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The effects of embodied rhythm and robotic interventions on the spontaneous and responsive social attention patterns of children with autism spectrum disorder (ASD): A pilot randomized controlled trial

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ABSTRACT

We compared the effects of 8-weeks of rhythm and robotic interventions with those of a comparison, standard-of-care intervention, on the spontaneous and responsive social attention patterns of school-age children with autism spectrum disorder. Attention patterns were examined within a standardized pretest/posttest measure of joint attention (JA) and a training-specific social attention measure during early, mid, and late training sessions. The rhythm and comparison groups demonstrated improvements in JA. Social attention was greater in the rhythm followed by the robot and lastly the comparison group. The robot and comparison groups spent maximum time fixating on the robot and objects, respectively. Across sessions, the robot group decreased attention to the robot and increased attention to elsewhere. Overall, rhythmic movement contexts afford sustained social monitoring in children with autism.

1. Introduction

Autism spectrum disorder (ASD) is characterized by persistent deficits in social communication skills and the presence of restricted and repetitive patterns of interests (American Psychiatric Association, 2013). Among the social impairments in ASD, atypical social attention is one of the primary impairments (Dawson, Bernier, & Ring, 2012). Children with autism show reduced eye contact (Rogers & DiLalla, 1990; Dawson et al., 2004), reduced interest in social stimuli (Maestro et al., 2002; Ozonoff et al., 2010), lack of response to name (Baranek, 1999; Osterling, Dawson, & Munson, 2002), reduced initiation of

Abbreviations: ASD, autism spectrum disorder; JA, joint attention; JTAT, joint attention test; RJA, responsive joint attention; IJA, initiating joint attention; PRT, pivotal response therapy; ABA, applied behavioral analysis; TEACCH, treatment and education of autistic and related-communication handicapped children; PECS, picture exchange communication system; VABS, Vineland adaptive behavior scales; SCQ, social communication questionnaire; SMD, standardized mean difference; CONSORT, consolidated standards of reporting trials; CI, confidence intervals.

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interactions (Bryson et al., 2007), poor sharing of interests with caregivers (Charman et al., 1998; Yoder, Stone, Walden, & Malesa, 2009), and impaired imitation skills (Bryson et al., 2007; Young et al., 2011). Deficits in social orienting and attention could have cascading effects on the social, cognitive, and language skills of children. For example, during caregiver-child interactions, children learn social skills such as turn taking, imitation, and sharing of interests (Dawson et al., 2004; Mundy & Hogan, 1994). Moreover, children learn functional skills such as brushing, using a spoon, riding a bicycle, etc. by observing and imitating the actions of others (Dewey, 1993; Mostofsky et al., 2006). Lastly, during triadic contexts involving the child, the caregiver, and interesting objects, children learn object labels and object affordances (Baldwin, 1995; Tomasello & Farrar, 1986). Overall, social attention abilities influence multisystem development in childhood. Given the pervasive attentional impairments in ASD, considerable research has focused on developing interventions to remediate attentional impairments. The focus of the present study was to compare the effects of two novel intervention approaches – rhythm and robotic – on the attentional patterns of school-age children with ASD.

Attentional impairments in children with ASD include a preference for non-social over social cues (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998), difficulty disengaging attention (Landry & Bryson, 2004), and poor sharing of attention with others (Mundy & Hogan, 1994). Children with ASD have difficulties in spontaneously orienting to social stimuli (Dawson et al., 1998; Swettenham et al., 1998). For example, compared to typically developing children and children with Down syndrome, children with ASD had greater difficulty orienting to social stimuli including name calling and hand clapping compared to non-social stimuli such as a rattle or a jack-in-the-box (Dawson et al., 1998). Social orienting impairments are compounded by children's preference for non-social stimuli such as objects (Hutman, Chela, Gillespie-Lynch, & Sigman, 2012; Klin, Jones, Schultz, Volkmar, & Cohen, 2002). Twenty-month-old toddlers with ASD who watched a video of an adult-child play interaction demonstrated lower social attention levels and instead focused on background toys compared to control infants (Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2011). Moreover, children have problems disengaging attention in the presence of competing stimuli (Courchesne et al., 1994). During a visual orienting task that required simultaneous attention to two stimuli, children with ASD had difficulty disengaging attention and instead fixated on only one of the stimuli for 20% of the trials (Landry & Bryson, 2004). Impaired social orienting, a preference for non-social stimuli, and difficulties in attention disengagement, have implications for the development of joint attention (JA), which is the ability to coordinate attention between social partners and interesting objects/events using eye gaze and gestures (Bakeman & Adamson, 1984; Mundy, 2003). To engage in shared attention, children need to orient to their social partners and shift attention rapidly between social and non-social stimuli in their surroundings (Courchesne, Chisum, & Townsend, 1995; Dawson et al., 1998). Children with ASD have difficulties in both responding to attentional bids of others, referred to as responding to joint attention (RJA), as well as initiating bids to direct others' attention towards salient objects, called initiating joint attention (IJA) (Charman, 1998; Mundy, Sigman, & Kasari, 1990). It has been argued that social attention during periods of shared attention could be an indicator of treatment efficacy in children with autism (Dawson et al., 2012). Interventions that facilitate social attention can increase children's opportunities to learn from their environment and change their developmental trajectory.

Current autism interventions that facilitate social skills are broadly classified into contemporary behavioral interventions, developmental approaches, and social skill interventions (Lovaas, 1987; Rao, Beidel, & Murray, 2008; Vismara & Rogers, 2010). Contemporary behavioral and developmental interventions use a comprehensive framework to address impairments in multiple domains (Vismara & Rogers, 2010), whereas social skill interventions focus on facilitating specific social skills (Rao et al., 2008; Reichow & Volkmar, 2010). Contemporary behavioral interventions such as Pivotal Response Therapy (PRT) (Schreibman & Koegel, 1996; Steiner, Gengoux, Klin, & Chawarska, 2013), incidental teaching (McGee, Morrier, & Daly, 1999), and milieu teaching (Yoder & Stone, 2006) use principles of Applied Behavioral Analysis (ABA) including reinforcement, repetition, and incremental prompting (Granpeesheh, Tarbox, & Dixon, 2009; Lovaas, 1987) to facilitate social communication skills and reduce negative behaviors. For example, peer-mediated PRT led to an increase in peer interactions, JA, play, social initiations, and language skills in children with ASD (Pierce & Schreibman, 1995). In contrast to behavioral interventions, developmental approaches such as the Early Start Denver Model (Rogers & Dawson, 2010), Developmental Individual-Difference, Relationship-Based model (Greenspan & Wieder, 1997), play-based JA intervention (Kasari, Paparella, Freeman, & Jahromi, 2008), and those targeting socially synchronous behaviors (Landa, Holman, O'Neill, & Stuart, 2011) promote age-appropriate skills such as imitation, JA, pretend play, and communication. For example, a 6-month intervention promoting interpersonal synchrony led to greater improvements in imitation, JA, and shared affective skills compared to a control group (Landa et al., 2011). Lastly, social interventions such as social skill groups (Kroeger, Schultz, & Newsom, 2007), social stories (Karkhaneh et al., 2010), Socio-Dramatic Affective-Relational Intervention (Lerner, Mikami, & Levine, 2011), and social skills training (Rao et al., 2008) focus on interpersonal skills such as turn taking, social initiations, and response to questions. For example, a 5-week group social skill intervention where children were taught skills such as turn taking and cooperative play led to greater improvements in social interactions of children compared to a free play intervention (Kroeger et al., 2007). Typically, behavioral interventions for autism are delivered for 30–40 h per week (Landa, 2007). Although intensive in nature, these therapies do not necessarily capitalize on the strengths and predilections of children with autism. Therefore, there is a need to diversify contemporary autism interventions by exploring therapies that tap into children's inherent strengths and are therefore enjoyable and motivating for them.

There is growing research on novel and motivating interventions, namely rhythm and robotic therapies, for children with ASD. Motivating and child-preferred contexts that facilitate interactions between children and their social partners are most effective in promoting social engagement (Kasari et al., 2008; Landa et al., 2011). Not surprisingly, music-based rhythm