

The contribution of auditory attention to reading processes of school-age children with and without dyslexia

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The overarching goal of the research presented in this dissertation was examining auditory attention as a potential contributor to individual differences in school-age children's reading abilities. This work is the result of an international and academia-industry collaborative effort between Birkbeck University, Maastricht University and the Regional Institute for Dyslexia (RID) in the Netherlands, established within the European Union's Horizon 2020 project INTERLEARN (Marie Skłodowska-Curie Grant agreement 721895). INTERLEARN was dedicated to characterising factors that might affect children's learning at multiple points in development, from infants to school-age children, towards the goal of individualising interventions based on a child's profile. Research questions of this PhD project stemmed from theoretical foundations as well as observations of the industrial partner. The results presented in this work have theoretical, clinical, and educational implications.

The first study investigated whether background speech can disrupt reading performance, and whether and why some school-age children may be more affected by background speech than others. More often than not, children perform their school tasks surrounded by a variety of acoustic distractions, and little is known about the effects of background noise or speech on their reading comprehension or speed. We found a differential effect of intelligibility and loudness of background speech, respectively affecting children's comprehension and reading speed. In addition, the intelligibility effect was larger in children with lower auditory interference control. To date, this is the first study investigating the effect of different types of background speech on online text reading performance of children. The results provided insight into the potential mechanisms through which background speech influences children's reading performance. They also identified auditory interference control as a source of inter-individual

variability in the susceptibility to the effects of speech on reading comprehension.

The next studies presented in this dissertation examined auditory attention and letter-speech sound learning as potential factors linked to reading fluency impairments in dyslexia and to dyslexia intervention outcomes. Disfluency is one of the most characteristic and developmentally persistent symptoms of dyslexia across languages. It is also less amenable to improvements after interventions, compared to reading accuracy. Persistent reading problems decrease individuals' quality of life and have potential academic, economic and psychosocial consequences. Thus, it is crucial to develop a better understanding of the risk factors leading to reading disfluency, and to evaluate effective diagnostic tools and treatments so as to prevent a cascade of psychosocial and societal economic costs.

The results of this thesis showed no group-level differences between children with and without dyslexia in behavioural and EEG measures of auditory selective attention and interference control. However, they did show that attentional abilities were associated with reading fluency impairments, and with difficulties in learning letter-speech sound associations. Furthermore, they provided evidence for the hypothesis that auditory attention is one of the factors underlying dyslexic children's difficulties with perceiving speech in complex environments. Finally, the last study suggested that selective attention to phonological information and letter-speech sound associations was predictive of dyslexia intervention outcome (with the proviso that the study was not a randomized controlled trial).

Altogether, this work showed that auditory attention may influence reading abilities by supporting fundamental processes underlying reading development. Improving our understanding of the prevalence and characteristics of attentional deficits in children with dyslexia will allow for

developing tools to identify and support children with compromised attentional skills even if these problems may not reach clinically significant cut-offs. Furthermore, the letter-speech sound learning task developed in this project was relatively short and child-friendly, and could be further developed for suitability in diagnostic assessments. The last exploratory study was informative as a starting point to understand whether attentional abilities interact with learning processes during interventions, and to contribute to explaining the observed large individual susceptibility in response to dyslexia treatment. Finally, the fact that children with poorer auditory attention skills found it harder to perceive speech with distracting speech in the background and were more affected by background speech while reading suggested that poor auditory attention (as well as the level of noise in the classroom) should be accounted for in educational practices, and represents a risk factor for general learning outcomes. In fact, educational information is usually conveyed orally, and after the first years of primary education, reading becomes a privileged tool for learning.

To summarize, the research presented in this thesis improve our understanding of the association between auditory attention and reading in school-age children, emphasise the heterogeneity of the factors leading to reading difficulties, and will help guide future directions in the field.

The findings have been presented at national and international scientific conferences and workshops, and to Marie Skłodowska-Curie European project representatives. The studies reported have been and will be published in open access scientific journals. Aspects of this research and more general concepts regarding dyslexia, attention and neuroimaging methods have also been communicated to the wider public. The electroencephalography (EEG) testing sessions were used as an opportunity to communicate to children notions regarding science and methods to investigate brain functions. For example, we demonstrated the neural signal and explained basic concepts regarding EEG. At the end of the study, results

have been shared with parents and children. Some parents made further contact with us to ask further questions regarding the study. Additionally, on the occasion of Brain Awareness Week in 2019, the results of this research were presented to secondary school pupils in the Netherlands.