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Development and application of a /bAk/–/dAk/ continuum for testing auditory perception within the Dutch longitudinal dyslexia study ☆

Florien J. van Beinum [a,*], Caroline E. Schwippert [a], Pieter H. Been [b,c], Theo H. van Leeuwen [d,e], Cecile T.L. Kuijpers [f]

[a] *Institute of Phonetic Sciences/ACLC, Herengracht 338, University of Amsterdam, 1016 CG Amsterdam, The Netherlands*
[b] *BCN Neuroimaging Center, University of Groningen, The Netherlands*
[c] *Department of Dutch, University of Groningen, The Netherlands*
[d] *Faculty of Behavioral and Social Sciences, University of Amsterdam, The Netherlands*
[e] *Department of Clinical Neurophysiology, Municipal Hospital Slotervaart, Amsterdam, The Netherlands*
[f] *Department of Special Education, Radboud University Nijmegen, The Netherlands*

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Abstract

A national longitudinal research program on developmental dyslexia was started in The Netherlands, including auditory perception and processing as an important research component. New test materials had to be developed, to be used for measuring the auditory sensitivity of the subjects to speech-like stimuli from birth until the age of 10 years. This paper describes the subsequent steps and experiments in developing the auditory test material. Several experiments showed that dyslexic adults, as compared to a control group, were less accurate and slower in discriminating phoneme contrasts with subtle acoustic differences. The continuum developed so far, was tested in an experiment using a mismatch negativity paradigm applied in an adult control group. Results of this ERP study indicated that reliable mismatch negativity could be obtained which warrants the application of the paradigm and the stimuli to be appropriate for the currently running Dutch longitudinal dyslexia study.

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* Corresponding author. Tel.: +31 20 5252183; fax: +31 20 5252197.
E-mail addresses: f.j.vanbeinum@uva.nl (F.J. van Beinum), caroline.schwippert@hetnet.nl (C.E. Schwippert), p.h.been@let.rug.nl (P.H. Been), t.h.vanleeuwen@uva.nl (T.H. van Leeuwen), c.kuijpers@pwo.ru.nl (C.T.L. Kuijpers).

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1. Introduction

Developmental dyslexia is a language disorder that is genetic in origin and touches on many aspects of human brain functioning. The disorder is related to problems in auditory (phonological) processing (Bradley and Bryant, 1993). A majority of dyslexics have phonological deficits, and their reading of pseudowords, for instance, is far below that of children with the same reading age. This is visible not only in the accuracy scores but also in the processing time (Sprenger-Charolles et al., 2000).

The deficit may arise from a specific problem in the access to phonemic representations. Many dyslexic children have a deficit in speech perception. Their phoneme discrimination is relatively weak, since they discriminate pairs of syllables that differ by only one phonemic feature less accurately than average readers (Adlard and Hazan, 1998; Reed, 1989; Snowling, 2000). Although it takes years to acquire stable phoneme categories (Werker and Polka, 1993; Kuijpers, 1996), it seems that dyslexic children keep a relatively weak representation of speech sounds as evident from a categorical perception deficit in dyslexia. As compared to normal readers, dyslexic children and adults are frequently reported to be less consistent in classifying ambiguous speech sounds and in discriminating subtle contrasts between speech sounds such as stop consonants (e.g. Werker and Tees, 1987; Serniclaes et al., 2001; Reed, 1989) or some other phoneme contrasts (e.g. Richardson, 1998). Categorical perception corresponds to the ability to perceive acoustic differences between speech sounds that belong to different phoneme categories, and to ignore differences of the same acoustic magnitude between speech sounds that belong to the same phonemic category (Liberman et al., 1957).

Serniclaes et al. (2001) indicate that the difference between dyslexics and controls can be reliably shown, provided that the data are collected in appropriate conditions. To find a reliable difference between groups the contrasts must be nor too easy nor too difficult for the control subjects. Taking into account the importance of these contextual demands, they found that dyslexic children discriminated speech sounds belonging to different phoneme categories less accurately than reading age controls, but they were better at discriminating acoustic differences within the same phoneme category. They argue that this might reflect a higher sensitivity to allophones (variants of the same phoneme), leading to an enhanced within-category discrimination, but a diminished phoneme discrimination. Serniclaes et al. (2004) investigating perception of allophonic variants of the French voicing contrast, found that nine-year-old dyslexic children tend to discriminate three voicing categories, which is a discrimination profile closer to that of pre-linguistic children. They argue that dyslexic children have a deficit in the development of phonetic pre-dispositions. Consequently, the process of identifying the number of independent categories might be endangered, since allophones are still considered as categories. A child that perceives allophones instead of phonemes will have difficulty in attributing the same written symbol (e.g., ''p'') to sounds belonging to different categories in his/her oral repertoire (/p/ and /p^h/).

As phonological processing is related to auditory perception and processing, it is not surprising that auditory perception of speech has repeatedly been found to correlate with reading performance. Much evidence points to a deficit in the processing of rapidly changing information that, for example, is present in rapid acoustic transitions between phonemes (Tallal, 1980; Kujala et al., 2000). There are many possible explanations for this. Some claim there is a problem in general auditory temporal processing (Tallal, 1980), others argue the effect has to do with a more specific phonological processing deficit (Mody et al., 1997). These behavioural studies confirm that dyslexic subjects perform worse in *attentive* discrimination tasks when the speed of acoustic formant transitions was manipulated. In addition, dyslexics also show impaired *pre-attentive* processing of auditory