Evidence for an interactive account of hemispheric lateralization in visual perception

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Introduction

A common account of cortical organization posits right-hemisphere (RH) specialization for faces and left-hemisphere (LH) specialization for words.

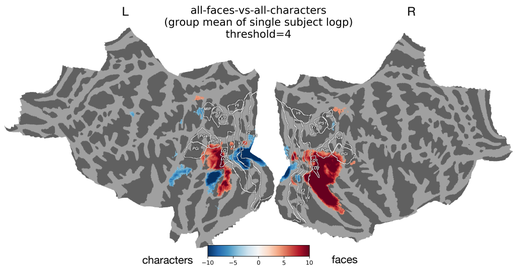
The extent of and factors underlying such specialization remain poorly understood. Possible accounts include:

- innate modularity
- innateness for faces, and recycling of other resources for words
- interactive competition among visual domains for constrained neural resources (see right panel)

We set out to understand connections between structural, functional, and behavioral lateralization.

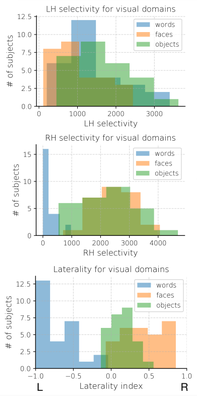
Here, we present functional results using fMRI

Group-level lateralization

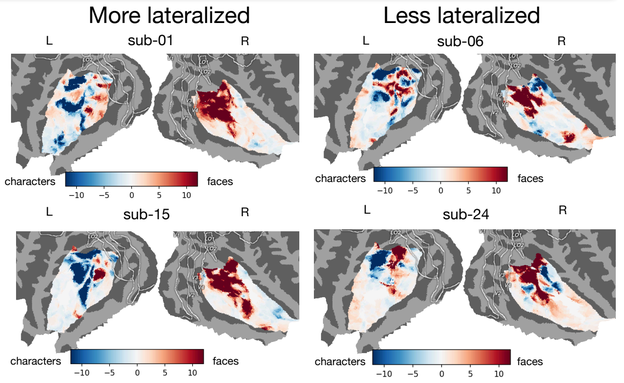


Words more lateralized than faces

Word selectivity is nestled in between face selectivity in LH



Individual lateralization in IT+fus



An interactive developmental account of word/face lateralization

In previous work we proposed a computational model and theory of hemispheric lateralization (Plaut & Behrmann, 2011; Behrmann & Plaut, 2020) focusing on 3 key factors:

- Distributed representations and knowledge
- Representational cooperation and competition
- Topography, proximity and hemispheric organization

Left-lateralization of words is interpreted as a result of pressure to couple visual-orthographic representations with left-lateralized language representations.

Right-lateralization of faces is interpreted as a consequence of LH tuning for words and resulting competition with LH face representations, resulting in RH optimization for faces

This model naturally predicts:

- Graded patterns of selectivity in individuals
- Anti-correlation between LH selectivity for words and faces
- Correlation between RH face selectivity and LH word selectivity

Methods

- fMRI + DTI experiment of 28 right-handed native English subjects
- Participants viewed mini-blocks of words, faces, objects, inverted words, inverted faces, and letter strings using a modified version of the *fLoc* experimental code (Stigliani et. al, 2015)
- Integrated domain selectivity *s* was computed in visually responsively voxels ($p<10^{-4}$) within inferior-temporal + fusiform cortex ROIs of each hemisphere *h* and domain *d* as the sum of domain-selective positive t-statistics:

$$s_{h,d} = \sum_{voxel\ i \in h} \max(t_{i,d}\ ,\ 0)$$

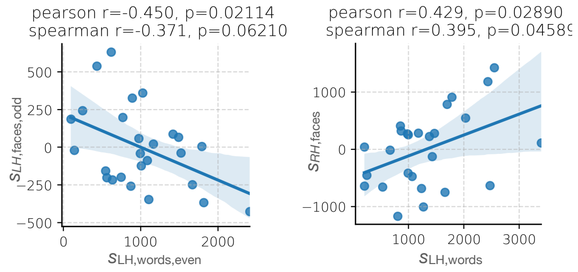
- Laterality for a given domain was computed as:

$$L_d = \frac{s_{RH,d} - s_{LH,d}}{s_{RH,d} + s_{LH,d}}$$

- Outliers beyond 3 SD from mean are iteratively discarded for each measure used in correlations
- Correlations used measures computed on all data for cross-hemisphere comparisons, or odd vs. even runs for within-hemisphere comparisons (including those using laterality)

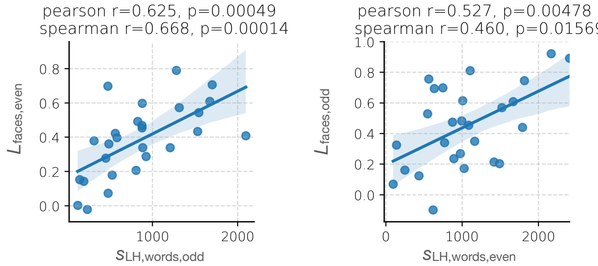
Evidence for specific competition between words and faces

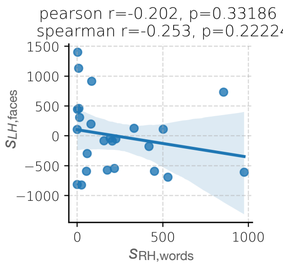
(all Y-axes show **residuals** after regressing out the total number of voxels in the hemispheric spatial ROIs used in the correlation; exception: plots of laterality (since it is a ratio))

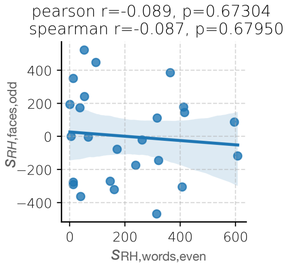


LH word/face competition, and LH word/ RH face correlation

LH word selectivity correlates with RH-dominant face lateralization (both independent splits of the data)

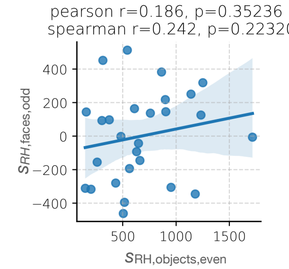


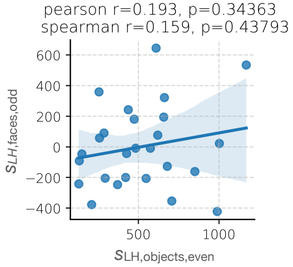




RH word selectivity is unrelated to face selectivity in either hemisphere

Objects and faces do not compete within hemisphere as faces and words do





Conclusions

Hemispheric specialization is more graded for faces than words and is variable across individuals

Increases in LH word selectivity are strongly correlated with increasing RH-dominant face lateralization, manifesting in both LH competition and pressure to increase RH face selectivity

This competition is specific both in terms of the hemisphere (LH words) and domain (no competition seen with objects)

Ongoing and future work

Examination of relationship between ventral temporal cortex word laterality with selectivity in language-related areas of cortex

Broader assessment of laterality including behavioral metrics (hemi-field paradigm) and structural metrics (DTI, white matter volume).

Computational modeling of principles of functional organization within and across hemispheres

References

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Acknowledgments

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