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Hybrid implementation model of community-partnered early intervention for toddlers with autism: a randomized trial

Stephanie Y. Shire,[1] Ya-Chih Chang,[2] Wendy Shih,[1] Suzanne Bracaglia,[3] Maria Kodjoe,[3] and Connie Kasari[1]

[1]University of California Los Angeles, Los Angeles, CA; [2]California State University Los Angeles, Los Angeles, CA; [3]New York Center for Child Development, New York City, NY, USA

Background: Interventions found to be effective in research settings are often not as effective when implemented in community settings. Considering children with autism, studies have rarely examined the efficacy of laboratory-tested interventions on child outcomes in community settings using randomized controlled designs. **Methods:** One hundred and thirteen children with autism enrolled in public early intervention classrooms in low resource neighborhoods were randomized to Joint Attention, Symbolic Play, Engagement, and Regulation (JASPER) intervention or treatment as usual waitlist for 10 weeks with 1-month follow-up. **Results:** Teaching assistants delivered JASPER at adequate fidelity. Children randomized to JASPER demonstrated significant gains over treatment as usual in core developmental outcomes of joint engagement, joint attention, and play skills that were maintained at follow-up. **Conclusions:** Supervised teaching assistants delivered JASPER intervention with a range of toddlers with autism leading to significant gains in developmental outcomes. **Keywords:** Autism; JASPER; early intervention; paraprofessionals; joint attention; joint engagement; play; implementation.

Introduction

Social communication and play skills are critical developmental domains in early childhood. Initiations of joint attention gestures (e.g. showing and pointing to share) and play level are associated with spoken language development for typically developing children (Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998). These same skills are core challenges for children with autism spectrum disorder (ASD); yet similarly associated with later developmental language and cognitive outcomes (Kasari, Gulsrud, Freeman, Paparella, & Hellemann, 2012; Mundy, Sigman, & Kasari, 1990). Interventions have demonstrated improvements in these core impairments for children with ASD when carried out under controlled conditions (e.g. Kasari, Gulsrud, Paparella, Hellemann, & Berry, 2015; Kasari, Gulsrud, Wong, Kwon, & Locke, 2010). However, within the health services sector, such interventions often fail to traverse the gap between controlled research trials and routine community practice (Damschroder et al., 2009). Closing this gap is critical to improving the outcomes of community children who may be different from and obtain generally poorer outcomes than those in research trials.

There are several barriers to improving community outcomes. First, community settings rarely exclude children's participation by characteristics commonly restricted in research samples, such as level of cognitive or language functioning. These differences in samples can hamper comparisons between laboratory and community implemented studies (Weisz, Chu, & Polo, 2004). Second, community practitioners vary in their expertise with children with ASD. Nonspecialists are routinely responsible for teaching children in community early childhood settings, whereas highly trained specialists execute controlled research trials. A third barrier is the difference in training, supervision, and fidelity between research trials and community practice.

Pragmatic approaches using implementation science methods aim to bridge the gap between effective evidence-based treatment and community routine practice by partnering with practitioners in real-world settings (Proctor et al., 2009). A few examples exist for children with ASD. Overall, these studies have focused primarily on the feasibility and acceptability of the intervention (Suhrheinrich et al., 2013) or fidelity of intervention implementation (e.g. Surheinrich, Stahmer, & Schreibman, 2007). Several studies have extended this work to include both community implementation fidelity and improvements in child outcomes. Outcomes have included child scores on cognitive tests (Mandell et al., 2013; Vivanti et al., 2014), parent reported problem behavior (Brookman-Frazee, Drahota, & Stadnick, 2012), and child verbal utterances (Bryson et al., 2007); however, only one study utilized a randomized, controlled trial design (Mandell et al., 2013).

When child outcomes are rigorously tested in the community, group differences are less evident. Insignificant differences may be due to poor implementation fidelity (Mandell et al., 2013; Stahmer et al., 2015), lack of fit with the community setting, or community services that are similar in quality to

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the experimental intervention. Given the cost of transferring research-tested interventions to the community, some have argued that implementation science should not overlook participant-level outcomes in research designs (Curran, Bauer, Mittman, Pyne, & Stetler, 2012). One solution is to use *effectiveness-implementation hybrid designs* that take a dual focus on community implementation and participant outcomes (Curran et al., 2012). By systematically testing a priori implementation and effectiveness aims together, hybrid designs hold the potential for effective tests of interventions in the community that can also reduce transfer time between laboratory and community.

Current study

The goal of the current study was to apply an implementation hybrid design with toddlers with ASD in publically funded community programs. The evidence-based intervention tested was Joint Attention, Symbolic Play, Engagement, and Regulation (JASPER; Kasari et al., 2014), a targeted social communication intervention. JASPER has been tested in the clinic with both preschoolers and toddlers (Kasari, Freeman, & Paparella, 2006; Kasari, Paparella, Freeman, & Jahromi, 2008; Kasari et al., 2010, 2015) and in the community with preschoolers (Chang, Shire, Shih, & Kasari, 2016; Kaale, Fagerland, Martinsen, & Smith, 2014; Lawton & Kasari, 2012) but *not toddlers*. Outcomes for preschoolers in the laboratory and in the community have been consistent, with gains in initiations of social communication, engagement, and play skills. The current study extended examination of community implemented JASPER under novel conditions: (a) remote support, (b) *toddlers* in early intervention settings, (c) treatment implementation by supervised teaching assistants (TAs), and (d) implementation of the distal outcome measure by the center staff rather than the research team. Utilizing an effectiveness-implementation hybrid design, the study aims addressed: (a) the feasibility of supervised TA-implemented JASPER within an early intervention program that has a base behavior analytic approach to analytic early intervention (Verbal Behavior: Sundberg, 2008), and (b) the influence of intervention on children's core developmental challenges of joint attention, joint engagement, play, and language skills.

Methods

School program characteristics

Children and school staff were recruited and consented from a state funded center-based early intervention program serving boroughs of New York City including the Bronx, Manhattan, and Queens. The program included sites in the Bronx and Harlem with two classrooms in each site. Within each classroom, four sequential 2-hr-long 'sessions' were conducted each day. A session consisted of 8–10 children where each child was paired with a TA for two components. The first component was a 1.5 hr of classroom Verbal Behavior (VB) applied behavior analysis programming (Sundberg, 2008) led by credentialed teachers and supervised by Board Certified Behavior Analysts. The VB programming provided instruction through a combination of discrete trial and natural environment teaching to focus on developing both speaking and listening language abilities (Carr & Firth, 2005). VB program targets include spoken requesting behaviors and responding to verbal directions. The second component of the session was a 30-min small group (five children) program led by the allied health professionals (i.e. occupational and speech therapists, social workers) and designed to use naturalistic strategies to target children's social engagement. TAs engaged in a maximum of four consecutive class sessions per day. Group Leaders could run a maximum of eight group sessions (one to two small groups for each of four sessions).

Participants

Children. Program enrollment was the only criterion for study inclusion. The program received referrals from the New York City Early Intervention (NYC EI) program. As part of a multidisciplinary team assembled by the state, independent assessors refer children who meet state criteria for EI programming in applied behavior analysis. As reported in NYC Early Intervention Program guide, eligible children included those who demonstrate a delay of at least two standard deviations in one functional domain (cognition, communication, physical, adaptive, and social/emotional development) or lesser delays in more than one functional domain. Children referred to the program by NYC EI Service Coordinators had to be a minimum of 24 months of age to enter and aged out at approximately 36 months. Study recruitment began in November and continued through the end of the school year in July. As new children became age eligible (24 months) for the program, they were offered study participation. Due to this rolling enrollment process, children continued to enter throughout the treatment and follow-up periods. Children who entered after week 4 of JASPER immediate treatment were not included in the analyses because the treatment dosage had been significantly reduced ($n = 34$). Therefore, of 147 total families who consented to study participation, the analyses included the 113 children (site 1 = 49; site 2 = 64) whose families consented prior to week four of immediate JASPER treatment. This sample size was large enough to achieve a moderate effect size of 0.32 (Cohen's f) with at least 80% power and 5% type I error rate (based on Chang et al., 2016).

These 113 children were primarily male ($n = 88$) and 31.63 months of age on average at entry ($SD = 3.05$ months). Children came to the center with outside clinical diagnoses of autism ($n = 89$) or pervasive developmental disorder-not otherwise specified (PDD-NOS: $n = 16$). In addition, eight children received other diagnoses including cerebral atrophy ($n = 1$), language delays ($n = 5$), and global developmental delays ($n = 2$). Children's age-equivalent receptive language ($M = 16.27$ months, $SD = 10.21$) and expressive language ($M = 16.87$ months, $SD = 9.03$) skills were measured using the Mullen Scales of Early Learning (MSEL: Mullen, 1995). Children were primarily Hispanic ($n = 74$), or African American ($n = 25$), with fewer children from other ethnicities (Caucasian, $n = 6$; Mixed, $n = 5$ or Asian, $n = 3$).

Only one third of families returned demographic information on family occupation and education. Of these, the average social-economic status (Hollingshead two-factor Social Position Score; Hollingshead, 1975) was 27, in the lower middle strata, semiskilled worker. To better characterize the entire sample, we accessed 2010 US Census data by zip code that was obtained for each participant. Data indicated that the average median income in the Bronx neighborhoods in which

the students resided was $33,913 (*SD* = $11,508) and $40,928 in Harlem (*SD* = $18,669). Using the American Community Survey from 2010 to 2014, the percentage of families living below the poverty line was 29.82% (*SD* = 10.12) in the Bronx, and 24.86% (*SD* = 8.69) in Harlem.

School staff. Forty-five TAs, 14 group leaders (GLs), and 1 on-site consultant were included. Each TA provided direct one-to-one intervention with up to four students a day. GLs included allied health professionals (e.g. speech language pathologists). GLs supervised up to eight 30-min group sessions a day providing environmental support (e.g. arranging materials) and trouble shooting for the TAs. The on-site consultant received JASPER training with ongoing remote supervision over the year. In turn, the on-site consultant provided ongoing coaching and JASPER troubleshooting assistance for the staff.

Teaching assistants: The 45 TAs were largely female (*n* = 41), had worked in the program for 2.56 years on average (*SD* = 2.28), and reported diverse ethnic backgrounds including Hispanic (*n* = 31), African American (*n* = 12), Asian (*n* = 1), and Caucasian (*n* = 1). The TAs reported college education (*n* = 20), current college enrollment (*n* = 16), professional degrees (*n* = 6), and high school degrees (*n* = 3).

Group leaders: The 14 GLs were primarily female (*n* = 13) and included speech and language pathologists (*n* = 7), occupational therapists (*n* = 2), occupational therapy assistants (*n* = 3), and social workers (*n* = 2). GLs held their positions for 1.75 years on average (*SD* = 1.10) and had graduate (*n* = 11) or college degrees (*n* = 3). GLs reported as Caucasian (*n* = 7), Hispanic (*n* = 5), African American (*n* = 1), and Asian (*n* = 1).

On-Site JASPER consultant: The consultant was a Caucasian female with a graduate degree in school psychology.

Randomization and study design

The center-based program included four classrooms across two sites. Randomization occurred at the classroom level. An independent statistician used a random number generator to allocate the first class within each site to the first treatment arm using R Cran version 3.0.0 (R Core Team, 2016) with the 'rbinom( )' function and a set seed of 2013. Within each site, classrooms were randomized to immediate treatment (JASPER) or to treatment as usual waitlist (WL). The two classrooms randomized to JASPER included 78 children and 34 staff including 26 TAs and 8 GLs. The other two classrooms randomized to WL included 69 children and 29 staff including 23 TAs and 6 GLs. All staff consented to participate. One TA and one GL from the JASPER group were absent due to maternity leave, and two TAs left the center. Therefore, a total of 45 TAs and 14 GLs were included in the analyses (Figure 1).

Intervention

Classroom programming. Children in both groups received 1.5 hr of VB programming. The VB programming was delivered in the classroom with all students present. The classroom teacher guided the group and TAs worked 1:1 with their students. In addition to the VB programming, all children received a 30-min group program each day. Classrooms were randomized to 30 min of treatment as usual (TAU) social programming or 30 min of JASPER programming.

TAU waitlist intervention. The goal of the 30-min TAU group program was to improve children's social skills through music and movement activities. Designed by allied health providers (OT and SLP), this activity-based social group included songs, book reading, free play, sensory play (e.g. bubbles), and instruments. TAs supported the children with one-on-one instruction while one GL provided group level support and instruction. High-level consultation and supervision for the TAU group programs was provided by the allied health programming coordinator.

JASPER immediate treatment intervention. JASPER is a targeted intervention delivered in the context of play to increase engagement, play, and social communication skills. Group level oversight and environmental support a GL while TAs provided individual support for their students. TAs focused on engaging the child by creating play routines through imitation and modeling of new play acts. Furthermore, TAs expanded children's initiations of play as well as nonverbal and spoken communication. Seven components of the intervention are described in Appendix S1.

Community-partnered participatory approach. The center administration was interested in comparing their current small group program to an evidence-based social communication program, and thus approached the originators of JASPER. Following a Community-Participatory Partnered Research (CPPR: Jones & Wells, 2007) approach, repeated meetings were held in the summer to coplan the research trial. These meetings included the center's administration and clinical leaders as well as the study's principal investigator. The team discussed the application of JASPER during the social group program and adaptations needed to fit the center context. The primary adaptation was environmental arrangement of the large group rooms to create five smaller sections to accommodate individual sessions given the current 1:1 assignment of a TA to each child. Staff roles remained the same where the GLs provided overall direction and support to the TAs who provided direct support to individual children. The additional role of an 'on-site consultant' was created to begin to build the center's supervisory capacity to sustain JASPER and coordinate the research trial.

It was within these daily group sessions where children were randomized to receive: (a) 10 weeks of JASPER intervention and 1-month follow-up or (b) 10 weeks of TAU and 1-month follow-up. Randomization was conducted prior to beginning the JASPER training. Training consisted of:

JASPER consultant training. The consultant visited the research laboratory at UCLA for a week-long introduction to the intervention including lecture and discussion as well as live coaching with children. Continued remote support was provided to the consultant weekly over the year. The goal of this ongoing training was to enable the consultant to provide support to the TAs and GLs.

Center staff training. Two university research staff led an initial 1-week on-site training focusing on the core components of JASPER including environmental arrangement, supporting engagement and social communication, establishing play routines, and responding to communication (see Appendix S1). Staff in attendance included the TAs, GLs, and on-site consultant who received the immediate JASPER condition. The week included: (a) a nonpupil day of group lecture/discussion, (b) four evening discussions introducing layers of JASPER strategies using PowerPoint and video, and (c) live coaching for TAs and GLs with children who were exiting the program and were not study participants.

Remote support. Due to the geographic distance between the center and the university team, in-person oversight by the university research staff was limited. Therefore, videos were uploaded to a password-protected private site weekly to the research team who provided weekly written feedback and

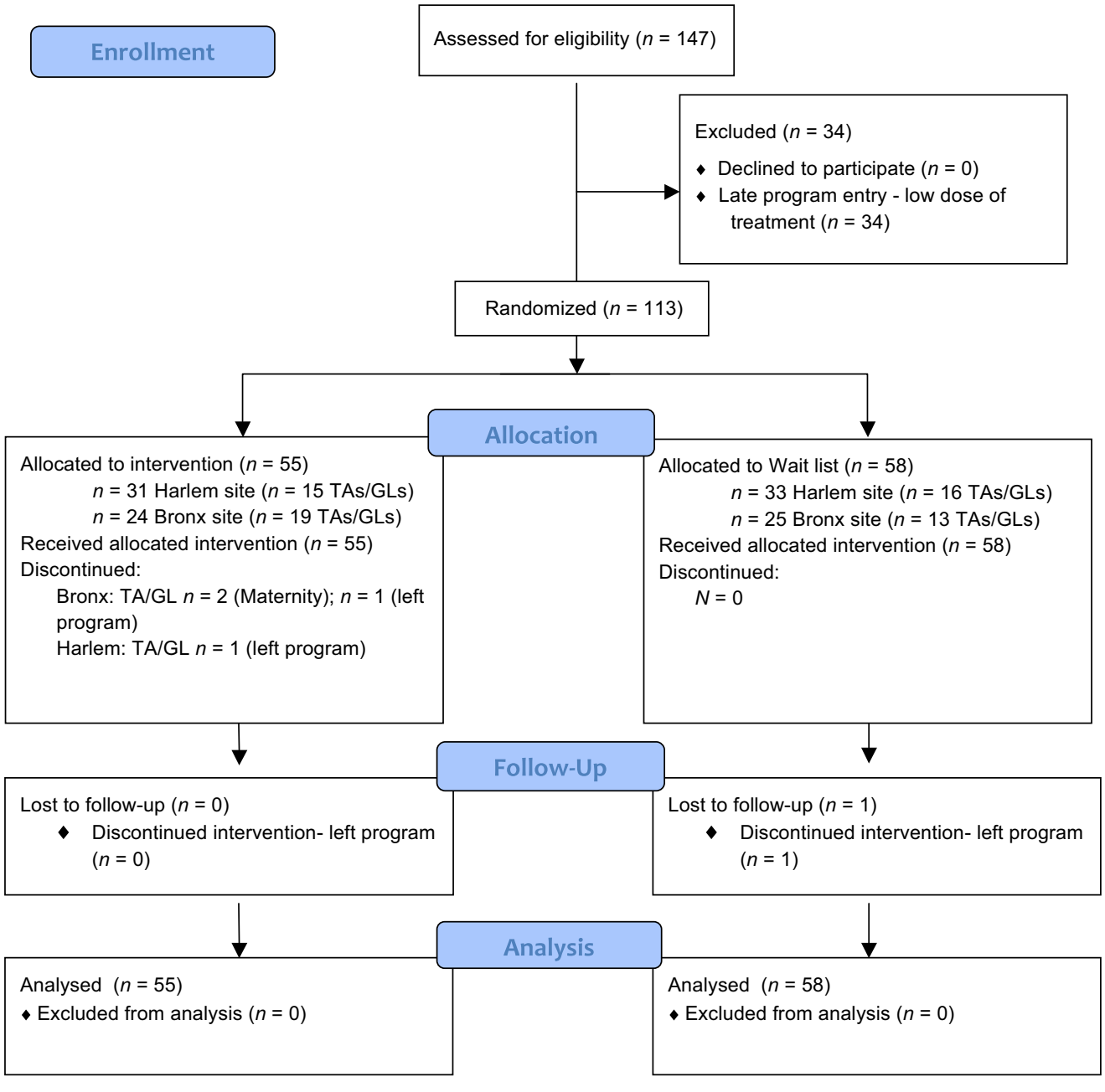

Figure 1 CONSORT flow diagram [Colour figure can be viewed at wileyonlinelibrary.com]

discussion on calls with the on-site consultant to troubleshoot challenges.

Booster live coaching session with continued remote support. The second on-site visit by the researchers was conducted during week 6–7 of JASPER immediate treatment. The training focused on layering in high-level JASPER strategies (e.g. expanding routines, programming for social communication) and troubleshooting challenges. This visit also provided additional coaching feedback and training for the on-site consultant. Weekly calls and video feedback continued after the visit.

One-month follow-up. To fit the study within the school year, follow-up assessments were conducted 1 month after JASPER immediate treatment was completed. During this time no remote feedback was provided. Waitlist classrooms continued with TAU.

Waitlist staff training and 10-week intervention. After completion of immediate group follow-up, the waitlist staff engaged in JASPER training. The format was similar to the JASPER immediate treatment group including a week-long training visit and weekly distance support for TAs and consultant.

Measures

Child measures. At entry, families completed a demographic form including basic information about the characteristics of the child and family. Psychology students supervised by the on-site consultant also assessed receptive and expressive language of children using the MSEL.

Attendance: Attendance records were provided by the center. Attendance was measured as a proportion: number of

days present divided by the total number of school days during immediate treatment (total of 50).

Staff measures. Teaching assistants and GLs were asked to complete a demographic form at entry.

Staff questionnaire: Before and after completion of the initial training visit, TAs and GLs completed a five-item questionnaire using a 5-point scale where a score of 1 indicated 'not true' and a score of 5 indicated 'very true'. Statements included: (a) children may benefit from JASPER, (b) I understand play and development, (c) I understand joint attention and requesting, (d) I am comfortable with the strategies, and (e) I feel I can implement JASPER.

Teaching assistant diaries (adapted from Kasari et al., 2014): Teaching assistants completed weekly diaries including four questions addressing adherence and two questions addressing competence. Each item was rated from 1 to 5 where higher scores represent greater adherence and competence.

Video coding measures

Graduate students and research assistants were trained to reliably code the two video-taped measures described below. Videos were distributed at random to independent coders. Video labels were identified by randomized numerical IDs so that coders were unaware of site, treatment condition, and time point. For each coding system, 20% of the videos were double coded to establish reliability statistics. Reliability statistics (interclass correlation coefficients and Kappa coefficients) are reported for each coding system below.

Proximal measure: Teaching assistant–child play interaction (TCX: Kasari et al., 2015). The TCX was considered the proximal measure because it took place in the same context as the intervention sessions with the familiar TA. The TCX consisted of a 10-min taping of the TA and child collected during a random segment of the group session by the GLs and consultant at study entry, exit, and follow-up. University researchers blind to study details coded the tapes for: (a) TAs' JASPER strategy implementation, (b) children's outcomes including joint engagement, initiations of joint attention and requesting, and play, and (c) clinical global impressions. The coding systems are described below.

Primary TA outcome: JASPER strategy implementation (TCX). The TCX videos were coded for TAs' JASPER strategy implementation of 31 items targeting the seven main intervention components including basic strategies, environment, following the child's lead, establishing play routines, expanding play routines, programming for joint attention and requesting skills, and language strategies (see Appendix S1). Each item was rated from 0 to 5, where '0' reflected incorrect or lack of strategy implementation, a '3' described mixed implementation where up to 50% of opportunities to use a strategy are missed, and a '5' represented accurate and developmentally appropriate strategy implementation at least 80% of the time. This rating system held TAs to the same JASPER standards as research clinicians. Item scores were summed and divided by the total number of possible points to obtain a percentage score for implementation. Two reliable raters scored the TA' strategy implementation (intraclass coefficient: ICC = 0.96).

Primary child outcome: Joint engagement (TCX). The TCX videos were divided into ten 1-min intervals. Each interval was given one of four mutually exclusive codes (unengaged, person, object, jointly engaged) to represent the child's engagement state for the majority of the interval (31+ seconds). See Appendix S2 for engagement state definitions. Intervals were also marked as adult-directed (e.g. redirects the child's attention, prompts or asks questions) or child-initiated using a dichotomous code (1 = adult-directed, 0 = child-initiated). Three independent raters scored engagement and the initiate of the state (child or adult). Kappa scores for engagement ratings ranged from 0.76 to 1.0. Kappa scores for child and adult initiated intervals ranged from 0.84 to 0.88.

Secondary child outcome: Children's initiations of joint attention and initiations of behavior regulation (TCX). The TCX videos were coded for the frequency of discrete initiations of joint attention (IJA) behaviors including eye gaze, gestures, and language consistent with the coding system applied in prior publications (e.g. Kasari et al., 2014). IJA behaviors were summed to create a total IJA count. The same process was conducted for initiations of behavior regulation skills (IBR) including eye gaze, gestures, and language to request. Three independent raters scored IJA and IBR. The range of ICCs for IJA was 0.90–0.99 and for IBR 0.89–1.0.

Secondary child outcome: Children's play (TCX). Children's play level during the TCX was also rated using 1-min intervals. Each interval was given one of eight mutually exclusive codes to represent the play level for the majority of the interval (31+ seconds). The eight levels were divided into three categories of simple, functional (including combination and presymbolic), and symbolic play. See Appendix S2 for play level descriptions. Kappa scores for play level identification ranged from 0.87 to 0.89 across three independent coders.

Secondary child outcome: Clinical global impressions-severity and -improvement (TCX). Clinical global impressions (CGI) rating scales were adapted (Guy, 1976) to rate severity of challenges in social communication and play skills at entry and exit. The CGI-Severity (CGI-S) rating included a score from 7 (most severe: no social communication, no play with objects) through a score of 1 (typical for chronological age). CGI-S ratings were conducted on the TCX videos from the first and last weeks of intervention by two members of the research team blinded to treatment allocation. Furthermore, at exit, a CGI-Improvement (CGI-I) rating was also scored to examine global change in social communication and play from entry to exit. CGI-I scores ranged from 7 (significantly worse) through 1 (very much improved). Kappa scores for the two raters were calculated based on double coding of 20% of the videos. Kappa scores for CGI-S play and social communication were 0.86 and 0.87 respectively, and for CGI-I were 0.80 and 0.84, respectively.

Distal measure: Short play and communication evaluation (SPACE: Shire, Shih, & Kasari, in press). The SPACE is a brief (15 min) community staff implemented assessment designed to obtain a profile of a child's spontaneous joint attention (IJA), response to joint attention (RJA), IBR, and spontaneous play skills. The SPACE was considered the distal measure of the child's skills because it was administered by a center staff member (e.g. TA or teacher) who had not worked directly with the child and the context of the assessment provides limited support for children's engagement and skills in comparison to the intensive intervention support provided in the TCX. The SPACE is based on established protocols including the Structured Play Assessment (Ungerer & Sigman, 1981) and Early Social Communication Scales (ESCS: Mundy et al., 2003). Items include: (a) bubbles, (b) two toy sets, (c) ball, and (d) distal points targeting response to joint

attention. The assessor may not prompt communication or play skills. Two teachers and five TAs who were not involved in the child's intervention administered the SPACE. WL staff were not included until they began intervention. The staff administered the SPACE with 91.76% fidelity (*SD* = 7.13%); individual averages ranged from 86.68% to 96.83%.

Secondary child outcome: Children's initiations of social communication gestures (SPACE). The SPACE videos were coded using the same procedures described for TCX IJA and IBR. Three independent raters scores IJA and IBR on the SPACE. ICCs were calculated for the total frequency of IJA (ICC = 0.91–0.99) and IBR (ICC = 0.89–0.92).

Secondary child outcome: Children's play (SPACE). The SPACE videos were examined for spontaneous play types. Each play type was coded as one of four play levels including simple, combination, presymbolic, and symbolic play. Combination and presymbolic categories were combined into 'functional play' in the same manner as the TCX. The total number of different play types and their frequency were obtained. Three independent coders scored play types on the SPACE. ICCs were calculated for number of types (ICC = .80–.90).

Statistical analyses

To assess the success of randomization, *t*-tests, Wilcoxon tests, chi-square tests, and Fisher's exact tests were used to compare characteristics between groups at baseline depending on the distribution of the variables. The trajectories of primary and secondary outcomes over treatment and follow-up were modeled using generalized linear mixed models (GLMM) including main effects of treatment group allocation (JASPER and WL), main effects of time, treatment group by time interactions, subject-level random intercepts. Time was modeled continuously in months controlling for children's average age-equivalent MSEL receptive and expressive scores (i.e. language age), and site main effects. Separate models were fit for each longitudinal outcome. All available observations from each participant were included. A 'treatment effect' was defined as a significant interaction effect between treatment group and time from baseline to exit. Maintenance of a significant treatment effect was defined as a significant improvement from entry to the follow-up within the JASPER treatment group. All outcome variables were continuous with exception of CGI scores (ordinal scales). Effect sizes including Cohen's *f* and φ are reported. Cohen's f was selected because it is appropriate for calculating effect size within a mixed regression framework and φ is more suitable for χ^2 tests. Effect sizes of 0.10, 0.25, and 0.40 are regarded as small, moderate, and large.

Two variables required another approach. First, due to the high prevalence of zero types at all-time points symbolic play was examined as a binary process where '0' represented children with no symbolic play types and where '1' represented those with at least one symbolic play type. Second, high-level IJA gestures (point, give, show) were examined separately from eye contact and language. Due to an overinflation of zeroes for high-level IJA gestures and symbolic play, hurdle models with random effects (using SAS NLMIXED; SAS Institute, Cary, NC, USA) were utilized to assess treatment effects on high-level IJA gestures across time. A hurdle model is a modified count model in which there are two processes, one generating the zeros and one generating the positive counts. A binary process models whether the count outcome has a zero or a positive value. If the count is positive (i.e. crossing the hurdle) then, the conditional distribution of the positive counts is assumed to be zero-truncated Poisson.

Results

Preliminary analyses

Sites and treatment groups were reviewed extensively for clustering effects and overall differences in child characteristics. No differences between the two physical sites were found. Furthermore, there were no significant differences in the distribution of gender, chronological age, receptive language, or expressive language between the treatment groups at entry (see Table 1).

Attendance. Children in JASPER attended an average of 38.5 days (*SD* = 9.3 days) compared to average of 37.9 days (*SD* = 7.7 days) for the WL group out of a possible 50 days. There was no significant difference in the number of days in attendance.

Teachers' perceptions – Acceptability and feasibility of implementation

Staff questionnaire. Prior to the initial training, TAs reported mean scores of 3.63 (*SD* = 0.77) indicating neutral views of their understanding of social communication and play, and their ability to implement the intervention. A significant increase in their understanding ($t(46) = 4.84$, $p < .001$, ES = 0.70) was found posttraining (*M* = 4.09, *SD* = 0.65). Exit average items scores of '4' indicated agreement with statements reporting confidence in both understanding the concepts and in delivering the intervention strategies.

TA diary. At entry, TAs reported a mean score of 3.20 (*SD* = 0.73) on the diary questions, increasing to a mean score of 4.04 (*SD* = 0.74) at exit. A significant change in TA's reported confidence in and adherence to JASPER strategies was found ($t(48) = 6.92$, $p < .001$, ES = 0.99).

Table 1 Participant characteristic at entry

Mean (*SD*)	Treatment as usual waitlist (*n* = 59)	Joint Attention, symbolic play, engagement, and regulation (*n* = 56)	*p*-value
Age (Months)	31.54 (3.17)	31.71 (2.94)	.8591
Boys: *n* (%)	45 (76.27)	44 (78.57)	.9428
Ethnicity: *n* (%)			
African American	10 (16.95)	15 (26.78)	.7034
Caucasian	4 (6.78)	3 (5.36)	
Hispanic	39 (66.10)	33 (58.93)	
Asian	1 (1.69)	2 (3.57)	
Mixed	2 (3.39)	3 (5.36)	
Did not report	3 (5.08)	0 (0)	
Mullen Scales of Early Learning Age-Equivalent			
Receptive language	16.00 (10.15)	16.55 (10.35)	.8226
Expressive language	16.44 (9.28)	17.32 (8.81)	.5772

TAs' JASPER strategy implementation. Overall, a main effect of time was found for all TAs' strategy implementation in the TCX videos (f(1,91) = 283.21, p < .001, ES = 1.76). Furthermore, a significant time by treatment group interaction was found (f(1,91) = 239.94, p < .01, ES = 1.62) where TAs in JASPER demonstrated greater strategy implementation. The treatment effect was maintained at follow-up (f(1,49) = 29.57, p < .001, ES = 0.78). Children's baseline MSEL language level and site were entered into the model. Neither parameter was significantly associated with TAs' strategy implementation indicating that TAs successfully applied JASPER with a wide range of children (Table 2).

Proximal and distal measures of children's joint engagement, social communication, and play

Child-initiated joint engagement: Proximal-TCX. A significant time by treatment interaction was found (f(1,70) = 46.13, p < .001, ES = 0.81) with children in JASPER spending significantly more time in child-initiated joint engagement than WL children (Figure 2). Treatment effects were maintained at follow-up (f(1,81) = 37.61, p < .001, ES = 0.68) (see Figure 2, Table 2).

Children's IJA and IBR gaze, gesture, and language: Proximal-TCX. A significant main effect of time for IJA (f(1,70) = 24.21, p < .001, ES = 0.59) and IBR f(1,70) = 6.88, p = .011, ES = 0.31) was noted in the TCX. The time by treatment interaction indicated greater growth for children in JASPER (f(1,70) = 13.98, p < .001, ES = 0.45; f(1,70) = 6.88, p = .011, ES = 0.31, respectively). Treatment effects for IJA and IBR were maintained at follow-up (f(1,81) = 4.57, p < .001, ES = 0.24; f(1,81) = 13.91, p < .001, ES = 0.41).

IJA language. To examine the complexity of children's language, the length of spontaneous comments (IJA), and spontaneous requests (IBR) were coded at three levels in the TCX: (a) one word, (b) two words, and (c) three or more words.

A significant time by treatment interaction was found for one word and two word IJA (f(1,70) = 3.89, p = .05, ES = 0.24; f(1,70) = 9.72, p = .003, ES = 0.37, respectively) with greater gains for those in JASPER. These gains were maintained at follow-up (f(1,81) = 9.54, p = .003, ES = 0.34; f(1,81) = 16.14, p < .001, ES = 0.45). Although there were 21 instances of children using three or more words at exit, there were too few occurrences at entry (two cases) to estimate a treatment effect.

IBR language. There were no significant treatment effects for one or two word IBR. However, there was an overall weak effect of time where on average, children increased their use of one and two word requests (f(1,107) = 4.14, p = .044, ES = 0.20; f(1,107) = 5.67, p = .019, ES = 0.23). Similar to IJA, too few children demonstrated three or more word requests at entry to model this variable over treatment.

Children's IJA and IBR gaze, gestures, and language: Distal-SPACE. There was a weak interaction between treatment group and time (increase for JASPER group) on the SPACE for IJA (f(1,95) = 3.47, p = .066, ES = 0.19). These gains were maintained at follow-up (f(1,99) = 14.75, p < .001, ES = 0.39). No significant time by treatment interaction was found for IBR (f(1,95) = 1.18, p = .279, ES = 0.11). There was an overall effect of time for both IJA and IBR (f(1,95) = 46.30, p < .001, ES = 0.70; f(1,95) = 25.86, p < .001, ES = 0.52), where children in both groups showed increases over time during the SPACE.

A hurdle model was applied to high-level IJA gestures (point, show, give) during the SPACE in which the two processes were modeled simultaneously. Children's language age at entry was the only significant estimated parameter for the binary model. Children who had higher language skills at entry had lower odds of having zero high-level IJA gestures (f(1,97) = 6.97, p = .01, ES = 0.27). The interaction between treatment group and time (f(1,97) = 11.97, p < .01, ES = 0.35) was significant in the truncated Poisson model, where among the children who had a positive count for high-level IJA (those who crossed the 'hurdle'), children in JASPER had significantly better rates of improvement over WL.

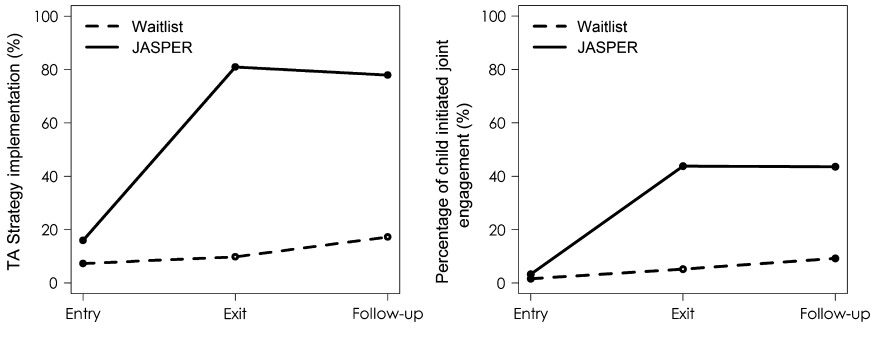

Figure 2 Teaching assistants strategy implementation and child outcomes by treatment groups

Children's play: Proximal-TCX. Change in the percentage of time spent in each of the three play levels: simple, functional, and symbolic was examined. There was no significant treatment effect for simple play (f(1,107) = 0.40, p = .53, ES = 0.06), but there was an overall effect of time with children in both groups decreasing in simple play (f(1,107) = 4.22, p = .042, ES = 0.20). There was a significant treatment effect for functional play where children in JASPER spent more time in functional play (f(1,111) = 161.94, p < .001, ES = 1.20) at exit and maintained gains at follow-up (f(1,111) = 75.01, p < .001, ES = 0.82). Too few children demonstrated symbolic play in either group (n = 9) to evaluate treatment effects.

Children's play: Distal-SPACE. There was no overall effect of time (f (1,91) = 0.55, p = .462, ES = 0.08) or treatment (f(1,91), p = .593, ES = 0.08) for simple play. There was a significant effect of time for functional and symbolic play, respectively (f (1,91) = 18.67, p < .001, ES = 0.45; f (1,91) = 35.48, p < .001, ES = 0.62), where children in both groups improved their diversity of functional play, but no treatment difference was found for either level (f (1,91) = 0.19, p = .662, ES = 0.05; f (1,91) = 2.03, p = .158, ES = 0.15).

Social communication and play: CGI. A main effect of time was found where both groups showed reductions in play and social communication severity scores in TA–child interactions captured in the TCX videos (f(1,82) = 58.45, p < .001, ES = 0.84; f(1,82) = 24.95, p < .001, ES = 0.55). A time by treatment interaction indicated greater reductions in play and social communication severity scores (CGI-S) from entry to exit for children in JASPER over WL (f(1,82) = 18.91, p < .001, ES = 0.48; f(1,82) = 11.67, p = .001, ES = 0.37), and greater improvement (CGI-I) in play (χ^2(1) = 41.65, p < .001, ES = 0.60) and social communication (χ^2(1) = 19.35, p < .001, ES = 0.41).

Discussion

This study demonstrates the feasibility of supervised paraprofessional-implemented JASPER intervention for toddlers with ASD in a public center-based early intervention program. We had two aims, one focused on fidelity of implementation, and the other on child outcomes. First, paraprofessionals implemented JASPER with adequate fidelity with up to four children per day. Children varied widely in their skills at entry; however, children's skills did not predict the TA's intervention strategy implementation. TAs were able to appropriately and flexibly apply the strategies across a wide range of children and reported increased acceptance of the intervention. The use of remote consultation and development of on-site supervisory capacity to sustain intervention implementation was a novel delivery design for JASPER. The remote video review and feedback from the research team was combined with ongoing troubleshooting support on site, and closer supervisory oversight than many implementation trials. Thus, future studies may want to assess the degree of support (internal and external) that may be required for successful implementation of the intervention. These findings result from a partnered deployment model where the center staff in collaboration with the researchers identified the component of their program they wished to target and together, designed the model with the staff: who were unfamiliar with the children delivering assessments, and staff paired daily with the children delivering the intervention.

In terms of child outcomes, the intervention targeted core challenges in social communication and play. Children with ASD have been documented to spend the majority of their time object engaged or unengaged (e.g. Adamson, Bakeman, Deckner, & Romski, 2009). Children in this study demonstrated a similar engagement profile with their TAs during the social group at entry where on average children spent <5% of the interaction jointly engaged. However, in JASPER, children made significant gains in time jointly engaged with their TAs during the TCX (M = 40%) providing the TAs with more opportunities to advance children's social communication and play skills.

Children improved in both play and social communication skills with significantly greater increases for the JASPER group. Functional play increased while simple play acts decreased in the proximal-TCX measure. Children began to demonstrate high-level functional play (e.g. building, extending acts to figures) rather than low-level (simple) cause and effect play demonstrated at entry (e.g. roll truck, push buttons). This increase in functional play and limited change in symbolic acts fits with the developmental level of the children (approximately 16-month language level at entry), and is consistent with clinic-tested studies of JASPER (Kasari et al., 2010, 2015). Children demonstrated more high-level play during the TCX interactions than when tested for play skills on the distal outcome measure (SPACE). The limited transfer of children's increase in functional play from the supported context of the TCX interactions to the unsupported context of the SPACE indicates that the children require the expert scaffolding provided by the TAs to foster initiations of a diverse range of functional play skills. It is reasonable to expect that young children with limited play skills will need the adult's environmental support (providing relevant materials within reach and sight), active turns (adult imitation of the child's acts), and provision of play expansions when needed, in order to stay engaged in the interaction and to demonstrate play

Table 2 Summary of results

	Waitlist	Joint attention, symbolic play, engagement, and regulation	Treatment effect	Maintenance effect
TCX				
Teacher strategies: %				
Entry	7.27 (5.63)	15.95 (16.31)	$p < .001$	$p < .001$
Exit	9.83 (6.06)	80.9 (13.28)		
Follow-up	17.22 (23.33)	77.91 (11.59)		
Engagement: %				
Entry	1.59 (5.42)	3.3 (7.75)	$p < .001$	$p < .001$
Exit	5.21 (11.06)	43.77 (31.87)		
Follow-up	9.23 (22.83)	43.58 (31.59)		
Joint attention				
Entry	1.53 (3.15)	2.19 (2.28)	$p < .001$	$p < .001$
Exit	1.91 (2.92)	14.13 (15.4)		
Follow-up	3.96 (7.12)	13.51 (13.74)		
Simple play: %				
Entry	15.36 (20.32)	11.17 (15.04)	.53	Not applicable
Exit	12.06 (14.93)	5.32 (10.81)		
Follow-up	11.26 (15.46)	5.97 (10.48)		
Functional play: %				
Entry	0.9 (5.47)	6.03 (19.73)	$p < .001$	$p < .001$
Exit	1.6 (5.94)	56.75 (26.37)		
Follow-up	9.75 (22.04)	51.25 (31.29)		
Symbolic play types: %				
Entry	0 (0)	0 (0)	Not applicable	Not applicable
Exit	1.47 (7.56)	3.45 (10.40)		
Follow-up	0.73 (3.25)	2.84 (7.76)		
Short play and communication evaluation				
Joint attention				
Entry	20.48 (21.32)	18.57 (15.61)	.066	$p < .001$
Exit	27.04 (20.08)	38.02 (35.5)		
Follow-up	26.25 (20.56)	28.75 (25.57)		
Simple play types				
Entry	5.9 (2.62)	5.67 (2.65)	.593	Not applicable
Exit	6.02 (3)	6.06 (3.41)		
Follow-up	6.42 (2.68)	5.46 (2.19)		
Functional play types				
Entry	6.54 (3.95)	7.5 (3.89)	.662	Not applicable
Exit	8.93 (4.78)	9.16 (6.3)		
Follow-up	8.47 (4.85)	8.39 (4.34)		
Symbolic play types				
Entry	0.44 (1.5)	0.5 (0.88)	.158	Not applicable
Exit	1 (1.65)	1.74 (2.55)		
Follow-up	1 (1.75)	0.71 (1.47)		

skills at higher levels. In terms of social communication skills, joint attention, particularly high-level skills involving pointing and showing, increased across the TCX and generalized to the SPACE.

Notable in this study is the low, nearly nonexistent attrition. Another strength is that all children received the same dose and type of early intervention classroom programming. Adult–child ratios were maintained across the entire school day with only the social skills programming different between the TAU and JASPER conditions. The classroom program followed principles of Verbal Behavior (VB: Sundberg, 2008). This curriculum focuses heavily on spoken language and language to request; however, the program does not include a focus on prelinguistic gestures or joint attention. Therefore, it is consistent with the goals of the classroom programming that all children would make gains in requesting as demonstrated by the main effect of time for requesting initiations for all children. Furthermore, although children in both treatment groups demonstrated gains in low-level IJA skills such as alternating or coordinating gaze, children in JASPER significantly improved in high-level IJA skills such as pointing and showing to share. To our knowledge, these data are the first from a randomized controlled trial to demonstrate spontaneous and sustained initiations of joint attention and play from an early intervention delivered by paraprofessionals. This finding is significant in light of the mixed evidence for both initiations of joint attention and play skills in controlled trials with specialized clinicians. This study adds to the literature demonstrating that targeted teaching is essential for the development of initiations of joint attention in young children with ASD.

Limitations and future steps

The study had a number of limitations including the lack of implementation fidelity checks of the on-site JASPER supervisor. The supervisor was at fidelity prior to beginning the study but her coaching of TAs was not formally evaluated. This would be important in future studies. Second, social validity of the intervention was limited to staff questionnaires. Interpreting the clinical significance of this change was done using Likert scale ratings but future studies may add additional measures in order to better understand the clinical significance of these ratings. Third, due to rolling program enrollment, the center becomes fully enrolled 5–6 months into the year, thus limiting the length of intervention and follow-up. The limited duration of follow-up allowed for only a brief examination of the sustainability of the intervention. However, the partnership between the center and the research team has continued and the early intervention program continues to provide JASPER as part of the overall program. In response to staff input, some additional changes have been made to the social programming to also include small peer groups while maintaining JASPER strategies. Documentation of these changes will be important in future studies.

Conclusions

Supervised TAs delivered JASPER with toddlers with ASD with high fidelity and these children gained significantly more in joint engagement, social communication, and play skills compared to children in TAU. These data confirm that effectiveness-implementation hybrid designs can be used to systematically examine both participant-level outcomes and staff implementation.

Supporting information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. JASPER components.

Appendix S2. Teaching assistant–child interaction coding variables.

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Correspondence

Stephanie Shire, University of California Los Angeles, 67-464 Semel Institute 760 Westwood Plaza, Los Angeles, CA 90024, USA; E-mail: spatterson@mednet.ucla.edu and Connie Kasari, University of California Los Angeles, 68-268 Semel Institute 760 Westwood Plaza, Los Angeles, CA 90024, USA; E-mail: kasari@gseis.ucla.edu

Key points

- Community-partnered trial including intervention implementation by supervised paraprofessionals.
- First trial of remote support and development of on-site community supervision for JASPER intervention.
- Children's gains in joint engagement, IJA, language, and play were made through brief daily JASPER sessions over treatment as usual ABA programming.

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