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Speaking of Reading. The Role of Basic Auditory and Speech Processing in the Manifestation of Dyslexia in Children at Familial Risk

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Summary

Dyslexia affects approximately 3 to 10% of the population. For children with a dyslexic parent, the risk of developing reading problems is significantly higher: 40 to 60% of children at genetic risk becomes a poor reader. What exactly causes reading problems is unclear, though deficits in phonological skills are generally acknowledged to relate to dyslexia. Knowledge about the phonological structure of language is extracted from the speech signal. Unsurprisingly, auditory and speech perception are thus often thought to be important for the development of apt phonological skills. Moreover, neuroimaging and neurophysiological research has demonstrated that brain networks that are employed for processing auditory information like speech, and networks employed for phonological processing and reading, largely overlap. Based on this information, a link between dyslexia and auditory and speech processing is expected. Indeed, several studies have shown speech processing deficits in dyslexia to be present. Yet, most of these studies did not include children at familial risk with and without reading problems. It is of importance to do so, to exclude the possibility that speech processing deficits, like deficits in phonological processing, are shared between familial risk children with and without dyslexia. If the latter is the case, these deficits might not actually contribute to the manifestation of reading problems, but be a characteristic of familial risk instead. Thus, the fact that most studies did not investigate children at familial risk for dyslexia may possibly have been a confounding factor. The studies in this thesis aimed to investigate whether auditory and speech processing are factors contributing to the manifestation of dyslexia, thereby taking familial risk status into account by including three groups of children: a control group without familial risk, a familial risk group without dyslexia (FRND), and a familial risk group with dyslexia (FRD). Studies were carried out on a behavioral as well as a neural level.

First, pre-attentive basic auditory processing was assessed in 11-year-old children (Chapter 2). Using ERPs, processing of amplitude rise time, frequency and intensity was assessed. Amplitude rise time detection is implicated in the perception of rhythm in speech, which provides important cues about syllable onset and rime. This may influence the perception of phonemes, and therefore affect reading skill. In our study, no differences in amplitude rise time processing were found at all. All three groups were able to discern rise time differences at age 11. Intensity processing, however, was problematic for the two groups of FR children. Only control children were able to discern intensity differences. Difficulties in processing intensity thus appeared to be a characteristic of familial risk children. Amplitude rise time processing is not implicated in reading ability or familial risk at age 11 at all.

After basic auditory processing, the next step was to investigate pre-attentive speech processing (Chapter 3). Adults and infants who would later develop dyslexia have been shown to have impaired speech processing on a neural level. In our study, processing of vowels and inflected words was examined using ERPs, to investigate whether complexity of the stimulus, i.e. lexicality and grammatical inflection versus a simple phoneme contrast, affected neural processing of speech. The results showed that, independent of lexicality, poorer speech processing was associated with dyslexia. Familial risk children without dyslexia and control children were better at processing vowel contrasts and words.

The ERP method in Chapter 3 allowed for the investigation of lateralization of speech processing. Evidence from neuroimaging literature suggests more symmetrical processing (i.e. activity in the right and left hemisphere, instead of a left hemispheric specialization for speech) to give rise to dyslexia. More symmetrical processing is associated with inefficient processing networks. Therefore, in Chapter 3, lateralization of speech processing was addressed as well, taking into account the lexicality of the stimulus (vowels versus words), since inflected words have been demonstrated to lateralize more strongly. However, results showed that both vowels and words lateralize to the left hemisphere. More importantly, no differences in lateralization of speech processing could be found between our three groups. Lateralization of speech processing on a neural level is therefore not associated with familial risk and dyslexia.

Chapter 4 also investigated lateralization of speech processing, using the behavioral dichotic listening method. In dichotic listening, participants are presented with a different stimulus to each ear simultaneously. The ear which is reported from most often, is dominant. It is thought that information is processed contralaterally. For example, if the right ear is dominant, this indicates left hemisphere dominance. As such, dichotic listening can provide a behavioral index of lateralization and support and extend neuroimaging findings. In our study, dichotic listening was measured at two timepoints, in Grade 3, and in Grades 5/6. At both timepoints, it was found that speech processing was lateralized to the left hemisphere in all groups. However, looking at the reports from each ear, we found that the FRD group was poorer at reporting from their left ear, which could indicate impeded right hemisphere processing. Reduced left ear performance thus relates to the manifestation of dyslexia.

Lastly, categorical speech perception was investigated (Chapter 5). Poorer categorical perception has previously been related to dyslexia and has also been found at a pre-reading age, indicating it is a possible precursor of poor reading. The current study investigated categorical perception in FR children in Grade 3, after determining the reading level of the children. We found impediments in categorical speech perception skills to be specific to poor readers, and thus to contribute to the manifestation of reading problems. Controls and FRND children performed at an equal level. Additionally, we investigated whether cascading relations between speech processing, phonological processing and reading were present. No clear evidence for a cascading relation between speech processing, phonological skills, and reading was found.

Taken together, the findings of the reported studies suggest that deficits in basic auditory processing relate to being at familial risk for dyslexia. On the other hand, impeded speech processing, both on a neural and behavioral level, contributes to the manifestation of reading problems. Yet, it appears that these speech processing deficits are generally not related to phonological skills. The implications of these findings are further discussed in Chapter 6.