Research in Developmental Disabilities 34 (2013) 3218–3225

Contents lists available at SciVerse ScienceDirect

Research in Developmental Disabilities

Cognitive flexibility impairments in children with autism spectrum disorders: Links to age, gender and child outcomes

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ARTICLE INFO

Article history:
Received 11 April 2013
Received in revised form 22 June 2013
Accepted 25 June 2013
Available online

Keywords:
Autism spectrum disorder
Child outcomes
Cognitive flexibility
Gender difference
Perseveration

ABSTRACT

There are still many questions about the cognitive flexibility in autism spectrum disorder (ASD) that remain unanswered. The goal of current study was to evaluate cognitive flexibility patterns and their demographic, clinical and behavioral correlates in large sample of children with ASD. A total of 123 children (94 boys and 29 girls) with ASD aged 7–14 years were assessed on the Wisconsin card sorting test (WCST). Findings showed that gender but not age was associated with the cognitive flexibility performance in ASD. Individuals who had more parent-reported language deficits, lower level of intelligence and education, and showed lower daily sleep time or more engagement in solitary instead of social daily activities were more likely to demonstrate perseveration. Findings provide tentative evidence of a link between cognitive flexibility deficits and sociodemographic or clinical child outcomes in ASD.

1. Introduction

There has been ongoing concerns that deficits in executive functions (EF) may link to various social and behavioral impairments in individuals with autism spectrum disorders (ASD), such as deficits in the theory of mind, communication skills and maladaptive behaviors (Gousse et al., 2002; Griffith, Pennington, Wehner, & Rogers, 1999; Happé, Booth, Charlton, & Hughes, 2006; Hill, 2004; McEvoy, Rogers, & Pennington, 1993). Executive function is an umbrella term for initiating and controlling functions such as planning, response inhibition and cognitive or mental flexibility (Anokhin, Golosheykin, Grant, & Heath, 2010; Kaland, Smith, & Mortensen, 2008). It is generally associated with frontal lobe structures of the human brain (Gousse et al., 2002; Kaland et al., 2008).

The EF problems are not exclusively seen in autism, though severity and profile of deficits differ across developmental disorders (Geurts, Corbett, & Solomon, 2009; Pennington & Ozonoff, 1996). The experimental data are rather controversial on EF measures particularly in ASD (Happé et al., 2006; Sergeant, Geurts, & Oosterlaan, 2002) which can be due to inconsistencies in definitions as well as the complexity and difficulty of assessments (Kenworthy et al., 2008). Some evidence highlight impairments in key aspects of EF in autism: inhibition, set shifting and cognitive flexibility (Hill, 2004; Hughes, 1998; Russo et al., 2007). Wisconsin card sorting test (WCST) is a standard neuropsychological measure of prefrontally mediated executive functions including cognitive flexibility, set maintenance and problem solving (Kaland et al., 2008; Rhodes, 2004). Several studies in which WCST were investigated in ASD, suggested that individuals with ASD are highly

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http://dx.doi.org/10.1016/j.ridd.2013.06.033

perseverative in comparison with typically developing (TD) children or other developmental disorders such as attention-deficit hyperactivity disorder (Geurts, Verté, Oosterlaan, Roeyers, & Sergeant, 2004; Ozonoff & Jensen, 1999; Ozonoff, Pennington, & Rogers, 1991; Rumsey, Rapoport, & Sceery, 1985). In other words people with ASD have difficulty in rule shifting even when they knew the rule was wrong.

Some previous research showed that there is no significant difference between individuals with ASD or developmental language disorders in making perseverative errors. The authors suggested that there may be a relationship between perseverative tendencies and language deficits (Liss et al., 2001). Furthermore the cognitive flexibility may be affected by other cognitive variables related to language such as education or learning abilities. Keeping in mind that children with ASD have different learning styles and show pervasive language impairments, examining cognitive flexibility in ASD will be worth it to make this relationship more clear (Lowe & Reynolds, 1999).

Among demographics, age is an important variable that can account for the different measures of EF (Lowe & Reynolds, 1999). While age is evidenced to alleviate perseverative errors in TDs (Happé et al., 2006), there has been little agreement on a significant relationship between age and cognitive flexibility in ASD (Happé et al., 2006; Ozonoff & Jensen, 1999; Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009). For example, some previous studies reported that older participants outperformed the youth with ASD on a battery of EF measures including response inhibition, working memory, cognitive flexibility and planning (Happé et al., 2006; Ozonoff & Jensen, 1999). However authors cannot provide a satisfactory explanation for it and the finding was not supported by later observations in individuals with ASD. Robinson et al. (2009) suggest that children with ASD may fail to exhibit typical age-related gains in self-monitoring that may contribute to their cognitive performance. Overcoming a major limitation of previous research about age range, the Ozonoff et al. (2004) study with participants aged 6–47 years also showed no age related improvement in performance on the set shifting task. Addressing other limitations, we were trying to investigate a large sample of children with ASD.

In addition, there is not much information about sex differences in neuropsychological performance in general, and cognitive flexibility in specific, in ASD (Lemon, Gargaro, Enticott, & Rinehart, 2011; Thompson, Caruso, & Ellerbeck, 2003). While Lemon et al. (2011) indicated a significant poorer inhibition in girls with ASD than boys with ASD, Bolte, Duketis, Poustka, and Holtmann (2011) could not show any gender differences on a cognitive flexibility task. Interestingly it has been suggested that the greater prevalence ratio of males to females (4:1) (Gray & Tonge, 2005) is partially caused by sex differences in the expression of ASD symptoms which may result in misdiagnosis among females (Attwood, 2008). Girls with ASD may be able to hide their symptoms by having greater early communication abilities (Attwood, 2008); though findings generally support the hypothesis that the females with ASD show more severe symptoms (e.g. social deficits) than males with ASD (Hartley & Sikora, 2009; McLennan, Lord, & Schopler, 1993). In contrast, a group of girls with ASD (mean age = 28 months) showed higher nonverbal problem solving abilities and better visual perception (Carter et al., 2007). Although current studies suggest that there may be neurobehavioral and cognitive gender differences responsible for clinical appearance in ASD (Lemon et al., 2011), it is unclear to what extent cognitive differences in autism can be attributed to the gender. Thus we were trying to investigate the gender differences in cognitive flexibility of children with ASD.

The picture of executive functions in ASD is essentially complex. This can be in part due to the complexity of underlying brain structures of cognitive flexibility. Among those, frontal cortex is an area uniquely positioned and designed to exert control over a wide array of social and environmental information processing (e.g. repetitive behaviors) (Ozonoff et al., 2004). Examining different social/environmental (e.g., education or daily activities) and clinical factors (e.g., language skills) in parallel with cognitive flexibility can provide an interpretation that accurately reflects the frontal lobe functions in children with ASD (Bigler, 1988).

Expectedly, cognitive flexibility plays an important role in the development of flexible behaviors (e.g., daily social activities). On the other hand, children with poor social and behavioral outcomes are more likely to live in substandard situations with difficulties in health care. They are less likely to have access to stimulating learning materials, and receive adequate parental support or educational services. These factors, in turn, contribute to an overall risk for negative cognitive outcomes in these children (Bradley & Corwyn, 2002; Evans, 2004). Children with poor social or behavioral profile are also at risk to experience cognitive developmental delays (Duncan & Brooks-Gunn, 2000). Several studies indicate that delayed cognitive skills are a marked presentation of children with ASD. Furthermore children with ASD show obvious impairment or delay in daily adaptive activities. Thus performance in daily activities (e.g., social activities) might be associated with the cognitive ability of autistic children to switch between environmental signals (i.e., cognitive flexibility).

The aim of this study was to investigate cognitive flexibility in children and adolescents with ASD and underlying factors together with the sociodemographic correlates such as child age, gender, daily activities and parent profile in addition to autism clinical features. We then hypothesized that the nature of the cognitive flexibility impairment differs across gender but not age in ASD. Furthermore, we presumed that social and behavioral skills deficits are directly associated with impairments in cognitive flexibility of autistic children.

2. Methods

2.1. Participants

The total sample for the current study included 123 high functioning children with ASD, (94 boys and 29 girls) with an age range of 7–14 years (9.6 ± 1.9 years). These children participated in the health survey of autism, which was a university-based