Neural effects of a tablet-based intervention in pre-readers at risk for dyslexia

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BACKGROUND AND AIM

- Early identification in dyslexia is very important since remediation is most effective at the onset of reading acquisition. However, remediation typically takes place only after years of reading failure, resulting in an increased gap between dyslexic and typical readers [1,2].
- There is recent evidence for widespread white matter training-induced plasticity in struggling readers who receive intervention [3], however very little is known on what the short- and long-term neural impact is of early intervention in children who haven't formally been taught how to read and how that compares to typical developmental patterns

- We aim to study neural training-induced effects in the context of a preventive intervention in young children. We are specifically interested in changes that can be uniquely attributed to the target intervention (reading-related training) and differ from typical neurodevelopmental patterns.
- We also aim to look at the underlying neurobiology of training-induced plasticity by using multi-modal MRI to quantify different white matter tissue properties

METHOD

60 children with an increased cognitive risk for dyslexia (<PC30 in PA& RAN, PA & LK or RAN & LK) and an additional group of 30 no-risk children were recruited for this study. All participants were native Dutch speakers in the last year of preschool. The at-risk groups received a tablet-based intervention which they played for 12 weeks, six days week in 15-minute sessions.

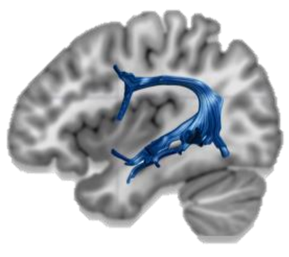
Cognitive risk	Yes	Yes	No
N (Male)	31 (15)	29 (16)	30 (14)
Mean age (SD)	5.5 (0.3)	5.5 (0.3)	5.6 (0.3)
Training condition	Graphogame (GG)	Active control (AC)	Control group (CG)



Multi-modal MRI (3.0 T)

- **DWI**: 3 b-values of 700, 1000, 2000 s/mm2 acquired at 119 non-collinear directions, voxel size=2.22×2.27×2.20 mm^3
- DWI pre-processing in mrtrix3 [4]
- Automated fiber tracking using AFQ [5]
- Tract property estimates (FA) were computed at 100 equidistant points along the tract.

Present analysis



- Focused on FA measured along the left arcuate fasciculus
- Three sub-groups of original sample:
  GG; N=18
  AC; N=13
  CG; N=14
- Generalized additive modeling (GAM) approach using the mcgv package in R [6]
- Model-predicted change in FA along the tract nodes

FIRST RESULTS

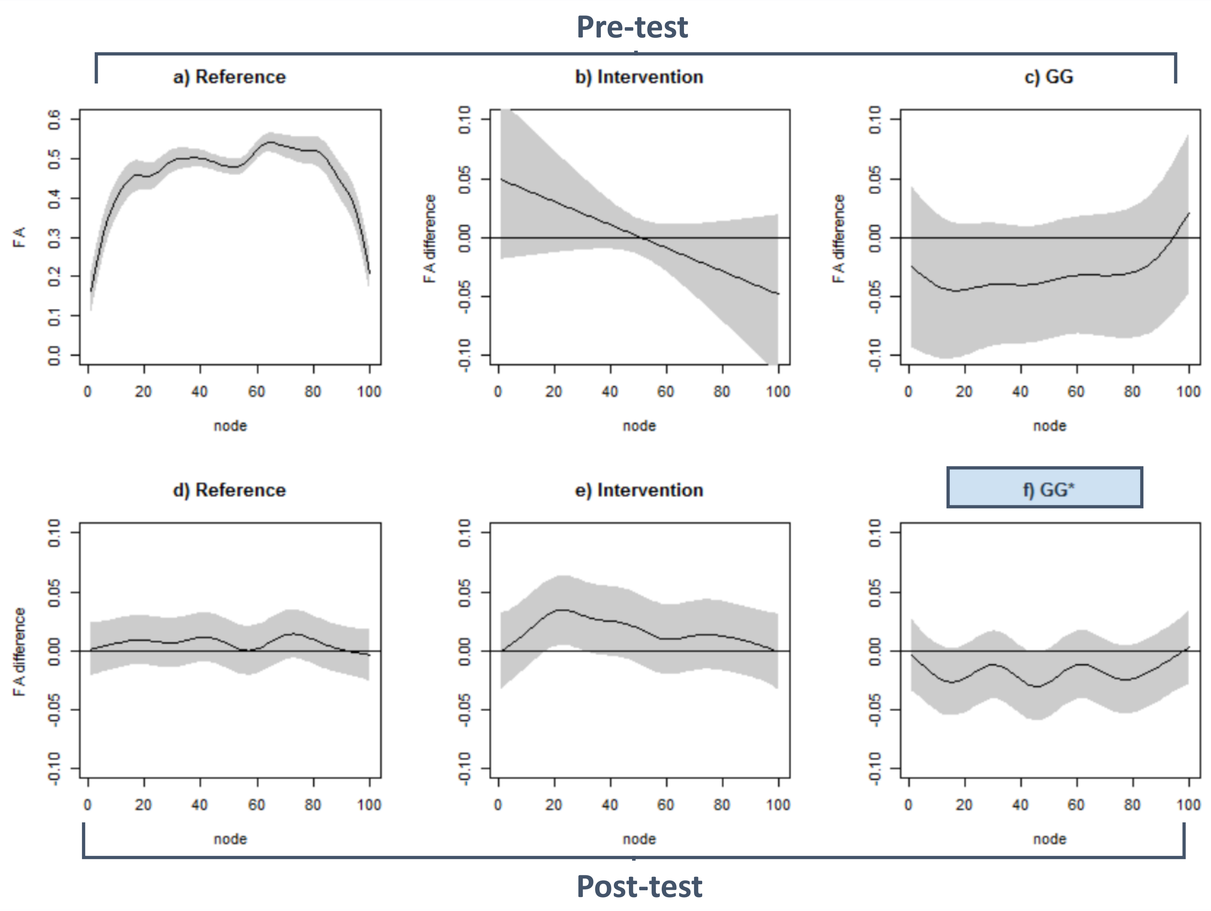


Figure 1. GAM results. Subplot a) shows the baseline for all children at pre-test, while subsequent plots represent the additive differences for the different contrasts. * represents significance at p<0.05. The shaded regions show 95% confidence intervals.

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Approximate significance of smooth terms:
                             edf  Ref.df      F p-value
Pre-test intervention      2.001   2.001  1.094  0.3349
Pre-test GG                5.355   5.806  1.671  0.1395
Post-test                  7.693   8.840  1.152  0.3458
Post-test intervention     7.658   8.722  1.143  0.3489
Post-test GG               8.606   9.462  1.930  0.0347 *
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R-sq.(adj) =  0.788   Deviance explained = 65.9%
fREML = 3748.5  Scale est. = 1         n = 8991


Model: fa ~ s(node, k = 20) + s(node, by = isIntervention)
      + s(node, by = isGG) + s(node, by = isPost)
      + s(node, by = isPostIntervention) + s(node, by = isPostGG)
      + s(id, node, bs = "fs", m = 1)
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TAKE HOME MESSAGE – NEXT STEPS

- FA along the trajectory of the arcuate seems to differ significantly post-intervention ; a change specific to the Graphogame group which is not seen in the active and passive control groups. The pattern of change suggests an overall decrease in FA from pre- to post, which is different to what we might initially expect and what was observed in previous studies looking at white matter change following intervention.

- Next steps include extending these analyses to include data for more children, as well as additional white matter pathways. Going further, we would like to combine different MRI indices to create a more informed tract profile that also provides insight on the neurobiological mechanisms that might drive the training-induced changes we observe.

[1] Wanzek, J.,Vaughn, S. (2007) 'Research-based implications from extensive early reading interventions', School Psychology Review, 36(4), pp. 541–561.
[2] Ozernov-Palchik, O. and Gaab, N. (2016). Tackling the 'dyslexia paradox': reading brain and behavior for early markers of developmental dyslexia. *Wiley Interdisciplinary Reviews: Cognitive Science*, 7(2), pp.156-176.
[3] Huber, E., Donnelly, P., Rokem, A. and Yeatman, J. (2018). Rapid and widespread white matter plasticity during an intensive reading intervention. *Nature Communications*, 9(1).
[4] Tournier, J., Smith, R., Raffelt, D., Tabbara, R., Dhollander, T., Pietsch, M., Christiaens, D., Jeurissen, B., Yeh, C. and Connelly, A. (2019). MRtrix3: A fast, flexible and open software framework for medical image processing and visualisation. *NeuroImage*, 202, p.116137.
[5] Yeatman, J., Dougherty, R., Myall, N., Wandell, B. and Feldman, H. (2012). Tract Profiles of White Matter Properties: Automating Fiber-Tract Quantification. *PLoS ONE*, 7(11), p.e49790.
[6] Wood, S. (2019). Mixed GAM Computation Vehicle with Automatic Smoothness Estimation. R package version 1.8-29

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