2pSC6. Effects of receptive language ability on the neural representation of phonetic category structure

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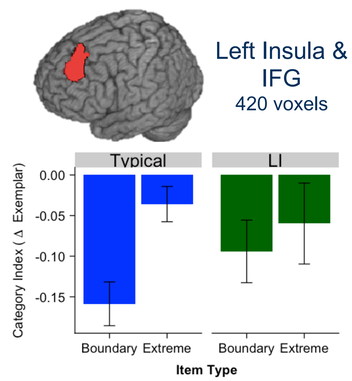
INTRODUCTION

- Speech sounds are perceived categorically and exhibit a graded internal category structure that reflects input statistics (Liberman et al., 1967; Pisoni & Tash, 1974; Drouin et al., 2016)
- Neuroimaging findings (Myers, 2007; Myers & Theodore, 2017) reveal that phonetic category structure is achieved through:
  - *Invariant response* to within-category variation in *frontal* regions including inferior (IFG) and medial frontal gyrus (MFG)
  - *Graded sensitivity* to within-category variation in *temporal* regions including superior (STG) and medial temporal gyrus (MTG)
- Children with language impairment (LI) show deficits in some auditory categorization tasks and show neuroanatomical differences in the IFG and STG (Nittrouer et al., 2011; Badcock et al., 2012)
- Some accounts of LI implicate higher-order receptive deficits as the etiological locus; an alternative account is that LI may also reflect impairment in lower-level speech processing
- ***Research Question:*** Is there a relationship between the neural representation of phonetic category structure and receptive language ability?
- ***Predictions:*** If LI individuals show impaired neural representation of phonetic category structure, then (1) frontal regions will fail to show invariant response to within-category variation and (2) temporal regions will fail to show graded sensitivity to within-category variation

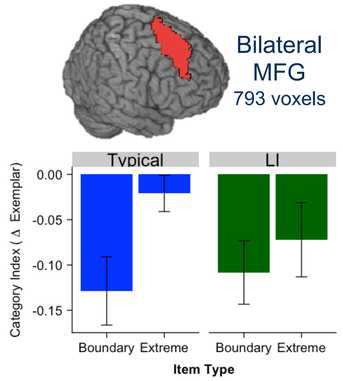
RESULTS

fMRI Data Analysis

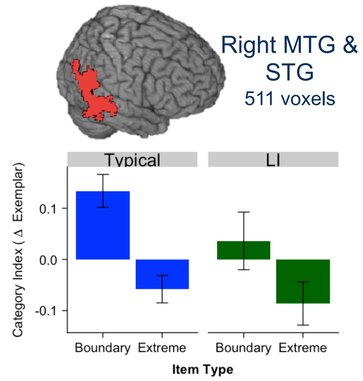
- Clusters significant at a whole brain level using a voxel-wise threshold of $p < 0.025$ and cluster-wise threshold $p < 0.05$ (263 contiguous voxels) yielded six clusters in three primary brain regions (left frontal, bilateral frontal, right temporal)
- In these clusters for each subject percent signal change was extracted and a category index was calculated as the difference between each item type relative to exemplar items
- Using this metric, category index measures closer to zero indicate no difference between that item type and exemplars, while measures further from zero indicate a difference between that item type and exemplars



TD group demonstrates invariant response, while LI group shows graded sensitivity in left frontal regions



TD group demonstrates invariant response, while LI group shows graded sensitivity in bilateral frontal regions



TD group demonstrates graded sensitivity, while LI group shows invariant response in right temporal regions

DISCUSSION

- Evidence of impaired neural representation of phonetic category structure in individuals with LI, who showed:
  - Increased recruitment of frontal regions for resolving within-category variance
  - Decreased sensitivity to the acoustic-phonetic cue in right temporal regions
- LI individuals may be working harder to resolve category membership by recruiting frontal regions
- LI individuals may be less efficient at tracking fine-grained acoustic information in temporal regions
- The results suggest that LI may arise due to deficits in lower-level speech processing, including processing at the phonetic level of analysis

METHODS

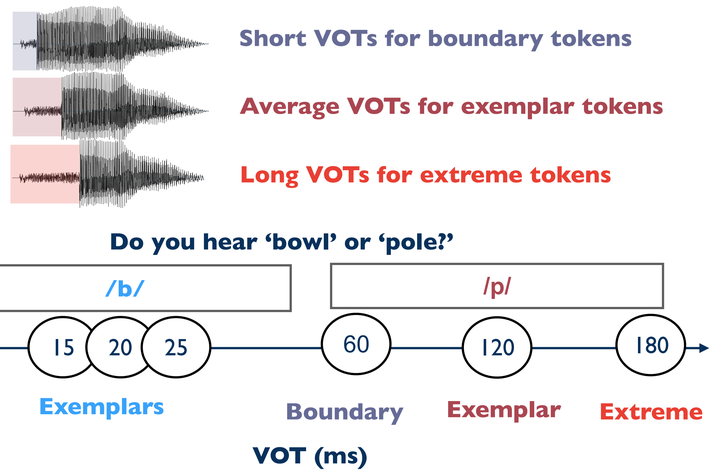
Participants

- Monolingual English adult participants (n = 23) completed a battery of speech, language, and reading assessments
- Assignment to **typical (TD)** or **language impairment (LI)** group based on a combined weighted score on the token & spelling test (Fidler et al., 2011)

Assessment		Construct	TD Group (n=13)	LI Group (n=10)
LI Screener		Receptive Language/ Spelling	-1.29 (0.52)	0.62 (0.49)
TONI–IV		Nonverbal IQ	105 (8)	95 (9)
CTOPP	Elision	Reading subskills	11 (1)	10 (1)
	Blending Words	Reading subskills	12 (1)	9 (2)
	Nonword Repetition	Reading subskills	9 (3)	8 (2)
TOWRE	Sight Word	Reading	111 (10)	100 (11)
	Phonemic Decoding	Reading	106 (13)	95 (8)
WRMT–III	Word Identification	Reading fluency: Words	104 (10)	93 (9)
	Word Attack	Reading fluency: Nonwords	103 (14)	89 (11)
	Passage Comprehension	Comprehension	100 (6)	88 (8)
CELF-V	Formulated Sentences	Receptive language	12 (2)	8 (2)
	Recalling Sentences	Receptive langauge	12 (3)	9 (2)
	Spoken Paragraphs	Receptive language	9 (2)	6.5 (1)
	Semantic Relationships	Receptive language	12 (2)	10 (2)

Stimuli & Procedure

- Participants performed an in-scanner phonetic categorization task on six stimuli drawn from a voice-onset-time (VOT) continuum

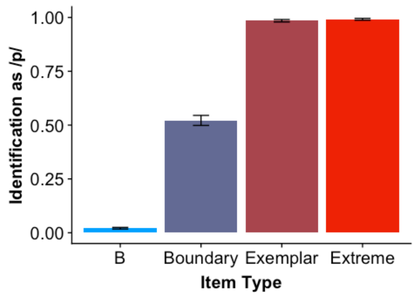


fMRI Methods

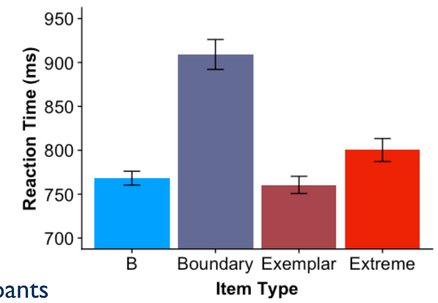
- EPI and anatomical images acquired with a Siemens 3T Scanner
- Sparse sampling, interleaved design (2.5 x 2.5 x 3.5 mm)
- Four functional phonetic categorization runs
- Functional data processed using standard preprocessing procedure
- Percent signal change was extracted for each item type across participants for all significant clusters

Behavioral Data Analysis

Phonetic categorization



Reaction Time (RT)



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