The Neural Bases of Phonological Acceptability Judgements

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The Big Questions

- **What kind of processes underlie judgements about the phonological acceptability (grammaticality) of novel auditory wordforms?**
- **To what extent do judgements reflect grammatical versus non-grammatical processes?**
- **Does the lexical network influence the acceptance or rejection of novel word forms?**

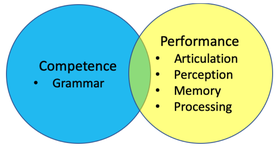
Why a theory of grammaticality judgements matters

• Cognitive theories of phenomena ranging from psychophysics to moral reasoning are built on well-articulated models of the processes and types of information that support experimental judgement (cf. [1,2]).

• Surprisingly linguistic research, which relies heavily on grammaticality or acceptability judgements, is carried out in the absence of <u>any</u> explicit processing model of these judgements.

• Linguists use these judgements to probe *domain-specific* constraints on linguistic structure (**competence**) but acknowledge that patterns of attestation and judgements are limited by *domain-general* processing (**performance**) constraints.

• **Challenge**: How can we accurately characterize competence until we understand the nature and extent of processes through which we view it?



The "Blik" Test

- Phonologists use phonological acceptability judgements (also called wordlikeness judgements or Blik testing) to characterize patterns of gradient acceptability that extend beyond attested patterns [3].

blick > bnik > bdik

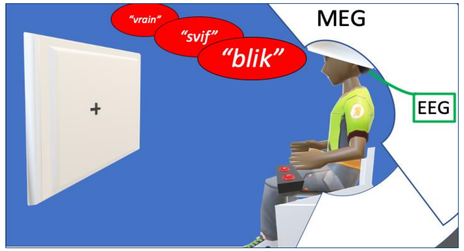
- These judgements show some variability and are sensitive to extragrammatical factors including wordlikeness [4].
- Moreover, there is strong evidence that listeners systematically misperceive (repair) phonotactically marginally unacceptable forms with feedback from the lexicon [5], making it unclear what is being judged.

Strategy

• Start with the activation of dorsal precentral gyrus activation associated with an overt behavioral response (button press), and *trace effective connectivity backwards in time* to identify the dynamics that drive that activation.

Method

Task: 2AFC Non-speeded auditory grammaticality judgment. "Could this word be an acceptable English word?"



Stimuli: 180 auditory CCVC nonsense words including 60 items consisting of only legal/attested consonant sequences (e.g. *blik* consistent with *black* and *brick*) All stimuli were normalized for duration (500 msec) and intensity using PRAAT.
Response: Left-handed button press (YES/NO)
Subjects: 14 right-handed native speakers of American English with no discernable auditory or motor deficits (6 male).

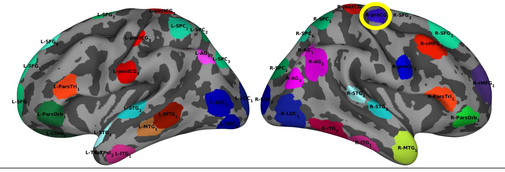
Imaging

- Simultaneous MEG (306 channel) and EEG (70 channel) were acquired during task performance.
- 3T MRI anatomical data were collected after MEG testing.
- High spatiotemporal MR constrained MNE MEG/EEG reconstructions of source space activity over all cortical surfaces [6].

Effective Connectivity

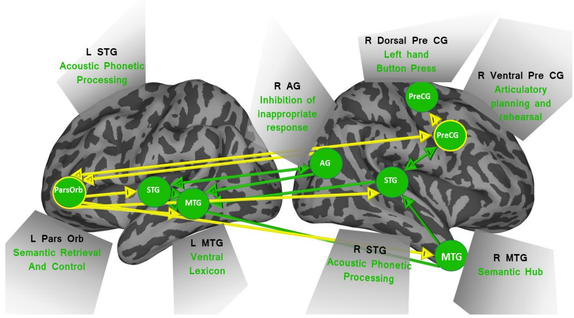
- All imaging and effective connectivity analyses were conducted using the GPS software package developed by our group (https://www.martinos.org/software/gps).
- Kalman filter-based Granger causality analysis [7] of ROI data to identify patterns of directed connectivity over large networks with millisecond resolution, and without the requirement of stationarity.
- Separate analyses were run for each response type using a common set of data-defined ROIs.
- Statistical significance was determined using permutation tests over 1000 ms before the button press (Mean RT was 700 ms).

Regions of Interest Identified by Data-Driven Algorithm

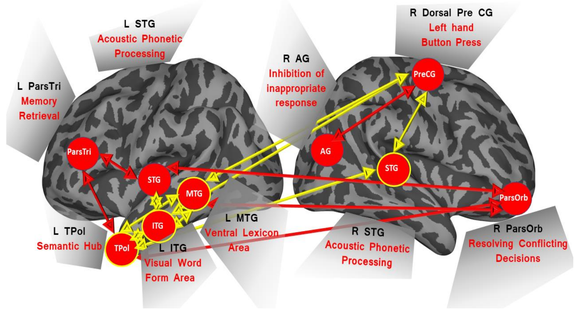


Dynamic Networks behind the Acceptability Judgments

Accept Network (YES response)



Reject Network (NO response)



Main Findings

Acceptability judgements are primarily driven by interactions between brain regions associated with lexical representation and selection.

• **The Accept Network**, mainly driven by the ventral pre CG (articulatory rehearsal) that is coordinated by left Pars Orbitalis semantic memory retrieval and control [8].
• **The Reject Network**, driven by a broader lexical work including the left MTG ventral lexicon [9], left anterior Fusiform visual word form area [10], and the bilateral temporal poles implicated in semantic coordination [11].

Discussion

- The current results are consistent with prior results showing that phonotactic influences on speech perception [5] and phonotactic frequency effects on lexical decision [12] are mediated by lexical representation.
- <u>No brain regions</u> appear to play a common role across networks that is consistent with rule representation (**competence**) that is dissociable from lexical representation and semantic search (**performance**).
- Failure to identify phonological word form representations in pMTG that overlap with unattested consonant clusters leads to secondary search of visual wordform patterns in the fusiform word area, and semantic search mediated by the temporal poles.
- These results are consistent with the predictions of connectionist (domain general associative) explanations of phonological constraints.
- Both networks are large and complicated, which is itself evidence that acceptability judgments are psychologically complex.

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Acknowledgements: This work was supported by NIDCD grant R01DC015455 and benefited from funding from CFNT grant P41EB015896 and S10RR014978. We would like to thank Adam Albright for his invaluable advice, and Nao Matsuda for her assistance running subjects.