The dyslexic brain before and after literacy - unifying structural signs

Ulrike Kuhl, Angela D. Friederici & Michael A. Skeide

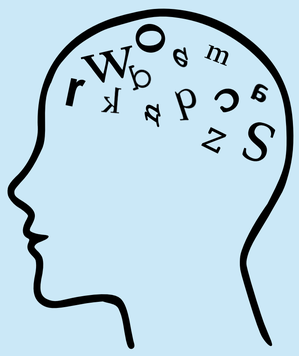
Department of Neuropsychology, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

kuhl@cbs.mpg.de

Introduction

Disentangling **neurobiological predisposition** from the **effect of literacy instruction**:

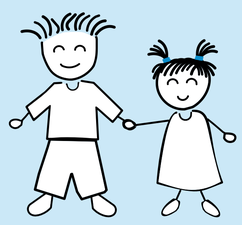
Which cortical features classify as **cause for developmental dyslexia**?



Changes in which cortical measures are a **consequence of being dyslexic**?

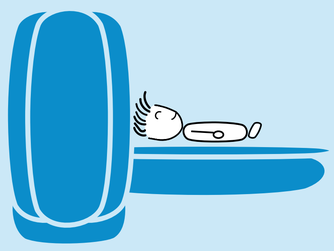
Goswami, 2015

Design



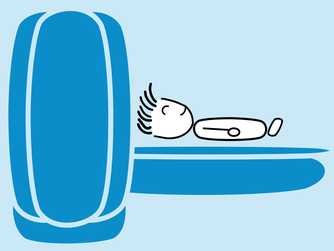
N_{DD} =16
N_{Con} =16

Before literacy instruction



5y;7mo±4

After literacy instruction

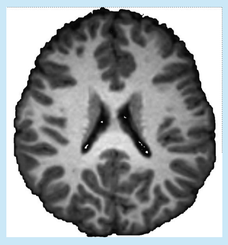


8y;6mo±3

Covariates: Sex, Age, IQ, handedness, parental education, arithmetic ability

Data processing

MP2RAGE

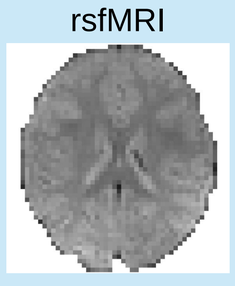


CAT12

Gaser & Dahnke, 2016

- Cortical thickness (**CT**)
- Cortical folding complexity (**CF**)
  Yotter et al., 2011
- Gyrification index (**GI**)
  Luders et al., 2006
- Sulcus depth (**SD**)
- Quantitative T1 (**T1w**)

rsfMRI



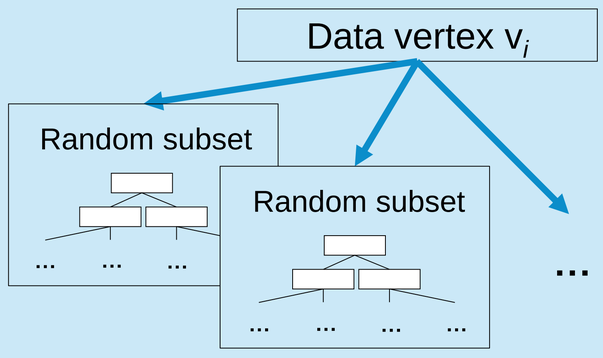
DPARFS

Chao-Gan &Yu-Feng, 2010

- Fractional amplitude of low frequency fluctuations (**fALFF**)
  Zou et al., 2008
- Regional functional homogeneity (**ReHo**)
  Zang et al, 2004

adjusted for **covariates**

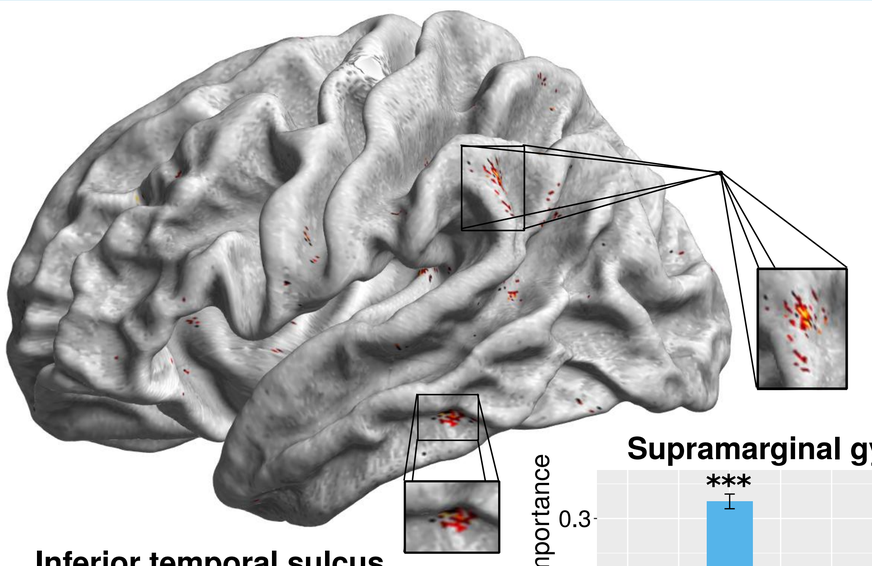
Vertex-wise random forest classification
Breiman, 2001

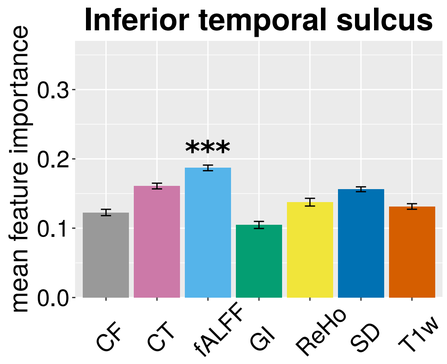


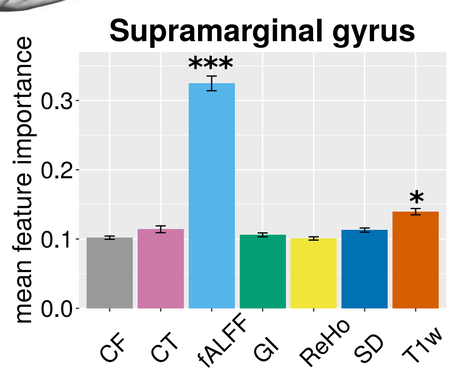
Vertex-wise whole brain accuracy map

Results

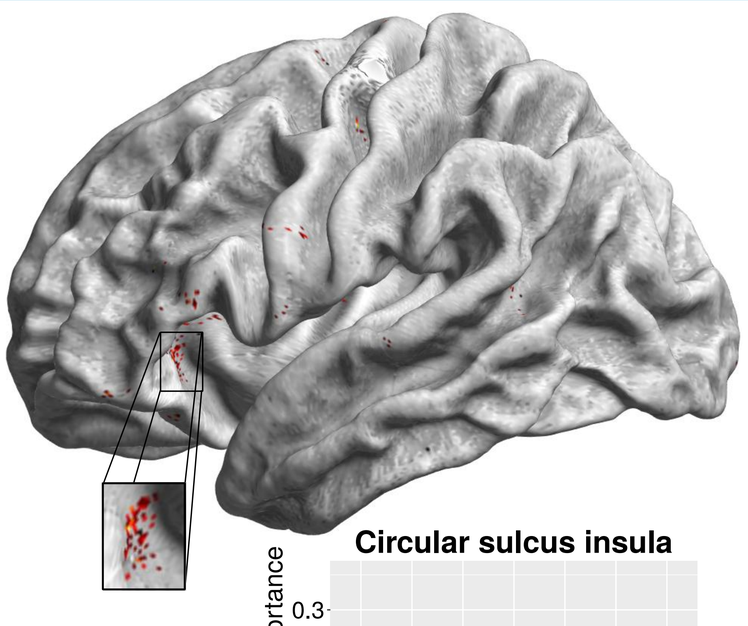
Before literacy instruction (5 years)

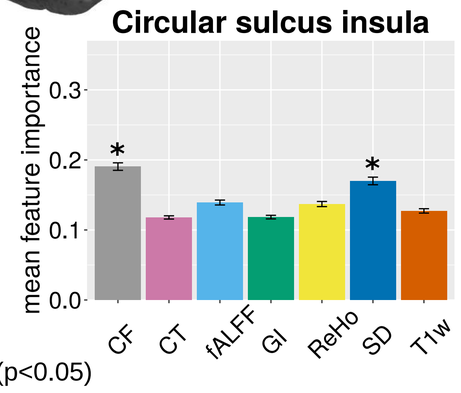


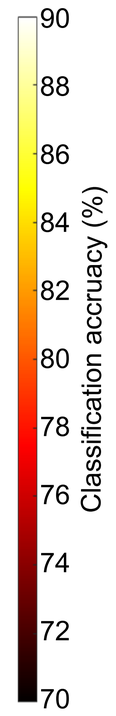




After literacy instruction (8 years)





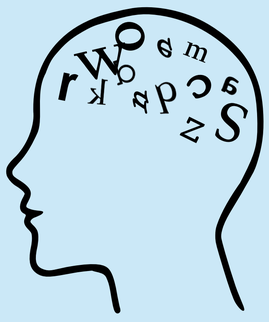


*** = significantly different from all (p<0.001); * = significantly different from all (p<0.05)

Discussion & Conclusion

Before literacy instruction

- Left occipito-temporal cortex
  - ➢ *close to the 'visual word form area'*
    Skeide et al., 2016
- Left supramarginal gyrus
  - ➢ *grey matter increase with literacy*
    Carreiras et al., 2009
- Left *superior temporal sulcus*
  - ➢ *integration of letters and speech sounds* van Attefeldt et al., 2004



After literacy instruction

- Left circular sulcus of the insula
  - ➢ *deficient temporal processing of speech and non-speech sounds*
    Steinbrink et al., 2009
- Left *superior temporal sulcus*
  - ➢ *integration of letters and speech sounds*
    van Attefeldt et al., 2004

Classification performance is **differentially driven by various cortical features**.

Discriminative of dyslexia outcome prior to reading: **Regions later forming the reading network**

References

Breiman, L. (2001). Random forests. Machine learning, 45(1), 5-32.

Carreiras, M., Seghier, M. L., Baquero, S., Estévez, A., Lozano, A., Devlin, J. T., & Price, C. J. (2009). An anatomical signature for literacy. Nature, 461(7266), 983.

Chao-Gan, Y., & Yu-Feng, Z. (2010). DPARSF: a MATLAB toolbox for "pipeline" data analysis of resting-state fMRI. Frontiers in systems neuroscience, 4.

Gaser, C., & Dahnke, R. (2016). CAT-A Computational Anatomy Toolbox for the Analysis of Structural MRI Data. HBM 2016, 336-348

Goswami, U. (2015). Sensory theories of developmental dyslexia: three challenges for research. Nature Reviews Neuroscience, 16(1), 43-54.

Luders, E., Thompson, P. M., Narr, K. L., Toga, A. W., Jancke, L., & Gaser, C. (2006). A curvature-based approach to estimate local gyrification on the cortical surface. *Neuroimage*, *29*(4), 1224-1230.

Skeide, M. A., Kraft, I., Müller, B., Schaadt, G., Neef, N. E., Brauer, J., ... & Friederici, A. D. (2016). NRSN1 associated grey matter volume of the visual word form area reveals dyslexia before school. *Brain*, *139*(10), 2792-2803.

Steinbrink, C., Ackermann, H., Lachmann, T., & Riecker, A. (2009). Contribution of the anterior insula to temporal auditory processing deficits in developmental dyslexia. Human brain mapping, 30(8), 2401-2411.

Van Atteveldt, N., Formisano, E., Goebel, R., & Blomert, L. (2004). Integration of letters and speech sounds in the human brain. Neuron, 43(2), 271-282.

Yotter, R. A., Nenadic, I., Ziegler, G., Thompson, P. M., & Gaser, C. (2011). Local cortical surface complexity maps from spherical harmonic reconstructions. NeuroImage, 56(3), 961-973.

Zang, Y., Jiang, T., Lu, Y., He, Y., & Tian, L. (2004). Regional homogeneity approach to fMRI data analysis. Neuroimage, 22(1), 394-400.

Zou, Q. H., Zhu, C. Z., Yang, Y., Zuo, X. N., Long, X. Y., Cao, Q. J., ... & Zang, Y. F. (2008). An improved approach to detection of amplitude of low-frequency fluctuation (ALFF) for resting-state fMRI: fractional ALFF. Journal of neuroscience methods, 172(1), 137-141.

AMLaP 2017