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Teaching Caregivers to Support Social Communication: Results From a Randomized Clinical Trial of Autistic Toddlers

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ABSTRACT

Background: Studies of early caregiver-mediated interventions targeting social communication of young autistic children have yielded variable child outcomes. This study examined the effects of combining two caregiver-mediated interventions on caregiver strategy use and child social communication and language outcomes.
Method: This was a multisite parallel randomized controlled trial. Participants included 120 caregivers and their autistic children between 24 and 36 months of age. Dyads were randomly assigned to receive a hybrid intervention that combined Enhanced Milieu Teaching (EMT) and Joint Attention, Symbolic Play, Engagement, and Regulation (JASPER) or to a behavior management control condition, each delivered over 6 months. Caregivers in the JASP-EMT group received twice-weekly, in-home, and hour-long sessions. Outcomes were measured at baseline, the end of intervention (T1), and 6 months later (T2) and included a naturalistic language sample procedure, standardized measures, and caregiver report measures. This trial was registered at clinicaltrials.gov (NCT02595697).
Results: Child outcomes did not differ between conditions at T1 or T2 for child primary (social communication) or secondary (language, play, and autism symptoms) outcomes. Relative to control group caregivers, intervention group caregivers demonstrated significantly higher use of JASP-EMT strategies at T1 and T2, with the exception of two strategies (Responsiveness and Matched Responsiveness), which were used significantly more by control group caregivers. Neither autism severity nor baseline caregiver responsiveness moderated outcomes. Post hoc analyses revealed significant correlations between specific strategies and all child outcomes.
Conclusions: Twice-weekly caregiver-mediated intervention that taught caregivers of autistic children to use social communication support strategies did not yield significant child outcomes. Future studies should examine possible sources for the lack of main effects including unexpected differences in linguistic features of caregiver input, changes in control group caregiver behavior, and insufficient intervention dosage.
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In the contemporary context of intervention research, studies on early interventions for toddlers with autism spectrum disorder (hereafter referred to as autism) are impressive in number. Over 140 peer-reviewed reports of group design studies have examined intervention effects for young autistic children (Sandbank et al., 2020). Interventions vary

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considerably in domains targeted, instructional approaches used, and magnitude of effects.

For autistic toddlers, social communication is most frequently targeted by teaching caregivers to use Naturalistic Developmental Behavioral Intervention (NDBI) strategies (Sandbank et al., 2020), which include a combination of adult- and child-led interactions during activities and routines (Schreibman et al., 2015). Recent meta-analyses of social communication outcomes of NDBIs indicate modest effects (g = 0.33, Fuller & Kaiser, 2020; g = 0.14, Tiede & Walton, 2019) with considerable variability across individual studies (g = −0.18 to g = 1.22; Fuller & Kaiser, 2020; Tiede & Walton, 2019). When only including studies (54%) that used naïve assessors of outcomes, social communication outcomes for NDBIs are no longer statistically significant, suggesting that study quality influences social communication outcomes (Sandbank et al., 2020).

One potential source of this variability is the measurement of social communication outcomes. Few toddler studies have measured social communication in nonelicited, natural language samples with a naïve assessor (i.e., spontaneous socially communicative acts while playing with an assessor who has no knowledge of the child's intervention group). Additionally, fewer than half of toddler studies have included multiple methods of measuring social communication (Sandbank et al., 2020). Well-designed studies should include a range of social communication and language measures conducted by assessors naïve to experimental condition to strengthen study validity.

Additionally, caregiver-mediated interventions for autistic toddlers often lack adequate measures of intervention fidelity. Because the intervention strategies are taught to caregivers, fidelity assessments should occur at two levels: (a) caregiver instruction and (b) caregiver use of strategies across experimental conditions. However, nearly half of toddler studies fail to report a fidelity measure of caregiver instruction. More studies report a measure of caregiver use of intervention strategies but vary widely in how they measure strategy use. Robust measurement of fidelity is critical to understanding intervention effects and mechanisms underlying intervention outcomes.

The purpose of this study was to examine the effects of a hybrid intervention (JASP-EMT) that blended two interventions: (a) a naturalistic language intervention (Enhanced Milieu Teaching [EMT]) that promotes functional use of new language forms in the context of everyday interactions with caregivers and teachers (Kaiser, 1993) and (b) a behavioral-developmental intervention that teaches the foundations of social communication (joint attention, symbolic play, and regulation of others through nonverbal commenting and requesting) in the context of social play (Joint Attention, Symbolic Play, Engagement, and Regulation [JASPER]; Kasari et al., 2010). The blended intervention (JASP-EMT) builds on the JASPER intervention to teach the social foundations of communication (Kasari et al., 2010) and the EMT intervention to teach spoken language (Hampton et al., 2020; Roberts & Kaiser, 2012). Although both interventions include play and communication strategies, each intervention offers more specific and nuanced strategies for teaching either joint engagement and play (JASPER) or social communication (EMT). This study also addressed the aforementioned methodological limitations by (a) including a broad set of social communication and language outcomes, (b) measuring fidelity of caregiver instruction and caregiver implementation of intervention strategies, and (c) designating a primary outcome measure in which assessors were naïve to experimental condition. Post hoc moderator analyses were included to explore the extent to which caregiver and child characteristics differentially impacted study outcomes, given that child baseline skills have previously been found to moderate intervention outcomes (Carter et al., 2011).

The following research questions guided the study: What are the effects of teaching caregivers to implement the JASP-EMT intervention on caregiver use of these intervention strategies? What are the effects of the JASP-EMT intervention on child social communication (primary outcome), expressive language, receptive language, and play (secondary outcomes)? Do child baseline measures of autism severity moderate intervention outcomes (exploratory, post hoc analysis)? Do caregiver baseline levels of responsiveness moderate intervention outcomes (exploratory, post hoc analysis)?

Method

Trial Design

This was a multisite parallel randomized controlled trial design study (NCT02595697, clinicaltrials.gov) that enrolled 120 caregivers and their autistic children between 24 and 36 months of age (see Supplemental Material S5). Recruitment began October 5, 2015, and the last follow-up assessment was completed September 9, 2019. Caregiver–child dyads were randomly assigned to the JASP-EMT group or to the positive behavior support control group (a low-dosage, attentional control group) using a 1:1 allocation ratio with blocks of 10 for feasibility in scheduling research therapists. Randomization was stratified by site and child language level. Language level was defined dichotomously (i.e., preverbal or verbal) using scores on Autism Diagnostic Observation Schedule (ADOS) item A1. Scores from 0 to 2 were defined as verbal, and scores from 3 to 4 were defined as preverbal. The randomization sequence was generated automatically and could only be

accessed by the data analyst. Randomization was completed by the project coordinator only after eligibility criteria were entered into a REDCap database (Harris et al., 2009). Data collection occurred at two urban areas: one in the Midwest and one in the Southeast. The study was approved by each site's institutional review board. Written informed consent was obtained from all caregivers. Assessors and therapists completed session logs after each session to track protocol deviations and adverse events (see Supplemental Materials S1 and S2). The clinical trial protocol is available from the first author upon request.

Sample Size

Participants were 120 autistic toddlers and their caregivers. The sample size was sufficient to detect an effect size of 0.42, assuming 80% power, 20% attrition (n = 96), a baseline covariate of 0.70 based on correlations in other studies, and an alpha of .05 (two-tailed). An effect size of 0.42 corresponds to a clinically significant difference of 9.6 socially communicative acts during a 20-min language sample with an unfamiliar, naïve (i.e., unaware of treatment allocation) assessor between experimental conditions (see below for details on child outcomes). Attrition was 15% at T1 (n = 103) and 21% at T2 (n = 92), which yielded this planned sample size.

Participants

Participants were recruited through diagnostic clinics, magazine and social media advertisements, local pediatrician offices, and by Early Intervention providers from October 5, 2015, until August 27, 2018. Child inclusion criteria were (a) diagnosis of autism based on the ADOS-2 (Lord et al., 2012), (b) chronological age between 24 and 36 months, (c) language that met the criteria for use of the ADOS-2 Toddler Module or Module 1 (preverbal/single words), (d) a caregiver willing to learn intervention strategies, and (e) English as the primary home language. Children with additional impairments were excluded. Tables 1 and 2 list child and caregiver demographic information. Tables 5 and 6 list baseline information regarding caregiver use of intervention strategies and child communication.

Intervention

Intervention activities for both groups occurred over 6 months. The frequency and duration of each session

Table 1. Child baseline characteristics by experimental condition.

Variable	Intervention n = 58	Control n = 62	Between-groups ES[a]
Age in months	31.48 (4.45)	31.75 (3.97)	d = 0.06
Biological sex			rr = 1.23
Male	43 (74%)	49 (79%)	
Female	15 (26%)	13 (21%)	
ADOS autism severity comparison score	7.93 (2.09)	7.81 (2.04)	d = –0.06
Use of spoken language			rr = 1.02
Verbal (0–2 on ADOS item A1)	42 (72%)	44 (71%)	
Preverbal (3–4 on ADOS item A1)	16 (28%)	18 (29%)	
Mullen T score	26.84 (10.22)	27.44 (10.5)	d = 0.06
RBS-R overall score	25.2 (16.73)	19.88 (14.69)	d = –0.34
CBCL total T score	59.00 (10.77)	55.74 (11.00)	d = –0.30
Community therapy in hours	3.8 (5.31)	4.34 (4.19)	d = 0.11
Bilingual			rr = 1.02
Monolingual	27 (50%)	31 (51%)	
Spanish	15 (28%	12 (20%)	
Other	12 (22%)	18 (30%)	
Race			rr = 1.17
American Indian	1 (2%)	1 (2%)	
Asian	5 (9%)	12 (19%)	
Black	4 (8%)	5 (8%)	
White	31 (58%)	31 (50%)	
More than one	4 (8%)	10 (16%)	
Other	2 (4%)	0 (0%)	
No response	6 (11%)	3 (5%)	
Ethnicity			rr = 1.21
Hispanic	19 (35%)	14 (23%)	
Non-Hispanic	33 (60%)	46 (74%)	
No response	3 (5%)	2 (3%)	

Note. ES = effect size; ADOS = Autism Diagnostic Observation Schedule; RBS-R = Repetitive Behaviors Scales–Revised; CBCL = Child Behavior Checklist.

[a]No between-groups differences were observed at baseline.

Table 2. Caregiver baseline characteristics by experimental condition.

Variable	Intervention *n* = 58	Control *n* = 62	Between-groups ES[a]
Role			*rr* = 1.53
Mother	51 (88%)	52 (84%)	
Father	6 (12%)	10 (16%)	
Age in years	34.14 (5.88)	34.84 (4.42)	*d* = 0.14
Education			*V* = 0.01
Less than HS	1 (2%)	0 (0%)	
HS graduate	5 (9%)	6 (10%)	
Special training	2 (4%)	4 (6%)	
Some college	17 (31%)	19 (31%)	
College graduate	13 (24%)	15 (24%)	
Graduate degree	16 (30%)	18 (29%)	
Employment status			*V* = 0.12
Not employed	33 (62%)	31 (53%)	
Part-time	5 (9%)	10 (17%)	
Full-time	14 (26%)	16 (28%)	
Second job	1 (2%)	1 (2%)	
Household income			*V* = 0.03
< $30,000	6 (13%)	7 (14%)	
$30,000–$50,000	8 (17%)	9 (18%)	
$50,000–$100,000	21 (46%)	22 (45%)	
> $100,000	11 (24%)	11 (22%)	

Note. HS = high school.

[a]No between-groups differences were observed at baseline.

varied by group as described below. Children in both groups continued to receive community-based interventions in addition to the research interventions. The number of hours per week and types of community-based interventions (i.e., speech therapy, developmental therapy, occupational therapy, physical therapy, feeding therapy, and applied behavior analysis) at baseline, during, and at follow-up did not differ between groups (see Table 1).

JASP-EMT Intervention Procedures

Caregivers assigned to the JASP-EMT intervention group received 48 intervention sessions across 6 months during two 1-hr sessions each week in their homes. See Table 3 for an overview of the intervention phases and session structure. During the first intervention phase (i.e., therapist modeling phase; Sessions 1–8), the therapist implemented all JASP-EMT strategies with the child. Caregivers observed these sessions and completed worksheets that guided their observations. During the second intervention phase (i.e., active learning phase; Sessions 9–40), caregivers were taught to use JASP-EMT strategies. To scaffold parent learning, strategies were taught in four subphases (see Table 4). Each subphase included eight sessions. The first session of each subphase was a standardized hour-long workshop, which introduced the caregiver to the strategies using examples, videos, and handouts individualized to the caregiver–child dyad. The seven subsequent sessions of each subphase were Teach–Model–Coach–Review sessions. The JASPER and EMT interventions were integrated, such that parents did not learn each set of intervention strategies separately. For example, parents learned language (EMT) and play (JASPER) expansions simultaneously, since the concept of "adding" applied to both language and play. During the third phase (i.e., review phase; Sessions 41–48), strategy implementation was reviewed and refined during eight Teach–Model–Coach–Review sessions. Example intervention and fidelity materials are provided in Supplemental Material S6.

Each caregiver instruction session contained four segments that followed the Teach–Model–Coach–Review instructional approach (Roberts et al., 2014): (a) The therapist reviewed the intervention strategies taught in the workshop and linked them to the session plan (Teach, 5 min), (b) the therapist modeled the intervention strategy with the child (Model, 20 min), (c) the caregiver practiced the strategy with their child with coaching from the therapist (Coach, 30 min), and (d) the therapist reviewed and summarized the session and answered caregiver questions (Review, 5 min).

Positive Behavior Support Group

Caregivers in the positive behavior support group received instruction about teaching their child a skill of their choice (e.g., toilet training) that was not related to social communication. Caregivers received two 1-hr home visits, during which the therapist guided the caregiver in developing a behavior support plan tailored to their child's needs. Over 6 months, caregivers participated in 12, 30-min bi-monthly phone consultations with their therapist to discuss the child's progress and the caregiver's implementation of the plan. Six months after baseline

Table 3. Overview of intervention phases and session structure.

Intervention phase	Session	Session structure
Phase 1: Therapist modeling	1	Therapist modeling
	2	Therapist modeling
	3	Therapist modeling
	4	Therapist modeling
	5	Therapist modeling
	6	Therapist modeling
	7	Therapist modeling
	8	Therapist modeling
Phase 2: Active learning	9	*Workshop - Setting the foundation for communication*
	10	Teach–Model–Coach–Review
	11	Teach–Model–Coach–Review
	12	Teach–Model–Coach–Review
	13	Teach–Model–Coach–Review
	14	Teach–Model–Coach–Review
	15	Teach–Model–Coach–Review
	16	Teach–Model–Coach–Review
	17	*Workshop - Modeling and expanding play and communication*
	18	Teach–Model–Coach–Review
	19	Teach–Model–Coach–Review
	20	Teach–Model–Coach–Review
	21	Teach–Model–Coach–Review
	22	Teach–Model–Coach–Review
	23	Teach–Model–Coach–Review
	24	Teach–Model–Coach–Review
	25	*Workshop - Using time delay strategies to increase communication*
	26	Teach–Model–Coach–Review
	27	Teach–Model–Coach–Review
	28	Teach–Model–Coach–Review
	29	Teach–Model–Coach–Review
	30	Teach–Model–Coach–Review
	31	Teach–Model–Coach–Review
	32	Teach–Model–Coach–Review
	33	*Workshop - Prompting communication*
	34	Teach–Model–Coach–Review
	35	Teach–Model–Coach–Review
	36	Teach–Model–Coach–Review
	37	Teach–Model–Coach–Review
	38	Teach–Model–Coach–Review
	39	Teach–Model–Coach–Review
	40	Teach–Model–Coach–Review
Phase 3: Review	41	Teach–Model–Coach–Review
	42	Teach–Model–Coach–Review
	43	Teach–Model–Coach–Review
	44	Teach–Model–Coach–Review
	45	Teach–Model–Coach–Review
	46	Teach–Model–Coach–Review
	47	Teach–Model–Coach–Review
	48	Teach–Model–Coach–Review

Note. Italicized font indicates the subphases within the second phase of the intervention sessions.

testing, caregivers received a home visit during which the therapist offered additional support.

Intervention Fidelity

The intervention was implemented by an experienced master's-level special educator or speech-language pathologist. All therapists reached expert levels of fidelity (> 90%) for use of JASP-EMT strategies and caregiver instruction strategies prior to intervention implementation with study participants. Throughout the study, 20% of intervention sessions (i.e., researcher–caregiver coaching sessions) for each participant were randomly selected, rated for fidelity, and reviewed by therapists across sites. Fidelity was high across all intervention sessions (96% for therapist use of JASP-EMT strategies, 92% for therapist use of caregiver instructional strategies; see Supplemental Material S3). Fidelity did not vary by site or by therapist.

Outcomes

Outcomes were measured at baseline (T0), the end of intervention (T1), and 6 months later (T2). All standardized and observational measures were conducted in a research lab by trained assessors naïve to experimental condition. Naïve coders (undergraduate and graduate students) were trained to point-by-point reliability of 0.90 prior to coding observational data. A second independent observer coded 20% of observational measures.

Caregiver Use of Intervention Strategies

Caregiver strategy use was measured during a 10-min caregiver–child interaction in which caregivers were instructed to play with a standard set of toys (e.g., blocks and dollhouse). Strategies that were considered facilitative of other strategies (i.e., play and engage, mirroring, and mapping) were not measured directly due to the time required to measure caregiver behaviors. Interactions were video recorded, transcribed using Systematic Analyses of Language Transcripts (SALT; Miller & Chapman, 2012), and coded for occurrence of the strategies listed in Table 4. See Supplemental Material S7 for a summary of codes. Reliability, measured by kappa, was moderate to strong, with lower kappa values for lower rate behaviors (matched turns = .87; responsiveness = .69; expansions = .98; target language = .83; time delays and prompting = .61).

Child Outcomes

Social communication was measured during a 20-min language sample with a naïve assessor and standard materials (see Supplemental Material S8). Number of socially communicative acts during the language sample was the primary dependent variable (kappa = .82). Socially communicative acts were defined as requests and comments that included a secondary indicator (e.g., reaching) that confirmed the social intention of the utterance; this is how social communication is measured in the Communication and Symbolic Behavior Scales Developmental Profile (CSBS-DP; Wetherby & Prizant, 2002), a commonly used outcome. Child prelinguistic communication was measured

Table 4. Sequence for teaching caregivers JASP-EMT intervention components.

Subphase	Strategy	Description	Outcome measure
Phase 2a: Setting the foundation for communication	Play and engage	Letting the child lead, getting face-to-face with them, and engaging in play routines at their play level.	No direct measure
	Responding	Recognizing and responding to all child communication attempts.	% of child communicative acts to which the caregiver responded within 3 s
	Matched turns	Taking paced, semantically, and temporally matched communicative turns in response to the child and limiting extraneous communicative turns.	% of adult utterances that were in response to a child utterance (within 3 s) and about what the child was saying or doing
	Mirroring and mapping	Using the child's play as an opportunity to teach language by supporting verbal turns with imitated play actions.	No direct measure
	Contingent extra turns	Taking contingent, intentionally paced, and visually supported (e.g., using a joint attention gesture) communicative turns when the child is not communicating or playing.	No direct measure
Phase 2b: Modeling and expanding play and communication	Target language	Modeling and prompting language at the child's target language level. Child target language levels reflected the word level target (e.g., one word, two words) for the individual child, which was determined by the child's therapist.	% of adult utterances that contained a child language target
	Expansion	Adding language to the child's communication attempts to teach more complex communication.	% of child communicative acts to which the caregiver added words
Phase 2c: Using time delay strategies to increase communication	Time delay	Using nonverbal prompting strategies (e.g., inadequate portions, assistance, waiting with routine, waiting with cue, or choice making) to elicit child communication.	Number and accuracy of time delay episodes
Phase 2d: prompting communication	Verbal prompting (Milieu Episodes)	Using specific verbal prompting sequences (e.g., open-ended question, choice prompt, say prompt) in response to child requests in order to encourage the child to use more advanced communication with the support of natural reinforcers.	Number and accuracy of prompting episodes

using the Total Weighted Raw Score on the CSBS, a structured, norm-referenced, observational measure (Percent Agreement = 0.94). During this 30-min sample, the child was presented with activities designed to elicit early communicative forms (e.g., gestures). Expressive vocabulary was measured by caregiver report using the MacArthur–Bates Communicative Development Inventories–Words and Sentences (MCDI; Fenson et al., 2007), which yields a total score for words produced (i.e., Total Words Said). Caregivers were not naïve to experimental condition; thus, the MCDI is an unblinded outcome measure. Expressive language and receptive language were measured using raw scores on the Preschool Language Scales–Fifth Edition (PLS-5; Zimmerman et al., 2011). Child play skills were measured using the Structured Play Assessment (SPA; Ungerer & Sigman, 1981), during which the child played with five toy sets for 5 min each. The video was coded for highest overall play level across toy sets (percent agreement = 0.93). Change in core autism symptoms was measured using the Brief Observation of Social Communication Change (BOSCC; Grzadzinski et al., 2016) total score. During the BOSCC, the assessor engaged with the child using two toy sets for 12 min. Child behaviors were rated from a video on eight social communication items and four restricted and repetitive behavior items, for a total of 12 items (Grzadzinski et al., 2016; intraclass correlation = .854).

Statistical Methods

Prior to conducting any main effects analyses, baseline data were analyzed for differences by (a) experimental condition, (b) site, and (c) participants with complete versus incomplete outcome data. All analyses were conducted using R Version 3.50 (R Core Team, 2018). All models included study site, baseline outcome scores, and days elapsed since baseline assessment as covariates. Prognostic indicators, such as ADOS-2 composite score, Mullen Scales of Early Learning (Mullen, 1995) Visual Reception

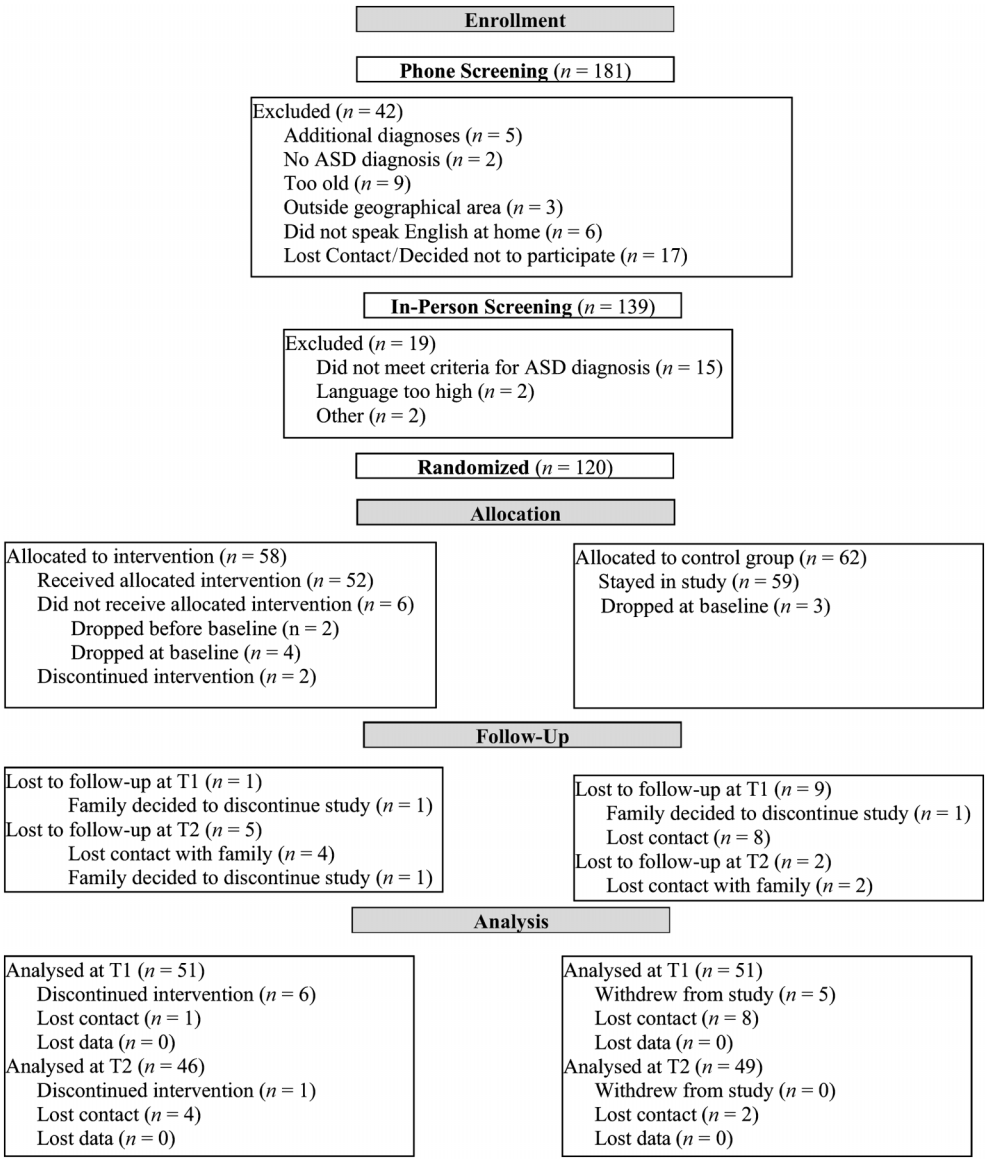
raw score, and hours of community services the child was receiving at baseline, were mean centered and included as covariates in all models to increase statistical power (Kahan et al., 2014). Multilevel growth models (MLMs) with random intercepts nested for each child were used to model social communication and expressive vocabulary from the MCDI, which were measured at several time points. All other main effects were modeled using multiple regression models. Moderators were examined by adding an interaction term. Moderators were mean centered in the MLM models. All missing data (identified at the summary statistic level for all measures) were imputed using multiple imputation by chained equations in the MICE R package (van Buuren & Groothuis-Oudshoorn, 2011). Results of analyses with the imputed data set (i.e., included all 120 caregiver–child dyads) and finisher-only data set (i.e., included participants with complete data only) did not differ. Therefore, the finisher-only data set was used for the final analyses. The analysis sample for each time point is provided in Figure 1.

Results

Baseline Analyses

There were no significant differences between experimental conditions at baseline. However, there were

Figure 1. CONSORT chart. ASD = autism spectrum disorder.



differences at baseline between sites as indicated in Supplemental Material S4. There were no differences in any baseline data between participants with complete versus incomplete outcome data.

Caregiver and Child Main Effects

See Table 5 for caregiver outcome data. Immediately after intervention (T1), there were significant differences favoring the intervention group for the majority of intervention strategies (i.e., matched turns, expansions, target language, time delay frequency, time delay accuracy, and prompting accuracy). However, significant differences in responsiveness and matched responsiveness favored the control group. Furthermore, there were no significant differences in prompting frequency. Six months after the intervention (T2), significant differences favoring the intervention group remained, with the exception of time delay frequency and prompting accuracy, which were no longer significantly different between the two groups. Significant differences favoring the control group remained for responsiveness but did not remain for matched responsiveness.

See Table 6 for child outcome data. Children in the intervention group did not have significantly more socially communicative acts than children in the control group immediately following intervention ($d = 0.01$, $p = .95$) or at the 6-month follow-up ($d = 0.02$, $p = .86$). Furthermore, there were no differences between experimental conditions immediately after intervention or at the 6-month follow-up for any secondary outcomes, including MCDI total words said ($d = 0.19$, $p = .18$; $d = 0.04$, $p = .75$), CSBS total weighted raw scores ($d = 0.07$, $p = .96$; $d = -0.08$, $p = .69$), Preschool Language Scales–Auditory Comprehension subscale scores ($d = 0.18$, $p = .08$; $d = 0.14$, $p = .24$), PLS-EC scores ($d = 0.08$, $p = .48$; $d = -0.03$, $p = .78$), SPA play levels ($d = -0.15$, $p = .35$; $d = -0.20$, $p = .26$), or average BOSCC scores ($d = 0.009$, $p = .54$; $d = 0.09$, $p = .47$).

Post Hoc Moderator Analysis

Child baseline measures of autism severity did not moderate socially communicative acts immediately after intervention ($B = 1.30$, $p = .64$) or at the 6-month follow-up ($B = 1.43$, $p = .65$). Caregiver baseline levels of

Table 5. Caregiver outcomes at baseline (T0), immediately after intervention (T1), and 6 months later (T2).

Outcome	*M* (*SD*)		Adjusted[c]			
	Intervention[a]	Control[b]	Mean difference	95% CI	*p*	Effect size[d]
Matched turns – T0	0.21 (0.13)	0.22 (0.14)	0.00	[–0.05, 0.05]	1.00	0.00
Matched turns – T1	0.45 (0.20)	0.28 (0.15)	0.18	[0.11, 0.24]	< .001	0.99
Matched turns – T2	0.40 (0.18)	0.30 (0.19)	0.10	[0.03, 0.17]	.005	0.55
Responsiveness – T0	0.94 (0.12)	0.95 (0.10)	–0.01	[–0.06, 0.03]	.58	–0.10
Responsiveness – T1	0.85 (0.13)	0.95 (0.08)	–0.09	[–0.13, –0.05]	< .001	–0.83
Responsiveness – T2	0.90 (0.12)	0.98 (0.05)	–0.06	[–0.09, –0.02]	.003	–0.60
Matched responsiveness – T0	0.71 (0.18)	0.73 (0.20)	–0.02	[–0.09, 0.06]	.68	–0.08
Matched responsiveness – T1	0.77 (0.14)	0.85 (0.11)	–0.07	[–0.12, –0.02]	.006	–0.56
Matched responsiveness – T2	0.84 (0.13)	0.88 (0.16)	–0.04	[–0.10, 0.03]	.25	–0.02
Expansions – T0	0.08 (0.12)	0.12 (0.17)	–0.03	[–0.09, 0.02]	.22	–0.23
Expansions – T1	0.32 (0.28)	0.05 (0.08)	0.27	[0.18, 0.35]	< .001	1.30
Expansions – T2	0.15 (0.17)	0.06 (0.11)	0.09	[0.03, 0.16]	.003	0.66
Target language – T0	0.08 (0.06)	0.10 (0.09)	–0.01	[–0.05, 0.01]	.27	–0.21
Target language – T1	0.32 (0.20)	0.09 (0.06)	0.21	[0.16, 0.27]	< .001	1.45
Target language – T2	0.22 (0.16)	0.09 (0.07)	0.12	[0.07, 0.17]	< .001	0.98
Time delay frequency – T0	0.07 (0.54)	0.18 (0.78)	–0.12	[–0.37, 0.13]	.35	–0.18
Time delay frequency – T1	0.87 (1.57)	0.06 (0.31)	0.76	[0.28, 1.24]	.002	0.69
Time delay frequency – T2	0.35 (0.84)	0.09 (0.48)	0.27	[–0.05, 0.58]	.10	0.39
Time delay accuracy – T0	0.01 (0.11)	0.06 (0.23)	–0.05	[–0.12, 0.02]	.13	–0.29
Time delay accuracy – T1	0.39 (0.47)	0.03 (0.15)	0.35	[0.20, 0.50]	< .001	1.02
Time delay accuracy – T2	0.19 (0.39)	0.03 (0.17)	0.15	[0.01, 0.29]	.03	0.51
Prompting frequency – T0	0.18 (0.55)	0.21 (0.56)	–0.01	[–0.20, 0.19]	.96	–0.01
Prompting frequency – T1	0.49 (1.14)	0.19 (0.72)	0.34	[–0.05, 0.74]	.09	0.36
Prompting frequency – T2	0.37 (0.69)	0.42 (1.12)	–0.07	[–0.50, 0.36]	.75	–0.08
Prompting accuracy – T0	0.06 (0.16)	0.08 (0.24)	–0.02	[–0.09, 0.06]	.69	–0.08
Prompting accuracy – T1	0.17 (0.34)	0.06 (0.21)	0.12	[0.004, 0.23]	.04	0.42
Prompting accuracy – T2	0.17 (0.32)	0.07 (0.19)	0.11	[–0.01, 0.23]	.08	0.41

Note. CI = confidence interval.

[a]For the intervention group at T0 $n = 58$, at T1 $n = 51$, and at $n = 46$. [b]For the control group at T0 $n = 62$, at T1 $n = 52$, and at T2 $n = 47$. [c]Adjusted analyses include study site, time in days since baseline, Autism Diagnostic Observation Schedule comparison score, total community service therapy hours, Mullen raw score, and the value of the dependent variable at baseline. [d]Effect size (*d*) calculated by dividing the adjusted mean difference by the pooled *SD* of the intervention and control arms.

Table 6. Child outcomes at baseline (T0), immediately after intervention (T1), and 6 months later (T2).

Outcome	Intervention		Control		Adjusted[a]			
	M (*SD*)	*n*	*M* (*SD*)	*n*	Mean difference	95% CI	*p*	Effect size[b]
Primary outcomes								
Socially communicative acts – T0	23.66 (33.46)	58	21.56 (23.36)	62	3.52	[–5.26, 12.30]	.42	0.13
Socially communicative acts – T1	29.24 (37.58)	51	30.77 (39.20)	52	0.38	[–10.70, 11.46]	.95	0.01
Socially communicative acts – T2	35.78 (44.91)	46	39.98 (46.36)	47	0.97	[–9.82, 11.76]	.86	0.02
Secondary outcomes								
CSBS total weighted raw score – T0	39.58 (28.86)	58	42.08 (31.81)	62	–3.17	[–14.96, 8.61]	.59	–0.10
CSBS total weighted raw score – T1	55.27 (38.27)	51	55.12 (37.35)	51	0.31	[–11.69, 12.31]	.96	0.01
CSBS total weighted raw score – T2	60.33 (39.42)	45	66.49 (39.19)	47	–2.95	[–17.54, 11.64]	.69	–0.08
MCDI total words said – T0	43.24 (75.1)	58	42.76 (66.9)	62	4.22	[–19.46, 27.90]	.72	0.06
MCDI total words said – T1	104.47 (120.38)	49	94.22 (118.63)	49	22.81	[–10.40, 56.01]	.18	0.19
MCDI total words said – T2	137.80 (143.34)	45	144.84 (156.40)	43	6.41	[–32.80, 45.62]	.75	0.04
PLS-AC raw score – T0	21.68 (5.15)	58	21.89 (5.03)	62	–0.65	[–1.99, 0.69]	.34	–0.12
PLS-AC raw score – T1	23.78 (7.43)	51	23.48 (7.61)	52	1.34	[–0.18, 2.87]	.08	0.18
PLS-AC raw score – T2	26.07 (9.40)	46	25.90 (9.52)	48	1.37	[–0.90, 3.64]	.24	0.14
PLS-EC raw score – T0	19.75 (5.06)	58	20.84 (5.69)	62	0.03	[–1.42, 1.49]	.97	0.01
PLS-EC raw score – T1	25.37 (5.14)	51	24.88 (5.60)	52	0.40	[–0.74, 1.55]	.48	0.08
PLS-EC raw score – T2	26.96 (6.98)	45	27.17 (7.46)	48	–0.25	[–1.97, 1.48]	.78	–0.03
SPA play level – T0	10.22 (12.51)	58	9.48 (3.88)	62	0.67	[–2.70, 4.03]	.69	0.07
SPA play level – T1	10.08 (2.91)	50	10.59 (3.24)	51	–0.48	[–1.49, 0.53]	.35	–0.15
SPA play level – T2	10.09 (2.73)	45	10.51 (3.38)	47	–0.62	[–1.70, 0.46]	.26	–0.20
BOSCC total score – T0	39.36 (8.95)	58	37.36 (9.93)	62	0.84	[–1.37, 3.05]	.45	0.09
BOSCC total score – T1	38.6 (10.24)	49	36.77 (9.57)	51	0.89	[–1.97, 3.75]	.54	0.09
BOSCC total score – T2	37.46 (11.43)	45	35.96 (12.35	46	1.12	[–1.94, 4.19]	.47	0.09

Note. CI = confidence interval; CSBS = Communication and Symbolic Behavior Scales; MCDI = MacArthur–Bates Communicative Development Inventories; PLS-AC = Preschool Language Scales–Auditory Comprehension subscale; PLS-EC = Preschool Language Scales–Expressive Communication subscale; SPA = Structured Play Assessment; BOSCC = Brief Observation of Social Communication Change.

[a]Adjusted analyses include study site, time in days since baseline, Autism Diagnostic Observation Schedule (ADOS) comparison score, total community service therapy hours, Mullen raw score, and the value of the dependent variable at baseline. [b]Effect size (d) calculated by dividing the adjusted mean difference by the pooled *SD* of the intervention and control arms.

responsiveness did not moderate socially communicative acts immediately after intervention ($B = 1.89$, $p = .96$) or at the 6-month follow-up ($B = 25.06$, $p = .42$).

Post Hoc Analyses

Given the lack of main effects and the unexpected significant difference in caregiver responsiveness favoring the control group, we completed several post hoc analyses. First, we examined correlations (collapsed across experimental conditions) between caregiver use of intervention strategies and child communication, language, and play skills at baseline, T1, and T2 (see Table 7). Covariates included in the main effects models were not included in the post hoc exploratory correlations. The purpose of the post hoc correlational analyses was to shed light on the impact of intervention strategy use (irrespective of experimental condition) on child communication, language, and play skills. Matched turns were significantly, positively associated with all child language outcomes across time points, with correlations ranging from $r = .31$ to $r = .58$ ($p < .05$). Target language was significantly, negatively associated with all child outcomes at T1 and T2. We hypothesized that if reducing input to match child language level had a negative association with child outcomes, then the number of different words the caregiver used (caregiver NDW) would be positively associated with child outcomes. Thus, we examined the association of caregiver NDW with child outcomes and found a positive, significant association between caregiver NDW and all child outcomes at T1 and T2. We then examined caregiver NDW between intervention and control groups and found a significant difference between groups, favoring the control group at T1 and T2 ($d = -1.27$, $p < .001$; $d = -0.78$, $p < .001$).

Discussion

The main effects indicated no differences in child outcomes or moderators of any child outcomes immediately after intervention (T1) or at the 6-month follow-up (T2). These findings are in line with recent intervention studies (Green et al., 2022) and meta-analytic findings (Sandbank et al., 2020), which suggest that outcomes of NDBI studies are largely influenced by the methodological rigor of the studies, with studies of poorer quality showing more favorable results. Given the variability of outcomes, it is critical to consider the efficacy of individual intervention strategies. As such, we conducted post hoc correlations, which suggest that many of the taught intervention strategies are positively associated with child outcomes.

Table 7. Correlations between caregiver use of strategies and child outcomes.

Variable	Socially communicative acts	CSBS	MCDI	PLS-AC	PLS-EC	SPA	BOSCC
T0							
Matched turns	**.371***	**.418***	**.390***	**.403***	**.359***	.019	**–.313***
Responsiveness	.132	**.222***	.166	.138	**.238***	**.195***	–.156
Matched responsiveness	**.217***	**.259***	**.193***	**.277***	**.337***	.144	–.101
Expansions	.035	–.022	–.009	–.019	.012	.154	.022
Target language	–.045	.000	–.033	.032	.017	–.032	–.005
Time Delay frequency	–.112	–.088	–.100	–.073	–.019	–.062	.096
Time Delay accuracy	–.119	–.113	–.112	–.107	–.094	–.063	.066
Prompting frequency	.173	**.330***	**.321***	**.381***	**.306***	.053	–.186
Prompting accuracy	.101	**.218***	**.245***	**.262***	**.240***	.060	–.123
NDW[a]	.173	**.225***	.158	**.217***	**.274***	.070	–.092
T1							
Matched turns	**.467***	**.393***	**.444***	**.386***	**.473***	**.300***	**–.321***
Responsiveness	**.231***	.188	.172	.063	.167	.086	–.182
Matched responsiveness	**.297***	.224	**.241***	.166	.185	.191	**–.207***
Expansions	.009	.008	.032	–.040	.072	–.041	–.014
Target language	**–.283***	**–.356***	**–.322***	**–.365***	**–.246***	**–.249***	**.258***
Time Delay frequency	–.085	–.102	–.139	–.153	–.052	–.103	.125
Time Delay accuracy	–.117	–.098	–.089	–.179	.001	–.044	**.211***
Prompting frequency	**.299***	**.340***	**.341***	**.275***	**.327***	.031	**–.267***
Prompting accuracy	**.231***	**.289***	**.357***	**.209***	**.358***	.013	–.127
NDW[a]	**.452***	**.392***	**.324***	**.414***	**.356***	**–.263***	**.287***
T2							
Matched turns	**.523***	**.479***	**.581***	**.518***	**.516***	**.329***	**–.350***
Responsiveness	.161	.134	.178	.084	.106	.126	–.099
Matched responsiveness	.148	.077	.153	.095	.112	.159	–.002
Expansions	.000	–.055	–.023	–.006	–.023	–.080	.149
Target language	**–.353***	**–.368***	**–.348***	**–.329***	**–.343***	**–.371***	**.345***
Time Delay frequency	–.004	.044	–.023	–.010	.021	.084	–.025
Time Delay accuracy	–.019	.012	–.079	–.004	–.052	–.018	.000
Prompting frequency	.116	.179	.140	.161	.114	.181	–.058
Prompting accuracy	.191	.192	.133	.190	.151	.224	–.055
NDW[a]	**.517***	**.387***	**.389***	**.411***	**.365***	**.392***	**–.293***

Note. Bolded data indicate statistically significant correlations. CSBS = Communication and Symbolic Behavior Scales; MCDI = MacArthur–Bates Communicative Development Inventories; PLS-AC = Preschool Language Scales-Auditory Comprehension subscale; PLS-EC = Preschool Language Scales-Expressive Communication subscale; SPA = Structured Play Assessment; BOSCC = Brief Observation of Social Communication Change.

[a]Number of different words.

*$p < .05$.

Therefore, there are several potential explanations that bear further investigation. First, there were some strategies (i.e., responsiveness and matched responsiveness) that control group caregivers used at a higher rate than intervention group caregivers. This is likely due to the fact that intervention group caregivers' use of responsiveness decreased from baseline (94%) to T1 (85%) and T2 (90%), whereas control group caregivers' use of responsiveness remained stable (95%, 95%, and 98%). In addition, control group caregivers' use of matched responsiveness increased from baseline (73%) to T1 (85%) and T2 (88%). It is unlikely that the increase in matched responsiveness is due to effects of community-based interventions, given that the majority of community-based intervention services use child-directed strategies without caregiver involvement (Lee et al., 2022). However, it is possible that community-based interventions provided child-directed strategies and improved child social communication. If community-based interventions increased rates of social communication, caregivers would have more opportunities for responding with linguistic input. One alternative explanation suggests that the activities of the positive behavioral support group indirectly increased caregivers' implementation of matched responsiveness. Supporting caregivers to develop a behavior support plan may have led to decreases in challenging behaviors. As a result, caregivers may be better able to engage and respond to their child's communication. Future research should address the extent to which supporting caregivers to address challenging behaviors increases the caregivers' capacity to implement language intervention strategies.

There are several potential explanations for these unexpected findings. First, simultaneously teaching caregivers play (JASPER) and communication (EMT) intervention strategies may have made it difficult for caregivers to respond to child communication while supporting play.

However, it should be noted that while responsiveness decreased for the intervention group, the magnitude of the decrease (94% at baseline to 85% at T1) is relatively small and high levels of responsiveness were maintained. Relatively lower responsiveness for trained caregivers was not observed in prior studies of EMT or JASPER when implemented separately. Child outcomes may be improved by teaching caregivers only the most effective strategies (e.g., matched turns) and incorporating therapist implementation of addition strategies, such as prompting, which require a significant amount of integration of skills (e.g., environmental arrangement, responsiveness, and sequencing of verbal prompts). Furthermore, identifying the optimal levels and ideal combinations of intervention strategies is critical to supporting caregiver instruction.

Caregiver linguistic input may have also influenced study results, as suggested by the negative association between caregiver use of language targets and all child outcomes at T1 and T2. These negative correlations may also indicate the transactional nature of caregiver input; caregivers used less complex language with children with lower language and play skills. Thus, it is not possible to know the direction of this association (i.e., if lower child language skills resulted in reduced caregiver input or vice versa). However, the significant difference in NDW favoring the control group suggests that regardless of child language level, intervention group caregivers used fewer different words than control group caregivers. These findings highlight the potentially negative impact of overrestricting linguistic input. Previous research suggests that increasing the diversity of lexical noun phrase subjects in caregiver input is directly related to child outcomes (Hadley et al., 2017). As such, intervention designs should consider the extent to which specific linguistic features of interventions for autistic children impact child outcomes.

Dosage may have also contributed to these null findings. Two 1-hr sessions per week for 6 months may not have been sufficient to change child outcomes. Other caregiver-mediated studies with similar dosage have reported similar null findings for social communication (Beaudoin et al., 2019; Carter et al., 2011; Oosterling et al., 2010; Rogers et al., 2012; Rollins et al., 2021; Venker et al., 2012; Watson et al., 2017). Although, cumulative intervention intensity was not found to moderate language intervention outcomes in a meta-analysis of clinician and caregiver-mediated language interventions for young children with autism (Sandbank et al., 2020), considering of intensity and dosage may be particularly important for caregiver-mediated interventions. The effects for child outcomes for the Early Start Denver Model were present only when children received clinician-implemented intervention (Rogers et al., 2019) as compared with the caregiver-mediated approach (Rogers et al., 2012). Furthermore, caregivers' use of intervention strategies decreased from T1 to T2, suggesting that caregivers may require continuous support to implement intervention strategies at high levels as their child's communication changes. It is challenging to estimate the overall dosage of intervention strategies delivered to the child, and no measures of caregiver strategy use outside of the assessment sessions were collected. Therefore, caregivers may not have used intervention strategies throughout the day at a high enough rate to elicit changes in child outcomes. As such, these findings warrant examination of generalization of strategy use and barriers to caregivers' strategy use throughout the day. Additionally, variability in rates of child communication also impacts the dosage of intervention strategies; many of which are dependent on the number of opportunities to respond (i.e., number of child communicative attempts).

Another challenge in studies of interventions for autistic toddlers is selecting an outcome measure that is sensitive to clinically significant changes in social communication. We included several measures of social communication and chose a primary outcome measure that was naturalistic yet with an adult who was naïve to experimental condition. To our knowledge, this is the first study to include a naturalistic communication measure that involves a naïve assessor. In caregiver–child interactions, it is likely that the caregiver supports child communication by using target intervention strategies. As such, a measure that eliminates this scaffolding may more accurately assess a child's spontaneous social communication skills. However, this robust assessor-implemented outcome measure may not have been sensitive enough to detect change over 6 months and potential gains in child communication may not generalize to a context with an unfamiliar communicative partner. Supplementing robust assessment measures with more ecologically valid, sensitive assessments (e.g., measures of joint engagement during caregiver–child interactions) may provide a more holistic evaluation of child outcomes. An additional challenge in caregiver-mediated studies, which teach a package of intervention strategies sequentially is that the caregiver may not reach criterion implementation (i.e., 80%) until relatively later in the intervention phase. Thus, children may receive the intervention at full fidelity for less than 25% of the intervention sessions and the actual dosage of the intervention may be lower than assumed even in the 6-month span of the intervention.

Limitations

The results should be considered in light of the limitations. The primary child outcome was measured during a lab-based assessment with an unfamiliar communicative partner. Although this assessment context includes advantages such as administration by a naïve assessor and standardization of the environmental context, the context may not be as ecologically valid as a home-based measure of

child communication with a familiar communicative partner. Additionally, it is important to consider that the majority of families enrolled in this study included a participating caregiver who was not working full time. As such, the feasibility of the current intervention approach and dosage (i.e., 2 hr/week) may not generalize to all families.

Results of this study suggest that a twice-weekly caregiver-mediated intervention that taught caregivers to use play and communication support strategies was insufficient to yield significant child outcomes. These results have immediate clinical implication and suggest that clinicians should select the most effective strategies, such as matched turns, when deciding how to support caregivers' implementation of language intervention strategies. Despite the methodological rigor of this clinical trial, changes in the behavior of control group caregivers may have influenced these findings. For example, although the positive behavior support condition was considered a benign treatment, by providing caregivers with training to address child behavior and other developmental issues they identified, the positive behavior support intervention may have increased caregiver-matched responsiveness and/or improved some aspects of children's behavior, which positively influenced caregiver–child interactions. Additionally, given the methodological rigor of the study, results suggest that combining JASPER and EMT may have unintended negative effects on some caregiver behaviors. Future research that considers specific caregiver linguistic input, includes a measure of caregiver daily use of intervention strategies, considers the range of child measures that represent proximal and distal outcomes of the intervention, and examines additional caregiver and child moderators is needed. Future research should also determine which strategies are best implemented by caregivers versus therapists.

Data Availability Statement

Data generated and analyzed for this study are available from the corresponding author upon request.

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