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Implicit and explicit motor learning: Application to children with Autism Spectrum Disorder (ASD)

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ABSTRACT

Aims and objectives: This study aims to determine whether children with Autism Spectrum Disorder (ASD) are capable of learning a motor skill both implicitly and explicitly.
Methods: In the present study, 30 boys with ASD, aged 7–11 with IQ average of 81.2, were compared with 32 typical IQ- and age-matched boys on their performance on a serial reaction time task (SRTT). Children were grouped by ASD and typical children and by implicit and explicit learning groups for the SRTT.
Results: Implicit motor learning occurred in both children with ASD ($p = .02$) and typical children ($p = .01$). There were no significant differences between groups ($p = .39$). However, explicit motor learning was only observed in typical children ($p = .01$) not children with ASD ($p = .40$). There was a significant difference between groups for explicit learning ($p = .01$).
Discussion: The results of our study showed that implicit motor learning is not affected in children with ASD. Implications for implicit and explicit learning are applied to the CO-OP approach of motor learning with children with ASD.

1. Introduction

1.1. Autism Spectrum Disorder (ASD)

According to the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-V), Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by impairments in social communication and social interaction (e.g., social initiation and response, non-verbal communication, social awareness and relationships) and

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repetitive, restrictive behavior, interests, or activities (e.g., atypical speech, movement, play, preoccupations with objects or topics, resistance to change, atypical sensory behavior) (APA, 2013b).

DSM-V explains that the symptoms must be present at age 8 or younger and have to interfere with daily activities to be diagnostic (APA, 2013b). The fourth edition of *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV) categorized children with ASD into four separate disorders: Autistic Disorder, Asperger's disorder, childhood disintegrative disorder, or pervasive developmental disorder not otherwise specified (APA, 2013a). Autism and Asperger Syndrome (AS) are the most prevalent subtypes of ASD which are distinguished by delays in language (APA, 1994). ASD prevalence has been estimated to be 157 in 10,000 in England (Baron-Cohen et al., 2009) and male:female ratio of ASD equals 3:1 to 4:1 (Filipek, Accardo, Baranek, & Cook, 1999; Freeman, Del'PHomme, Guthrie, & Zhang, 1999).

1.2. Developmental Coordination Disorder in children with ASD

Praxis is a neurocognitive process and described as the ability to create an idea cognitively, plan the motor function, sequence unfamiliar actions appropriately and execute it (Schaaf et al., 2010). Children who experience praxis problems are identified as having Developmental Coordination Disorder. These children may present with a normal appearance in many other ways but yet constantly attract the attention of the peers and adults by dropping everything that is handled or falling frequently (Kurtz, 2007). Children with Developmental Coordination Disorder work hard to learn a skill and have trouble being flexible in changing situations. Moreover, it affects children's ability to participate in daily living tasks and occupations (Schaaf et al., 2010). Children with ASD have trouble with skills such as dressing, toileting, writing, etc. (AOTA, 2010). Occupational dysfunction is a special concern for the occupational therapists who are working with these children. It is common for these children to have low self-esteem (Kurtz, 2007).

High prevalence of motor problems and Developmental Coordination Disorder in children with ASD has been reported in some studies (Freitag, Kleser, Schneider, & Von Gontard, 2007; Green et al., 2002; Manjiviona & Prior, 1995; Matson, Mahan, Kozlowski, & Shoemaker, 2010). Developmental Coordination Disorder is strongly correlated with diagnostic criteria of autism consisting of social, communicative and behavioral impairments (Dziuk et al., 2007; Ghaziuddin, Butler, Tsai, & Ghaziuddin, 1994). This similarity in the symptoms has led the psychiatrics to consider that Developmental Coordination Disorder may be a core and salient feature of ASD (Dziuk et al., 2007; Ghaziuddin et al., 1994).

1.3. Motor learning

It is suggested that two types of learning processes occur simultaneously during the acquisition of a functional motor skill: explicit learning and implicit learning processes (Gentile, 1998). These are interdependent processes that might change at different rates and levels for different motor functions. Moreover, treatment methods are typically different according to each of these two learning processes (Gentile, 1998). Serial reaction time task (SRTT) is one of the most common methods of evaluating both implicit and explicit motor learning (Nissen & Bullemer, 1987). SRTT contains motor and cognitive components and requires motor responses to visual stimuli (cues) appearing in a patterned or random sequence. Sequence repetition speeds up responses to stimuli by decreasing time needed to make proper response. This decrement is seen in both patterned and random sequences. Changes in duration of patterned sequences imply learning speed. Error making decrement in responding to stimuli (learning accuracy) is another criterion of leaning.

A few studies have been implemented in the last decade investigating implicit and explicit motor learning processes in the children with ASD, some of which report intact implicit and explicit motor learning in this population, and others reported impaired ones. Table 1 provides a summary of these studies.

1.3.1. Implicit motor learning

Implicit learning process is the process by which knowledge about the rule-governed complexities of the stimulus environment is acquired independently of conscious attempts to do so. Implicit motor learning results when the children are unaware of movement components (Robertson, 2007).

There are several studies indicating intact implicit motor learning in children with ASD. Gordon and stark (2007) conducted a study on 7 children with Autism (age range: 6–14 years) comparing short and long sequences of learning and concluded that individuals with Autism, even those with low-functioning Autism, learn motor sequences implicitly. It is suggested that the result of this study is also obscured because of two main reasons; first, IQ differences in compared groups (Individuals with Autism vs. the matched group) (Brown, Aczel, Jimenez, Kaufman, & Grant, 2010); second, long response stimulus intervals (RSI = 500 ms). According to Brown and colleague'shypothesis, longer RSIs makes it possible to use explicit strategies during implicit learning task (Brown et al., 2010) and according to Nemeth et al. (2010) hypothesis longer RSIs make it difficult for children with Autism to group stimuli due to their attentional preference for local over global context.

Rotary pursuit is a visuomotor task also used to assess motor sequence learning by time changes spent on target across trials. Unlike SRTT, it controls for differences in motor execution by adjusting the speed of the Rotary pursuit and equilibrating initial motor performance across individual subjects (Gidley Larson & Mostofsky, 2008). They concluded that the children with high-functioning ASD are able to learn a novel motor sequence and neither the motor execution nor the attention impairment causes different pattern of motor learning in children with high-functioning ASD. Gidley Larson and Mostofsky (2008) suggested that cognitive inflexibility in children with high-functioning ASD makes it difficult for them to