

/Aba/ or /ada/, that is the question

Citation for published version (APA):

Romanovska, L. (2021). */Aba/ or /ada/, that is the question: Longitudinal investigation of letter-speech sound processing in children with and without developmental dyslexia*. [Doctoral Thesis, Maastricht University]. Maastricht University. <https://doi.org/10.26481/dis.20210412lr>

Document status and date:

Published: 01/01/2021

DOI:

[10.26481/dis.20210412lr](https://doi.org/10.26481/dis.20210412lr)

Document Version:

Publisher's PDF, also known as Version of record

Please check the document version of this publication:

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Learning to read involves making associations between spoken words and symbol strings (text). It has been proposed that this coupling of spoken and written language may be particularly difficult in children with dyslexia. The research conducted in the scope of this doctoral thesis aimed to explore how the coupling between letters and speech sounds differs in children of varying reading skills, including children with dyslexia. We conducted a three year longitudinal study with annual measurements, which allowed us to follow the dynamic, individual developmental changes in the neural processing of these couplings. To study learning processes involved in coupling letters to speech sounds we used a novel text-based recalibration paradigm in which the combination of “aba” or “ada” text with an ambiguous speech sound /a?a/ mid-way between /aba/ and /ada/ temporarily biases children’s perception of the ambiguous sounds towards the text. To investigate how children’s brains processed the letters and speech sounds we looked at the behavioural task performance (i.e. whether they perceived the ambiguous sound as /aba/ or as /ada/ after text exposure) as well as brain activation during the task using magnetic resonance imaging.

Despite similar behavioural task performance, children with and without dyslexia showed different brain activation in response to letters and speech sounds. Namely, children with dyslexia showed less brain activation in an area involved in text processing compared to typically reading children, indicating that they may have additionally relied on other brain areas to successfully link letters and speech sounds. We also saw that regardless of whether or not a child had dyslexia, more activation in this brain area was associated with better reading skills. Moreover, children who were slower in combining letters and speech sounds, regardless of dyslexia diagnosis, had more activation in auditory brain areas important for successfully linking of speech and text. These findings show that reading proficiency is closely associated with brain activation, with differences between poor and fluent readers represented as increased or decreased activation depending on the brain area and its role in reading.

We also explored developmental changes in brain activation of typical readers during a three year period when the children came to our scanning facility once a year. We found that a brain area involved in speech processing and important for linking letters to speech sounds is activated more strongly when children are nine years old as compared to ages 8, 10 and 11. These findings suggest that there is a specific time window when children learn to read, during which their brains are more

sensitive to letters and speech sounds. This time window around age nine has been proposed to indicate a turning point in text processing. Namely, around this time, children start to rely less on explicit sounding out and linking of letters and speech sounds and instead begin to process text more automatically.

To summarize, the research reported in this dissertation has shown that brain activation is tightly linked to children's reading skills and, importantly, that different brain areas may be active in children with and without dyslexia to perform the same task. The observed associations between brain activation and reading skills have shown the importance of taking into account children's reading performance when researching and interpreting brain activation results, regardless of a dyslexia diagnosis. Our findings have enhanced the reading research field and will help improve our understanding of reading development, as well as provide new directions for future studies. The close links between brain activation and reading skills observed in our research are informative for dyslexia healthcare institutes as well as readers with dyslexia and their families, as it helps them better understand the neural mechanisms involved in reading and dyslexia and guide remediation and education.

The research findings reported in this dissertation have been presented in international scientific conferences and are continuously communicated to the families who took part in the research. We publish all of our most recent findings on our research group's website¹ and communicate this to the parents via e-mail. This website was created at the beginning of the project ('Project Leeswinst') and alongside updates of our findings, contains useful and practical information about the study for the participating families. In addition to scientific conferences that allowed us to interact with and gain feedback from experts with diverse scientific backgrounds, we also organised a children conference in February 2019 for the families of children participating in our longitudinal research project. The conference was organized during the afternoon and included a children-focused presentation about reading development, dyslexia and the brain, colourful poster

¹ <https://mbic-languagelab.nl/en/>



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presentations with updates on our research findings and a tour of the scanning facility for the family members who had not previously accompanied our participants. This offered the children and parents an opportunity to ask questions about the research and more general topics related to reading, brain development and brain scanning. Beyond the communication to families, the conference was also reported in a regional newspaper² disseminating our findings to the general audience and raising awareness of developmental research in Maastricht. Furthermore, representatives of the regional dyslexia institute attended the conference and asked insightful questions about our findings and their relevance for dyslexia remediation. Overall, our research project aimed to link brain activation to reading performance in children during the first years of reading instruction to better understand reading development and reading difficulties underlying dyslexia. The findings were informative for both, the scientific community as well as the children and families who took part in the research.

² https://www.limburger.nl/cnt/dmf20190220_00093446

