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Communicating Without Words: School-Based RCT Social Intervention in Minimally Verbal Peer Dyads with ASD

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Despite their social withdrawal, school-age children with autism spectrum disorder who are minimally verbal (MVASD; i.e., use a limited repertoire of communicative spoken words) have received few interventions supporting peer engagement. This study examined efficacy of a novel ecological randomized controlled trial—school-based peer social intervention—designed to increase social engagement (via available communication channels) in school-age peer dyads with MVASD. Fifty-four children with MVASD (8–16 years) in 9 Israeli special education schools were randomly assigned to conversation intervention, collaboration intervention, or waitlisted treatment-as-usual (control) group (n = 18 per group). Manualized conversation and collaboration interventions each included 60 lessons (15 weeks × 4), implemented by teachers at school and supervised by researchers. Pretest–posttest improvement in spontaneous peer interaction was measured via 3 data sources/methods: teacher-reported social behavior (Vineland: Socialization domain) and direct observations of children's spontaneous free play (Modified-Classroom Observation Schedule to Measure Intentional Communication) and free conversation (Social Conversation Scale). Allocation group was masked from reporters/coders. As secondary outcomes, children's progress was measured in executive functions (BRIEF Inventory), and communication (Vineland). Significant pre–post improvement emerged for both intervention groups' spontaneous free conversation and for the collaboration group's spontaneous free play. Teacher reports, although mixed, indicated that the conversation group's socialization skills improved, but communication did not. Children in the conversation group also improved their metacognitive executive skills (e.g., planning, monitoring, organization). Strengthening this high-risk school-age population's ability to interact more spontaneously with peers through conversation and collaboration intervention holds promise for reducing social withdrawal in MVASD.

School-age children with autism spectrum disorder who are minimally verbal (MVASD)—namely, who use a limited repertoire of communicative spoken words—pose a unique challenge to both theoreticians and interventionists because of this group's heterogeneity in language and cognitive functioning (Bal, Katz, Bishop, & Krasileva, 2016; Kasari, Brady, Lord, & Tager-Flusberg, 2013; Tager-Flusberg & Kasari, 2013). The most prominent defining characteristic of MVASD is the deficit in spoken language. These children exhibit few words, ranging from none up to 20 to 30, which are used in limited contexts and for restricted functions (e.g., requesting) and which may or may not be accompanied by "scripted" phrases—fixed phrases or word chunks used to communicate in routinized contexts but not used as separate words or not yet decontextualized (Kasari et al., 2013). Studies suggest that 17%–30% of children along the spectrum can be classified as MVASD, depending on the diagnostic instrument and child's chronological age (e.g., Bal et al., 2016; Rose, Trembath, Keen, & Paynter, 2016; Wodka, Mathy, & Kalb, 2013).

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Yet the clinical profile of MVASD is complex, necessitating consideration of (a) cognitive functioning, which may range from profoundly impaired to average intelligence, with 16% showing nonverbal IQ of 70 or more; (b) multifaceted receptive language, where approximately half of the children show greater nonverbal than verbal IQs and the other half show equivalent verbal and nonverbal IQs (e.g., Bal et al., 2016); and (c) diverse nonverbal communication abilities and preferences such as sign language, gestures, writing, and digital devices (Tager-Flusberg & Kasari, 2013). Bal et al. (2016) emphasized the cognition–language link by showing that a more stringent definition of minimally verbal (no words rather than few words) was linked with more homogenously severe cognitive functioning. A multiple-method investigation of receptive language variability in MVASD (ages 5.75–21.4 years; M = 12.5), combining standardized verbal and nonverbal measures (Peabody, Raven) with objective eye-tracking procedures and caregiver reports, indeed verified large heterogeneity in receptive language abilities (Plesa-Skwerer, Jordan, Brukilacchio, & Tager-Flusberg, 2016). However, these participants across all ages demonstrated nonverbal Raven IQ ratio scores (Raven's Colored Progressive Matrices; Raven, Raven, & Court, 1998) that exceeded their receptive vocabulary scores (Peabody Picture Vocabulary Test-III; Dunn & Dunn, 1997).

In contrast to the heterogeneous linguistic and cognitive profiles found for these children, consensus exists regarding the severe adaptive functioning deficits that consistently characterize the MVASD population, especially in the socialization and communication domains. The increasingly serious social withdrawal with age in this population (e.g., Frost, Hong, & Lord, 2017; Lord, 2010) implies the likelihood of poor long-term prognosis for social adjustment (Howlin, Mawhood, & Rutter, 2000).

Prior Interventions for School-Age Children with MVASD

Despite this high social risk for individuals with MVASD, social interventions are scarce for developing their peer dyadic interactions at school ages. To date, school-age interventions in MVASD have mostly targeted an increase in spoken words rather than enhancing social interaction per se (e.g., Chenausky, Norton, Tager-Flusberg, & Schlaug, 2016), have generally been adapted from preschool ages rather than designed specifically for school ages, have mainly been implemented in the context of child–adult interaction rather than peer interaction, and have rarely used a randomized controlled trial (RCT) model (e.g., Tager-Flusberg & Kasari, 2013). Furthermore, those who did conduct large-scale RCT school-based interventions to successfully facilitate social skills and active social participation in autism spectrum disorder (ASD) focused on young (kindergarten through second grade) heterogeneous samples of verbal and nonverbal participants without reporting the percentages of MVASD (e.g., Morgan, Hooker, Sparapani, & Reinhardt, 2018; Young, Falco, & Hanita, 2016).

In one series of studies exploring social engagement, mostly in the context of child–adult interactions (with professionals and/or parents), the JASPER evidence-based preschool intervention model (for Joint Attention, Symbolic Play, and Emotion Regulation) was applied to young school-age children (M = 6.31 years, range = 4.2–9.0) as compared to another intervention modality (enhanced milieu teaching) with/without a speech-generating device (e.g., Almirall et al., 2016; DiStefano, Shih, Kaiser, Landa, & Kasari, 2016; Kasari et al., 2014; Shire et al., 2015). Some advantages were noted for using a speech-generating device in adaptive intervention. On the whole, results were encouraging in that these relatively young school children with MVASD improved their verbal communication with adults (e.g., spontaneous communicative utterances, number of novel word roots) and their nonverbal communication with adults (e.g., initiation of joint attention and behavioral regulation), but children demonstrated no improvement in play actions (e.g., Almirall et al., 2016).

Another prominent direction of RCTs (e.g., Carr & Felce,, 2007b; Gordon et al., 2011; Howlin, Gordon, Pasco, Wade, & Charman, 2007) and non-RCT research (e.g., Boesch, Wendt, Subramanian, & Hsu, 2013) for school-age children with MVASD has employed the Picture Exchange Communication System to teach functional communication and social-communicative skills. Overall, those studies demonstrated Picture Exchange Communication System's modest effectiveness, mainly in enhancing instrumental communication (e.g., requesting, commenting) during child–adult dyadic interaction.

Importance of Peer-Based Interventions for Social Collaboration and Conversation in MVASD

Considering the paucity of research directly investigating social interventions for school-age peers with MVASD, lacunae exist in today's understanding of how to help these children develop and maintain spontaneous dyadic interactions in their natural social environment—at their schools. Relations with peers are necessary to facilitate children's emotional well-being and their cognitive, language, and interpersonal skills. Longitudinal evidence shows that individual variations in behavior and in responding to peers' behavior at early ages predict later social competence (Hay, Caplan, & Nash, 2009). The ability to converse and the ability to cooperate with peers are keys to the success of such interactions (Coplan. & Arbeau., 2009).

Difficulties in cooperating with peers and poor pragmatic conversational skills are considered the hallmark of the ASD deficit (American Psychiatric Association, 2013). Deficient in verbal expressive abilities or alternative ways to interact with peers, children with MVASD are caught in a vicious circle of social isolation lacking productive channels for effective engagement with peers. DiStefano et al. (2016) highlighted the important link between social engagement and expressive language development, pointing out the need to incorporate sustained communication interchanges as a target for intervention with MVASD. Becaues of its reciprocal nature, peer engagement is a more challenging form of interaction than interaction with adults, who can scaffold the interaction. Interactive skills that are expressed with an adult do not naturally transfer into peer settings (e.g., Dekker, Nauta, Mulder, Systema, & de Bildt, 2016). Furthermore, poor peer-interaction capabilities put children with ASD at greater risk to be bullied and victimized by other children (e.g., Lebrun-Harris, Sherman, Limber, Miller, & Edgerton, 2018).

The Current Study

The school-based peer social intervention (S-PSI; Bauminger-Zviely, Estrugo, Samuel-Magal, & Friedlin, 2015) is a manualized intervention for children with MVASD that aims to enhance peer interaction and social engagement in two core areas that are essential for effective social interaction but noticeably deficient in MVASD—namely, social collaboration and social conversation. Thus, the S-PSI comprises two main curriculum protocols, one for conversation and one for collaboration. Designed specifically for school-age children with MVASD, the S-PSI is based on nonverbal activities and learning processes. Throughout the intervention, children with MVASD are taught to engage with their peers (“converse” or “collaborate”) in ways that are alternative to spoken words by using any available communication channels including sign language, gestures, handwriting or drawing, touch, facial expression, kinesthetic movement in space, and digital devices.

In this study, S-PSI efficacy was examined using an RCT model that compared three groups of children with MVASD: those receiving the two curriculum protocols (a social conversation group and a social collaboration group) and those waiting for a delayed S-PSI intervention (a treatment-as-usual control group). Comparison of the two intervention protocols aimed to help delineate each treatment modality’s unique contribution to improvements in social engagement in MVASD, whereas comparison of each modality with the waitlisted group aimed to verify improvement beyond natural maturation. More specifically, we aimed to evaluate change from pretest to posttest in children’s social engagement, within each study group (conversation, collaboration, control) and between groups.

Children’s social engagement outcomes were measured via pretest and posttest comparison of (a) observations of peer dyads’ interactions during two social situations, free conversation and free play, as well as (b) reports on children’s socialization by a familiar member of the children’s special education teacher team who was not the teacher trained to lead the current intervention and who was unaware of children’s research condition. We predicted that both intervention groups (conversation, collaboration) would surpass the control group regarding pre–post improvement in social engagement; however, because of a lack of previous empirical data, we did not formulate hypotheses regarding the differences between the conversation and collaboration treatments.

Executive functions, especially mechanisms like metacognition, planning, and monitoring, were found to have important implications for social functioning (e.g., Best, Miller, & Jones, 2009). Therefore, as a secondary aim, we measured possible change in children’s executive functioning capabilities in view of prior research showing social treatments’ indirect effects on such functions. For example, after participating in a social intervention that did not target cognitive flexibility, high-functioning school-age children with ASD demonstrated higher flexibility in restructuring concepts and ideas (e.g., Bauminger, 2007). We predicted that both intervention programs (conversation, collaboration) would have an indirect effect on children’s executive functions and metacognitive capabilities.

METHOD

Participants

The sample comprised 54 participants with MVASD (8–16 years of age) out of an original pool of 110 potential participants recruited from nine special education schools for children with ASD in large middle-class urban areas in Israel (see Figure 1 for sample identification and selection details). As seen in the figure, children and adolescents who met the inclusion criteria (N = 58) were initially randomized into the three study groups, but two dyads (N = 4) dropped out very early in the intervention, leaving 54. One dyad from the conversation group dropped out because of one child’s personal issues; and the second dyad started the collaboration intervention but was too agitated to follow the protocol. This left 18 participants in each of the three groups: conversation intervention, collaboration intervention, and waitlisted controls.

Inclusion criteria comprised (a) formal clinical ASD diagnosis, based on the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.; American Psychological Association, 2000) criteria, given by a licensed psychologist unassociated with this study as mandatory for inclusion into these special education

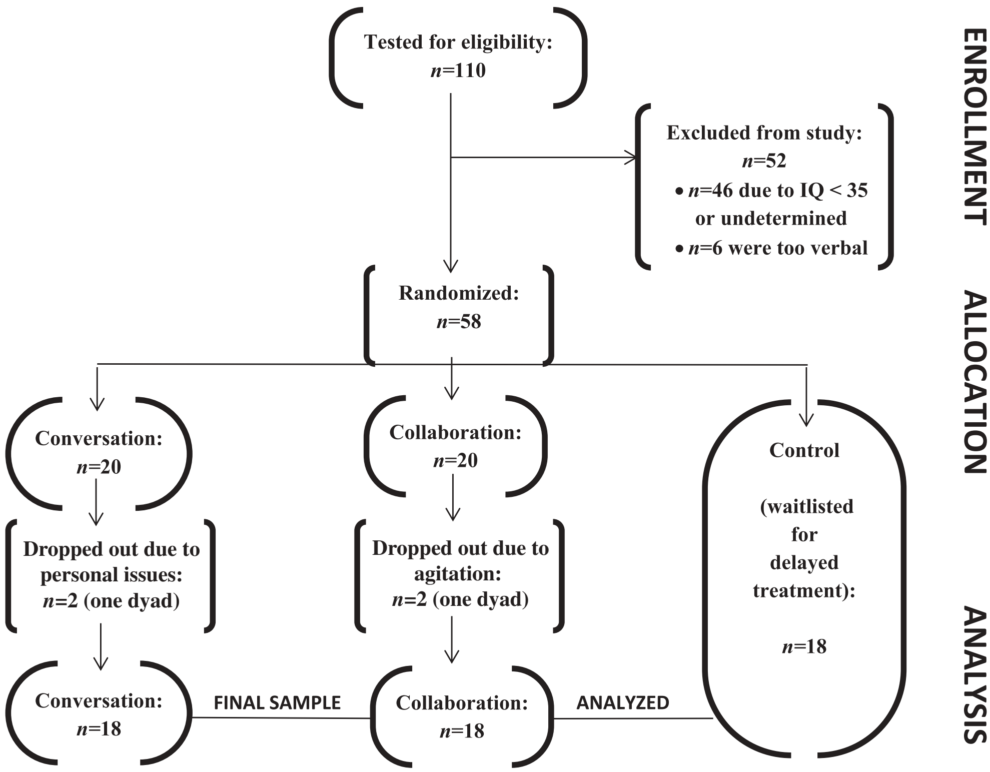

FIGURE 1 Flowchart illustrating sample selection.

schools according to Israeli Ministry of Education policy; (b) verification of the child's ASD clinical diagnosis (scores above the autism cutoff) by a parent's report on the Social Communication Questionnaire (Rutter, Bailey, & Lord, 2003); (c) verbal and nonverbal IQ scores equal to or greater than 35 (the minimum IQ in the moderate intellectual disability range; World Health Organization, 1993) to enable basic understanding of intervention demands (receptive vocabulary using Peabody Picture Vocabulary Test–III, Dunn & Dunn, 1997; Nonverbal IQ test: Raven's Colored Progressive Matrices, Raven et al., 1998); (d) fewer than 30 spontaneous spoken words according to teacher report (based on Kasari et al.'s, 2013, definition for MVASD); and (e) no comorbid diagnosis except for intellectual disability. As seen in Table 1, before intervention, groups differed only on nonverbal IQ (Raven).

Allocation and Randomization Process

After receiving permission from the chief scientist of the Ministry of Education, we approached the principals of 10 special education schools specializing in ASD. Nine agreed to take part in the study: one middle to high school (serving 12- to 21-year-olds), two elementary schools (serving 6- to 12-year-olds), and six elementary to high schools (serving 6- to 21-year-olds), including 91 multiage special education classes. We then identified children with MVASD according to teachers' report. Letters were sent by school principals to parents of the identified children, explaining study aims and procedures. The 110 parents who consented to their children's participation were contacted by the research team for parents' SCQ interview while their children underwent Raven and Peabody testing for eligibility (see Figure 1).

For randomization of the 58 eligible children (from 37 classes), each school's participants were initially randomly allocated to all three conditions whenever student numbers and teacher availability permitted (as in Schools A–E; see Table 2). In cases where student numbers or teacher availability were insufficient to initially allocate children to all three conditions in the same school (Schools F–I, Table 2), randomization was performed across schools. Allocation continued randomly across schools until all participants had been assigned (Table 2 describes randomized allocation of dyads to the three groups, per school).

Teachers who were familiar with the children and were willing to implement the 4-hr weekly intervention in their school over 4 months were then randomly assigned to deliver one of the two intervention protocols. The 18 female teachers who delivered the S-PSI were specialists in special education (had at least a BA in special education and teaching certification) and had an average of 6.61 years of educational experience in working with ASD

TABLE 1
Pretest Characteristics of Study Participants with MVASD by Group

	Study Group			
	Conversation[a]	*Collaboration*[a]	*Control*[a]	*Pretest Group Differences*
Boys/Girls	15/3	16/2	13/5	
Chronological Age in Months				
M	122.61	134.76	136.17	*ns*
(SD)	(18.61)	(28.56)	(22.52)	
Range	96–162	92–181	94–182	
No. of Spoken Words (SCS-A)				
M	6.44	10.33	8.22	*ns*
(SD)	(6.90)	(10.25)	(8.14)	
Range	0–25	0–30	0–30	
Receptive Vocabulary (Peabody)				
M	58.11	57.83	52.83	*ns*
(SD)	(15.62)	(19.55)	(13.25)	
Range	37–101	37–97	36–80	
Nonverbal IQ (Raven)				
M	62.28	71.22	54.17	$F(2, 53) = 3.21$, $p < .05$
(SD)	(20.65)	(24.97)	(13.15)	Collaboration > Control
Range	41–109	44–125	38–87	
ASD Diagnostic Score (SCQ)				
M	22.56	22.00	21.67	*ns*
(SD)	(3.57)	(4.10)	(3.38)	
Mothers' Education[b]				
M	3.16	3.44	3.00	*ns*
(SD)	(.85)	(1.50)	(1.37)	

Note: $N = 54$. MVASD = school-age children with autism spectrum disorder who are minimally verbal; SCS-A = Social Conversation Scale; Peabody = Peabody Picture Vocabulary Test-III; Raven = Raven's colored progressive matrices; ASD = autism spectrum disorder; SCQ = Social Communication Questionnaire.

[a] $n = 18$.

[b] A 6-point scale ranging from 1 (*elementary school*) to 6 (*graduate degree or higher*).

TABLE 2
Randomized Allocation of Dyads to the Three Groups, per School

	No. Dyads Allocated to School						
School	*Conversation*	*Collaboration*	*Control*	*Total*	*No. Participants*	*No. Classes*	*No. Teachers*
A	1	2	2	5	10	6	3
B	2–1 = 1	1	2	5–1 = 4	10	4	3–1 = 2
C	2	1	1	4	8	4	3
D	1	1	2	4	8	7	2
E	1	1	1	3	6	6	2
F	1	1	0	2	4	3	2
G	0	1	1	2	4	2	1
H	1	1	0	2	4	3	2
I	1	1–1 = 0	0	2–1 = 1	4	2	2–1 = 1
Total	10–1 = 9	10–1 = 9	9	29–2 = 27	58–4 = 54	37	20–2 = 18

Note: After initial randomization, two dyads dropped out: School B's conversation group and School I's collaboration group.

(*SD* = 3.63; range = 2–12 years). Teachers underwent a full-day training seminar at the university specializing in either the conversation or collaboration treatment, including instruction on the need for a "Chinese wall" information barrier between teachers in the two intervention conditions. In addition, teachers signed a nondisclosure agreement including the request not to share intervention content with school colleagues.

Research team members met every 2 weeks to provide teachers with active ongoing coaching and supervision only regarding their assigned S-PSI intervention manual's implementation. To enlist principals' and teachers' intensive cooperation, schools were promised materials, manuals, and study results to design the most effective future treatments.

Intervention Design and Content

Design

All study participants were assigned to fixed dyads in their study groups (conversation, collaboration, and control) based on age and preferred communication channel (e.g., sign language, computers, tablets, gestures, writing). Both of the manualized S-PSI treatment conditions (conversation and collaboration) included 60 lessons delivered to each peer dyad separately, for 1 hr each, four times per week over 15 weeks; implemented by trained special education teachers in the schools during school hours; and supervised by the research team. Social interaction was emphasized in each intervention, combining learning and practicing while using fun nonverbal activities and games, as well as visual stimuli and symbols.

Over these 15 weeks, the assigned peer dyads in the control group continued their treatment as usual in their educational settings; they did not meet as a dyad in any structured way or receive any S-PSI treatment while waiting for their turn to receive the intervention, beyond participating in the pretest and posttest sessions where they completed assessments with their assigned partner.

Content

Each of the two S-PSI curricula (conversation and collaboration) included seven main units. The conversation group's curriculum focused on conceptual clarification of social "conversation," defined as interactive reciprocated initiations and responses between dyad partners, whether via minimally verbal or nonverbal channels such as gestures (Unit 1); understanding conversational rules such as taking turns (Unit 2); discussing adequate conversational topics with peers (Unit 3); learning how to initiate a conversation (Unit 4); learning how to develop and maintain a conversation adequately by conveying and sharing information, emotions, and content, and/or by switching between topics (Unit 5); learning to ask questions (Unit 6); and learning how to end a conversation (Unit 7). The collaboration group's curriculum focused on creating "camaraderie and team spirit" through ice-breaker games and developing the dyad's name and rules (Unit 1); experiencing shared tasks with an emphasis on the three phases of collaboration, defined as selection of activities, mutual planning, and then joint performance (Units 2–3); developing prosocial skills such as sharing, helping, and encouraging (Units 4–6); and closure activities (Unit 7).

Lesson Examples

In the conversation group, the topic of "What is Conversation?" was taught as follows: The definition of conversation was presented on the "communication board," which displayed words and relevant symbols and icons, while the teacher read aloud and explained in words and symbols. Students were then exposed to various dyadic activities to teach them the concept of conversation and help them differentiate conversation versus nonconversation situations (children laughing together, monologue, play) using materials like film clips, puzzles, and memory games. Then children practiced "talking to each other" by choosing and exchanging cards with words, pictures, or icons of things they like to eat/do/watch or things they fear/dislike. Over the lessons, each dyad's communication board gradually expanded in line with the intervention contents, to include possible conversational topics, various opening sentences for conversation, sentences to use for switching between topics, WH-questions, elaborations, closer sentences, and so on.

In the collaboration group, the topic of "Working Together" was taught as follows: The definition of working together and cooperation was presented on the dyad's communication board, both in words and in relevant symbols and icons, while the teacher read aloud and explained in words and symbols. Students were exposed to pictures describing situations of working together versus working alone. Activities in this module included creating joint artwork, playing musical or rhythmic sequences together, and performing motor tasks that required imitation and movement coordination. Students reflected on their joint efforts through the use of communication board and by observing a video of their own activity to identify ways to work better as partners using the skills learned so far (e.g., waiting your turn, looking at your friend). Each dyad gradually expanded its communication board with concepts related to collaboration (giving and getting help, comforting, collaborating, sharing). In both intervention protocols, gestures were also taught, such as touching your partner's arm to draw his or her attention, gestures to show encouragement, and pointing at an object. In both interventions, the adult presented the activity at hand and then faded out while the two children interacted with each other.

Fidelity Self-Rating and Formative Evaluation

To ensure uniformity and consistency in curriculum delivery according to the protocol, each teacher who delivered one of the intervention programs completed a self-rated fidelity questionnaire once a week regarding implementation. The research team reviewed and discussed these weekly fidelity self-ratings with each teacher every second week to monitor teachers' self-rated adherence to the assigned protocol. In addition, ongoing teacher fidelity was monitored by our research team through informal dialog with the teachers (providing feedback and discussion) during and after monthly live observation of classroom activities by our research staff, although no formal fidelity was rated by our research team.

Our research team did not report any mixed or shared intervention strategies within each school, indicating successful maintenance of nondisclosure.

Weekly Self-Rated Fidelity Questionnaire. Teachers rated 18 items on a Likert scale from 1 (*agree*) to 5 (*disagree*) assessing four categories: teachers' accuracy in implementing the intervention, that is, self-reported fidelity (nine items); the intervention content's relevance (nine items); the participants' motivation and satisfaction from intervention (three items); and participants' skill generalization to other settings like recess or other lessons (one item). Overall, teacher's self-reported accuracy of intervention implementation was adequate (conversation = 75.5%, collaboration = 81.3%, total = 78%), as were children's motivation and satisfaction (conversation = 70.44%, collaboration = 72.1%, total = 71%). Teachers' evaluations of the relevance of intervention contents were a little lower but still adequate (conversation = 67.3%, collaboration = 63.8%, total = 66%). Children's transfer of skills learned in the intervention was lower (conversation = 52.89%, collaboration = 40%, total = 46.4%); however, considering the severity of the population and the relatively short intervention duration, these percentages indicating 40%–53% generalization are noteworthy.

Intervention Outcome Measures

The primary S-PSI outcome—social engagement—was assessed by coding of videotaped free-play and free-conversation situations and via external teacher reports of participants' socialization. The secondary S-PSI outcomes—executive functions and communication—were assessed using teacher reports.

Primary Outcome: Social Engagement Observations

Children's interactive social engagement behaviors with their fixed partner were videotaped during free-play and free-conversation/communication situations at pretest and posttest in all three groups. Observation took place in counterbalanced order between free-play situations and free-"conversation" situations (nonverbal "talk" or minimally verbal communication), during school hours, in a quiet room free of distractions. Two coders, who were expert special educators masked to participants' group assignment, obtained high intraclass correlation coefficients (ICC) on independent coding of 25% of videotapes, randomly selected from the three groups, the two time intervals, and the two social situations (ICC = .98 on free-play coding and ICC = .88 on free-conversation coding).

Free-Play Observations. Each fixed dyad was observed for 8 min at pretest and 8 min at posttest, playing the same game at both intervals that the dyad chose at pretest and revisited at posttest, out of three options: a puzzle, a soap-bubble gun toy, or a collapsing tower game. Children received no special instructions during the play session, but a familiar adult (a school staff member unrelated to the study) was present during the observation and was instructed to encourage the dyad to play with each other.

Children's interactive social engagement behaviors during free play were coded using the Modified–Classroom Observation Schedule to Measure Intentional Communication (M–COSMIC; Clifford, Hudry, Brown, Pasco, & Charman, 2010). Based on the M–COSMIC, coders counted the frequency of two *Role* behaviors and three *Function* behaviors along the 8-min videotaped observation at each interval. The Role that children took in their play interaction was defined as either *active* (any initiations or responses exhibited) or *passive* (any behaviors such as withdrawing, avoiding further interaction, or replying nonmeaningfully). The communication Functions of the interaction were defined as *behavior regulation* (requests for object/action/help, refusal/protest, compliance), *social interaction* (requests for social routine; showing off to direct peer's attention to oneself; verbal/nonverbal acknowledgment behaviors such as "yes," "okay," a thumbs-up gesture, or a nod), and *joint attention* (comments, requests for information). Our preliminary analyses of the M-COSMIC correlation matrix revealed high correlations between active role and social-interaction function (r = .92, p < .001); thus, our final analysis included two roles (active, passive) and two functions (behavior regulation and joint attention).

Free-"Conversation" Observations. Each fixed dyad was observed for 6 min at pretest and 6 min at posttest, in a free-"conversation" situation aiming to elicit interactive communication through their everyday nonverbal "talk" or minimally verbal communication channels between the dyad partners. The procedure resembled the Autism Diagnostic Observation Schedule (Lord et al., 2000) free-conversation situation. Children were instructed to "talk" with their peer partner. During the first 3 min, the same familiar adult staff member who was present in the free-play situation was instructed to help the children enter "conversation" with each other. During the first part of this task, the adult was instructed to provide structured support to help children enter the interaction. Then, in the following 3 min, the children were left to communicate without adult support (other than encouraging comments such as "remember to talk with your friend").

Children's interactive social engagement behaviors during free conversation were coded using the Social Conversation Scale (SCS), based on Capps, Kehres, and Sigman (1998), which we adapted to MVASD for the purpose of the current study (e.g., using nonverbal communication channels to interact). The SCS-A included a frequency scale and a quality scale. Six communication behaviors were rated for frequency as exhibited toward the adult staff member and for frequency as exhibited toward the peer partner, during each 10-s interval of the observed 6-min free conversation: (a) communicative *initiations* (e.g., asking a question, waving hi, showing a "How are you?" card to the peer), (b) communicative *responses* (e.g., replying to peer's/adult's questions, stretching one's hand out to meet the other's handshake), (c) *relevance* of communicative behavior (adequacy of attunement and participation in a reciprocal communication chain; e.g., Partner A listens and looks at Partner B's communication board while Partner B writes a question for Partner A, and then Partner A replies by showing a word on his own communication board), (d) *social smile* toward peer/adult, (e) *vocalization* (any words conveyed by any communication channel), and (f) *eye contact* (looking at partner's face with/without words). For each of the six interactive behaviors during conversation, we calculated a separate total frequency for those directed toward the adult and those directed toward the peer partner. The preliminary correlation matrix within the SCS-A variables permitted use of all categories.

The SCS-A *Social Conversation Quality* Scale comprised a general evaluation of the entire 6 min of observation, rated separately for the entire interaction with the adult and for the entire interaction with the peer partner. Coders rated social conversation quality along a 5-point Likert scale ranging from 1 (*poor quality with no reciprocity or acknowledgment of conversation partner*) to 5 (*good/adequate quality that included reciprocity and acknowledgment of the listener*). The adult and peer ratings were then summed to create an overall quality score.

Primary Outcome: Teacher-Reported Socialization

Because of our specific interest in pretest–posttest change in children's social engagement, we used teacher reports on the Socialization domain of the Vineland Adaptive Behavior Scale (Sparrow, Balla, & Cicchetti, 1984), which comprises three subdomains: interpersonal, play, and coping. Children's special education teachers (who were familiar with the children but unrelated to the current study and masked to children's study group) completed the questionnaire before and immediately after the intervention for all three groups. Lower Socialization domain standard scores (and subdomain *v*-scale scores) indicated greater impairment in social functioning. The Vineland was used recently to reliably assess the adaptive capabilities of school-age children with MVASD (e.g., Frost et al., 2017).

Secondary Outcome: Teacher-Reported Communication

We used the Communication domain standard score of the teacher-reported Vineland Adaptive Behavior Scale (Sparrow et al., 1984).

Secondary Outcome: Executive Functions

The same special education teachers as just mentioned (involved in teaching the participants but unrelated to the study and masked to group) completed the Behavior Rating Inventory of Executive Function—Teacher Version (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000) before and immediately after intervention for all three groups. The BRIEF was developed to assess everyday behavior associated with specific executive function domains in children ages 5–18 years. This 86-item ratings-based survey yields a *global executive composite* score as well as two major indexes of executive functioning: *behavioral regulation* and *metacognition*. The behavioral regulation index contains three subdomains: *inhibition, shifting*, and *emotional control*. The metacognition index contains five subdomains: *initiation, working memory, planning, organization*, and *monitoring*. The BRIEF has high internal consistency and test–retest reliability (Gioia et al., 2000). Higher scores on the BRIEF indicate more impairment.

Data Analysis

To examine group differences (conversation vs. collaboration vs. control) in social engagement and communication, the various domains on the M–COSMIC scale, the SCS-A scale, and the Vineland's Socialization and Communication scales were analyzed independent of one another within a generalized estimating equations (GEE) framework (SPSS V.24.0). The same GEE analysis was also used to test differences in executive functions (BRIEF). Because the intervention was implemented in a dyadic context, we used the GEE procedure to test changes over time within a dyadic structure, that is, for paired children. Measurements were nested within pairs of children and included two time points for each child in a working pair (T1 before intervention, and T2 after intervention). Thus, to assess changes over time, dyads were controlled by the individual child's effect. Put differently, this modeling structure ensured that the time effect was not obscured by the within-nest child effect.

The GEE is a generalization form of regression that allows assumptions that are alternative to normal distribution, and a test for the correlation between repeats, also known as the working covariance matrix (Hardin & Hilbe, 2013). We also selected the GEE because it enabled control over the effect of the groups' pretest differences in nonverbal IQ (Raven's matrices) on treatment gains (see Table 1), in a repeated-measure (Time) model. We performed our test for group, time, dyad, and interaction (Group × Time) effects. The source of Group × Time interaction was determined using post hoc pairwise comparisons (least significant difference, subject to p < .05 significance level). Because of the nature of our data (dependent variables that are not normally distributed), we used negative binomial distributions for the M-COSMIC and SCS-A data (except for the SCS-A General Quality Rating Scale) and a non-negative distribution (gamma) for the Vineland and the BRIEF. Effect sizes were computed using Cohen's d test. Preliminary analyses of pretest differences yielded nonsignificant findings. In line with our study aim, we reported on interaction effects first, followed by a description of time, dyad, and Raven effects. Main effect of group beyond time can be seen in Tables 3 and 4.

RESULTS

Primary Intervention Outcome: Social Engagement

Free-Play Observations: Group Differences on the M–COSMIC

As just described, we used GEE to independently analyze children's frequency of two role behaviors (active, passive) and two functions of the interaction (behavior regulation, joint attention) during free play. As seen on Table 3, a Group × Time interaction effect emerged for active role, demonstrating significantly greater activity at T2 than at T1 in the collaboration group (with a high effect size: d = .58). In addition, there was significantly lower activity at T2 in the conversation group compared to the collaboration and control groups (see Table 4 for model effects and Table 3 for descriptive statistics and effect sizes). A main effect was found for time in the passive role, demonstrating a reduction in role passivity at T2 (M = .36, SE = .10) compared to T1 (M = .93, SE = .21), beyond groups. In joint attention, we could not compute our GEE model

TABLE 3
Descriptive Statistics (Marginal Mean, Standard Error) for T1, T2, and Effect Size on Social Engagement Variables

			Group								
			Conversation[a]			*Collaboration*[a]			*Control*[a]		
Scale	*Variable*		*T1* M (SE)	*T2* M (SE)	d	*T1* M (SE)	*T2* M (SE)	d	*T1* M (SE)	*T2* M (SE)	d
M-COSMIC	Role	**Active**	6.56 (1.68)	4.74 (.71)	0.34	**4.97 (1.04)**	**7.87 (1.37)**	**0.58**	7.66 (1.66)	7.78 (1.06)	0.02
		Passive	1.06 (.31)	0.45 (.18)	0.58	0.84 (.34)	0.22 (.08)	0.61	0.86 (.38)	0.41 (.22)	0.35
	Function	Regulation	0.10 (.07)	0.13 (.07)	0.10	0.23 (.12)	0.44 (.11)	0.45	0.23 (.11)	0.29 (.12)	0.13
SCS-A	Relevance	Adult	**13.08 (1.15)**	**18.74 (.81)**	**1.38**	**17.03 (1.43)**	**23.21 (1.87)**	**0.90**	18.17 (1.41)	17.56 (2.39)	0.08
		Peer	**6.49 (1.89)**	**12.91 (2.17)**	**0.77**	**11.25 (2.08)**	**20.19 (2.08)**	**1.04**	13.23 (1.46)	12.90 (1.86)	0.05
	Eye Contact	Adult	19.96 (1.17)	16.23 (.98)	0.84	15.14 (1.07)	17.45 (2.63)	0.64	15.65 (1.93)	16.33 (2.65)	0.07
		Peer	10.56 (1.59)	9.73 (2.09)	0.11	**11.83 (2.04)**	**17.49 (2.74)**	**0.57**	13.94 (1.43)	14.01 (1.78)	0.01
	Vocalization	Adult	8.36 (1.58)	13.80 (2.46)	0.64	13.77 (2.99)	12.04 (1.29)	0.18	9.33 (2.41)	9.60 (2.61)	0.03
		Peer	2.31 (1.19)	6.78 (2.01)	0.66	4.10 (1.70)	4.42 (1.02)	0.06	1.59 (.63)	2.11 (.88)	0.16
	Gesture	Adult	2.53 (.89)	2.84 (.65)	0.44	3.32 (.90)	4.03 (1.04)	0.75	4.13 (.79)	7.37 (2.16)	1.41
		Peer	1.53 (.88)	0.55 (.23)	0.37	2.76 (.86)	3.53 (1.07)	0.09	1.93 (.70)	1.04 (.46)	0.36
	Initiation	Adult	2.40 (.62)	3.24 (.78)	1.40	3.02 (.95)	3.62 (1.73)	0.34	2.15 (.47)	3.13 (1.39)	0.83
		Peer	**1.81 (.72)**	**4.06 (1.32)**	**0.51**	**2.84 (.66)**	**4.68 (.66)**	**0.68**	1.85 (.44)	1.23 (.48)	0.33
	Response	Adult	7.00 (1.02)	6.51 (.72)	0.13	7.95 (.95)	8.92 (.57)	0.30	6.88 (.80)	7.55 (.98)	0.18
		Peer	0.28 (.16)	0.04 (.05)	0.49	0.66 (.32)	1.01 (.30)	0.27	0.89 (.24)	0.72 (.31)	1.16
	Smile	Adult	1.90 (.76)	3.60 (.88)	0.50	3.55 (.89)	4.26 (1.10)	0.17	3.10 (1.21)	3.88 (1.77)	0.15
		Peer	0.83 (.44)	0.71 (.32)	0.08	2.86 (.97)	3.20 (1.30)	0.07	1.96 (.68)	3.07 (1.13)	1.19
	General Quality		**4.64 (.24)**	**6.66 (.43)**	**1.41**	**6.27 (.32)**	**7.87 (.36)**	**1.14**	6.53 (.26)	6.19 (.52)	0.17
Vineland	Socialization Domain		**56.19 (2.19)**	**59.79 (2.27)**	**0.39**	58.15 (1.75)	60.11 (1.61)	0.29	59.76 (1.46)	58.76 (1.39)	0.17
	Interpersonal		**6.25 (.50)**	**10.27 (2.40)**	**0.56**	**6.78 (.44)**	**11.78 (1.95)**	**0.86**	**7.07 (.37)**	**8.52 (.76)**	**0.59**
	Play		7.08 (.38)	11.72 (1.71)	0.91	7.18 (.29)	11.16 (1.37)	0.97	7.54 (.32)	10.29 (.87)	1.02
	Coping		7.36 (.43)	11.16 (2.22)	0.58	8.01 (.34)	13.51 (1.29)	1.41	7.83 (.04)	12.33 (1.11)	1.39
	Communication Domain		53.72 (1.48)	52.62 (1.09)	0.21	56.23 (1.19)	57.87 (1.10)	0.35	51.96 (2.10)	51.16 (1.82)	0.10

Note: Cohen's d effect size: d < .20 small, .20 < d < .50 medium, d > .50 large. T = time point of measurement; M = marginal estimated mean; M-COSMIC = Modified–Classroom Observation Schedule to Measure Intentional Communication; SCS-A = Social Conversation Scale; Vineland = Vineland Adaptive Behavior Scales. Bold marks denote significant pre-post differences.

[a]n = 18.

TABLE 4
Social Engagement: Results of Generalized Estimating Equations for Main Effects, Group × Time Interactions, and Post Hoc Analyses

			Effects (Wald)					*T1–T2 Within-Group Diff.*			
Scale	*Variable*		*Group*	*Time*	*Dyad*	*Raven*	*Group × Time*	*1*	*2*	*3*	*Between-Group Diff. at T2*
M-COSMIC[a]	Role	Active	2.15	0.22	0.94	0.33	**7.93****		p = .018		2,3 > 1
		Passive	0.60	9.47*	0.37	0.27	0.91				
	Function	Regulation	5.81	1.40	0.11	0.10	0.47				
SCS-A[a,b]	Relevance	Adult	6.56*; 2 > 1	11.59***	0.76	13.28*** ß=-.006	**10.51*****	p = .000	p = .000		2 > 1; 2 > 3[d]
		Peer	5.06	19.21***	1.65	3.74	**21.60*****	p = .000	p = .000		2 > 1,3
	Eye Contact	Adult	6.17*; 1 > 2	0.002	1.37	8.57*** ß=-.008	**5.61**				
		Peer	3.89	1.06	5.59**	5.12* ß=-.005	**5.87***		p = .007		2 > 1
	Vocalization	Adult	1.70	0.55	0.96	.03	3.96				
		Peer	6.21*; 2 > 3	1.86	2.98	.30	3.44				
	Gesture	Adult	5.17	1.73	.05	.06	0.78				
		Peer	8.48	1.76	.20	3.22	**9.69****				2 > 1,3
	Initiation	Adult	0.37	2.40	1.34	4.34* ß=-.017	0.16				
		Peer	1.96	2.09	.55	4.71* ß=-.019	**9.60****	p = .007	p = .031		1,2 > 3
	Response	Adult	4.03	0.25	0.36	3.52	1.26				
		Peer	13.56***;1 < 2,3	0.24	.07	7.63** ß=0.16	3.29				
	Smile	Adult	2.08	1.61	3.73	1.79	0.67				
		Peer	8.48**;1 < 2.3	0.34	2.34	3.51	0.61				
	Quality[c]		28.06***;1 < 2,3	13.18***	.16	10.96*** ß=-.026	**22.60*****	p = .000	p = .000		2 > 1,3
Vineland[b]	Socialization Domain		0.12	3.04	0.62	1.12	**6.63***	p = .046			
	Interpersonal		0.64	20.76***	2.38	0.014	**7.04***	p = .067	p = .003	p = .015	
	Play		.022	45.27***	0.27	0.10	2.09				
	Coping		1.14	55.43***	0.19	.001	0.57				
	Communication Domain		12.39**; 2 > 1,3	0.05	1.76	0.00	3.56				

Note: Differences at T1 were nonsignificant. T = time point of measurement; Group 1 = conversation; Group 2 = collaboration; Group 3 = control; Diff. = difference; M-COSMIC = Modified–Classroom Observation Schedule to Measure Intentional Communication; SCS-A = Social Conversation Scale; Vineland = Vineland Adaptive Behavior Scales; GEE = generalized estimating equations; ß= Standardized effect of Raven when $p< .05$; Bold marks denote significant interaction effect.

[a]Negative binomial distribution GEE model.

[b]Gamma distribution GEE model.

[c]Normal distribution GEE model for the SCS-A quality scale.

*$p < .05$. **$p < .01$. ***$p < .001$. [d]$p = .06$.

because of low frequency of this behavior in the GEE-dyadic structure; thus, we computed our analysis combining the two intervention groups versus the control, which yielded a nonsignificant Group × Time interaction effect, Wald = 2.50, $p > .05$: Intervention, T1 M (SE) = .02 (.017); T2, M (SE) = .17 (.017); Control, T1 M (SE) = .19 (.010), T2, M (SE) = .23 (.09).

Free-Conversation Observations: Group Differences on the SCS-A

As described earlier, the SCS-A included a Frequency scale and a Quality scale. First, we used GEE to independently analyze children's frequency of six interactive behaviors (initiations, responses, relevance, social smile, vocalization, and eye contact) toward the adult and toward the peer during the free-conversation situation. Results of the GEE yielded significant Group × Time interactions for relevance toward the adult and the peer and for eye contact, and gesture and initiation toward the peer (see Table 3 for descriptive statistics and Table 4 for model results).

As can be seen in Table 3, post hoc analyses revealed significant progress from T1 to T2 only for the two intervention groups in (a) relevance toward the adult and peer (both with high Cohen's d effect size that ranged from .77 to 1.38, vs. the control group's d = .08 toward the adult and .05 toward the peer; see Table 3) and (b) initiation toward the peer (Cohen's d = .68 for collaboration, .51 for conversation, .33 for control). In eye contact toward the peer, significant progress from T1 to T2 was found only for the collaboration group (Cohen's d = .57 for collaboration, .11 for conversation, and .01 for control). At T2, frequencies were significantly higher in initiation toward the peer in both intervention groups versus the controls. In addition, the collaboration group showed higher frequencies than the other two groups in relevance and gestures toward the peer and higher frequencies than the conversation group in relevance toward the adult (with only a near-significant difference vs. the controls, p = .06) and in eye contact toward the peer. Altogether, improvement over time emerged only for the two intervention groups, with the collaboration group outperforming the other two groups at T2, whereas T1 differences were nonsignificant.

A main effect for time was found for relevance toward the adult (T1: M = 16.26, SE = .79; T2: M = 19.81, SE = 1.07) and toward the peer partner (T1: M = 10.15, SE = 1.17; T2: M = 15.04, SE = .1.25), in both cases with higher frequencies at T2 than at T1. Another main effect was found for dyad in eye contact toward the peer, in which Partner A had higher scores compared with Partner B (A: M = 14.13, SE = 1,32; B: M = 11.45, SE = .97). However, the interaction of Dyad × Time was not significant.

Next, results of the GEE for the SCS-A social conversation quality scale yielded a significant Group × Time interaction, with higher overall social conversation quality at T2 than at T1 for both intervention groups (both with high effect sizes: Cohen's d = 1.41 for conversation, 1.14 for collaboration, and .17 for control). Also, at T2, the collaboration group showed higher quality scores than the conversation and control groups (see Table 3 for descriptive statistics and Table 4 for model results). A main effect for time was significant, with higher quality at T2 (M = 6.9, SE = .29) than at T1 (M = 5.81, SE = .17), beyond group.

To be noted, nonverbal IQ revealed significant effects on several SCS-A measures (see betas in Table 4). This supports the utilization of the Raven as a covariate in our analyses to control for group or individual differences on the SCS-A measure as related to performance IQ.

Teacher-Reported Social Behavior: Group Differences on the Socialization Domain of the Vineland

As can be seen in Table 4, results of the GEE for the Socialization domain's standard score yielded only a significant interaction effect, demonstrating progress from T1 to T2 only for the conversation group (d = .39, vs. d = .29 for collaboration and d = .17 for controls; see Table 3 for descriptive statistics). Results for the Socialization domain's three subdomains (interpersonal, play, and coping) yielded a significant interaction effect only for the interpersonal subdomain, with the collaboration and control groups showing a significant increase from T1 to T2 and the conversation group nearing significance (p = .067). Effect size was high for the collaboration group (d = .86) and medium to high for both the conversation (d = .56) and control (d = .59) groups. A main effect of time was found for all three subdomains; in all cases T2 (Interpersonal: M = 10.14, SE = 1.07; Play: M = 11.05, SE = .79; Coping: M = 9.97, SE = .74) was higher than T1 (Interpersonal: M = 6.71, SE = .24; Play: M = 7.26, SE = .18; Coping: M = 9.53, SE = .65), beyond group.

Secondary Intervention Outcomes

Teacher-Reported Communication

As seen in Table 4, results of the GEE for the Vineland Communication domain's standard score yielded nonsignificant time and interaction effects.

Executive Functions

Using the BRIEF to measure executive functions, we examined group differences (conversation vs. collaboration vs. control) for the global executive composite score, the major index of behavioral regulation and its three subdomains (inhibition, shifting, emotion control), and the major index of metacognition and its five subdomains (initiation, working memory, planning, organization, monitoring). Significant Group × Time effects were found for the metacognition major index and the metacognition subdomains of planning, organization, and monitoring, indicating lower executive function deficits in these areas at T2 than at T1 for the conversation group in contrast to higher planning scores at T2 than at T1 for the control group and near-significance in their organization skills. Altogether, at posttest, the conversation group showed better executive functioning (medium to high effect sizes: d = .68 for organization, d = .50 for monitoring, and d = .43 for planning and metacognition), whereas the control group showed lower executive functioning (high effect sizes for both planning, d = .92, and organization, d = .62; see Table 5).

To be noted, nonverbal IQ revealed significant effects on several BRIEF measures (see betas in Table 5). This supports the utilization of the Raven as a covariate in our analyses to control for group or individual differences in executive functioning as related to performance IQ.

TABLE 5
Executive Functions (BRIEF): Significant Results of Generalized Estimating Equations for Group × Time Interactions

			Metacognition											
									Subdomains					
	Regulation		*Major Index*		*Initiation*		*Working Memory*		*Planning*		*Organization*		*Monitoring*	
Group	.28		.14		.60		.88		.28		.74		.82	
Time	.91		.58		.01		2.34		.90		.19		.43	
Dyad	.75		2.72		.76		1.67		2.14		.007		1.79	
	3.50		23.23***		4.61*		20.54***		7.18**		5.29*		16.96***	
Nonverbal IQ (Raven)			–.003		–.002		–.003		–.007		–.003		–.003	
Group × Time	.15		$8.71^{.013}$		2.23		2.28		17.71***		13.25***		6.08*	
	M (SE)	***d***	*M (SE)*	***d***	*M (SE)*	***d***	*M (SE)*	***d***	*M(SE)*	***d***	*M(SE)*	***d***	*M(SE)*	***d***
Conversation T1	75.87 (3.25)	.33	**74.09 (2.54)**	**.43**	72.39 (2.58)	.22	77.12 (2.81)	.05	**65.16 (2.42)**	**.43**	**67.70 (2.26)**	**.68**	**75.14 (2.96)**	**.50**
Conversation T2	74.28 (3.50)		**69.39 (2.73)**		69.64 (3.47)		76.45 (3.53)		**60.73 (2.53)**		**61.46 (2.20)**		**68.93 (3.12)**	
Collaboration T1	77.05 (2.65)	.06	69.21 (1.89)	.09	71.19 (2.20)	.21	74.37 (1.90)	.09	62.18 (2.43)	.13	59.07 (3.76)	.23	68.50 (1.73)	.07
Collaboration T2	76.37 (2.91)		70.05 (2.50)		73.08 (2.23)		73.60 (2.20)		63.46 (2.38)		62.14 (2.67)		69.12 (2.29)	
Control T1	75.87 (3.45)	.14	70.42 (2.77)	.08	69.42 (2.10)	.19	74.92 (1.40)	.53	**57.52 (2.44)**	**.92**	**60.45 (3.02)**	**.62**	69.84 (2.73)	.21
Control T2	73.80 (3.77)		71.12 (1.42)		70.91 (1.63)		71.61 (1.62)		**64.90 (1.30)**		**66.37 (2.82)**		71.77 (1.61)	
T1–T2 Difference			Group 1; p = .000						Group 1; p = .014 Group 3; p = .000		Group 1; p = .002 Group 3; p = .07		Group 1; p = .008	

Note: Gamma distribution model. BRIEF = Behavior Rating Inventory of Executive Function–Teacher Version; Group 1 = conversation; Group 2 = ollaboration; Group 3 = control; M = marginal estimated mean; d = Cohen's d effect size.

$*p < .05$. $**p < .01$. $***p < .001$.

DISCUSSION

The major aim of this novel RCT for the ecological implementation of the manualized S-PSI intervention was to increase spontaneous social engagement among school-age children with MVASD, especially with their peers. The most defining characteristic of children with MVASD, beyond their limited speech capabilities, is their social withdrawal (Frost et al., 2017; Howlin et al., 2000), calling for empirical scrutiny of explicit intervention efficacy using multiple reporting sources. In this study, using observations of spontaneous behavior and teacher reports, our comparison of pretest–posttest improvement in two intervention groups versus a control group aimed to elucidate treatment efficacy beyond natural maturation, whereas our comparison of the conversation versus collaboration treatment modalities aimed to help demarcate each modality's unique contribution to children's social engagement. Moreover, we examined possible indirect effects of training on children's executive functions. Overall, findings of the study are positive and encouraging.

Intervention Effects on Social Engagement versus Controls

Children in both intervention groups revealed significant improvement at the posttest along some important measures. Specifically, when offered opportunities to communicate freely with their fixed peer partner or with a familiar adult, children who had undergone either of the two interventions could produce more relevant communicative interactions than those who had not yet participated in an intervention. This occurred not only when "conversing" with the adult but also in the more challenging task of "conversing" with their assigned peer, showing better overall quality of social conversation with both partners. High Cohen's *d* effect sizes emerged for each intervention group for the pretest–posttest improvement on relevance, substantiating treatment effects (adult: conversation = 1.38, collaboration = .90; peer: conversation = .77, collaboration = 1.04), which were much higher than for the control group (adult: $d = .08$; peer: $d = .05$). Moreover, important pretest–posttest improvement was also found for both intervention groups in initiation toward the peer partner, yielding high (*d*) effect sizes (collaboration = .68, conversation = .51). Also, at T2, both intervention groups outperformed the control group on initiation toward the peer partner (with no significant differences at T1). Finally, children in both intervention groups showed higher pre–post quality of their communication, demonstrating a very high effect size for each intervention group (conversation = 1.41, collaboration = 1.14). This change was not noticed for the control group.

Relevant communication and initiations toward peers were important aims of the current study. The interventions showed, in practice, more adequate interactive peer engagement in those children with MVASD who had undergone S-PSI. Previous intervention studies have also documented improvements in social engagement, albeit in the child–adult context (e.g., DiStefano et al., 2016; Franco, Davis, & Davis, 2013; Gordon et al., 2011; Kasari et al., 2014). Our study's novelty centers on its enhancement of social engagement in the peer context in addition to the adult context because the former poses a more challenging social setting for pairs of children with MVASD yet a very important one for these children's social-emotional development.

An interesting and somewhat different finding was obtained on evaluations by teachers, who gave higher T2 scores versus T1 scores to children in all groups in the interpersonal subdomain of the Socialization report (Vineland), with higher effect size for the collaboration group ($d = .68$). It is important to note that despite the relatively large pretest–posttest change in the conversation group's interpersonal subdomain scores (*M* at T1 = 6.25, *M* at T2 = 10.27, change score = 4.02), which was a much larger change score than for the control group (*M* at T1 = 7.07, *M* at T2 = 8.52, change score = 1.45), the findings for the conversation group only neared significance ($p = .067$). We assume that the high standard error (2.40), showing high heterogeneity in children's gains at T2 in this group, might provide some explanation for this. Strengthening our assumption is the significant increase in children's Socialization domain standard score that was found only for this group. Noteworthy as well is the significant time effect found for the other two subdomains of teacher-reported Socialization (Vineland), demonstrating increases in both the play and the coping subdomains over time beyond group. The partial differences between the teacher-reported Vineland scores and the directly observed social communication skills need to be examined further, especially with regard to the role that individual differences play in social behaviors, in light of the heterogeneity in MVASD as reflected in the data's non-normal distribution.

The Two Intervention Modalities' Comparative Effects on Social Engagement

In comparing the relative contribution of these two novel S-PSI peer dyadic intervention protocols, the collaboration intervention (which focused on conceptual learning and practice of prosocial skills, mutual planning, and joint activity skills) appeared to lead to better social engagement outcomes than the conversation intervention (which focused on conceptual learning and practice of communicative social interaction). Of the two intervention groups, only children who received the collaboration curriculum improved their social engagement capabilities during the free-play situation by taking on a more active role (showing more communicative initiations and responses). Also, only children in the collaboration group improved their eye contact toward their peer partner during the free-conversation situation. In both cases, the effect size was large (> .50), much larger than the effect sizes of the conversation and control groups (see Table 2).

Furthermore, some interesting skill generalization emerged for the collaboration group: As reported earlier, like their counterparts in the conversation group who received direct training for these conversational skills, the children in the collaboration group also succeeded in exhibiting pretest–posttest improvement in the relevance of their initiation/response to conversational flow and in their general social conversation quality, which were not directly trained in the collaboration intervention. The two interventions shared structure and principles; however, they differed in content and activities. As such, the collaboration intervention aimed at creating camaraderie and joint action while building key social capabilities for collaboration (e.g., sharing, helping) through physical-motoric and musical activities and games (rhythm and mirroring games, joint drumming, dyadic movement coordination). In contrast, the conversation intervention was language-pragmatic oriented, building necessary social skills for more adequate social dialog with the peer (e.g., question asking, conversation topics, sentences for initiating/ending a conversation), via board games and memory games as well as visual symbols and signs. It may be speculated that the collaboration intervention was more stimulating because of its greater motoric activity; thus, the collaboration curriculum may have been more motivating and less demanding compared to the conversation intervention. Perhaps the improvements noted in conversation skills were obtained indirectly through the children's mutual involvement in planning and enacting shared activities, which required listening to and responding to peers. The role of motivation to take part in each intervention should be taken into consideration because the conversation group showed less active participation during the free-play situation (evaluated by the M-COSMIC) at T2 compared to both the collaboration and control groups.

Indirect Intervention Effects on Executive Functions and Metacognition

Of interest, pretest–posttest improvement in executive functioning was found for only one of the three groups: those who had undergone the conversation intervention. Although executive skills were not explicitly trained in either of the interventions, participants in the conversation group demonstrated significant positive changes over time in their overall metacognition skills, as well as in three of five important metacognitive subcomponents—namely, planning, organization, and monitoring (with medium to high effect sizes ranging from d = .43 to .68). To be noted, the control group showed higher scores in planning at the posttest compared to the pretest (demonstrating lower executive functioning over time) and tended to show lower functioning in organization (with large effect sizes in both cases, d = .92 and .62, respectively).

Thus, differently from the social engagement results, which indicated some advantages for the collaboration intervention, the conversation intervention led to better progress in metacognitive capabilities. Of interest, improvement in executive functioning skills as a result of social intervention coincides with Bauminger's (2007) results for high-functioning school-age children with ASD and with Hughes and Dunn's (1998) finding of a link between typically developing children's improvement in social conversation and metacognitive skills. Executive functions are cognitive mechanisms with important implications for social functioning (e.g., Best et al., 2009). The ASD literature has shown links between executive functions (e.g., planning, monitoring, set shifting) and social understanding, social competence, theory of mind, social interaction, adaptive skills (including socialization), and pragmatics (e.g., Berger, Aerts, van Spaendonck, Cools, & Teunisse, 2003; Best et al., 2009; Gilotty, Kenworthy, Sirian, Black., & Wagner, 2002; Joseph & Tager-Flusberg, 2004; McEvoy, Rogers, & Pennington, 1993; Ozonoff, Pennington, & Rogers, 1991; Pellicano, 2007). Thus, the current school-age children's progress in executive functions and metacognitive skills—even without direct training—is encouraging and meaningful; yet the particular components of the conversation intervention that led to this improvement should be furthered explored.

Several study limitations should be considered. The first involves intervention duration and intensity. Although we implemented a fairly intensive training model (four times per week, 1 hr each, along 4 months), longer intervention duration with substantial repetitions would seem critical to obtain better results, considering the manifold complexities in MVASD. Second, generalization and maintenance of study gains should be further explored. Indeed, teachers who did not take part in the intervention reported improvement on children's socialization and executive functions or metacognitive skills; however, direct exposure of school staff and parents to the intervention should further increase skills' generalization. Third, because of the low frequency of MVASD, our study design included dyads in the same school who received different interventions (by different teachers). As described, we took steps to eliminate information sharing; however, in future studies it is advisable to use only one intervention modality in each school to better control for unintentional disclosures that could have some influence on study results. Fourth, in this study we compared two active intervention groups to a treatment-as-usual control group; hence, dyads in the control group met formally only for pretest and posttest evaluation. It may be important to also explore the effect of a control group where dyads meet regularly for informal social meetings along the course of the intervention, to better tap intervention efficacy in comparison to the possible effect of the regularly structured dyadic interaction.

Fifth, in this study, the S-PSI's results are reported using group means; however, unsurprising for this population, our measures yielded non-normal distribution, with large variance relative to the mean, signifying individual differences in social behaviors. Considering the heterogeneity in MVASD as discussed earlier, we plan to further our understanding about intervention efficacy by looking at individual differences in treatment gains. Sixth, we provided effect sizes to estimate the magnitude of our significant results; however, our analyses did not include correction for multiple comparisons, which might increase the risk for Type II errors, to prevent losing the power to detect real differences in this low-functioning population. Nevertheless, caution should be made in interpretation of the results, and future replication of our results seem important. Seventh, fidelity of the S-PSI's implementation was reported only based on weekly self-ratings by teachers. The research staff provided informal feedback and discussion on adherence to assigned protocols based on monthly observations and bimonthly discussion of teachers' self-ratings, but research staff did not conduct formal fidelity assessments. Finally, in the current study, we controlled for pretest group differences on the Raven by using its scores as a covariate, thus equalizing the groups and verifying that group differences were due to treatment effects and not to preliminary differences in nonverbal IQ. Yet the role played by the Raven scores, reflecting performance IQ, for social conversation and executive functioning skills should be further explored for children with MVASD in future research.

Conclusions

Overall, this study for school-age children and adolescents with MVASD was innovative in its RCT design, ecological school-based implementation, peer-dyad focus, and especially its explicit aim of increasing spontaneous peer interaction rather than merely increasing spoken words. Preliminary results for the S-PSI are positive because both intervention programs led to some increase in social engagement in this high-risk population. Some advantages were noted for the collaboration curriculum in building up social interactive behaviors and for the conversation curriculum in building up metacognitive skills. Of importance, the intervention's noted impact on peer engagement suggests the potential for productive behavioral change in this population that may bypass verbal limitations and instead focus on strengthening alternative nonverbal communication channels that may be available to these youngsters. Altogether, strengthening youth with MVASD to interact more spontaneously with peers may lead to a reduction in social withdrawal, thereby increasing life quality and reducing risk for poor long-term adjustment prognosis.

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No potential conflict of interest was reported by the authors.

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