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Coherent motion detection in preschool children at family risk for dyslexia

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Abstract

We tested sensitivity to coherent motion (CM) in random dot kinematograms in a group of 5-year-old preschool children genetically at risk for dyslexia, compared to a group of well-matched control children. No significant differences were observed, either in a group analysis or in an individual deviance analysis. Nonetheless, CM-thresholds were significantly related to emerging orthographic skills. In a previous study on the same subjects (Boets, Wouters, van Wieringen, & Ghesquière, in press), we demonstrated that both risk groups already differed on measures of phonological awareness and letter knowledge. Moreover, auditory spectral processing (especially 2 Hz FM detection) was significantly related to phonological ability. In sum, the actual visual and previous auditory data combined, seem to suggest an exclusive relation between CM sensitivity and orthographic skills on the one hand, and FM sensitivity and phonological skills on the other.

Keywords: Dyslexia; Preschool children; Motion Coherence; Auditory frequency modulation; Magnocellular

1. Introduction

Developmental dyslexia is a specific failure to acquire reading and spelling skills despite adequate intelligence and education, affecting around 5–10% of children and adults. The predominant etiological view postulates that dyslexia results from a phonological deficit (Snowling, 2000). However, extensive research during the last decade also demonstrated a specific sensory processing deficit in individuals with dyslexia and it has been suggested that this deficit might be causal to both the observed phonological and literacy problems (Farmer & Klein, 1995; Stein, 2001). To investigate the assumed causality of this sensorial deficit hypothesis we assessed auditory and visual processing in two contrasting groups of 5-year-old preschool children, a genetically high risk and a genetically low risk group. In a previous paper (Boets, Wouters, van Wieringen, & Ghesquière, in press) we reported the absence of a significant group difference for any of three administered auditory measures, in the presence of a significant difference for phonological awareness and letter knowledge. However, spectral auditory tasks (particularly 2 Hz frequency modulation detection) turned out to be highly significantly related to phonological awareness. In this paper, we will focus upon sensory processing in the visual modality, assessed in the same group of preschool children. In particular, we consider the question whether a deficit in coherent motion processing may already be observable in preschool children at risk of dyslexia and we investigate the relationship between motion processing and developing literacy skills.

Within the visual modality, dyslexia research has mainly focused upon sensory processing in the magnocellular visual pathway. Early studies using stimuli that assess the peripheral visual system (e.g., contrast sensitivity and flicker sensitivity paradigms) demonstrated that dyslexics tend to show a deficit in processing stimuli with low spatial

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and high temporal resolution (for a review, see Lovegrove, 1996; but see Skottun, 2000 for a critical revision). More recently, interesting results have also been obtained with stimuli that imply higher level magnocellular functioning such as coherent motion detection tasks (CM). These tasks, relying predominantly upon processing in area V5/MT of the cortex, have proven to differentiate relatively reliable between groups of dyslexic and normal reading subjects (Cornelissen, Richardson, Mason, Fowler, & Stein, 1995; Everatt, Bradshaw, & Hibbard, 1999; Hansen, Stein, Orde, Winter, & Talcott, 2001; Raymond & Sorensen, 1998; Ridder, Borsting, & Banton, 2001; Talcott, Hansen, Assoku, & Stein, 2000; Talcott et al., 2003; Van Ingelghem, Boets, van Wieringen, Ghesquière, & Wouters, 2004; Wilmer, Richardson, Chen, & Stein, 2004; Witton et al., 1998). Moreover, functional imaging studies have confirmed that activation of area V5/MT in response to coherent motion stimuli was not as robust in dyslexics compared to controls (Eden et al., 1996). Demb, Boynton, and Heeger (1997) have even demonstrated a reliable relation between the magnitude of the hemodynamic BOLD-response in extrastriate area MT and overall reading skills in dyslexic subjects. In psychophysical studies too, sensitivity to motion stimuli has been related to (nonword) reading ability (Talcott et al., 1998; Van Ingelghem et al., 2004; Witton et al., 1998), orthographic ability (Talcott, Hansen, et al., 2000; Talcott, Witton et al., 2000; Talcott et al., 2002; Van Ingelghem et al., 2004) and letter position encoding (Cornelissen et al., 1998). However, evidence of a motion coherence deficit in dyslexia is not yet unequivocal since some studies failed to find differentiating thresholds (Amitay, Ben-Yehudah, Banai, & Ahissar, 2002; Hulslander et al., 2004; Kronbichler, Hutzler, & Wimmer, 2002; Ramus et al., 2003). Moreover, a deficit in motion processing might not be an exclusive characteristic of dyslexia, since it has also been demonstrated in other developmental disorders like for example autism (Milne et al., 2002) and Williams-syndrome (see e.g., Atkinson et al., 1997).

Regarding the specific mechanism by which coherent motion sensitivity may limit normal literacy development, there is still much speculation. Since CM-thresholds are a robust measure of magnocellular processing and since this visual subsystem is mostly involved in encoding spatial information, it is probable that poor magnocellular functioning might result in uncertainty about letter position while reading and writing (Cornelissen et al., 1998). Furthermore, a magnocellular deficit has also been related to binocular instability and poor eye movement control, visual attention and visual search—all factors that might interfere with the development of orthographic skills and subsequent reading and spelling skills (Stein & Talcott, 1999; Stein, 2001; Talcott, Hansen, et al., 2000; Talcott, Witton et al., 2000).

Notwithstanding the considerable empirical evidence that CM-thresholds are able to differentiate reliably between adult and school-aged dyslexic and normal reading subjects, the differentiating and predictive power of this task has never been investigated in preschool children. In this study, we want to address this issue. Furthermore, to investigate the specific relation between sensory processing and different aspects of literacy development, we will also integrate the previously administered phonological measures and the 2 Hz FM detection thresholds in our correlation analyses. This has been done since in a series of former studies CM detection has gradually been linked to FM detection (see e.g., Witton et al., 1998; Talcott, Hansen, et al., 2000; Talcott, Witton et al., 2000; Talcott et al., 2002; Talcott et al., 2003). According to Talcott, Witton, and colleagues both psychophysical tasks could be regarded as 'dynamic' stimuli tasks by relying upon long-duration stimuli that require the perception of a dimension changing in time ('perception of rate'). While CM detection depends on the successful detection and integration of local motion signals over both time and space, FM detection depends on tracking the dynamic changes in the frequency of a tone over time. Interestingly, in some recent studies where FM and CM-detection tasks have been administered to the same subjects (school-aged children), it has been demonstrated that orthographic skills co-vary most strongly with CM sensitivity, whereas phonological skills co-vary most strongly with FM sensitivity (Talcott, Hansen, et al., 2000; Talcott, Witton et al., 2000; Talcott & Witton, 2002). In this study we will explore whether these specific relations might already be present in preschool subjects.

2. Materials and methods

2.1. Participants

Sixty-two 5-year-old children attending the last year of kindergarten[1] were included in the study (36 boys/26 girls). Half of the participants were children of 'dyslexic families', the so-called high-risk group (HR); the other half were control children of 'normal reading families,' the so-called low-risk group (LR). All children were native Dutch speakers without any history of brain damage, long term hearing loss or visual problems. Additionally, at the moment of data collection they did not present any gross deficiencies in visual acuity (Landolt-C single optotypes Snellen acuity >0.85) and/or audiology (audiometric pure-tone average <25 dB HL). The HR children were selected on a basis of having at least one first-degree relative with a diagnosis of dyslexia. The LR children showed no history of speech or language problems and none of their family members suffered any learning or language problems. For every individual HR child we selected the best matching LR control child based on five criteria: (1) educational environment, i.e., same nursery school, (2) gender, (3) age, (4) nonverbal intelligence, and (5) parental educational level. Nonverbal intelligence was assessed by an adapted version of the Raven Coloured Progressive Matrices (RCPM) (Raven, Court,

[1] In the Belgian school system formal instruction starts in Grade 1 at 6 years. This means in kindergarten no reading instruction is offered.