An fMRI study of phonological decoding: Learning to read in an artificial script

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INTRODUCTION

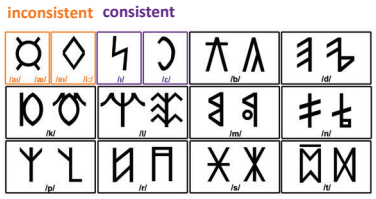
- Skilled reading is characterized by efficient visual word recognition and relies on an extensive network of dorsal and ventral brain regions, supporting phonology-based and orthography-based processes.
- In contrast, emergent reading is characterized by heavy reliance on **phonological decoding**, or the process of transforming letters into speech sounds (Share, 2008; Ziegler, Perry & Zorzi, 2014).
- We used an artificial grapheme-phoneme training paradigm to emulate the initial stage of reading acquisition to characterize the brain network that supports this process in novice reading.

➢ **Does phonological decoding rely on the domain-specific Language network because the task involves language learning?**

➢ **Does it rely on the domain-general Multiple Demand (MD) network, which has been shown to be active during learning of new information?**

METHODOLOGY

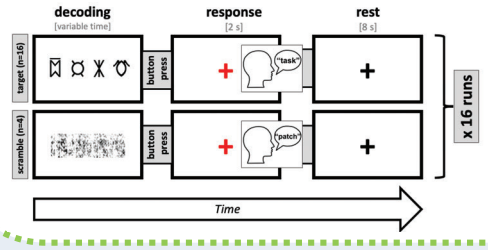
A. Artificial Orthography (AO)



C. AO training protocol

Day	Format	Task
1	Online	Cognitive assessment
2	Online	AO learning & AO test AO decoding training #1
3	In-person	fMRI #1: Localizer
4-13	Independent	AO decoding training #2-10
14	In-person	**fMRI #2: Decoding task** Tests of Ortho learning

B. Example of the Decoding trial



D. Participants

- N=32 neurotypical
- Mean age = 26
- Gender: F=21/M=9/ Other=2

E. Analysis

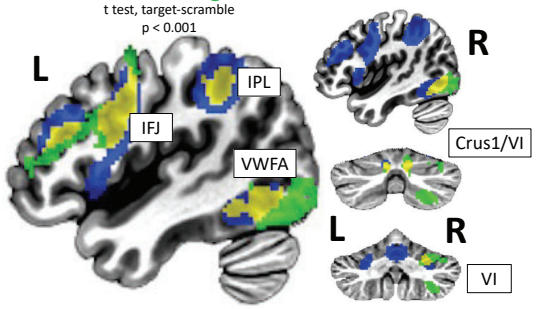
MD parcels:
- Fedorenko et al., 2013

Language parcels:
- Fedorenko et al, 2010

RESULTS

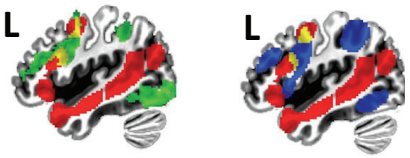
Decoding vs. MD network

t test, target-scramble
p < 0.001



1. There is a substantial overlap between brain regions activated during phonological decoding and the MD network (additionally: overlap in L SMA, L Precent, LR Insula, LR SPL, LR Inf Occ).
2. Activation in the dorsal regions (IFJ and IPL) is left-lateralized rather than bilateral.

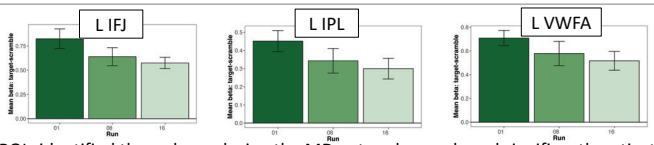
Decoding vs. Language network / MD network vs. Language network



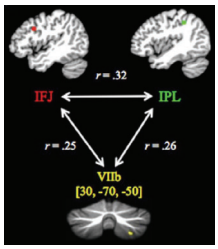
3. Our data and Language network overlap only where Language and MD networks overlap.

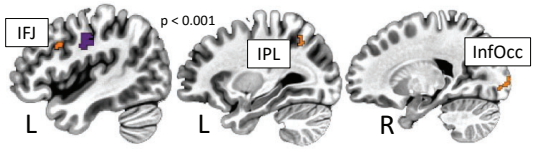
Decoding vs. Neurosynth reading network

4. Brain activation during novice decoding is different from that of skilled reading.

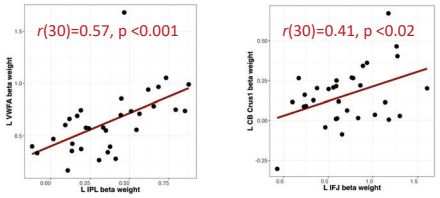


5. ROIs identified through overlaying the MD network parcels and significantly activated regions during decoding show a gradual decrease in activation across runs, implicating them in decoding and suggesting learning over time.





6. Greater brain activity during decoding of inconsistent as opposed to consistent words is observed in the ROIs previously implicated in the meta-analysis of reading development in Alvarez & Fiez (2018).



7. Brain activity in the identified ROIs correlates, suggesting they may underlie the same behavior.

CONCLUSIONS

- Our findings highlight differences in the brain networks supporting novice reading as opposed to skilled reading and are consistent with the idea that the nature of decoding changes over reading development.
- Phonological decoding in novice readers involves MD network rather than the Language or Reading networks.
- The lack of significant activation of the language network regions may be indicative of decoding that has not yet become lexicalized.
- Inferior Frontal Junction and Inferior Parietal lobe play a critical role in phonological decoding, which seems to be left-lateralized.

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1) Alvarez, T. A., & Fiez, J. A. (2018). Current perspectives on the cerebellum and reading development. *Neurosci & Biobeh Reviews, 92*, 55-66. 2) Fedorenko, E. et al. (2010). New method for fMRI investigations of language: defining ROIs functionally in individual subjects. *J of Neurophys, 104*(2), 1177-1194. 3) Fedorenko, E., Duncan, J., & Kanwisher, N. (2013). Broad domain generality in focal regions of frontal and parietal cortex. *Proc of the Nat Acad of Sci, 110*(41), 16616-16621. 4) Share, D. L. (2008). Orthographic learning, phonological recoding, and self-teaching. *Adv in Child Devel and Beh, 36*, 31-82. 5) Ziegler, J. C., Perry, C., & Zorzi, M. (2014). Modelling reading development through phonological decoding and self-teaching: Implications for dyslexia. *Phil Trans of the Royal Society B: Biol Sciences*, 369(1634), 20120397.