Language selectivity may be highly localized: Evidence from univariate and multivoxel analyses

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Summary

How localized is functional selectivity for language in the brain? Prior work distinguishes areas that are maximally selective for language vs. domain-general cognition [1-3]. Here, we investigated the functional profile of cortex between these maximally selective regions, asking whether language is highly localized or whether intermediate areas show a response gradient between language and domain-general cognition. As a function of these regions' language selectivity (obtained via a functional localizer [3]), we examined **(i)** modulation of their response to language vs. two working memory tasks, **(ii)** the test-retest reliability of their functional response profile for language, and **(iii)** their spatial consistency within and between individuals.

fMRI Acquisition

Subjects: N = 28; 16 F, 12 M; age 19–32 years, mean=22.9
MRI Acquisition: Whole-brain T1w anatomical and T2*w functional (TR = 750 ms, 3mm^3 voxels); Siemens Trio 3T
In-Scanner Tasks: 2 runs per task

- **Listening Language Localizer:** passively listened to 18s–blocks of intact or degraded speech; *contrast: intact > degraded* [3]
- **Verbal Working Memory:** listened to pairs of long or short digit sequences, indicating same/different; *contrast: hard > easy*
- **Spatial Working Memory:** viewed pairs of long or short sequences of spatial locations, indicating same/different; *contrast: hard > easy*

MRI Analysis: sMRI processing performed via *FreeSurfer* v5.3.0, Desikan-Killiany atlas; fMRI analysis performed via *Lyman* v1.0.0 [4]

Analysis

Defining selectivity-gradient functional regions of interest (fROIs)

- Divided each lobe into 10 fROIs based on ranked degree of language selectivity from the *intact > degraded* z-stat volume (0 –10%ile, 10–20%ile, ..., 90–100%ile)
- fROIs obtained separately for each of the runs (1 fROI / decile / run)

For each subject, for each fROI, we calculated:

Average fMRI response magnitude per task

- Selectivity contrast of interest (*intact > degraded* or *hard > easy*)
- Computed within the decile fROIs from other run for independence

fMRI response pattern similarity (MVPA)

- Correlated voxelwise response magnitudes within each fROI between runs (language task only)

Within-subject fROI location consistency

- Spatial overlap of decile fROIs between runs based on the Jaccard Index (JI; shared voxels between fROIs / total voxels in both fROIs)

Between-subject fROI location consistency

- JI was calculated for all pairs of subjects for each decile fROI
- The 2 per-run JIs were averaged by subject pair, then for the group

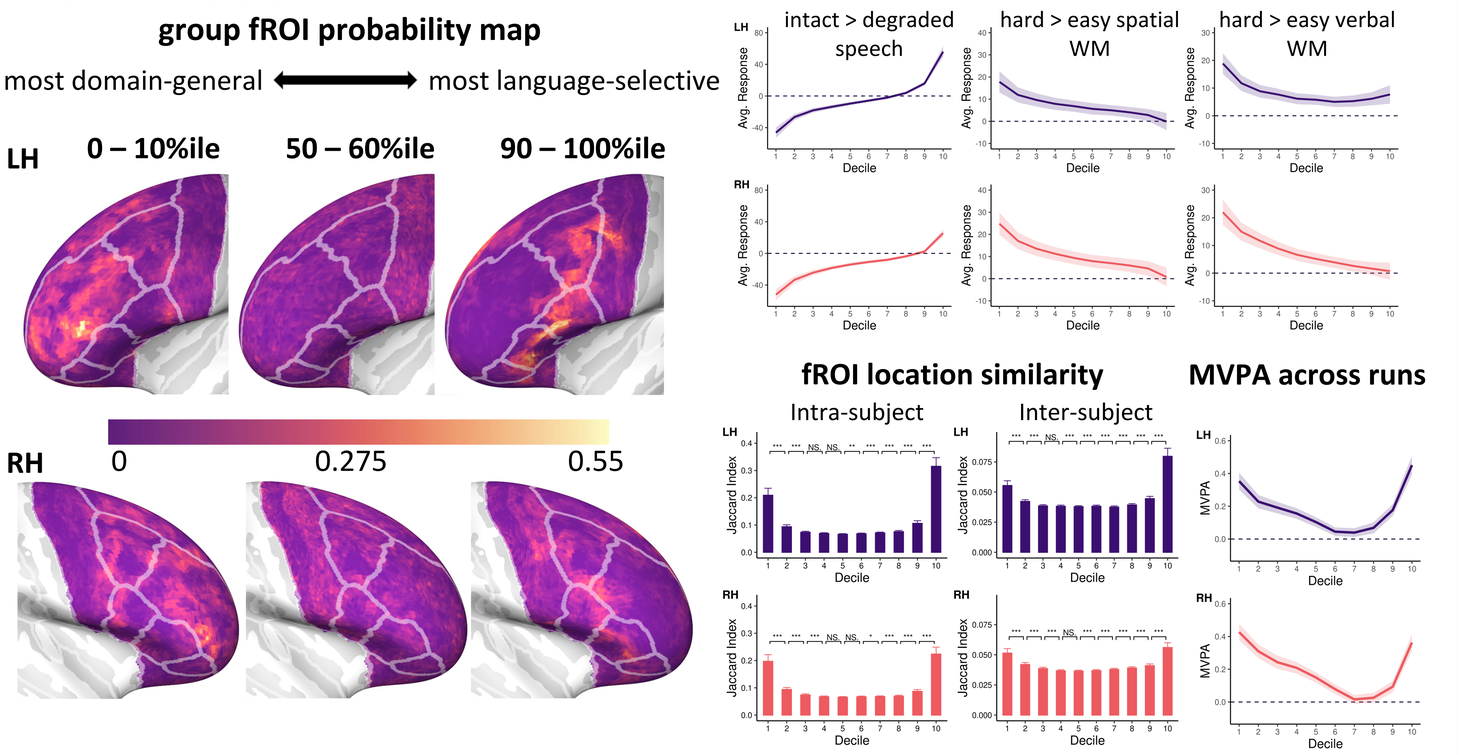
Decile fROI probability maps

- Illustrate the likelihood of each language-selective decile at each location across subjects

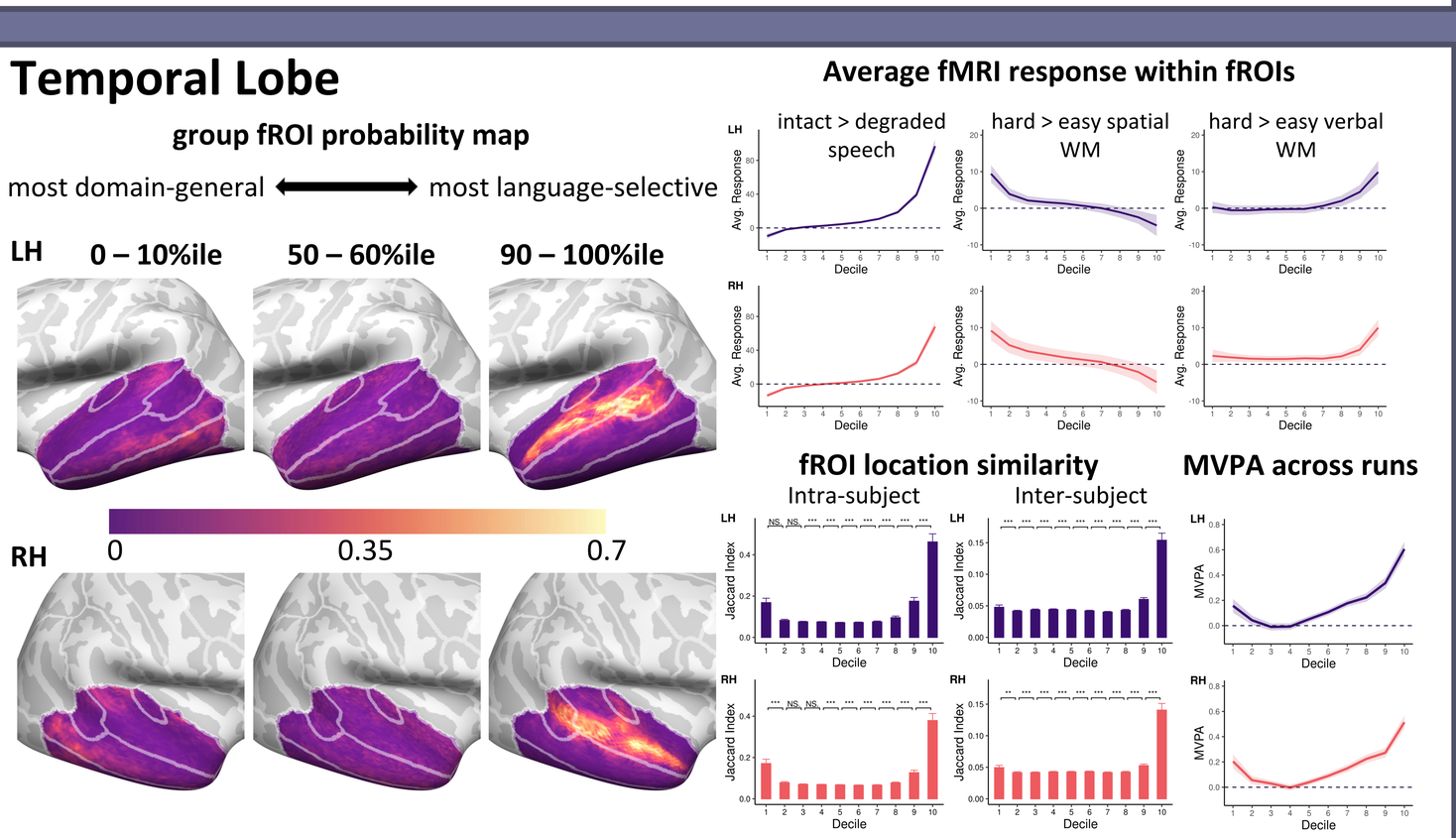
Discussion

- For each lobe, language selectivity decreased nonlinearly and dramatically outside of the most selective areas.
- Areas of maximally high and low selectivity were most spatially similar within and between individuals, whereas the locations of intermediate deciles were variable across time and people.
- MVPA revealed highly similar response profiles within top and bottom deciles, with more variable responses in intermediate areas.
- The response to domain-general tasks across fROIs was similarly nonlinear, but opposite that of language (with the exception of verbal WM in the temporal lobe).
- Cortex in intermediate deciles may be either non-selective for language, or may have transient involvement in language processing [5], suggesting that core language processing takes place in highly localized hubs.

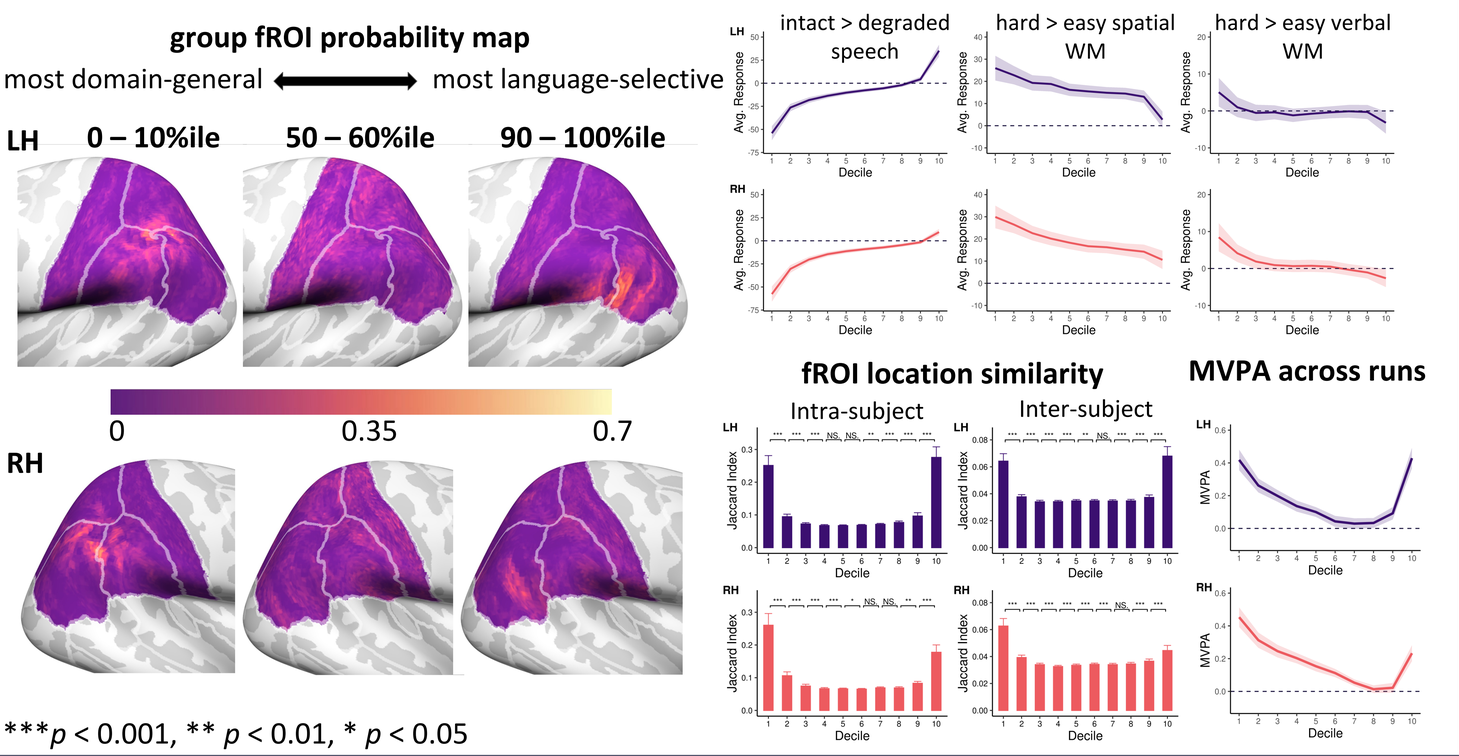
Frontal Lobe



Temporal Lobe



Parietal Lobe



$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

References

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[2] Scott & Perrachione (2019) *Neuroimage*
[3] Scott et al. (2017) *Cognitive Neuroscience*
[4] Scott (2020) Doctoral dissertation, Boston University
[5] Chai et al. (2016) *Cerebral Cortex*

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