



The neurobiological profile of adult disabled readers supports the phonological deficit of dyslexia

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Reading and Dyslexia

Background

- The cognitive profile of reading disability is marked by phonological processing deficits.
- The neurobiological profile that has emerged recently includes decreased activity in posterior brain regions such as the superior temporal gyrus (STG), and particularly the occipitotemporal region (OT).
- STG is associated with phonological access (Fiez and Petersen, 1998); OT is associated with orthographic processing.
- Effects of orthographic frequency and familiarity have been found in OT (Kronbichler et al, 2004, 2007; Bruno et al., 2008).
- Developmental data have suggested that OT is a skill zone because activation increases as reading skill increases (Shaywitz et al., 2002).
- Researchers have interpreted increased activity in more anterior regions of poor readers (Inferior Frontal Gyrus; IFG) as a reflection of compensation; deficits in orthographic and phonological processing demand greater decoding and articulation effort.
- In light of these findings, it is of interest to examine the fMRI activation patterns of these regions in adult disabled readers who have become competent word readers – that is, they have developed sufficient orthographic skill.

Present Study

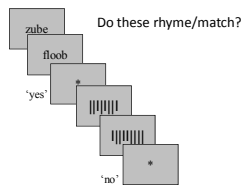
- Do neuronal responses to words, pseudohomophones, and pseudowords vary with reading ability?
- Does neuronal activity in the reading network correlate with individual verbal and reading abilities?

Participants

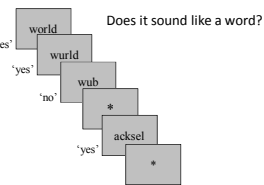
- Participants included 28 right-handed adults (15 nonimpaired; 13 reading disabled) with average to above-average nonverbal IQ scores (as assessed by Woodcock-Johnson Tests of Cognitive Ability, Woodcock, McGrew & Mather, 2001).

Design

ROI Localizer – Block Design
Rhyming vs. Barcode Matching

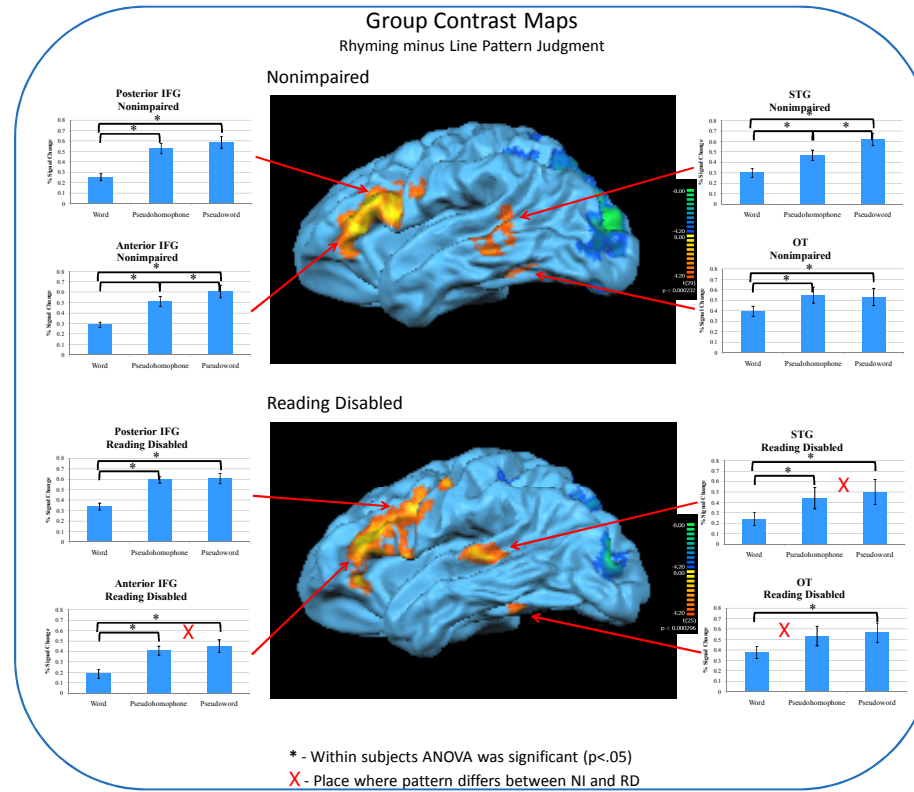


"Pseudohomophonix" – Event Related
Phonological Lexical Decision Task



Phonologically familiar [Words Pseudohomophones (PH) Pseudowords (PW)] Orthographically unfamiliar

Critical comparisons: PH vs. PW; difference reflects sensitivity to phonological familiarity.
Words vs. PH; difference reflects sensitivity to orthographic familiarity.
All stimulus types were equated for bigram frequency and orthographic neighborhood.



Results

- In STG and anterior IFG, the RD group displayed deficits in phonological sensitivity; activation by the phonologically familiar PH was equivalent to that by phonologically unfamiliar PW.
- Positive correlations were found between language skills and activation by PW in STG and activation by all word types in anterior IFG.
- In OT, the RD group displayed an overall deficit in orthographic sensitivity; activation by words did not significantly differ from PH. No overall activation differences or correlations with skill were detected.
- Negative correlations were found between language skills, excluding verbal IQ and reading rate, and activation by words in posterior IFG.
- In anterior IFG, words elicited greater activation in the nonimpaired group than in the reading disabled group.

Conclusions

- The pattern of results in STG and anterior IFG provide evidence for the phonological core deficit hypothesis. The findings also supports the hypothesis that dysfunction in OT is one of the markers of reading disability.
- The combination of the two observations in STG and anterior IFG – reduced activation and a lack of phonological sensitivity for reading disabled individuals – may account for the inefficient decoding and slow access to phonological representations observed in numerous behavioral studies.
- Negative correlations in posterior IFG with phonological skills may reflect phonological compensation.
- Previously reported activation differences in OT may be the result of variation in type of fMRI task, difficulty of task, sample age and reading ability, or fMRI localization methods.

Future Directions

- Two regions, anterior IFG and STG, reflected phonological deficits, but it is possible that the deficit originates in one and propagates to the other. In order to dissociate the two regions' functions, future imaging studies should examine the structural and functional connectivity between them.
- It is possible that OT underactivation is found in the childhood reading disability profile, and by adulthood (after many years of compensation or remediation) the dysfunction that remains is primarily a matter of tuning. Perhaps the OT "skill zone" interpretation is only applicable during reading skill development. Future studies should compare functional activation patterns in the reading network between reading disabled children and adults.

Activation – Skill Correlations

	STG Words	STG PH	STG PW	pIFG Words	pIFG PH	pIFG PW	aIFG Words	aIFG PH	aIFG PW
Word ID	0.10	0.17	0.33	-0.40	-0.29	-0.14	0.27	0.24	0.20
Word Attack	0.23	0.27	0.39	-0.32	-0.01	-0.11	0.50	0.48	0.40
TOWRE Word	0.00	0.03	0.14	-0.40	-0.10	-0.07	0.31	0.20	0.27
TOWRE Pseudoword	0.10	0.19	0.29	-0.52	-0.33	-0.16	0.18	0.22	0.23
Nelson-Denny Reading Rate	0.02	-0.02	0.01	-0.27	-0.09	0.06	-0.03	0.15	0.45
Memory for Words	0.03	0.07	0.22	-0.39	-0.30	-0.15	0.36	0.42	0.42
Sound Blending	0.08	0.26	0.40	-0.25	-0.17	-0.01	0.21	0.15	0.17
Spelling	0.09	0.12	0.24	-0.57	-0.34	-0.15	0.21	0.20	0.28
Phoneme Elision	0.16	0.32	0.43	-0.51	-0.26	-0.20	0.25	0.39	0.22
Verbal IQ	0.04	-0.06	0.07	-0.12	-0.18	-0.17	0.25	0.14	0.03

Red - Significant correlation (p<.05)