Research in Developmental Disabilities 43–44 (2015) 61–71

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Use of prism adaptation in children with unilateral brain lesion: Is it feasible?

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ARTICLE INFO

Article history:
Received 24 November 2014
Received in revised form 12 June 2015
Accepted 23 June 2015
Available online 8 July 2015

Keywords:
Prism adaptation
Children
Visuospatial deficits
Neglect
Unilateral brain lesion
Game task
Cerebral palsy

ABSTRACT

Introduction: Unilateral visuospatial deficits have been observed in children with brain damage. While the effectiveness of prism adaptation for treating unilateral neglect in adult stroke patients has been demonstrated previously, the usefulness of prism adaptation in a pediatric population is still unknown. The present study aims at evaluating the feasibility of prism adaptation in children with unilateral brain lesion and comparing the validity of a game procedure designed for child-friendly paediatric intervention, with the ecological task used for prism adaptation in adult patients.
Methods: Twenty-one children with unilateral brain lesion randomly were assigned to a prism group wearing prismatic glasses, or a control group wearing neutral glasses during a bimanual task intervention. All children performed two different bimanual tasks on randomly assigned consecutive days: ecological tasks or game tasks. The efficacy of prism adaptation was measured by assessing its after-effects with visual open loop pointing (visuoproprioceptive test) and subjective straight-ahead pointing (proprioceptive test).
Results: Game tasks and ecological tasks produced similar after-effects. Prismatic glasses elicited a significant shift of visuospatial coordinates which was not observed in the control group.
Conclusion: Prism adaptation performed with game tasks seems an effective procedure to obtain after-effects in children with unilateral brain lesion. The usefulness of repetitive prism adaptation sessions as a therapeutic intervention in children with visuospatial deficits and/or neglect, should be investigated in future studies.

1. Introduction

Prism adaptation (PA) is an effective therapeutic intervention to deviate the visual field laterally (Yang, Zhou, Chung, Li-Tsang, & Fong, 2013; Brookes, Nicolson, & Fawcett, 2007; Frassinetti, Angeli, Meneghello, Avanzi, & Làdavas, 2002; Rossetti et al., 1998). The lateral displacement of the visual field has been shown to directionally bias visuo-motor and sensory-motor

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http://dx.doi.org/10.1016/j.ridd.2015.06.009
0891-4222/

correspondences. To compensate the visual field deviation, the individual has to re-orient his actions, resulting in a drift of sensorimotor coordinates (Serino, Barbiani, Rinaldesi, & Làdavas, 2009). After removal of the glasses the egocentric coordinates of the sensory-motor reference frame are shifted, producing immediate visual and proprioceptive changes in the direction of pointing and reaching, named after-effects (Morton & Bastian, 2004). After-effects are considered to be key indicators of the effectiveness of PA (Fortis, Ronchi, Calzolari, Gallucci, & Vallar, 2013).

PA has been shown to modify performances in a variety of spatial tasks in adults: both in healthy individuals and in patients with unilateral neglect after stroke (Serino, Bonifazi, Pierfederici, & Làdavas, 2007). Due to its long-lasting effect, PA is regarded as an effective procedure for rehabilitating unilateral spatial neglect by bringing the neglected hemispace into the task-work space (Facchin, Beschin, Toraldo, Cisari, & Daini, 2013; Rusconi & Carelli, 2012; Làdavas, Bonifazi, Catena, & Serino, 2011; Eramudugolla, Boyce, Irvine, & Mattingley, 2010; Turton, O'Leary, Gabb, Woodward, & Gilchrist, 2010; Serino et al., 2007). Indeed, this rehabilitation method elicits a shift of the visual field towards the non-neglected ipsilesional side during the execution of pointing or reaching tasks, forcing subjects to compensate and to re-orient movements in the direction of the neglected contralesional side (Rossetti et al., 1998). The effects are suggested to emerge from bottom-up transfer of sensory-motor adaptation inducing high-order adaptive neuronal plasticity in cognitive function (Rode, Pisella, Rossetti, Farnè, & Boisson, 2003). A short period of PA has been shown to improve visuomotor tasks, such as cancellation and line bisection tests, both in personal and extra-personal space (Shiraishi, Muraki, Ayakatou, & Hirayama, 2010; Serino et al., 2007). Several studies have proved the clinical efficacy of PA on the following symptoms: (a) reduction of tactile inattention and improvement of tactile extinction (Maravita et al., 2003), (b) improvement of mental imagery tasks (Rusconi & Carelli, 2012), (c) improvement of eye movements on the neglected visual field, (d) shift of the center of gravity towards the neglected side (Shiraishi et al., 2010; Shiraishi, Yamakawa, Itou, Muraki, & Asada, 2008) and (e) improvement of activities of daily living in stroke patients (Mizuno et al., 2011; Shiraishi et al., 2010; Rode, Klos, Courtois-Jacquin, Rossetti, & Pisella, 2006).

In children, PA is used for correcting strabismus (Savino, Colucci, Rebecchi, & Dickmann, 2005; Burke & Firth, 1995) and it is likely to induce beneficial effects in autism and ADHD (Gidley Larson, Bastian, Donchin, Shadmehr, & Mostofsky, 2008; Colvin, Yeates, Enrile, & Coury, 2003; Carmody, Kaplan, & Gaydos, 2001; Kaplan, Edelson, & Seip, 1998). It seems that even infants at 6–9 months of age may show adaptative responses to PA (McDonnell & Abraham, 1981). Visuo-motor interaction is an interesting target for therapeutic intervention in children as perceptuo-motor procedural learning crucially occurs at school age (Lejeune, Catale, Schmitz, Quertemont, & Meulemans, 2013; Contreras-Vidal, Bo, Boudreau, & Clark, 2005). While unilateral neglect, characterized by a deficit in attention and appreciation of stimuli on the paretic side of the body, has been described in children with cerebral damage (Chevignard et al., 2008; Laurent-Vannier, Chevignard, Pradat-Diehl, Abada, & De Agostini, 2006; Laurent-Vannier, Pradat-Diehl, Chevignard, Abada, & De Agostini, 2003; Trauner, 2003; Billingsley et al., 2002; Thompson, Ewing-Cobbs, Fletcher, Miner, & Levin, 1991; Katz, Cermak, & Shamir, 1998), the feasibility of PA in these children has not been investigated previous to the present study.

Prism adaptation requires the concomitant execution of a sensorimotor task within the visual space, while wearing prismatic glasses. Repetition of pointing movements toward visual targets is considered the standard procedure, both in healthy individuals and in unilateral neglect patients (Fortis et al., 2013). Other possible tasks include line bisection training, reaching tasks, pegboard exercises, goal-oriented locomotion or ball throwing (Fortis, Chen, Goedert, & Barrett, 2011; Goedert, Leblanc, Tsai, & Barrett, 2010; Michel, Vernet, Courtine, Ballay, & Pozzo, 2008; Morton & Bastian, 2004; Fernandez-Ruiz et al., 2003; Martin, Norris, Greger, & Thach, 2002). Commonly, the tasks performed during prism adaptation are repetitive in nature and therefore poorly suitable for long-term treatment (Fortis et al., 2010, 2013). In adults, an alternative procedure, using series of visuomotor activities performed with daily life objects i.e. ecological tasks, has been proposed as a more diverse and engaging alternative for long-term interventions. These ecological tasks were shown to produce similar beneficial effects as repeated pointing tasks on prism-induced after-effects and neglect tests in healthy individuals and in adult patients with unilateral neglect (Fortis et al., 2010, 2013). PA accompanied by selected game tasks may provide a viable, child-friendly alternative to the previously described ecological task procedures schemed for adults.

The purpose of the present study was two-fold: (1) determining whether one session of prism adaptation can produce significant visuomotor after-effects in children with unilateral brain lesion compared with neutral glasses, and (2) investigating if game tasks during prism adaptation are equally effective at producing after-effects as ecological tasks.

2. Material and methods

2.1. Participants

Participants were 21 children with unilateral brain lesion (congenital = 20, acquired = 1). Fourteen children had a left hemispheric lesion and seven children had a right hemispheric lesion. All children but one, had congenital hemiparesis. One child had acquired hemiparesis since two years. Therefore, all participants in this study protocol were in a chronic phase after the start of their neurological illness. Descriptive and clinical variables were determined using specific tests for brain-damaged children, as described in Table 1.

The recruitment of participants was performed in collaboration with clinical centers dedicated to the treatment of children with CP in Belgian University hospitals. These centers are mandated by the Belgian social security to coordinate clinical evaluations and interventions in children with CP. Potential participants for this experimental protocol first were