

Neural correlates of (dys)fluent reading acquisition in typically reading and dyslexic children

Citation for published version (APA):

Zaric, G. (2016). *Neural correlates of (dys)fluent reading acquisition in typically reading and dyslexic children*. [Doctoral Thesis, Maastricht University]. Maastricht University.
<https://doi.org/10.26481/dis.20160203gz>

Document status and date:

Published: 01/01/2016

DOI:

[10.26481/dis.20160203gz](https://doi.org/10.26481/dis.20160203gz)

Document Version:

Publisher's PDF, also known as Version of record

Please check the document version of this publication:

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Chapter 7

Knowledge valorization

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A modern society is information based and most of the information is given in a written form. A successful and efficient processing, understanding, and remembering of the information is dependent on an individual's reading skills. Thus, timely and smooth acquisition of reading skills is a sine qua non for the successful completion of education, success in a large percentage of professions and, after all, the easiness of a daily life, foremost in urban environments. As computers and machines take over more and more of manual works from humans, more and more job descriptions are looking for individuals with higher education certificates than just a couple of decades ago. The technological advancements set new requirements for societies, a need for more engineers and programmers, and the increasing population asks for more doctors, dentists, and medical staff in general; more teachers, professors, administrative workers, lawyers, and so on. Although all these professions are very different in most of their demands, they all have one thing in common - they require good literacy skills (although anyone who tried to read a doctors' handwriting on a receipt would think differently!). Thus, literacy acquisition is not only important for the wellbeing of an individual, but it is an important skill for the society as a whole. The importance of this twofold social aspect of literacy, for individual members of society and for the society itself, is now recognized and literacy was set as a core goal of the UNESCO's 2006 worldwide campaign to bring "Education to All", with an accent on "the indispensable role that education – with literacy at its core – plays in bettering the lives of individuals, their communities and nations" (UNESCO, 2005).

Although reading is a highly complex and demanding skill, the vast majority of children is capable of mastering it. Nevertheless, one in every ten to twenty children has problems in acquiring proficient reading skills without any accompanying cognitive disability or lack of reading instructions and schooling (Blomert, 2005; Lyon et al., 2003; Snowling, 2013). These children are suffering from developmental dyslexia, "a specific learning disability that is neurobiological in origin" (Lyon et al., 2003). Due to their reduced literacy skills, these children are in danger of adverse academic, economic, and psychosocial consequences (Undheim and Sund, 2008; Undheim et al., 2011).

Despite substantial advancements in our understanding of the neurobiology of reading and dyslexia, reading dysfluency (a lack of fluency) remains the most persistent and impaired symptom in dyslexic individuals (Shaywitz, Morris, & Shaywitz, 2008). The NIHC ('Nationaal Initiatief Hersenen en Cognitie') project that funded this PhD thesis, aimed to gain insight in the brain networks involved in reading fluency development in dyslexia and to improve it through an intervention. As dyslexia is a developmental disorder, we examined neurophysiological correlates of letter-speech sound coupling and visual word recognition in 8-9 year old typical and dyslexic Dutch speaking children. Next to investigating group differences, we specifically focused on differences within the group of dyslexic children based on the severity of reading dysfluency. Moreover the project aimed to examine abnormalities in the reading network, by means of functional and anatomical connectivity at rest and during word reading. Importantly, we crossed the bridge on a gap between science and practice and explored the efficiency a reading training for dyslexic children in terms of both reading improvement and related changes in the brain responses.

As cognitive neuroscience is a relatively young scientific field, our understanding of how the brain processes information is still limited. Especially as we now know that this processing is not constant, but a function of development, i.e. children of different ages may exhibit different brain responses. This thesis, builds upon the existing knowledge on development of neural letter-speech sound integration and word processing by investigating how nine year old children process letters and speech sounds and visually presented words. We focused on neural time course correlates of these processes by measuring EEG in typically reading children and dyslexic children with different levels of reading dysfluency. Moreover, we studied functional and anatomical connectivity within the reading network using EEG measures of visual word recognition and anatomical (DTI) measures of white matter integrity. The children in our study had received 2.5 years of reading instruction ("groep 5" in Dutch educational system). At this stage neural letter-speech sound is still far from adult-like (Froyen et al., 2008, 2009), and, moreover, the

brain shows increased sensitivity for the orthographic and phonological material compared to both prereading children and adults (Maurer et al., 2006; Bonte and Blomert, 2004; Maurer et al., 2011). Thus, it is important to investigate how a child's brain responds to the basic reading skills, such as letter-speech sound associations, both when the children are successful in mastering reading and when they are not. In this way we are furthering our knowledge of how our brains work, but also we gain deeper understanding of the hurdles encountered by children (and adults) with dyslexia. In this thesis we go a step further and look at the brain responses, not only as a binary category of successful/unsuccessful, but as a continuous function of a reading fluency. This allowed us to investigate individual differences within a group of dyslexic children and to show that the more severe the impairment of reading fluency, the more their brain responses and anatomy differ from those of typically reading children. This type of findings has a twofold importance. First, it can lead towards discovery of neural markers of dyslexia, leading to a better diagnostics. Second, as also indicated in this thesis, it can help in tailoring reading trainings towards the need of specific subgroups, and, ultimately (with the advancement of brain and behavioral measurements and knowledge), of specific individuals.

The goal of this thesis was not only to search for the possible benefits in the future, but to investigate if the currently provided help is efficient and for whom. Thus, we went out of, as some would call it, "a tower of academia" to the society, and related reading gains accompanying a six month reading training with the changes in the brain. Our work shows the benefits of reading practice, both behaviorally and electrophysiologically. First, both latency and amplitude of the late negativity (LN, 600-750ms) could be a marker of a successful letter-speech sound integration, as both dyslexic groups differed in the late negativity window from typical readers, and earlier LN was related to better letter-speech sound coupling after training. Second, it also warrants for the further modification to help the most severely dysfluent readers, as the timing of the early crossmodal change detection responses (MMN, 100-250ms), that significantly differed between the groups based on fluency, may provide a

biomarker that could contribute to a better prediction of reading gains and/or individual tailoring of dyslexia training/intervention strategies (Leppänen, 2013).

Consequently, the results presented in this thesis are of interest to individuals suffering from dyslexia and their families, especially the parents of the children with developmental dyslexia, professionals providing reading trainings, such as Regionaal Instituut Dyslexie (RID) and IWAL Instituut voor leerproblemen in the Netherlands, for educational institutions, to adapt exams, e.g. longer time for written exams, for the pupils/students with dyslexia, and finally to provide lawmakers with specific and objective criteria with respect to diagnostics and reading trainings to guide their policy with respect to healthcare insurance, e.g. as is currently the case in the Netherlands.

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