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The effects of intensive bimanual training with and without tactile training on tactile function in children with unilateral spastic cerebral palsy: A pilot study

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A B S T R A C T

Children with unilateral spastic cerebral palsy (USCP) often have tactile impairments. Intensive bimanual training improves the motor abilities, but the effects on the sensory system have not been studied. Here we compare the effects of bimanual training with and without tactile training on tactile impairments. Twenty children with USCP (6–15.5 years; MACS: I–III) were randomized to receive either bimanual therapy (HABIT) or HABIT + tactile training (HABIT + T). All participants received 82 h of standardized HABIT. In addition 8 sessions of 1 h were provided to both groups. The HABIT + T group received tactile training (without vision) using materials of varied shapes and textures. The HABIT group received training with the same materials without tactile directed training (full vision). Primary outcomes included grating orientation task/GOT and stereognosis. Secondary outcomes included two-point discrimination/TPD, Semmes-Weinstein monofilaments/SWM. The GOT improved in both groups after training, while stereognosis of the more-affected hand tended to improve (but $p = 0.063$). No changes were found in the TPD and the SWM. There were no group × test interactions for any measure. We conclude tactile spatial resolution can improve after bimanual training. Either intensive bimanual training alone or incorporation of materials with a diversity of shapes/textures may drive these changes.
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What this paper adds

- This is the first study in USCP to test the effect of systematic tactile training.
- Tactile spatial discrimination was improved following intensive bimanual training.
- HABIT with and without tactile training improved tactile function similarly.

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1. Introduction

Impaired function in children with unilateral spastic cerebral palsy (USCP) does not purely result from motor impairments, but is also affected by concomitant sensory impairments. Tactile registration, tactile perception, and sensorimotor integration are essential for grasping and releasing objects (Gordon & Duff, 1999a, 1999b), dexterous manipulation (Bleyenheuft & Gordon, 2013), and activities of daily living (Auld, Boyd, Moseley, Ware, & Johnston, 2012). There have been studies investigating sensory contribution to motor control in children with USCP (Auld et al., 2012; Auld, Russo, Moseley, & Johnston, 2014; Gordon & Duff, 1999a). However, whether intensive bimanual training or tactile training is effective in modifying tactile impairments in children with USCP has never been investigated.

Early animal studies directly tested how sensory deprivation affected the motor system. Mott and Sherrington (1895) showed that deafferentation, an abolition of sensory input, impaired the performance of skilled movements in monkeys. Although the underlying pathophysiology is different in deafferented monkeys and in USCP, these studies highlighted the contribution of sensory input to fine motor control. Recently, neuroplastic changes were demonstrated in rats' sensory cortex (S1) after enhanced environmental or motor training. Joo et al. (2012) showed increased somatosensory evoked potentials that paralleled motor recovery. Alwis and Rajan (2013) showed that 8 weeks of environment enrichment increased electrophysiological responses to tactile stimuli. These studies highlight the interaction between sensory and motor systems.

Studies investigating effects of somatosensory training programs on modifying sensorimotor functions in adult stroke are emerging (Carey, Macdonell, & Matyas, 2011). While it has been acknowledged that the sensory impairment is a major contribution to motor impairments in children with USCP (Bleyenheuft & Gordon, 2013), effective therapy in improving tactile impairment is lacking (Auld et al., 2014). The study by Charles, Lavinder, and Gordon (2001) is the only study using intensive hand therapy which reported an improvement in tactile discrimination in 3 children after constraint-induced movement therapy (CIMT). They attributed the improvement in tactile discrimination to an increase in tactile input and its subsequent change in cortical receptor fields for the fingers. More recently, studies investigating neuroplastic changes associated with intensive hand therapy using functional Magnetic Resonance Imaging (fMRI) or magnetoencephalography (MEG) demonstrated increased activation associated with CIMT (Juenger et al., 2013) or HABIT (Bleyenheuft et al., 2015) in S1 or M1 in USCP and in adult stroke (Laible et al., 2012). In summary, tactile function could be improved after intensive hand therapy in children with USCP, and neurophysiological changes associated with intensive therapy may be found in S1 or M1. These studies prompted us to probe deeper into the relationship among intensive hand training, tactile training, and their impact on tactile function in children with USCP.

Both unimanual and bimanual intensive therapy have been shown to improve hand motor function in children with USCP (Gordon et al., 2011, 2008; Sakzewski, 2012; Sakzewski et al., 2011). Bimanual intensive therapy improved self-determined goals more than unimanual therapy as bimanual training allows use of both hands (e.g., tying shoes) (Brandao, Gordon, & Mancini, 2012; Gordon et al., 2011). In addition, bimanual training improved bimanual coordination more than unimanual training (Hung, Casertano, Hillman, & Gordon, 2011). Consequently, we adopted bimanual training as a common ingredient in our study. We further aimed to compare the efficacy of two interventions in this pilot study: intensive bimanual training (hand–arm bimanual intensive therapy, HABIT) vs. intensive bimanual training that includes tactile training (HABIT + T) on modifying tactile function in children with USCP. We hypothesized that tactile function could be enhanced after HABIT due to the enriched environment created by exposure to objects of varied textures, and tactile function could be further enhanced with additional tactile training.

2. Methods

2.1. Participants

Participants included a sample of convenience that was recruited from a subset of two ongoing trials (Bleyenheuft, Arnould, Brandao, Bleyenheuft, & Gordon, 2015; Brandao et al., 2013). The inclusion criteria were established based on prior HABIT trials (Brandao et al., 2013; Gordon et al., 2011; Gordon, Schneider, Chinnan, & Charles, 2007): (1) age 6 to 18, diagnosed with congenital USCP, (2) the ability to lift the more-affected arm 15 cm above a table surface and grasp light objects, (3) cognition level defined as mainstreamed in school (Kaufman Brief Intelligence test score >70), (4) demonstrated ability to follow instructions and complete testing. Exclusion criteria included: (1) health problems unrelated to USCP, (2) uncontrolled seizures, (3) visual problems interfering with intervention/testing, (4) severe muscle tone at any joint (Modified Ashworth score >3.5), (5) orthopedic surgery on the more-affected hand within one year, and 6) botulinum toxin therapy in the upper limb within the last 6 months or intended treatment within the study period. Informed assent/consent forms were obtained from participants and caregivers. This study was approved by the respective Universities' Institutional Review Boards.

2.2. Procedures

2.2.1. General intervention procedures

One bimanual training camp was conducted at Teachers College in New York City in early July 2012. Another bimanual training camp was conducted at Université Catholique de Louvain in Brussels, Belgium in late July 2012. In each site,

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