



The link between impaired theory of mind and executive function in children with cerebral palsy



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ABSTRACT

The aim of the study was to explore the relationship between theory of mind (ToM) deficits and executive function (EF) impairments in children with cerebral palsy (CP), 42 CP with children and 42 typically developing (TD) children, acting as controls, were assessed on the tasks of ToM (false belief and faux pas) and EF (inhibition, updating and shifting). Results showed that CP children had deficits both in ToM and EF tasks. The correlation analyses showed that two EF components (inhibition and updating) were strongly related to false belief and faux pas in both two groups. We also found correlation between shifting and false belief and faux pas. However, this correlation was only found in TD children and not in children with CP. These findings suggest that children with CP lag behind TD children in both ToM and EF. Further, the results reveal, interestingly, that ToM deficits in CP children might be related to their inhibition and updating impairments, but not to shifting impairments.

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1. Introduction

Cerebral palsy (CP) is defined as a group of disorders in movement and posture, causing activity limitations, attributed to nonprogressive lesion of the immature brain (Rosenbaum et al., 2007). Compared with their peers, children with CP often experience less contact with the environment. This is because children with CP have motor dysfunction and speech impairment, which reduces their potential for social interaction reduced (Caillies, Hody, & Calmus, 2012; Pennington & McConachie, 2001; Voorman, Dallmeijer, Van Eck, Schuengel, & Becher, 2010). However, there have been minimal discoveries of underlying cognitive deficits associated with social function difficulties in children with CP.

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'Theory of mind' (ToM) is by far the most representative mechanism of social cognition. ToM refers to an individual's ability to represent and understand another person's psychological perspective by attributing mental states such as beliefs, intentions, emotions, and desires (Amodio & Frith, 2006). Researchers have found that false belief is the benchmark for assessing the acquisition of ToM in typically developing (TD) children (Abbeduto, Short-Meyerson, Benson, & Dolish, 2004). Many studies reported that TD children around the age of 4 can pass first-order false belief task (Thirion-Marissiaux & Nader-Grosbois, 2008; Wimmer & Perner, 1983), while TD children around the age of 6 pass the second order task (Perner & Wimmer, 1985). Subsequent studies developed new tasks to test 'more advanced' ToM ability at the 9- to 11-year-old level (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999). One of such tasks is faux pas, which requires the representation of two mental states: (1) the person saying something does not know that he/she should not say it and (2) the person hearing it would feel insulted or hurt (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997).

ToM deficits have been observed in a number of psychiatric disorders including autism (Mason, Williams, Kana, Minshew, & Just, 2008; Schneider, Slaughter, Bayliss, & Dux, 2013; Tajmiriyahi, Nejati, Pouretamad, & Sepehr, 2013), deaf children (e.g., Courtin & Melot, 2005; Meristo et al., 2012), intellectual disabilities (Cornish et al., 2005; Tager-Flusberg & Sullivan, 2000) and schizophrenia (Greig, Bryson, & Bell, 2004; Schenkel, Spaulding, & Silverstein, 2005). However, there is still little study on the ToM understanding in CP children.

Recently, some studies have attempted to assess ToM in children with CP, but have produced mixed results. On the one hand, some studies found that the CP children performed worse than the children matched for mental age and/or IQ on first-order false belief tasks (Dahlgren, Dahlgren-Sandberg, & Larsson, 2010; Dahlgren, Dahlgren-Sandberg, & Hjelmquist, 2003; Falkman, Sandberg, & Hjelmquist, 2005). On the other hand, other studies found that the CP children performed equally with TD children on first-order belief task, but performed worse than TD children only on second-order false belief tasks (Caillies et al., 2012). We noted that almost all of these studies only focused on the false belief tasks. From the literature that we have consulted so far, we have not identified any research that has employed faux pas in assessing CP children. This, however, is contrary to the basic understanding that faux pas recognition is an important social function.

Difficulties of children with CP in ToM may result from executive function (EF) deficits. EF refers to an interrelated set of higher cognitive processes used in the control of action and thought (Garon, Bryson, & Smith, 2008). Numerous researchers have studied EF's composition from different perspective. Some considers EF as a unitary component process (e.g., Kimberg, D'Esposito, & Farrah, 1997), while the others suggest that EF is multidimensional (e.g., Brocki & Bohlin, 2006; Ettenhofer, Hambrick, & Abeles, 2006; Garon et al., 2008; Huizinga, Dolan, & van der Molen, 2006; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; St Clair-Thompson & Gathercole, 2006). In particular, Miyake et al. (2000) identified three different components of EF: "inhibition" (inhibition of proponent responses), "updating" (information updating and monitoring), and "shifting" (mental set shifting). The Miyake et al.'s model is widely cited as a seminal model (Brydges, Reid, Fox, & Anderson, 2012).

To date, there has been no systematic study of EF in children with CP. Existing literature on EF mainly focuses on working memory, control, and inhibition of attention (Bottcher, 2010). Some researchers have pointed out that CP children have impaired performance in inhibitory control (Christ, White, Brunstrom, & Abrams, 2003) and in cognitive flexibility (Nadeau, Routhier, & Tessier, 2008; Warschausky, Argento, Hurvitz, & Berg, 2003).

Recently, many researchers have tried to explore the relationship between ToM in typical populations and EF (e.g., Bull, Phillips, & Conway, 2008; Carroll, Riggs, Apperly, Graham, & Geoghegan, 2012; Henning, Spinath, & Aschersleben, 2011; Müller, Liebermann-Finestone, Carpendale, Hammond, & Bibok, 2012). However, only one study has explored the relationship between ToM and EF in children with CP (Caillies et al., 2012). This study used a Stroop Test to investigate the ability of inhibition and assess the relationship between ToM and EF. However, this study did not assess the other components of EF (e.g., the updating and shifting), and as such, the unique contribution of each aspect of EF to ToM remains unclear.

In the current study, we tried to answer the following three questions:

Firstly, do children with CP have deficits in ToM? In order to respond to this question, two tasks, second-order false belief and faux pas were used. The first-order false belief was not used, because of the possibility of ceiling effects. To our knowledge, this is the first study that has attempted to examine faux pas in children with CP. Our hypothesis was that children with CP would display significant second-order false belief and faux pas impairments.

Secondly, do children with CP have deficits in all three components of EF? Based on the Miyake et al.'s model, we assessed all three components of EF, and examined whether children with CP have deficits in inhibition, updating, or shifting. Only one study used a similar mode to investigate EF and arithmetic ability in children with CP (Jenks, de Moor, & van Lieshout, 2009). In this study, we used different tasks to assess all components of EF.

Thirdly, is ToM disability in CP children related to these EF components? Our expectation was that difficulties of children with CP in ToM may result from executive dysfunction. We assessed whether different ToM understanding (false belief or faux pas) is related to the specific EF components (inhibition, updating or shifting).

2. Method

2.1. Participants

Forty-two children with CP (age: 10.40 ± 1.45 ; 17 girls and 25 boys) participated in this study. Thirty-five children had spastic CP, 4 children had athetoid and 3 children had ataxia. Of the children with spastic CP, 18 children had hemiplegia, 13

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