Longitudinal Development of Executive Functions in Children at Risk for Co-Occurring Dyslexia and ADHD

Silke Kellens[a,b], Rory T. Devine[c], Dieter Baeyens[a,b], & Pol Ghesquière[a,b]

[a]Parenting and Special Education Research Unit, Faculty of Psychology and Educational Sciences, KU Leuven, Leuven, Belgium

[b]KU Leuven Child and Youth Institute, Leuven, Belgium

[c]Centre for Developmental Science, School of Psychology, University of Birmingham, Birmingham, United Kingdom

Abstract (241 words)

Executive functions (EFs) play a critical role in academic achievement, yet the development of EFs in children at risk for co-occurring dyslexia and ADHD is poorly understood. Given the high co-occurrence of dyslexia and ADHD (15-40% overlap), and the link with the individual disorders, the current study aimed to investigate EF development in these children.

We assessed 186 children (49% boys), categorising them in 4 groups: at risk for dyslexia ("DR"), ADHD ("AR"), co-occurring dyslexia and ADHD ("DAR"), or not at risk ("NR"). They were tested at three time points: preschool (age 5), first grade (age 6), and third grade (age 8). Using confirmatory factor analysis, we examined the factor structure of EF in our sample at each wave. Additionally, latent growth curve modelling was employed to assess EF growth and to determine whether risk group membership predicted this growth.

Our results showed that a one-factor solution fitted the data best across all timepoints, with partial longitudinal measurement invariance. Latent growth curve modelling revealed that across the whole sample, half of the total change occurred between preschool and first grade (1-year period) and the other half between first and third grade (2-year period). The DR and DAR groups exhibited lower baseline EF levels and a steeper incline in growth trajectories compared to the NR group. This was the first study to examine EF growth in a preclinical population, providing essential insights into EF development and laying the groundwork for future research.

Extended summary (including table and references, 999 words)

Dyslexia and ADHD are among the most common developmental disorders [1, 2], and overlap in 15-40% of cases [3]. This co-occurrence has unique challenges, especially as children transition from preschool to primary schNoool. Since executive functions (EFs), cognitive skills necessary for regulating thought and behavior, are essential for school achievement [4, 5], understanding EF development in children with these co-occurring conditions is crucial. Research on EF deficits in dyslexia and ADHD has largely been conducted separately, and are more commonly linked to ADHD [6, 7] but are also observed in dyslexia [8]. In conclusion, given that most existing studies on the factor structure and development of EF have focused on typically developing children, our study aimed to investigate the factor structure of EF in a diverse sample of preschool children, using diverse measures and confirmatory factor analysis [9].

In this study, children were screened for dyslexia and/or ADHD risk [10]. The sample included 50 children at dyslexia risk (DR), 35 at ADHD risk (AR), 50 at risk for both (DAR), and 50 without risk (NR). We followed these children up for four years; in the last year of preschool (age 5), first grade (age 6), and third grade (age 8). We administered the same test battery to all children at each time point (Table 1).

Using confirmatory factor analysis, we fitted one-factor models for each time point. Longitudinal measurement invariance testing support configural invariance, indicating a consistent factor structure across time. We also found evidence for partial weak factorial invariance, meaning that most factor loadings of the indicators are consistent over time. Lastly, we achieved partial strong factorial invariance, showing that the majority of score levels are equal across time points.

Looking at the growth of EF, unconditional latent growth curve modelling (LGCM) provided good fit to the data, showing that initial levels of EF were significantly different from 0 across the whole sample and indicating an increase in EF over time. Results also showed that children with higher initial levels showed less growth in EF. Specifically, 52% of EF growth occurred between preschool and first grade, with the remaining 48% taking place between first and third grades.

Then, continuing with a conditional LGCM with risk groups as a categorical dummy predictor, the intercepts of the DR and DAR groups were significantly lower than the intercept of the NR group, but the intercept of the AR group did not differ from the NR group. Considering the slopes, the DR and DAR groups had a different growth rate than the NR group, but the AR group did not. Results also indicated that the DR and DAR groups experienced a steeper increase in EF compared to the NR group. However, on average, the DR and DAR groups do not reach the EF level

of the NR and AR groups, as the group differences persist with the same pattern at each time point.

In summary, we found that one-factor models best explained EF development across age groups (5, 6, and 8 years). This contrasts with previous studies that find differentiated EF structures from age 8, suggesting unique developmental trajectories in at-risk children. Growth models indicated that all children showed improvement in EF, with half of the overall EF change occurring between ages 5 and 6 and the other half between ages 6 and 8. Children at risk for dyslexia (regardless of ADHD status) started with lower EF baseline scores at age 5 but exhibited significantly faster growth compared to the children without risk. As multiple studies have established a link between EF and future achievement, this study again highlights the importance of monitoring EF deficits in children and the need for early interventions that target EF skills to support academic success. Future studies should include measures of school achievement and ecologically valid questionnaires to fully understand the educational implications of EF deficits in at-risk children.

Table 1 Overview of tasks.

Executive function	Task	Outcome
Working memory		
	Digit span forwards and backwards	Number of correctly repeated lists
	Nonword repetition task	Number of correctly repeated nonwords
	Corsi block forwards and backwards	Number of correctly repeated sequences
Inhibition		
	Go/no go task	No go accuracy
		Reaction time variability (inversed)
	Delay of gratification	Number of delayed rewards chosen
	Flanker fish	Accuracy difference between incongruent and congruent trials
Cognitive flexibility		
	Semantic fluency	Number of named items
	Shifting	Accuracy/time difference between rapid naming and shifting trials

References

1. Yang, L., et al., *Prevalence of developmental dyslexia in primary school children: A systematic review and meta-analysis*. Brain Sciences, 2022. **12**(2).
2. Thomas, R., et al., *Prevalence of Attention-Deficit/Hyperactivity Disorder: A systematic review and meta-analysis*. Pediatrics, 2015. **135**(4): p. e994-e1001.
3. Willcutt, E.G., et al., *Etiology and neuropsychology of comorbidity between RD And ADHD: The case for multiple-deficit models*. Cortex, 2010. **46**(10): p. 1345-1361.
4. Cortés Pascual, A., N. Moyano Muñoz, and A. Quílez Robres, *The relationship between executive functions and academic performance in primary education: Review and meta-analysis*. Frontiers in Psychology, 2019. **10**: p. 1582.
5. Vandenbroucke, L., K. Verschueren, and D. Baeyens, *The development of executive functioning across the transition to first grade and its predictive value for academic achievement*. Learning and Instruction, 2017. **49**(Supplement C): p. 103-112.
6. Willcutt, E.G., et al., *Validity of the executive function theory of attention-deficit/hyperactivity disorder: A meta-analytic review.* Biological Psychiatry, 2005. **57**(11): p. 1336-1346.
7. Pievsky, M.A. and R.E. McGrath, *The neurocognitive profile of attention-deficit/hyperactivity disorder: A review of meta-analyses*. Archives of Clinical Neuropsychology, 2018. **33**(2): p. 143-157.
8. Lonergan, A., et al., *A meta-analysis of executive functioning in dyslexia with consideration of the impact of comorbid ADHD.* Journal of Cognitive Psychology, 2019. **31**(7): p. 725-749.
9. Booth, J.N., J.M.E. Boyle, and S.W. Kelly, *Do tasks make a difference? Accounting for heterogeneity of performance of children with reading difficulties on tasks of executive function: Findings from a meta-analysis*. British Journal of Developmental Psychology, 2010. **28**(1): p. 133-176.
10. Kellens, S., D. Baeyens, and P. Ghesquière, *Cognitive profiles in preschool children at risk for co-occurring dyslexia and ADHD.* Education Sciences, 2024. **14**(4): p. 435.