The present study addressed auditory processing in dyslexic 8-11-year old children by the means of event-related brain potentials (ERP). Cortical sound discrimination was evaluated by analyzing the mismatch negativity (MMN) to syllable and tone changes. We found that cortical sound discrimination was impaired in dyslexic children. The analysis of the data obtained from two dyslexic sub-groups, Dyslexics-1 being impaired in non-word reading (or both non-word and frequent word reading) and Dyslexics-2 in frequent word reading but not in non-word reading, revealed that the MMN was specifically diminished in the latter group whereas it was normal-like in Dyslexics-1. These results show that different diagnostic sub-groups of dyslexics have different patterns of auditory processing deficits. This may underline the importance of psychophysical and psycho-physiological paradigms for research on and treatment of specific learning disabilities and generally for educational and applied sciences.

Phonological discrimination is known to be an indicator for the quality of phonological coding. However, there is a serious discourse about whether or not phonological deficits are due to a more general, that is, a non-linguistic, auditory low-level dysfunction, such as a temporal processing deficit, which is either assumed to be of general nature or specific to the auditory domain. According to a number of authors (e.g., Tallal, 1980) low-level processing deficits cause problems in discriminating rapid temporal chances (as typical for speech), and thus, disturb the adequate development of phonological
codes up from an early age in childhood on. Other authors failed to find low-level auditory deficits in Dyslexics (e.g., Snowling, 2001).

Two reasons may account for the inconsistency of results in this respect. The first is that most of these studies are behavioral and therefore, they can only be used under restriction in order to decide on whether the revealed phonological problems are the result of a low-level deficit. The second is that diagnostic subgroups are not considered in most of the studies. According to the Functional Coordination Deficit model of reading disability (Lachmann, 2002), a failure in reading may in some Dyslexics be caused by a low-level deficit while not others.

For these reasons, in more recent study (Lachmann, Berti, Kujala and Schröger, subm.) both phonological and non-phonological auditory discrimination skills were tested in subgroups of Dyslexics and in Controls using event-related potentials (ERPs), allowing one to specify temporal and spatial components of the information processing before the response to a given task is made. In a number of studies, ERP parameters such as latency and amplitude of different potentials were found to discriminate between Dyslexics and Controls. For instance, for oddball tasks, in which the ERPs to so-called deviant sounds, which are presented amongst a row of standard sounds, were compared between groups, Breznitz and Meyler (2003) found significant group differences.

A paradigm which was developed in order to measure the pre-attentive processes underlying sound discrimination is the so-called Mismatch Negativity (MMN) paradigm (cf., Näätänen, 1992; Schöger, 1997). The MMN is an evoked cortical potential that reflects the outcome of an automatic comparison between acoustic stimuli when a deviant is presented randomly at a certain rate among repetitive standard stimuli. The MMN results from the difference between the ERP evoked at about 100-250 ms after deviant-stimulus onset and that evoked by the standard stimulus.

The MMN has already been applied in order to study dysfunctions in Dyslexics. One of the first studies was carried out by Schulte-Körne and colleagues (Schulte-Körne, Deimel, Bratling and Remschmidt, 1998), who compared syllable (/da/ vs. /ba/) and tone (1000 vs. 1050 Hz) discrimination with the MMN in dyslexic teenagers and Controls. They found that, whereas the MMN amplitude elicited by the tone deviant did not significantly differ between the Dyslexics and Controls, the MMN elicited by the syllable deviant was diminished in Dyslexics. They interpreted their results in terms of a speech-specific pre-attentive processing deficit in Dyslexics.

At about the same time, Baldeweg and colleagues (Baldeweg, Richardson, Watkins, Foale and Gruzelier, 1999) found a diminished MMN for tone deviants in dyslexic adults. In their study, the MMN was different between Dyslexics and Controls for pitch deviants (standard: 1000 Hz, deviants: 1015, 1030, and 1060, but not for 1090 Hz), which suggests a non-speech specific auditory deficit underlying phonological processing deficits in Dyslexics. The group difference was found to be larger the smaller the difference between the deviant and standard was. The MMNs elicited by duration differences, however, did not differ between the groups.

In our recent study we the MMN paradigm in order to investigated the neuronal processing of tones and phonemes in twelve Controls (7 female; mean age 9.3, .6 SD; mean IQ = 104, 11 SD) and 16 Dyslexics (8 female; mean age 9.3, .5 SD; mean IQ = 96, 19 SD), which did not differ in age, grade, and intelligence. Two conditions were applied: *Phonological*: consonant-vowel syllables /ba/: /da/

*Non-phonological*: sinusoidal tones of 700 Hz versus 770 Hz.
The probability for the deviant stimuli was 12% in all blocks and conditions. The children were watching a self-selected adventure movie without sound while the sound stimuli were presented through headphones with about 70 db. The EEG was measured at F3, FZ, F4, CZ, PZ of the 10-20-system and left and right mastoids, referred to the nose.

A very important purpose of the Lachmann et al. study was to investigate the neuronal processing of linguistic and non-linguistic material in subgroups as evaluated by diagnostic tests. In this respect, the reading time in the subtests non-word-reading (NWR) and frequent-word-reading (FWR) from the Salzburger Lese- Rechtschreibtest (SLRT, Landerl and Wimmer, 1997) were used to differentiate subgroups of dyslexic children. There were eight children (five female, mean age = 9.4, .6 SD; IQ = 98.9, SD 23) which performed 2 SD below the reference population in NWR or both tests and, therefore, were identified as having at least phonological problems. This subgroup of Dyslexics will be termed as Dyslexics-1. In the literature it is often argued that these children should show problems in phoneme discrimination. Another eight children (three female, mean age = 9.1, SD = .4; IQ = 93, SD 14) performed NWR equally with the reference population but failed in FWR (2 SD below the reference population). This subgroup will be termed Dyslexics-2. According to many authors (e.g., Boder, 1970), they should have other than phonological deficits (more related to the visual domain).

Figure 1. MMN for Syllables and Tones for Controls and Dyslexics.

The results of the MMN analysis are displayed in Figure 1. Significant MMNs were found for Dyslexics-1 in both conditions whereas Dyslexics-2 had no significant MMN in either stimulus conditions. There was a significant group main effect, but no interaction. It was revealed that for F4 the Dyslexics-2 differ from Dyslexics-1 and Controls, but the latter two do not differ. Stimulus specific analyses revealed that these
differences are present for the syllable condition only. These results confirm the importance of the consideration of diagnostic subgroups in dyslexia.

Taking other results (Fuchs and Lachmann, 2003; Lachmann, 2003), it was concluded that Dyslexics-1 have a low level auditory reception deficit affecting grapheme-to-phoneme-conversion. In contrast, Dyslexics-2 may be characterized by a low level auditory reception deficit affecting phoneme discrimination; both represents a temporal processing deficit affecting the time of activation of phonological representations.

In another recent study (Witruk, Gräfe and Lachmann, in prep.) a behavioral same-different task was applied in order to search for specific deficits in dyslexics. Dyslexic children and controls were asked to compare two successively presented linguistic (letters) or non-linguistic (dot-patterns) items. It was found that dyslexics show differences in both the processing of linguistic and of non-linguistic material. For linguistic material, however, it was found that dyslexics relay more on those visual processing strategies which are used by controls only for non-linguistic material.

These results underline the importance of psychophysical and psychophysiological paradigms for research on, and treatment of specific learning disabilities, and generally for educational and applied sciences.

References


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