Electrophysiological correlates of phonological and temporal regularities in speech processing

Appendix

Impact Paragraph

The goal of the current research was to investigate how the brain uses familiar patterns of speech sounds (here: combinations of consonants) and speech rhythm (here: stress patterns) to process speech more efficiently. Every language has its own characteristic patterns in speech sounds and speech rhythm. For example, in Dutch the consonant combination -ts- is fairly common, while the combination -tk- is less common. The probability of different combinations of speech sounds is called phonotactic probability, so we could say that the pseudoword *notsal* has a high phonotactic probability compared to the pseudoword *notkal.* Similarly, first syllable stress is more common than second syllable stress in Dutch. Some theories suggest that implicit knowledge of these patterns can be used to anticipate or predict upcoming speech input. This can be particularly useful in situations where we cannot hear the speaker properly, such as when we are in an environment with background noise like a noisy bar, or when the sound on our Zoom call is disrupted because of poor internet connection. We know from previous studies that being able to learn these patterns is important for developing typical language and reading skills. Therefore, we also studied whether adults with dyslexia are able to use these familiar patterns in the same way as typical readers.

The current research used electroencephalography (EEG), which is a non-invasive method of measuring electrical brain activity through electrodes that are placed on the scalp. Our main findings highlight that familiar patterns of speech sounds (as in the pseudoword *notsal*) allow native Dutch speakers to process speech more efficiently, but that this effect is reduced in dyslexic adults. In contrast, differences in stress patterns (first vs. second syllable stress) did not appear to influence how Dutch speakers process pseudowords presented in isolation. This dissertation has also highlighted that changes in sound combinations and speech rhythm are processed with different brain mechanisms, which we can observe through different changes in neural oscillations. Finally, we show preliminary evidence suggesting that regularities influence speech processing differently depending on whether the speech is self-generated or externally presented.

By studying dyslexic readers, this dissertation extends our understanding of reading difficulties to inform research leading to future interventions. Developmental dyslexia is characterized as persistent reading difficulties despite adequate schooling. Reports of the prevalence of dyslexia range from 3% to values as high as 20%,

however, these estimates vary due to differences in diagnostic criteria across countries and institutions, as well as different characteristics of languages such as orthographic transparency. Developmental dyslexia can have a substantial impact on the individual later in life, as it is associated with poor outcomes in a range of domains including academic and professional success as well as emotional wellbeing. Thus, early diagnosis and intervention is crucial for improving later life outcomes. Recent theories propose atypical processing of rhythm may be an underlying risk factor for various developmental language difficulties, such as dyslexia and specific language impairment. While we were unable to find evidence for atypical processing of speech rhythm in Dutch adult dyslexic readers, previous studies have shown differences in neural sensitivity to variations in syllable stress in pre-reading children who later develop reading difficulties. Future approaches could apply the paradigm used in Chapters 2 and 3 to pre-reading children, to study differences in the developmental trajectory of a sensitivity to syllable stress regularities and phonotactic probability and their relationship with phonological, rhythmic and reading skills at different stages of development. Such investigations could eventually give insights into potential early markers for dyslexia, to allow for early detection and intervention.

The research in this thesis has been presented at several international scientific conferences to contribute to scientific exchange and progress in the field. All findings reported in this thesis either have been or will be made publicly available via publication in open access journals to support accessibility of the generated knowledge. In addition to communicating with the scientific community, aspects of the current research have also been shared with the general public in the Netherlands, Germany and the United States, including introductions on how to study the brain for children and adolescents in primary and secondary schools as well as talks for bachelor students in linguistics to introduce them to the interdisciplinary field of studying language in the brain, and online events highlighting the work of women in science at Maastricht University. To promote accessibility of science communication to non-English speaking communities, the research has also been shared with a German-speaking audience.