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The effects of embodied rhythm and robotic interventions on the spontaneous and responsive verbal communication skills of children with Autism Spectrum Disorder (ASD): A further outcome of a pilot randomized controlled trial



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ABSTRACT

The current manuscript is the second in a mini-series of manuscripts reporting the effects of alternative, movement-based, rhythm and robotic interventions on the social communication skills of 36 school-age children with ASD. This pilot randomized controlled trial compared the effects of 8-weeks of rhythm and robotic interventions to those of a standard-of-care, comparison intervention. The first manuscript reported intervention effects on the spontaneous and responsive social attention skills of children. In this manuscript, we report intervention effects on the spontaneous and responsive verbal communication skills of children. Communication skills were assessed within a standardized test of responsive communication during the pretest and posttest as well as using training-specific measures of social verbalization during early, mid, and late training sessions. The rhythm and comparison groups improved on the standardized test in the posttest compared to the pretest. The rhythm and robot groups increased levels of social verbalization across training sessions. Movement-based and stationary contexts afford different types and amounts of communication in children with ASD. Overall, movement-based interventions are a promising tool to enhance verbal and non-verbal communication skills in children with ASD.

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Abbreviations: ASD, autism spectrum disorder; TD, typically developing; JA, joint attention; RCT, randomized controlled trial; JTAT, joint attention test; ABA, applied behavioral analysis; TEACCH, treatment and education of autistic and related communication-handicapped children; VOCAs, voice output communication aids; PECS, picture exchange communication system; ADOS-2, autism diagnostic observation schedule, 2nd edition; SMD, standardized mean difference; CI, confidence intervals; CONSORT, consolidated standards of reporting trials.

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1. Introduction

Autism Spectrum Disorder (ASD) is a common pediatric developmental disorder with 1 in every 68 children in the US being diagnosed with ASD (Baio, 2010). Given the rising prevalence of ASD, there is growing research on developing novel and engaging interventions for children with ASD to address their core social communication impairments. The current manuscript is the second paper in a mini-series of manuscripts reporting the findings from a pilot randomized controlled trial (RCT) conducted to assess the effects of novel, multisystem, rhythm and robotic therapies compared to a standard-of-care intervention on the non-verbal and verbal communication skills of school-age children with ASD. The first manuscript reported the effects of rhythm and robotic therapies on the spontaneous and responsive social attention patterns of children with ASD. In the current manuscript, we will report the effects of rhythm and robotic interventions on the spontaneous and responsive verbal communication skills of children.

Verbal communication impairments in children with ASD include difficulties with initiation of conversations, responding to communicative bids of others, and engaging in reciprocal conversations (Eigsti et al., 2011). In addition, children with ASD have difficulties understanding and integrating non-verbal behaviors such as eye contact, body language, gestures, and facial expressions into their social interactions (Eigsti et al., 2011). In fact, delays in language milestones such as the onset of first words are amongst the earliest causes for parental concern and physician referral in children who eventually develop an ASD diagnosis (Luyster, Kadlec, Carter, & Tager-Flusberg, 2008; Dahlgren & Gillberg, 1989; De Giacomo & Fombonne, 1998; Lord, Risi, & Pickles, 2004; Luyster et al., 2008; Mitchell et al., 2006; Wetherby et al., 2004). However, there is tremendous variability in the language profiles of children with ASD; around 25% never develop functional speech (Kjelgaard & Tager-Flusberg, 2001; Tager-Flusberg, Paul, & Lord, 2005), whereas other children develop vocabularies comparable to typically developing (TD) children (Luyster et al., 2008; Thurm, Lord, Lee, & Newschaffer, 2007). Nevertheless, even children at severity level 1 according to the latest DSM V criteria (American Psychiatric Association, 2013) demonstrate subtle difficulties in using language appropriately during social interactions (Eales, 1993; Luyster et al., 2008). Early language skills of children with ASD have been associated with long-term outcomes and future prognoses (Gillberg & Steffenburg, 1987; Gillberg, 1991; Howlin, Mawhood, & Rutter, 2000; Kobayashi, Murata, & Yoshinaga, 1992; Lincoln, Courchesne, Kilman, Elmasian, & Allen, 1988; Rutter, 1970; Sigman & Ruskin, 1999; Venter, Lord, & Schopler, 1992). Overall, impaired verbal and non-verbal communication skills negatively affect children's abilities to engage in meaningful interactions, which in turn may lead to missed opportunities to learn skills associated with adaptive functioning, academic competence, and social engagement.

Children with ASD demonstrate poor receptive and expressive communication skills, with greater impairments in receptive compared to expressive language (Charman, Drew, Baird, & Baird, 2003b; Hudry et al., 2010; Kjelgaard & Tager-Flusberg, 2001; Luyster et al., 2008). Poor receptive language could be due to both a core difficulty in understanding linguistic input and an impaired perception of subtle cues that accompany speech, including the speaker's facial expressions, tone of voice, etc. (Landa, 2007; Tager-Flusberg & Caronna, 2007; Tager-Flusberg et al., 2005). In terms of language production, children have impaired responsive and spontaneous speech production, although deficits in spontaneous communication are more severe and persistent (Vismara & Rogers, 2010). For example, children with ASD have difficulty offering relevant information during ongoing conversations initiated by others (Adams, Green, Gilchrist, & Cox, 2002; Chuba, Paul, Miles, Klin, & Volkmar, 2003; Lord et al., 1989; Surian, Baron-Cohen, & Van der Lely, 1996; Ziatas, Durkin, & Pratt, 2003). Children also demonstrate difficulties in spontaneously initiating speech and engage in lower rates and variety of speech compared to TD children (Koegel, Koegel, Harrower, & Carter, 1999; Stone & Caro-Martinez, 1990; Tager-Flusberg et al., 2005). Moreover, instead of using language to communicate with others, children with ASD frequently engage in echolalia (repetition/echoing of words and phrases heard in the past), self-directed speech, and speech monologues (Eigsti, de Marchena, Schuh, & Kelley, 2011; Ramberg, Ehlers, Nydén, Johansson, & Gillberg, 1996; Tager-Flusberg and Calkins, 1990). In addition to these obvious communication impairments, children demonstrate impaired joint attention (JA), motor imitation, and play skills that are foundational for the development of language skills (Amato, Barrow, & Domingo, 1999; Charman et al., 1998; Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Mundy, Sigman, & Kasari, 1990; Rogers, 1999; Smith & Bryson, 1994). For example, JA and motor imitation skills were predictive of future language abilities in children with ASD (Bono, Daley, & Sigman, 2004; Charman et al., 2003a; Dawson et al., 2004; McDuffie, Yoder, & Stone, 2005; Murray et al., 2008; Stone, Ousley, & Littleford, 1997; Toth, Munson, Meltzoff, & Dawson, 2006). Similarly, functional and symbolic play have been linked to receptive and expressive language abilities in ASD (Mundy, 1987; Sigman & Ruskin, 1999). Given these developmental links, it is imperative that interventions targeting communication skills in ASD also promote precursors of language including JA, play, and motor imitation.

Current autism interventions can be classified into two types – communication interventions that primarily facilitate speech or provide children with alternative modes of communication and holistic interventions that facilitate language and related skills such as JA, play, and motor imitation (Delprato, 2001; Paul & Sutherland, 2005). Communication interventions include contemporary behavioral interventions (Hart & Risley, 1968; Lovaas, 1987, 2003; McGee, Krantz, Mason, & McClannahan, 1983) based on principles of applied behavioral analysis (ABA) as well as augmentative and alternative communication strategies such as sign language training (Sundberg & Partington, 1998), pictorial communication systems (Bondy & Frost, 2003), and voice output communication aids (VOCAs) (Paul & Sutherland, 2005). Contemporary ABA interventions use stimuli centered on the child's interests to promote spoken language using repeated practice and reinforcement within naturalistic environments (Delprato, 2001; Goldstein, 2002; Rogers & Vismara, 2008). In contrast,

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