Neural Representations for Spoken and Written Language In Beginning Readers: Insights from fNIRS and fMRI Neuroimaging

Kaja Jasińska[1], Bonnie Buis[1], Bryan Cort[1], Peter Molfese[2], Einar Mencl[1], Nicole Landi[1,2,3], Heather Bortfeld[1,2], Ken Pugh[1,2,3]

[1]Haskins Laboratories [2]University of Connecticut, [3]Yale University – Child Study Center

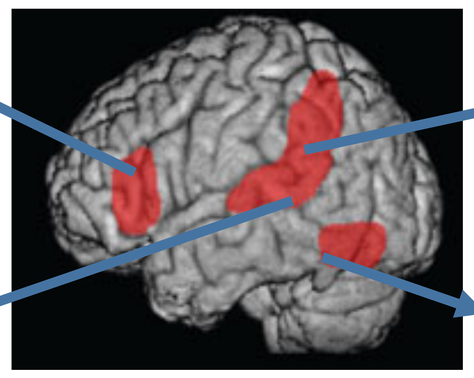
RESEARCH QUESTIONS

How does the young brain's neural circuitry for language support the development of skilled reading?

- Young children learning to read are already proficient users of spoken language
- Left Inferior Frontal Gyrus (LIFG) and left Superior Temporal Gyrus (STG) are involved in relating phonological information to printed text, phonological decoding and segmentation during reading, and semantic word retrieval[1-3]
- Left supramarginal gyrus (SMG) and left fusiform gyrus (VWFA) become increasingly specialized for aspects of printed word processing[2,4]

Inferior Frontal (IFG)
Word meaning morphology, syntax

Superior Temporal (STG)
Phonology



Temporoparietal
Letter to sound correspondence

Occipitotemporal
Visual word form

METHODS

Participants

Children
N=52
Ages 3.5-6.5y

Pre-Literacy
N=28
Ages 3.5-4.5y (M=4.2)

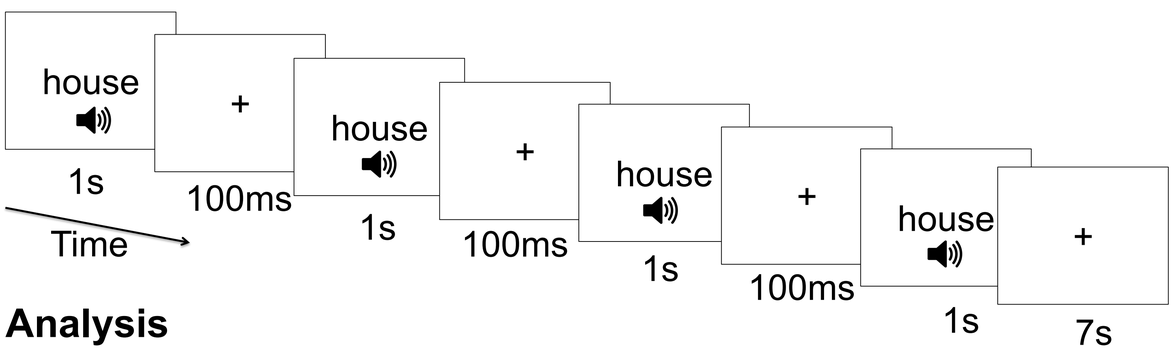
Emergent Literacy
N=24
Ages 4.5-6.5y (M=6.2)

Neuroimaging

- Near Infrared Spectroscopy (fNIRS) Neuroimaging: Hitachi ETG 4000 and Shimadzu LABNIRS
- fMRI: 3T Scanner (N=11, older emergent literacy group only)

Task

- Spoken and written words in a repeating sequence, 6 trials/block



Analysis

- NIRS: Data from 44 channels were preprocessed and analyzed using GLM in Statistical Parametric Mapping for NIRS, Ver. 4[5].
- MRI: Data were preprocessed and analyzed with the Analysis for Functional NeuroImages (AFNI) package using 3dMVM[6]
- Correlations computed between beta values from HbO and HbR NIRS analyses and the average beta values of MRI voxels within 3 cm of each NIRS channel MNI locations

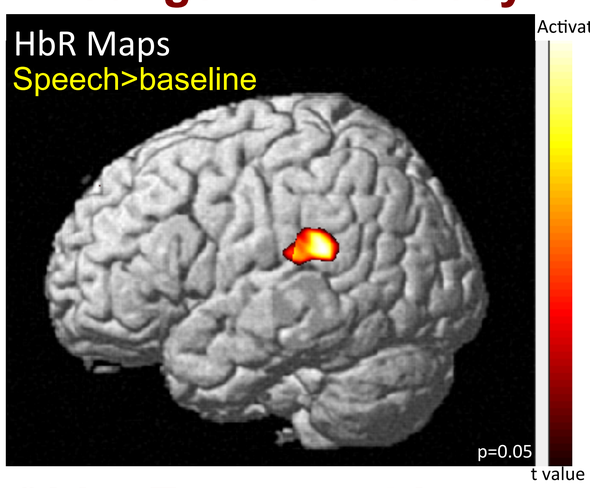
REFERENCES

1 Poldrack *et al.* (1999) *NeuroImage*, 10, 15-35.
2 Pugh, *et al.* (2013). *Brain and Language*. *125,* 173-83.
3 Jasinska & Petitto (2013). *Developmental Neuropsychology, 6*, 87-101.
4. Pugh *et al* (2000). *Psychological Science* 11, 51-56.
5 Ye, *et al.* (2009). *NeuroImage, 44,* 428-44
6 Cox (1996). *Computers and Biomedical Research, 29*(3), 162-173.

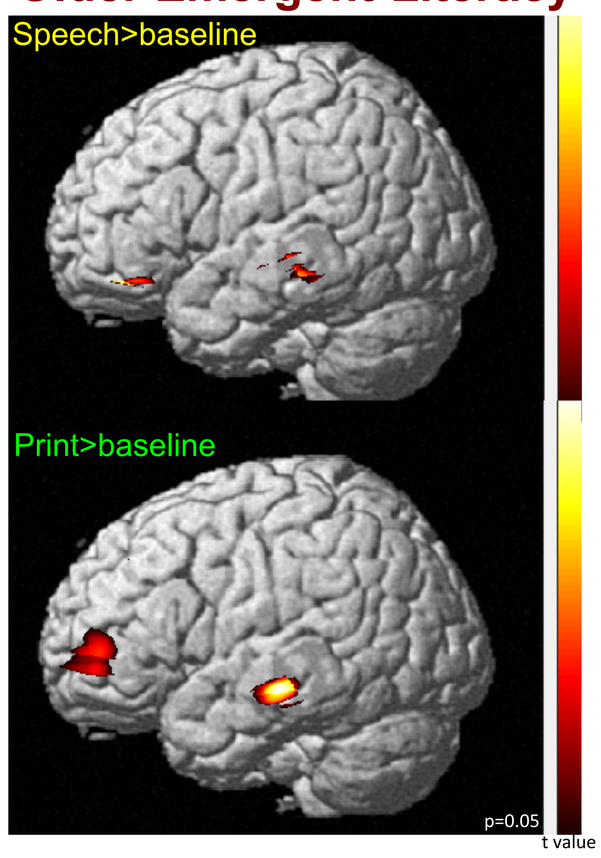
***CORRESPONDING AUTHOR:* kaja.jasinska@yale.edu**
www.haskins.yale.edu/staff/jasinska

NIRS RESULTS

Younger Pre-Literacy

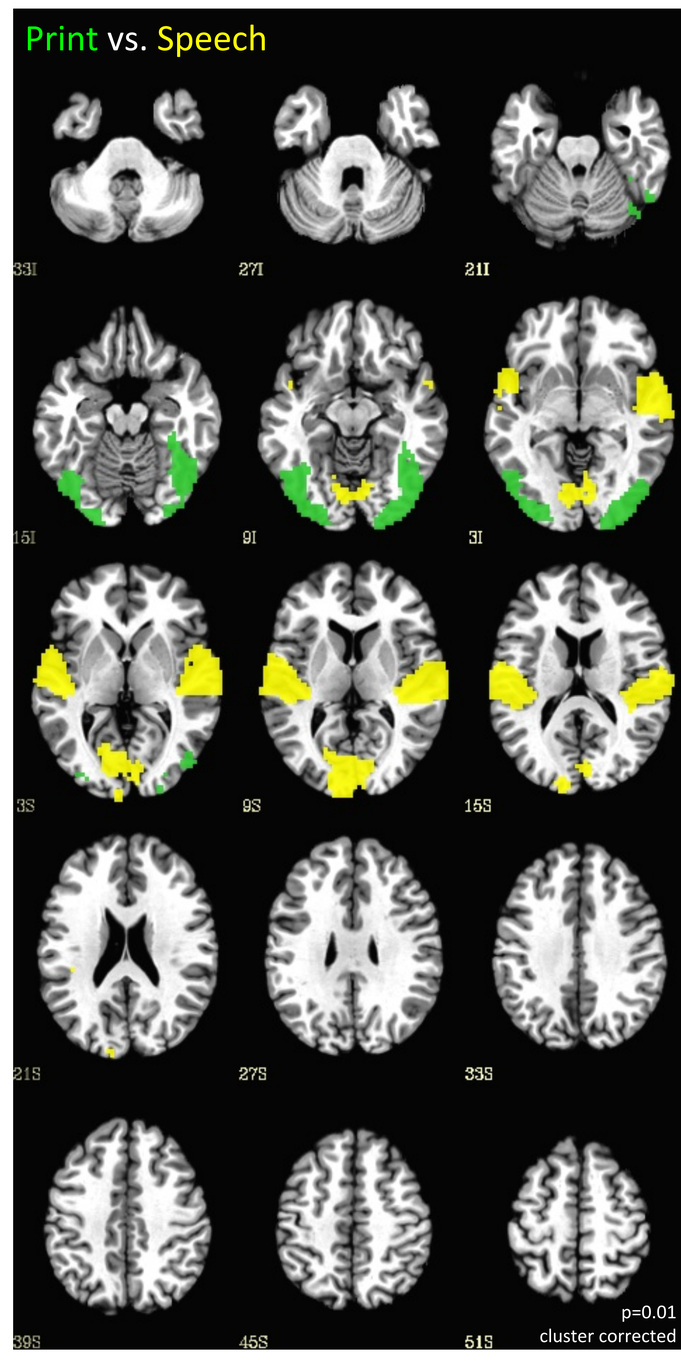


Older Emergent-Literacy



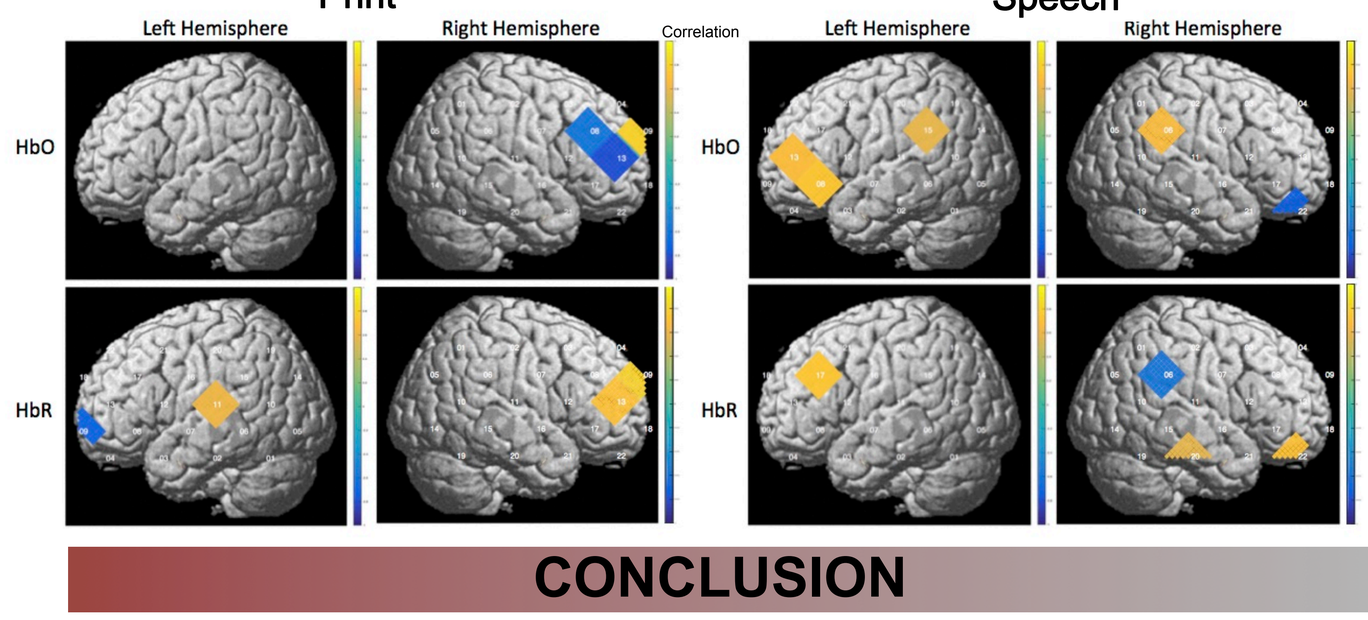
MRI RESULTS

Older Emergent-Literacy



NIRS-MRI CORRELATION

Older Emergent-Literacy



CONCLUSION

- Patterns of neural activation that support spoken language processing change over development as a child learns to read
- Pre-literacy children show greater activation in L STG for speech
- Emergent literacy children show greater L IFG activation for speech and greater L IFG and L STG activation for print than speech
- Differences in neural processing of print and speech reveal how the developing brain allocates neural resources towards reading
- Correlated MRI and NIRS signals in language brain regions indicate these different neuroimaging methods reliably measure brain activation during language processing and support NIRS neuroimaging for even younger children for whom MRI may be difficult to acquire

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