# Child and adult spatial distribution of responses to American Sign Language and English using fMRI

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## INTRODUCTION

- The majority of studies investigating sign language in the brain have focused on adults, and have broadly shown that canonical language regions in the brain respond to sign language in d/Deaf individuals fluent in sign language.[1-4]
- Here, we examine the **consistency of the spatial distribution of language responses** within American Sign Language (ASL) speakers and between ASL speakers and English speakers, in children and adults.
- We additionally examine the **effects of delayed access to language** on this spatial distribution of the language response.

## METHODS

Participants: English-speaking adults (n=24), signing adults (n=36, 29 d/Deaf, 7 hearing children of d/Deaf adults (CODA)), English-speaking children (n=96, age range 5-12 years), and signing children (n=24, 20 d/Deaf, 4 CODA, age range 6-12 years)

Signing adults: 20 native signers, 16 delayed signers (range of delay = 1.5-20 years, M(SD) = 6.5(6.2)),

Signing children: 16 native signers, 8 delayed signers (range of delay = .25-7 years, M(SD) = 2.7(2.3)),

*All participants were fluent in the language the tasks were conducted in.

fMRI Task:

English: 20-second blocks of stories, music, foreign speech

ASL: 29-41-second blocks of stories, non-signs

Language contrast:

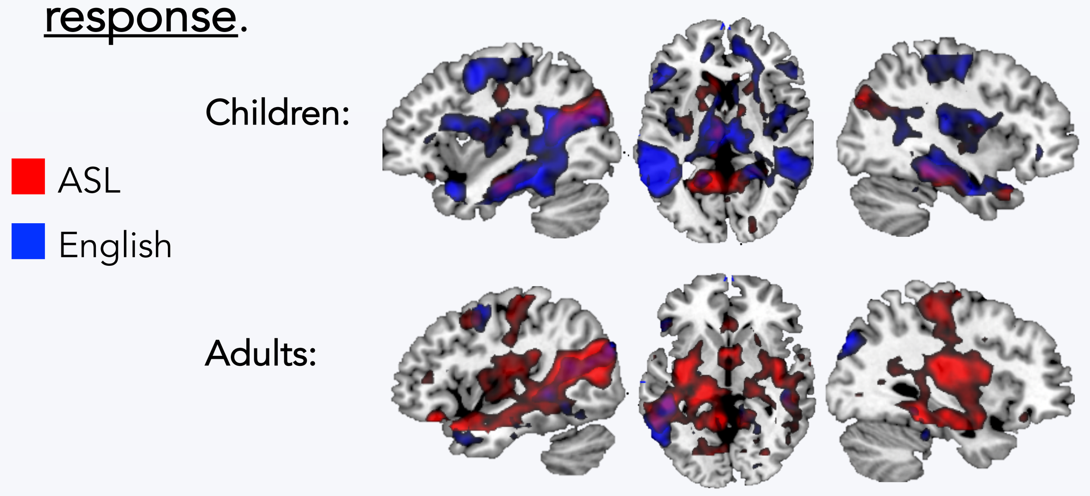


ASL Non-sign

Example story: *One day, a little robin landed on a huge, strange-looking tree. This was a magical tree that had special powers. The robin ate one berry. In the spring, the robin laid three eggs. After a month, two of the eggs cracked and little robins came out. The last egg did not crack for a long time.*

## ANALYSIS

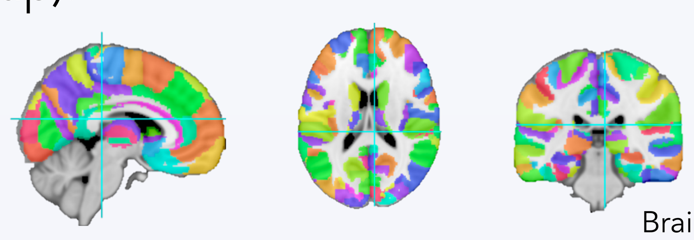
1) Raw data show spatial overlap of language response.




Uncorrected whole brain RFX. Threshold t>2.3.

2) Quantifying spatial distribution.

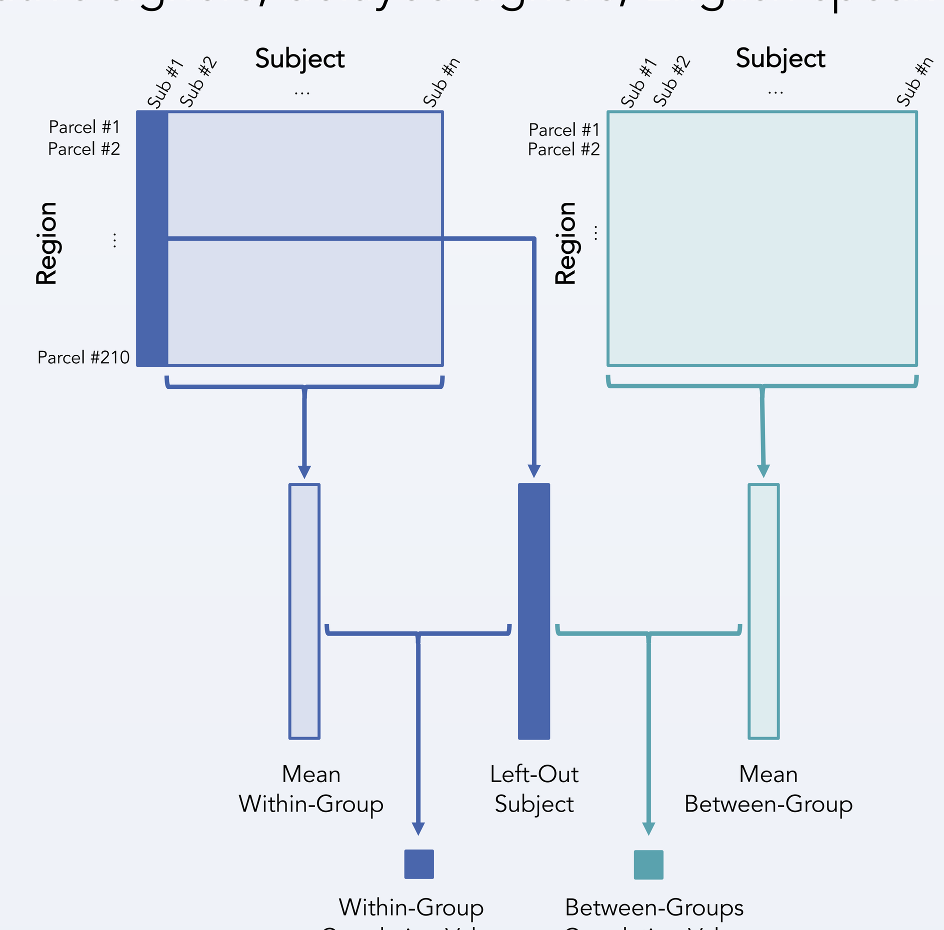
Analyzed response in 210 parcels from the Brainnetome Atlas[5] (excluded parcels without at least 80% coverage in at least 80% of participants per group).



Brainnetome atlas.

Per parcel and per participant, extracted responses in the 50 voxels with largest response to language contrast (English – Foreign, ASL – Non-sign). Thus each participant's language response was encoded as a vector across all 210 parcels, i.e. a spatial pattern of language responses across brain regions.

Using leave one subject out approach, we then compared this vector to (1) the mean contrast vector of the remaining group members, and (2) and to the mean contrast vector of the other group. Compared between ASL and English groups, and between native signers, delayed signers, English speakers.



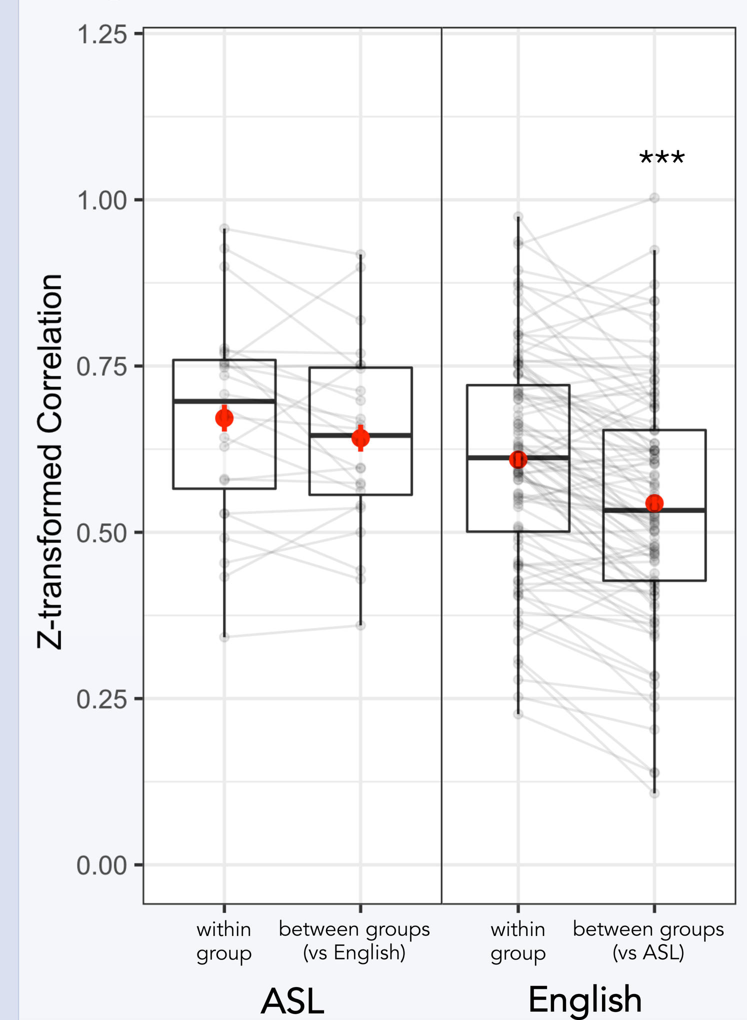

3) Statistical analysis. Two-tailed paired t-tests were conducted to compare within-group and between-group z-transformed correlations.

## RESULTS

Comparison Between ASL and English

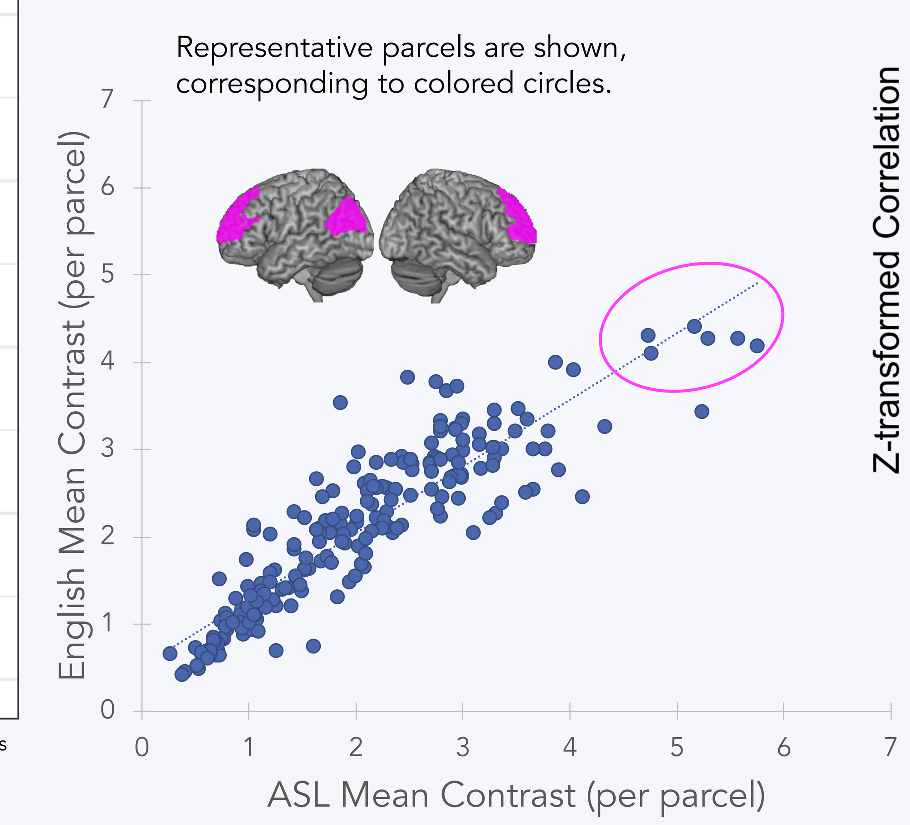
Native and Delayed Language Exposure

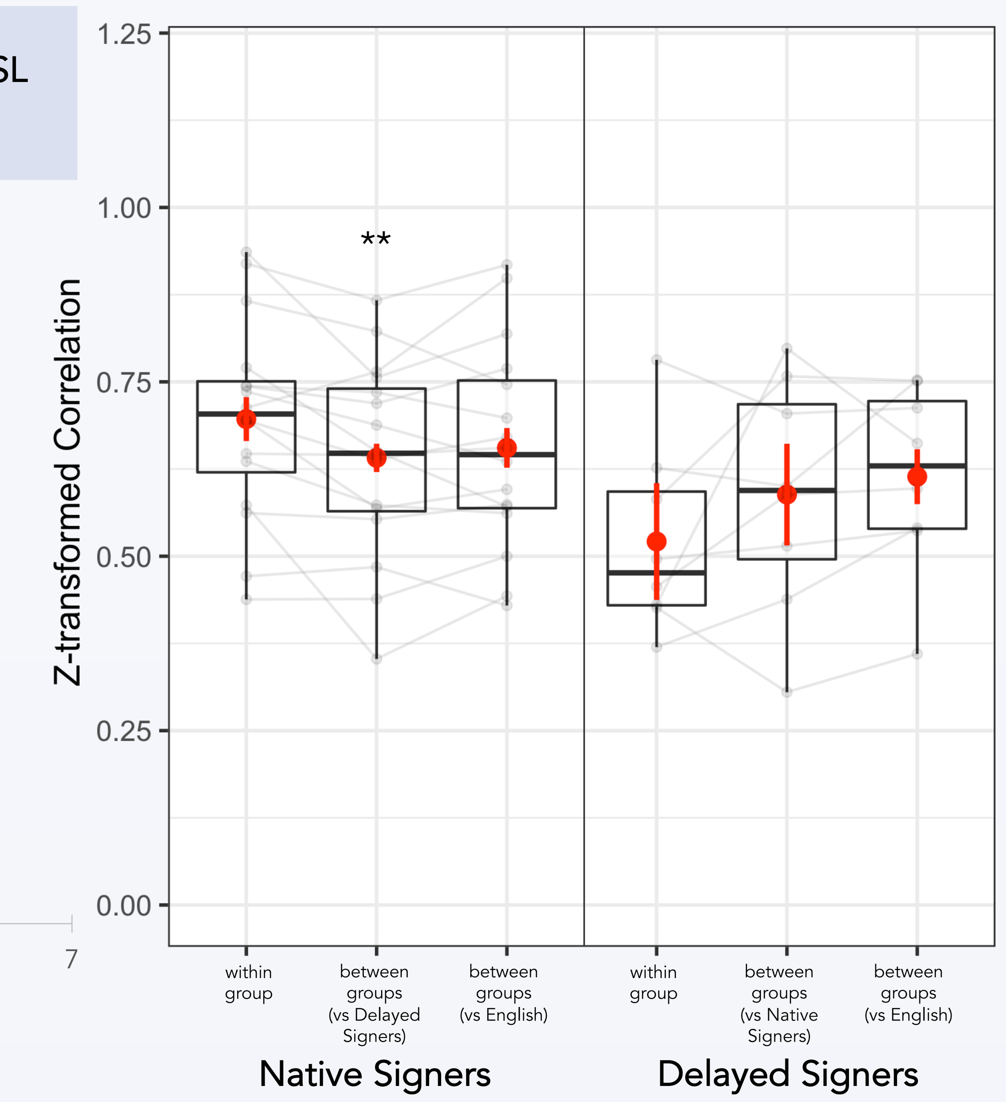
Children:



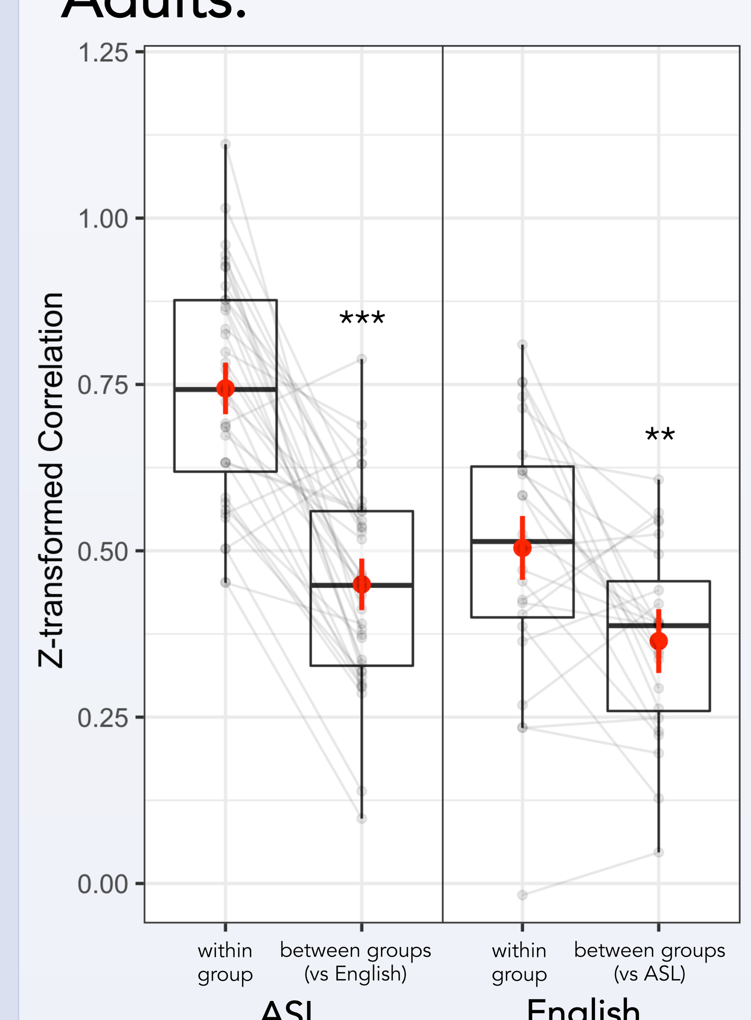

Mean contrast values for each parcel, for ASL and English:

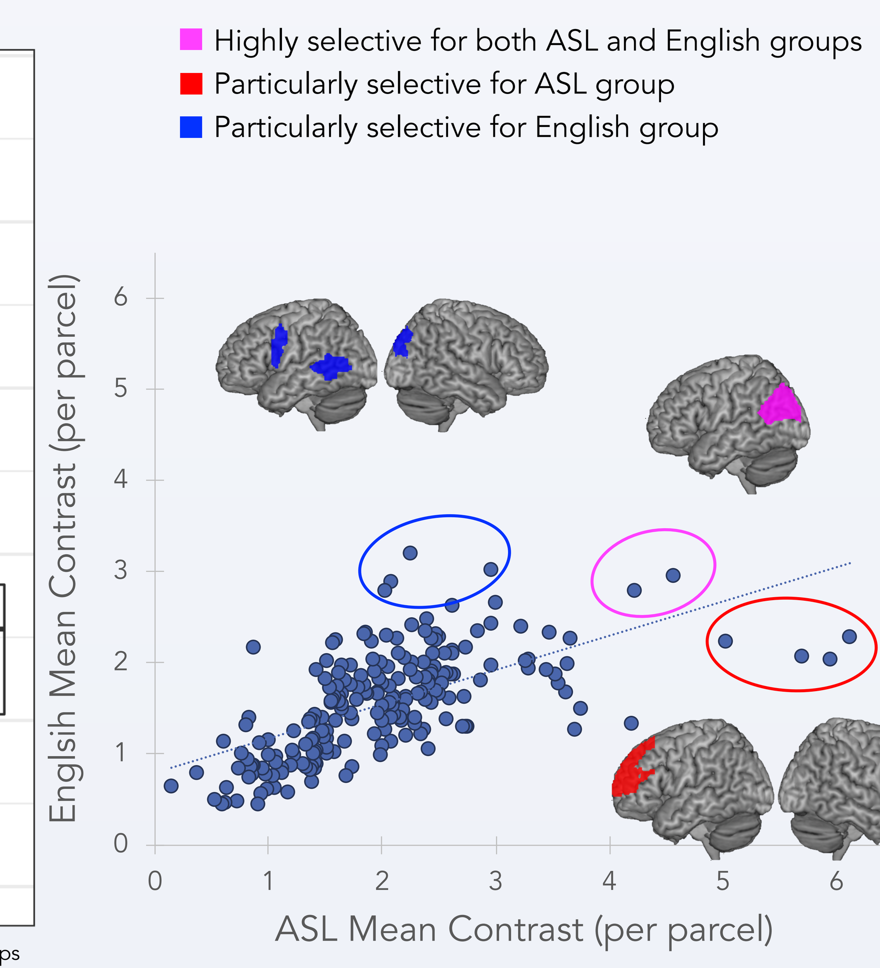
Representative parcels are shown, corresponding to colored circles.

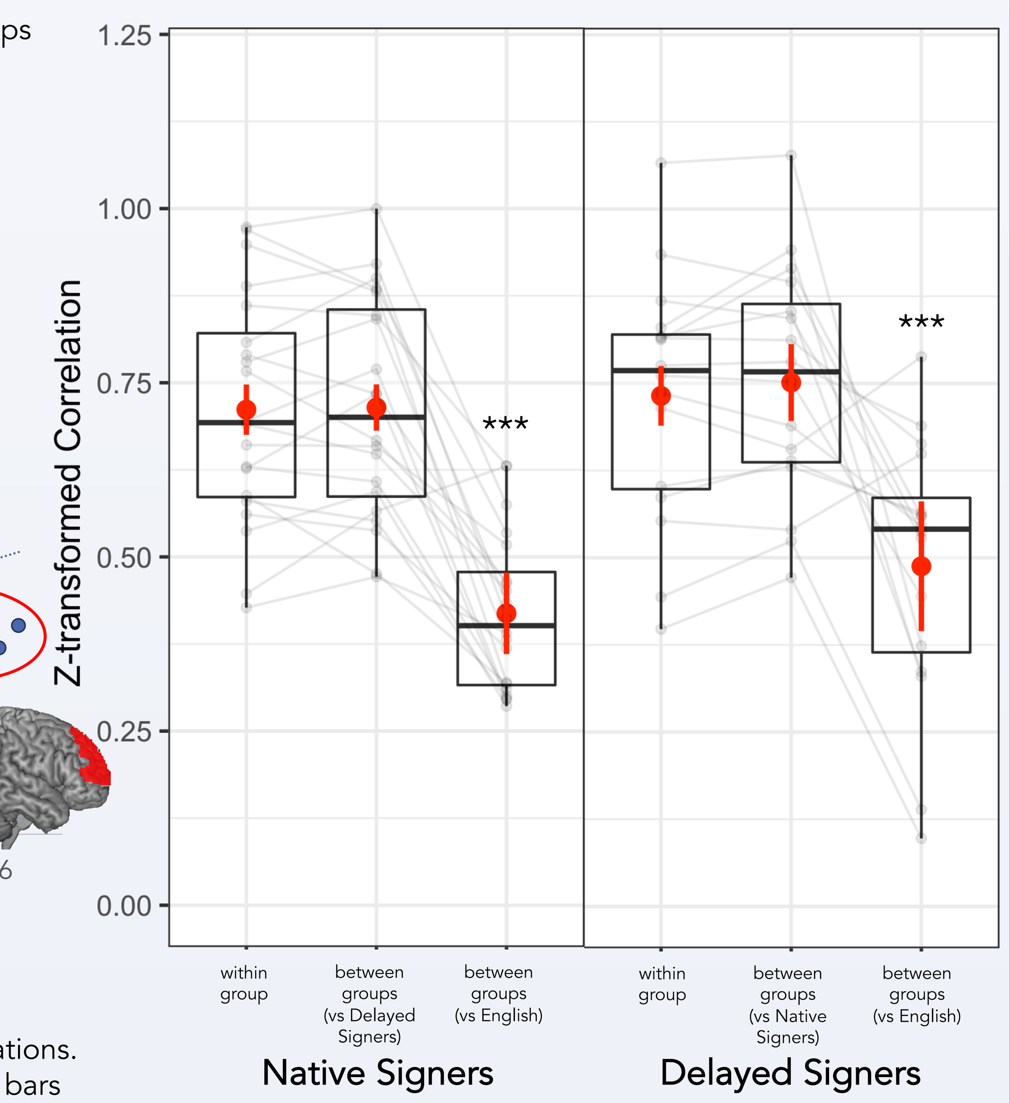



Adults:




Two-tailed paired t-tests were conducted to compare within-group and between-group z-transformed correlations. *p<.05, **p<.01, ***p<.001. Bars connect data from individual participants. Means shown in red (dots). Error bars (red) show 95% confidence interval.

## CONCLUSIONS

- In children, but not adults, delayed access to sign language was associated with a **less consistent** pattern of selectivity for language across the brain.
- Adult ASL speakers activated a consistent set of regions for language comprehension, but these were significantly **different** from the regions activated by English.
- Language modality may impact the spatial distribution of selective language responses in the brain.

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