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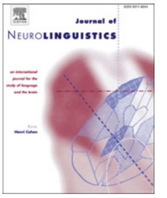

Language lateralization in children: A functional transcranial Doppler reliability study

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A B S T R A C T

We used bilateral simultaneous functional Transcranial Doppler Ultrasonography (fTCD) measurements in the middle cerebral arteries (MCA) to obtain information on hemispheric specialization for language processing in individual children. Twenty-six healthy right-handed children (49–113 months) participated in an active, expressive language task (talking about pictures) and a more passive, receptive language task (listening to stories). One-month-retest reliability was evaluated in 20 children. Both tasks elicited a mean left hemispheric lateralization, which was more pronounced in the expressive task. Retesting confirmed the initial lateralization in 90% of the cases of the expressive paradigm and in 55% for the receptive task. Lateralization of blood flow accelerations in the MCA did not depend on demographical variables (age and gender), degree of hand dominance, performance quality, or language skills. The expressive language paradigm measured by fTCD is a reliable and non-invasive alternative to current language lateralization methods in children.

1. Introduction

The clinical relevance of determining language lateralization in children predominantly lies in the examination of young patients with epilepsy or brain tumours in order to avoid operation-induced aphasia after removal of brain tissue. At present, the gold standard for the presurgical detection of hemispheric language dominance (HLD) is the Wada or intracarotid amobarbital procedure (IAP). This invasive technique requires a high degree of cooperation, appears relatively insensitive in children (Schevon et al., 2007),

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and has a higher failure rate of testing compared to adults (Hamer et al., 2000). All sorts of non-invasive alternatives have been under development in recent years. Functional magnetic resonance imaging (fMRI) is probably the most frequently used non-invasive alternative to the IAP (Abou-Khalil, 2007), but it requires the child to lie still for a considerable amount of time during a potentially frightening procedure. Moreover, a minimum age of 5 years for the procedure is generally required (Holland et al., 2007). Pelletier, Sauerwein, Lepore, Saint-Amour, and Lassonde (2007) also mentioned positron emission tomography (PET) and single-photon emission computed tomography (SPECT) as possible alternatives.

Functional transcranial Doppler ultrasonography (fTCD) does not suffer from the same drawbacks. This technique is non-invasive and easy to perform in children (Bishop, Watt, & Papadatou-Pastou, 2009; Haag et al., 2010; Lohmann, Dräger, Muller-Ehrenberg, Deppe, & Knecht, 2005). FTCD monitors relative changes in blood flow velocity (BFV) in the main cerebral arteries induced by cognitive tasks. The spatial resolution is limited to the vascular territory of the insonated blood vessels. Nevertheless, fTCD seems able to offer a valid index for language lateralization, as demonstrated in direct comparison to the results of the IAP (Knake et al., 2003; Knecht et al., 1998a; Rihs, Sturzenegger, Gutbrod, Schroth, & Mattle, 1999) and fMRI assessment (Deppe et al., 2000; Lohmann et al., 2005). Also, retest reliability during determination of HLD proved to be very good in healthy adults (Knecht et al., 1998b; Vadikolias et al., 2007). Although split-half reliability in children of an animal description task showed to be valid (Bishop et al., 2009), to date, only one fTCD-study has inquired into retest reliability in children, by using a picture description language task (Lohmann et al., 2005). Given the clinical relevance for the presurgical work-up of brain-diseased children, we aimed to replicate and extend the findings of HLD determination through fTCD.

Besides an expressive task based on Lohmann's picture description language task (Lohmann et al., 2005) we also introduced a less demanding receptive task (auditory story comprehension), which could be used in less cooperative children (because of cerebral palsy, mental retardation and other disorders), although receptive language tasks are known to activate more posterior and less lateralized language areas (Thivard et al., 2005; Tzourio-Mazoyer, Josse, Crivello, & Mazoyer, 2004). Nevertheless, we hypothesized to find not only a greater acceleration of BFV in the left MCA than in the right based on fTCD-findings during auditory language stimulation (Carod Artal, Vázquez Cabrera, & Horan, 2004), but also a left hemisphere dominance in language comprehension (Gaillard et al., 2001). Assessing both expressive and receptive language functions offers the added advantage of a more complete, representative view of language processing in the child's brain (Stroobant, Buijs, & Vingerhoets, 2009). Retest reliability was assessed after one month. Additional points of interest were a possible influence of hand dominance, age, gender, language proficiency, and performance quality on the lateralization of BFV accelerations during task execution.

2. Methods

2.1. Participants

Parents of children were contacted with permission of school boards. All children were right-handed (index of $\geq$50%, Edinburgh Handedness Inventory) (Oldfield, 1971). Exclusion criteria were neurological, cardiovascular or broncho-pulmonary disorders, developmental and learning disorders and visual impairment. One girl was excluded because of an insufficient signal through the temporal bone window. TCD measurement was possible in 26 other children (14 female, 12 male; mean age 82 months; range 49–113 months). Twenty children were examined twice. The other six were excluded from retesting because of agitation ($n = 2$), lack of cooperation ($n = 3$) or technical difficulties ($n = 1$). Time interval between two sessions was 32.5 days (range 27–44 days). The study was approved by the local Ethics Committee of the Ghent University Hospital. Parents and children over the age of 8 gave written informed consent before participation.

2.2. Procedure

The tasks were performed in a quiet room without auditory or visual distractions and with constant illumination. The child was seated in a comfortable chair. During the positioning of the transducers, the