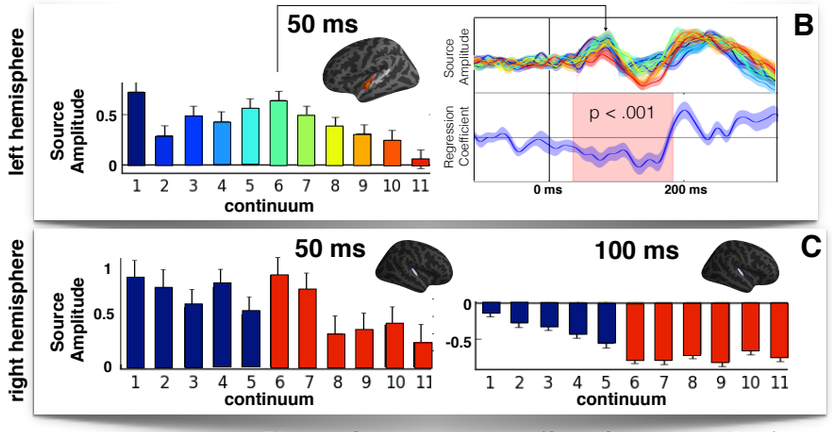
- Selected 5 continua steps of spoken words, based on the psychometric functions of experiment 1
- 65 word pairs, with identical speech stream until divergence point (also see McMurray et al., 2009)
- Match/mismatch task: written words presented 500 ms after speech offset; <u>22 participants'</u> responses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



Experiment 1: Ambiguity reflected early in left auditory cortex

- Extracted time course of activation in Heschl's gyrus and the superior temporal gyrus bilaterally
- Coded ambiguity as the distance from each subject's 50-50 selection point
- Ran spatio-temporal regression over ROIs from 0-200 ms





- Increased activity for ambiguous tokens around 50 ms after sound onset (for VOT but not PoA)
- Located in Heschl's gyrus, left lateralised
- Right hemisphere responds categorically and apparently not sensitive to within-category variation
- Sensitivity to phonological ambiguity earlier than previously considered

Discussion

- Sensitivity to phoneme categories ~50 ms after syllable onset - earlier than typically considered
- Left hemisphere is modulated by phoneme ambiguity; Right hemisphere responds categorically - this is surprising
- Ambiguity effect re-surfaces around 50 ms after a word's point of disambiguation (PoD)

References

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Di Liberto, G. M., O'Sullivan, J. A., & Lalor, E. C. (2015). Low-Frequency Cortical Entrainment to Speech Reflects Phoneme-Level Processing. Current Biology, 25(19), 2457-2465.

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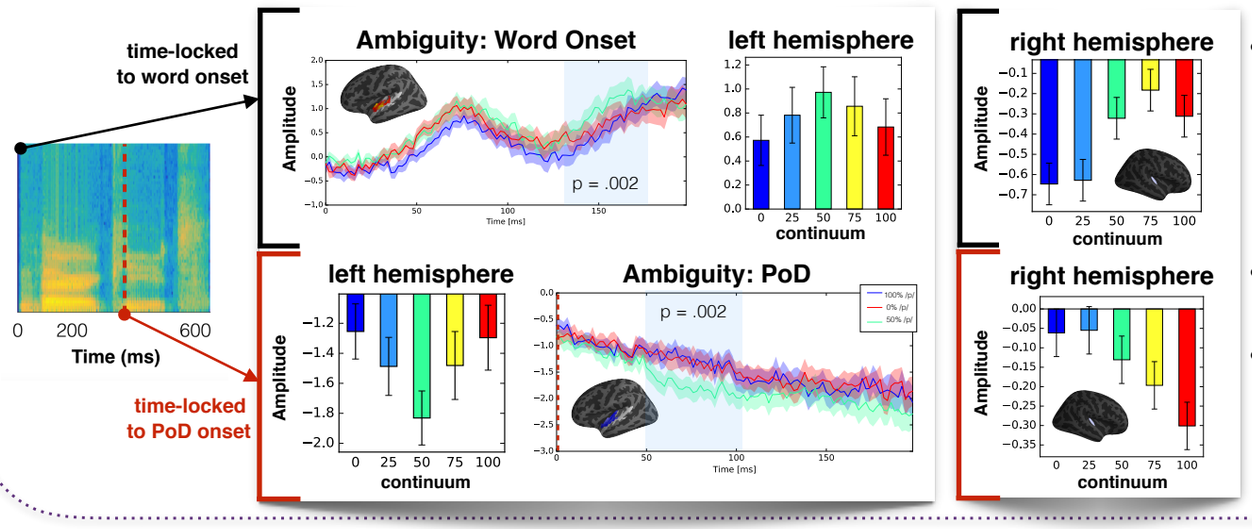
Experiment 2: Ambiguity effect re-surfaces at a word's point of disambiguation

- Presented participants with words that are consistent with a paired item until a given <u>point of disambiguation</u> (PoD)
- PoD varied between 200-700ms and 3-7 phonemes; Ambiguity was coded as above, based each item's average psychometric function from experiment 1



- Ambiguous sounds in the context of a word elicit more activity in the **left hemisphere** ~150 ms after word onset, and again ~50 ms after a word's point of disambiguation, weighted by the extent of ambiguity at onset
- This is observed along the VOT continua but not the PoA continua
- By contrast, the **right hemisphere** responds categorically, both when locked to the onset of the word and the point of disambiguation

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