HHS Public Access

Author manuscript

Int Rev Psychiatry. Author manuscript; available in PMC 2018 July 06.

Published in final edited form as:

Int Rev Psychiatry. 2018 February ; 30(1): 25–39. doi:10.1080/09540261.2018.1432574.

Efficacy of early interventions for infants and young children with, and at risk for, autism spectrum disorders

Rebecca J. Landa[a,b]

[a]Center for Autism and Related Disorders, Kennedy Krieger Institute, Baltimore, MD, USA

[b]Psychiatry and Behavioral Sciences, The Johns Hopkins University School of Medicine, Baltimore, MD, USA

Abstract

With advances in the field's ability to identify autism spectrum disorders (ASD) at younger ages, the need for information about the evidence-base for early intervention continues to rise. This review of the ASD early intervention (EI) literature focuses on efficacy studies published within the past 15 years. The neurodevelopmental context for early intervention, timing of initiating intervention, primary intervention approaches, and predictors of treatment outcomes are discussed. The evidence indicates that young children with ASD benefit from EI, and their parents learn to implement child-responsive engagement strategies when a parent-coaching intervention is provided. Evidence supports combining parent-mediated and direct clinician-implemented intervention to maximize child developmental gains. Clinical practice recommendations are presented, based on the literature reviewed.

Keywords

Autism spectrum disorders; early intervention; efficacy

Introduction

Autism spectrum disorders (ASD) are neurodevelopmental disorders defined by impairing levels of social and communication impairment, along with repetitive and stereotyped patterns of behaviour and interests (American Psychiatric Association, 2013). The average age of diagnosis in the US is 4 years (Christensen et al., 2016). However, ASD can be detected as early as 14 months of age in some children (Landa, Gross, Stuart, & Faherty, 2013; Landa, Holman, & Garrett-Mayer, 2007); stability of diagnosis is high by age 18 months (Ozonoff et al., 2015), although many children with signs of risk for ASD will not be detected or diagnosed by this age (Ozonoff et al., 2015). The ability to detect ASD risk at younger ages is heightening the demand for early intervention (EI) services. To support clinicians' EI decision-making, the EI literature as reported in the last 15 years is reviewed herein.

CONTACT Rebecca J. Landa, landa@kennedykrieger.org.

Disclosure statement

The author reports no conflicts of interest. The author alone is responsible for the content and writing of the paper.

Neurodevelopmental context of early intervention

Recent meta-analysis studies and systematic reviews have concluded that EI has positive effects on development in young children with ASD (e.g. Beaudoin, Sébire, & Couture, 2014; Eldevik et al., 2010; Hampton & Kaiser, 2016; Lane, Lieberman-Betz, & Gast, 2016; Reichow, 2012; Virués-Ortega, 2010), although effects are greater for some children than others (Sallows & Graupner, 2005). EI is designed to capitalize on experience-dependent neuroplasticity, a fundamental property of the brain, by which neuronal connections are created and organized, and learning occurs in response to a child's experiences with the environment (Kolb & Gibb, 2011). Self-generated experience, rather than observation (Cannon et al., 2014) or passive experiences (Weisen, Watkins, & Needham, 2016), are most influential in early learning processes. However, infants later diagnosed with ASD have atypical attention and engagement patterns (Bhat, Galloway, & Landa, 2010; Chawarska, Macari, & Shic, 2013) and altered sensory and motor functioning (e.g. Baranek, 1999; Flanagan, Landa, Bhat, & Bauman, 2012) that likely disrupt the quality and quantity of experiences they cultivate for themselves (Karmiloff-Smith, 2015). These disruptions in developmental processes, detected as early as 3 months of age (Bhat, Galloway, & Landa, 2012), characterize a prodromal phase of ASD that may extend into the second and third years of life.

During the prodromal phase, and as ASD symptoms begin to manifest, infants and toddlers may experience diminished, unelaborated, and truncated social and communication learning opportunities that would otherwise occur within sustained, dynamic dyadic (social partner–child) and triadic (social partner–object–child) interactions. Such altered experiences could hamper cortical specialization for faces and language, and associated processes as well as the functional integration of this circuitry (Johnson et al., 2005). Indeed, prospective, longitudinal neuroimaging research has identified a link between expanded cortical surface area and visual attention atypicalities in 6-month-olds later diagnosed with ASD having an older sibling with ASD (Elison et al., 2013). Developmental processes involving selected neural circuitry are, thus, altered, disrupting the refinement of these circuits. Over time, the formation of distributed networks of brain regions and the interaction between these regions is hampered, affecting cognitive and sensorimotor functioning as the ASD symptom complex emerges. The brain abnormality in children with ASD changes across the first 2 years, likely the result of a dynamic interaction between neurobiological and cascading effects of atypical developmental processes (Karmiloff-Smith, Casey, Massand, Tomalski, & Thomas, 2014), with cumulative effects that further contribute to shifting phenotypic features (Piven, Elison, & Zylka, 2017). This highlights the importance of early access to intervention, the need for intervention to address multiple aspects of development, and for ongoing intervention that addresses developmental delays and atypicalities as these unfold over time (Karmiloff-Smith et al., 2014).

When to start intervention?

The neurosciences offer a compelling rationale for providing strategically enhanced experiences for children with disrupted development early in life. Yet ASD cannot be diagnosed in infants, and there is no clear predictor of ASD in infants. Given that ~20%

(Ozonoff et al., 2011) and 30% (Charman et al., 2017) of younger siblings of children with ASD, respectively, will receive a diagnosis of ASD or meet criteria for other developmental disruptions by 36 months of age, a public health approach to detecting ASD risk and monitoring at-risk children is needed (e.g. pre-term infants; Darcy-Mahoney et al., 2016). Given the decline in skills and social engagement seen in most children with ASD in the second year of life (Landa et al., 2007), infants or toddlers showing concerning signs of social and communication delays or qualitatively atypical developmental patterns, despite being sub-threshold for an ASD diagnosis, should have access to EI or developmental enrichment programs (including parent coaching to immerse children in development-enhancing experiences to accelerate learning and generalization of skills [Reichow, 2012; Warren et al., 2011]). However, access to such services for undiagnosed infants and toddlers is variable, due to the wide discrepancy in eligibility criteria for accessing EI services (Twardzik, Cotto-Negrón, & MacDonald, 2017). Among the children having the lowest enrollment in EI services are those displaying mild severity and those without a diagnosis (Twardzik et al., 2017).

Once a diagnosis has been made, children with ASD often will qualify for public EI services. Intervention is needed because they are not developing in social, play, and, in most cases, language and cognitive domains at the expected pace or in the expected multi-modal, integrated way. Incidental learning during interaction with others is impeded by ASD-related impairments, especially those affecting attention and social initiation. Indeed, a relation between impaired attention-following and incidental vocabulary learning in young children with ASD has been reported (Yoder & McDuffie, 2006). EI aims to accelerate the rate of child learning, foster new development and generalization of skills, and attenuate effects of ASD on development by maximizing the benefit of experience-dependent neuroplasticity.

What are the main early intervention approaches?

Intervention approaches for young children with ASD are behavioural and educational, as there is no medical cure for core ASD impairments (Kaplan & McCracken, 2012). There are two primary evidenced-based approaches to EI: Naturalistic Developmental Behavioural Interventions (NDBI; Schriebman et al., 2015), and those more singularly aligned with principles of operant conditioning, commonly referred to as applied behaviour analysis (ABA) or Early Intensive Behavioural Intervention (EIBI), involving a discrete trial instructional format.

Naturalistic developmental behavioural interventions (NDBI)

NDBI (Schriebman et al., 2015) approaches usually cultivate a continuous back-and-forth flow of social engagement patterns between the child and interventionist. Intervention providers respond intentionally and contingently to a child's interests, communicative bids, and play. Clear and developmentally appropriate cues (antecedents) are provided to the child to elicit specific behaviours, along with natural consequences (rewards/reinforcement) and systematic prompt hierarchies to promote child engagement and skill development. Carefully-timed and formed models may be given, with expansion of the child's communication, social signals, and play, to scaffold more consistent, complex, and

differentiated child language, social, and play behaviour. These goals are interspersed throughout the interaction rather than being discretely and explicitly taught. Developmental sequences are generally followed when determining the level of skill complexity to be targeted. NDBIs are aligned with EI practice recommendations from the Division of Early Childhood (DEC) (Division for Early Childhood (DEC), 2014), which emphasize the importance of embedding EI in routines and contextually relevant environments.

Applied behaviour analysis (ABA) and early intensive behavioural interventions (EIBI)

In contrast to the NDBIs, delivery of ABA principles in an operant conditioning paradigm employs a more explicit, decontextualized, and highly structured approach. This method is commonly referred to as EIBI. Specific, discrete skills are taught in a prescribed order. EIBI curricula are comprehensive, targeting social, communication, cognitive, pre-academic (e.g. matching; colour, letter, and number recognition), and self-management skills (Smith, 2011). Adult-selected materials and tasks are presented in sets of structured discrete trials, often adult-initiated, characterized by antecedent–behaviour–consequence chains. Well-defined prompt hierarchies and reinforcement schedules are used. Unlike in the NDBIs, reinforcers usually are not related to the social–communication–play context and the child's behaviour (e.g. giving access to a toy car if the child says 'car'), but, rather, are selected based on individualized motivators for the child (e.g. favourite toy or food). EIBI is usually conducted in a 1:1 instructional, non-distracting context. Upon acquisition of a skill, generalization training begins, system-atically reinforcing target behaviours and teaching children to distinguish between different cues (Smith, 2011).

Interpreting the results of early intervention studies

The results of the EI studies reviewed below provide general themes to guide clinical care. However, inconsistencies in findings across studies are not uncommon. This may be attributable to the wide variation across studies in participants' phenotypic profile and ages, intervention delivery setting, details of the intervention approach, intervention duration, frequency of intervention delivery, intervention implementer (e.g. parent, clinician, teacher, researcher), and targeted outcomes and outcome measures. Given that ASD is a disorder of neurodevelopment emerging from infancy, affecting multiple brain regions and functional connectivity, behaviourally-based interventions cannot be expected to 'cure' ASD. The gains in language, social, play, cognitive, and adaptive functioning, sometimes substantial, associated with some interventions, is very encouraging, and can have sustained effects (e.g. Green et al., 2017; Landa & Kalb, 2012). However, identification of positive treatment effects in the literature does not imply that EI should be limited to the early childhood period. Supporting children with ASD in surmounting a set of developmental challenges prepares them for the next set of achievements. As children progress into school-age, intervention targets, intensity, context, and methodologies will change to meet the child's individual needs. EI is expected to reduce developmental and behavioural barriers to participation in inclusive educational contexts.

Early intervention literature review

This review of the evidence-base presents the most scientifically rigorous EI studies published in the past 15 years that focused mainly on children younger than 5 years of age. This review is organized as follows:

1. NDBI-related approaches: exclusively, or partially, parent-mediated.
    a. NDBI approaches focused on infants and 1-year-olds at heightened risk for ASD, but not yet diagnosed. Note that the research in this section is at an immature stage of investigation, particularly the studies that employed single subject or quasi-experimental designs.
    b. NDBI approaches focused on toddlers and pre-schoolers already diagnosed with ASD: exclusively parent-mediated interventions being reviewed first, followed by review of primarily professional- or researcher-implemented interventions.
2. ABA/EIBI approaches.

Naturalistic developmental behavioural intervention (NDBI) and related approaches

Pre-diagnosis interventions: high-risk infants and toddlers

Null treatment effects—Three studies, focused on short-term interventions (≤12 sessions) for high-risk infants and toddlers, failed to identify effects on parents' implementation of child-responsive strategies to children aged 8–25 months when compared to business-as-usual, or no-treatment groups (Carter et al., 2011; Green et al., 2013; Rogers et al., 2012). The remaining studies, most of which also were short-term interventions, identified intervention effects on parent responsivity during interactions with their child and/or on child behaviour. These are reviewed below.

Positive treatment effects of pivotal response training (PRT)—Two multiple baseline single-subject design studies, involving three parent–child dyads per study, coached parents to implement a small set of PRT (R. Koegel & Koegel, 2006) strategies, emphasizing those most suited to motivating infant engagement (Koegel, Singh, Koegel, Hollingsworth, & Bradshaw, 2013; Steiner, Gengoux, Klin, & Chawarska, 2013). In both studies, parents received 1-h weekly training for 12 weeks and reached fidelity in implementing the PRT strategies. In addition, children (aged 4–9 months in Koegel et al.'s (2013) home-based study; 12 months old in Steiner et al.'s (2013) centre-based study) in both studies showed gains in communication development. In Koegel et al.'s (2013) study, parents were trained to pair themselves with children's preferred activities to increase children's social motivation. The infants in that study sustained their gains in communication skills at a 2-month follow-up (Koegel et al., 2013).

In a short-term intervention (12 weekly sessions) study (quasi-experimental), Rogers et al. (2014) compared a PRT-like child-responsive approach (Infant Start) to an archival dataset of younger siblings of children with ASD who later received an ASD diagnosis. Group-level

analyses indicated that the seven symptomatic children in the Infant Start group, aged 6–15 months, achieved higher levels of non-verbal cognitive and language functioning at 36 months of age. The Infant Start group also exhibited lower rates of ASD diagnosis at 36 months than four infants who qualified for the intervention study at 9 months of age, but whose parents declined to participate.

Positive treatment effects associated with video feedback during parent coaching— Another 12-session parent coaching intervention used an adaptation of Video Interaction for Promoting Positive Parenting (VIPP; Juffer, Bakermans-Kranenburg, & van IJzendoorn, 2008) to provide video feedback as a means of supporting parents' increased understanding of, and responsive adaptation to, their infant's communicative behaviour and style, with the aim of promoting child social and communication development (Green et al., 2015). Infants were 9-month-old younger siblings of children with ASD. Compared to a no-treatment group, parents in the VIPP group displayed significantly less directiveness in their interaction with their infants. In addition, a non-significant but moderate-sized effect favouring the VIPP group was identified for reduction of child ASD symptoms and attention disengagement, and parent-reported improvement in child social adaptive scores. Non-significant negative treatment effects were identified for child receptive language and P100 in an evoked response potential task. Infant follow-up at 1- and 2-years (Green et al., 2017) identified beneficial treatment effects on reduced severity of ASD symptoms and increased levels of child social engagement with parents in the VIPP group, from baseline to 39 months of age. The negative treatment effects identified in the VIPP group at the end of the intervention period were not sustained; there were no group differences in language performance at either follow-up visit. Unlike Rogers et al.'s (2012) preliminary finding, the VIPP intervention did not yield ASD protective effects. Furthermore, parents did not retain gains in implementation of child-responsive engagement strategies at the 1-year follow-up (child age 27 months), indicating the need for ongoing coaching to support parents' implementation of child-responsive engagement strategies.

Positive treatment effects: adapted responsive teaching (ART)— In a slightly older group of at-risk children (13–17 months), targeting children's sensory, social, and communication functioning, Baranek et al. (2015) randomly assigned parent–child dyads to ART, where parents were coached in use of child-responsive engagement strategies, or a community-intervention and monitoring group. Parents received a mean of 33.5 in-home visits and phone/email coaching sessions over ~8 months, nearly 3-times as many as in the studies described above. Like Green et al. (2015), Baranek et al. (2015) reported a reduction in parent directiveness, and improvement in child social adaptive behaviour. The ART group also exhibited greater gains in language performance and reduction in hypo-responsiveness on parent-report measures. Although these child treatment effects were not observed in a replication study, treatment effects on parent responsiveness and parent production of positive affect during parent–child interactions were identified (Watson et al., 2017). Watson et al. (2017) reported considerable evidence for mediation of the effect of group assignment on child outcomes via changes in parent responsiveness, despite the general lack of main effects when parent responsiveness was not accounted for in the models. The lack of change in control parents' responsiveness and a decrease in their affect, compared to the ART

parents' gains in both of these domains, implies a protective effect of training parents in use of responsive strategies (Strain & Bovey, 2011; Watson et al., 2017).

Summary—The studies reviewed above have shown that early development in infants and toddlers at heightened risk for ASD can be accelerated in a brief period of time as their parents adopt child-responsive strategies (Mahoney & Solomon, 2016). This is encouraging, given that precursors to important social and communication skill development are being acquired during this early stage of development. In addition, the reported gains are occurring during a time in development when rate of development is slowing and ASD symptoms are emerging (Landa et al., 2007).

Post-diagnosis: parent-mediated interventions

Null or positive treatment effects on parents only—Some randomized controlled trials (RCTs) involving young children diagnosed with ASD have focused on parent implementation of child-responsive engagement strategies. In the RCT reporting null effects, parent coaching occurred only once every 6 weeks for 12 months (Drew et al., 2002). Two RCTs identified effects on parent responsivity in a parent coaching condition, compared to a treatment-as-usual group (Solomon, Van Egeren, Mahoney, Quon Huber, & Zimmerman, 2014) or parent advocacy control group (Siller, Hutman, & Sigman, 2013), even when coaching occurred only once monthly for 12 months (similar to Drew et al., 2002) (Solomon et al., 2014) or once weekly for 12 weeks (Siller et al., 2013). In a 1-year follow-up of participants in Solomon et al.'s (2014) sample, the lack of child treatment effects persisted (Oosterling et al., 2010). In Siller et al.'s (2013) study, children in the parent coaching group having baseline expressive language skills below the 12-month level showed greater expressive language gains compared to controls 1 year later, at follow-up.

Positive treatment effects on children—Most studies involving even short-term (≤12 weeks) parent-mediated interventions have reported positive treatment effects on measures of child behaviour. Most of the brief early interventions reviewed here are considered targeted interventions, focusing on one (imitation [Ingersoll, 2010]; communication [Hardan et al., 2014]) or a small set of highly related (i.e. joint engagement, joint attention, play [Kasari, Freeman, and Paparella, 2006; Kasari, Gulsrud, Paparella, Hellemann, & Berry, 2015]) skills or behaviours.

The briefest of these was a five-session, home-based, attachment-focused intervention similar to that used by Green et al. (2015) (Video-feedback Intervention to promote Positive Parenting adapted to Autism; VIPP-AUTI). This intervention reduced parent intrusiveness during interaction with their child (aged 16–61 months) with ASD (Poslawsky et al., 2015). Compared with parents in the treatment-as-usual group, greater parent-reported self-efficacy in parenting was identified as a treatment effect in the VIPP-AUTI group. Children in the VIPP-AUTI group exhibited more initiation of joint attention (IJA) behaviours at the 3-month follow-up, not mediated by parenting-related intervention effects (Poslawsky et al., 2015). This study indicates that targeted short-term interventions may play a specific role in the intervention process, such as supporting families when they are first receiving the ASD diagnosis or after years of navigating the intervention system.

Another RCT demonstrated treatment effects on children (utterances produced) despite providing a low intensity intervention (12-week) that involved only four parent coaching sessions (Hardan et al., 2014). In that study, parents were coached in the use of PRT strategies, and provided with a manual and illustrative video examples to promote their child's expressive communication behaviour. One of the features of PRT that may promote communication gains in children is known as 'child choice'. This strategy involves frequently offering the child a choice between two objects, one usually being a preferred object for the child, creating a communicative temptation. When the child's request is made using the targeted form of communication (gesture, word, phrase) or, for children with emerging communicative intent, a behaviour that could be shaped into a communicative signal (e.g. a gaze shift to one of the objects), the child is 'rewarded' by giving them the requested object. Effective use of this strategy may quickly empower parents to elicit adaptive (speech, speech approximations, gesture) behaviours to replace maladaptive (tantrums, screaming) behaviour from their child (Wetherby et al., 2014). This may hasten children's behaviour regulation and language acquisition.

One short-term (8-week) but intensive (24 h), hands-on coaching approach guided parents in the use of child-responsive strategies aimed at promoting child joint attention in play routines, and child engagement with people and toys (Kasari, Gulsrud, Wong, Kwon, & Locke, 2010). The children (aged 21–36 months) of coached parents showed greater gains in joint engagement, response to joint attention (RJA), and functional play acts compared to waitlist controls. While no between-group differences in IJA or symbolic play were detected, treatment effects were maintained 1 year after treatment ended (Kasari et al., 2010). In a similar study, Schertz, Odom, Baggett, and Sideris (2013) identified intervention effects in a 16-session home-based Joint Attention Mediated Learning (JAML) intervention group compared to a business-as-usual group. In the JAML condition, a video review of parent–child interactions was used to guide parents' reflection on children's (mean age 24–27 months) targeted behaviours (focusing on faces, turn-taking, joint attention) and their own implementation of the intervention principles (focusing, organizing/ planning, encouraging, giving meaning, and expanding). Treatment effects were identified in examiner-measured RJA, attention to faces, and receptive language, and on a standardized parent-report measure of adaptive communication functioning. The gains children made during the JAML treatment period were sustained in the 4–8-week follow-up period, while controls exhibited no significant gains (Schertz et al., 2013). This indicates that an important advance in child social communication has been activated.

The lack of child gains in initiation of social communication (e.g. IJA) in some joint attention-focused interventions (e.g. Kasari et al., 2006; Kasari et al., 2015; Schertz et al., 2013) may reflect the need for greater intervention intensity, a longer treatment interval, or a different intervention approach to cultivate and consolidate these core deficit area skills. Indeed, treatment effects for emerging or fully self-generated IJA have been identified in more intensive interventions targeting this skill. In an RCT comparing a more intensive intervention (104 h in 12 months) to treatment-as-usual, imitation of joint attention (although not spontaneous IJA), enjoyment and involvement in interaction with people, and attention to the activity were identified as treatment effects (Casenhiser, Shanker, & Stieben, 2013). The intervention was delivered in centre- and home-based settings, with a review of

videotapes of parent–child interaction to support parents' implementation of the intervention strategies.

Treatment effects on other aspects of social and communication functioning have been reported in two additional RCTs examining intensive childresponsive parent-mediated interventions (Green et al., 2010; Wetherby et al., 2014). In both studies, parents were guided to support social communication development in their children with ASD. Wetherby et al. (2014) compared a 9-month (mean of 88.56 h) 1:1 clinic-, home-, and community-based caregiver coaching intervention to a centre-based play group- + group parent education condition. Children were 18–20 months of age. Treatment effects were identified for examiner-measured social communication and receptive language, and on standardized caregiver-report measures of social, communication, and adaptive skills. Green et al. (2010) compared the Preschool Autism Communication Trial (PACT) intervention to treatment-as-usual with pre-school-aged children (mean age 45 months). The PACT intervention, delivered in centre- and home-based contexts, provided parents with 96 h of video-supported coaching over 12 months. Treatment effects were identified in child communicative initiations and shared attention, and parent synchrony in parent–child interactions (Green et al., 2010). While no group treatment effect was detected in autism severity in that study (Green et al., 2010), follow-up of the participants nearly 6 years later revealed that the PACT group displayed less severe ASD symptoms (Pickles et al., 2016). Attenuation of ASD symptomatology was also reported in pre-schoolers of parents who were coached for 1 year in the use of strategies to promote child communication development, but not in treatment-as-usual controls (Aldred, Green, & Adams, 2004).

Summary—Results of a meta-analysis of parent-mediated intervention studies were suggestive of improvements in child vocabulary comprehension and reduced ASD symptom severity, with the most robust effects (statistically significant with strong effect sizes) being improved patterns of parent engagement with children, such as increased shared attention and parent synchrony (Oono, Honey, & McConachie, 2013). While many parents benefit from coaching in implementation of child-responsive strategies, some are slow adopters (Schertz & Odom, 2007; Shire, Gulsrud, & Kasari, 2016). This could be due to a number of factors. One possibility is that parents did not consolidate the responsivity skills on which they were coached. This is not surprising, because effective implementation of child-responsive engagement strategies is a complex process. The implementation of responsivity strategies requires many skills, such as the ability to: read a child's non-linguistic cues, which often are idiosyncratic in young children with ASD; scaffold developmentally-appropriate engagement activities for the child; provide clear and effective cues to the child about the behaviour being targeted; prompt the child to support emergence of more complex and integrated skills; and systematically expand child utterances and expand and vary engagement routines. Furthermore, these child-responsive intervention strategies must be implemented in different ways, as children's developmental and behavioural profiles change over time. The coaching provided to parents at one point in their child's development may not generalize to another point in their child's development. Additional approaches to ensuring greater adoption of responsivity strategies are needed for families having a child with ASD.

Post-diagnosis: primarily, or exclusively, clinician-/teacher-implemented interventions

In addition to parent-mediated intervention, clinician- or teacher-implemented intervention has been recognized as an important component of the intervention package (e.g. Stahmer et al., 2015). In a systematic review and meta-analysis of the ASD EI literature, Hampton and Kaiser (2016) found that the greatest gains in spoken language outcomes occur for young children with ASD who received both clinician- and parent-delivered intervention, as opposed to only one or the other. For example, Roberts et al. (2011) found that children randomized to a centre-based clinician-administered group intervention for children, paired with parent training (combined intervention), was associated with better child social communication outcomes than a home-based parent-mediated intervention or waitlist control group. Likewise, parents of children in the combined condition reported having a greater sense of competence and quality-of-life than did parents in the other two groups. Rogers et al. (2012) concluded that parent-mediated interventions do not yield child gains comparable to those of interventionist-delivered treatment (particularly intensive interventions) (e.g. Dawson et al., 2010; Landa, Holman, O'Neill, & Stuart, 2011; Rickards, Walstab, Wright-Rossi, Simpson, & Reddihough, 2007; Roberts et al., 2011).

In an RCT comparing centre-based intervention only or a combined centre- + home-based intervention for a mixed group of pre-schoolers (3–5 years) with developmental delays, including ASD, Rickards et al. (2007) found greater cognitive and behavioural improvements in children receiving the home-based supplemental intervention. The home-based supplemental intervention did not provide added benefit for improving family functioning. Yet children in the centre- + home-based intervention who made the greatest gains were those from more highly stressed families. This study highlights the need to intentionally transfer skills taught at school into the home, where those skills can be reinforced. In contrast to findings reported by Rickards et al. (2007), Roberts et al. (2011) identified greater social and communication gains in children who received a combination of small-group centre-based intervention + parent training and support program compared to children who received individualized home-based intervention only or in waitlist controls. Improvements in parents' perception of competence and quality-of-life were greater in the combined intervention condition as well (Roberts et al., 2011).

Effects of an intensive home-based intervention were examined in a comparison of the Early Start Denver Model (ESDM) to a business-as-usual condition (Dawson et al., 2010). Children with ASD (18–30 months) in the ESDM condition received 15 h per week of direct 1:1 clinician-child intervention, plus 5 h per week of parent-mediated ESDM intervention. At the end of 2 years, the ESDM group exhibited significantly greater gains in developmental quotient compared to the BAU group by 17.6 vs 7.0 points, respectively. The greatest impact was on receptive and expressive language outcomes.

Landa et al. (2011) conducted a comparative efficacy trial, wherein all of the 2-year-olds with ASD received a comprehensive centre-based group intervention for 10 h per week for 6 months. Children were randomized to receive a supplemental interpersonal synchrony (IS) curriculum or just the comprehensive intervention (non-IS). Parents in both conditions participated in parent education classes, guided classroom observations, and in-home coaching on NDBI strategies. Moderate-to-large effect sizes indicated that children receiving

the IS curriculum made greater social, language, and non-verbal cognitive gains than the non-IS group. A significant effect was observed on generalized interpersonally synchronous imitation, favouring the IS group (Landa et al., 2011). In another RCT examining an inclusive classroom-based intervention (Learning Experiences and Alternative Program for Preschoolers and Their Parents), pre-schoolers with ASD in classrooms of trained and coached teachers exhibited significantly greater gains in cognitive, language, social, and problem behaviour domains, as well as reduction in autism symptoms after 2 years of intervention, compared to students of teachers given the intervention manual but no formal training in implementation (Strain & Bovey, 2011). While neither child behaviour nor family socio-economic status at study entry predicted child outcomes, the level of teacher fidelity of implementation of the intervention did (Strain & Bovey, 2011).

In another RCT, an intensive joint attention-focused intervention (80 20-min sessions) delivered by a trained teacher was compared to a treatment-asusual group (Kaale, Smith, & Sponheim, 2012). Treatment effects included more frequent IJA in children aged 21–60 months with teachers and joint engagement with parents (Kaale et al., 2012). The importance of targeting joint attention in EI is highlighted by Gulsrud, Hellemann, Freeman, and Kasari's (2014) 6-year follow-up of a sub-sample of preschoolers who had received EIBI only or EIBI supplemented with a brief intervention targeting either joint-attention or play (Kasari et al., 2006). The most rapid growth in frequency of triadic gaze and showing behaviour, and most significant expressive language gains, were observed in children who had received the intervention targeting joint attention. From preschool-age to school-age, a positive growth curve was identified for frequency of triadic gaze (looking from an object to the engagement partner, and back to the object) and showing (Gulsrud et al., 2014). Frequency of IJA production, however, decreased over time in all three pre-school-age intervention groups (Gulsrud et al., 2014).

Summary—Combining parent- and clinician/teacher-implemented intervention, implemented with high fidelity, has the benefit of immersing children in a learning environment where increasingly complex skills are consistently enticed and reinforced. Professionals, trained in child development and in how to adapt developmental and applied behaviour analysis instructional strategies to the child's temperament, learning style, strengths and needs, can deliver effective intervention to the child, provide models for parent implementation, and support parents' acquisition of responsive engagement strategies. Research is needed to address the gap between treatment effects attained in well-controlled clinical research settings and/or executed by trained research staff, and those reported in community settings and executed by community providers (Dawson et al., 2010; Smith, Klorman, & Mruzek, 2015).

Early intensive behavioural intervention (EIBI)/applied behaviour analysis

Two reports focused on evaluating the evidence base for ASD early interventions, which have classified EIBI as a well-established intervention approach (Rogers & Vismara, 2008; Smith & Iadarola, 2015). This classification is in agreement with most of the systematic reviews and meta-analyses examining individual, comprehensive ABA (e.g. Eldevik et al., 2009; Reichow, 2012). Four studies of 1:1 (adult:child) implementation of EIBI, based on

the original Lovaas model and using a comprehensive curriculum, met Smith and Iadarola's (2015) criteria for examination of efficacy based on the *Journal of Clinical Child and Adolescent Psychology*'s methods criteria. All four of these studies (Eikeseth, Klintwall, Jahr, & Karlsson, 2012; Eikeseth, Smith, Jahr, & Eldevik, 2007; Eldevik, Hastings, Jahr, & Hughes, 2012; Peters-Scheffer, Didden, Mulders, & Korzilius, 2010) employed a quasi-experimental design. Intervention was delivered 6.5–28 h per week in school settings with children between 2 and 7 years of age by trained interventionists. In all four studies, the EIBI group demonstrated greater gains in IQ and adaptive behaviour than the comparison group. The only one of these studies to assess ASD symptoms and problem behaviour (Peters-Scheffer et al., 2010) failed to detect an effect of EIBI on these aspects of child functioning. Greater improvement in IQ and adaptive behaviour is associated with greater intervention intensity (≥ 36 h per week) (Eldevik et al., 2009). Little is known about the efficacy of EIBI for language and social functioning in young children with ASD (Reichow, Barton, Boyd, & Hume, 2012).

Several studies have revealed that not all children benefit equally from EIBI (see section Predictors of positive child outcomes). About 19–30% of children receiving EIBI (vs 8.7% of controls) exhibit gains in IQ beyond that expected, due to random fluctuations in IQ performance (Eldevik et al., 2009; Eldevik et al., 2012). These children, likely to reach age-expected IQ and/or adaptive functioning during the study, met Sallows and Graupner's (2005) criteria for rapid learning (Eldevik et al., 2009). Sallows and Graupner (2005) cautioned that even rapid learners may show uneven rates of development across developmental domains, such as improving more in the cognitive than social domain. Based on a meta-analysis, ~20% of children receiving EIBI (vs 5% of controls) exhibit reliable gains in adaptive behaviour (Eldevik et al., 2009). Poor response to EIBI is expected in 10–20% of children with ASD (Lovaas, 1987; Smith, Groen, & Wynn, 2000). EIBI, as delivered in the community, has limited effects on reducing ASD symptom severity (Smith et al., 2015).

Summary

EIBI, usually delivered in a 1:1 instructional format, is an effective intervention approach for many children. The comprehensive skill sets targeted by EIBI may contribute to cognitive gains. Research examining the effects of pairing EIBI/ABA with developmental/NDBI approaches to maximize development in children with ASD is needed.

Predictors of positive child outcomes

ASD encompasses a wide range of symptom expression, with heterogeneity in neurobiological (e.g. Salmond, Vargha-Khadem, Gadian, De Haan, & Baldeweg, 2007) and behavioural phenotypes, such as symptom severity, intellectual functioning, spoken language ability, social disability, and adaptive functioning. Layered on this heterogeneity is variability across children in environmental experiences (e.g. caregiver engagement style, parental education, socioeconomic status, age at ASD detection, intervention exposure). Not surprisingly, there is variability in children's response to EI (e.g. Eldevik et al., 2010; Smith et al., 2000). In a literature review focused on pre-intervention predictors of outcome,

Zachor and Ben-Itzchak (2017) organized results by child outcome. Predictors of reduced severity of autism symptoms included age, cognitive functioning, ASD symptom severity, and treatment approach. Predictors of cognitive outcomes included ASD symptom severity, maternal educational level, and treatment type and intensity. Adaptive behaviour outcomes were predicted by the level of cognitive functioning, ASD symptom severity, maternal age, and treatment type and intensity.

In a systematic prospective study of children with ASD aged 20–59 months enrolled in community-based EIBI, Smith et al. (2015) examined numerous commonly reported treatment outcome predictors. Stereotyped motor movements and sensory responses, as opposed to pre-occupations and inflexible routines, were not linked to attenuated treatment response (Smith et al., 2015), in contrast to findings by Klintwall and Eikeseth (2012). Social functions (actively seeking social engagement, joint attention, and imitation), originally expected to independently predict outcomes, loaded onto a single factor and, thus, were combined to form a social engagement variable. Higher baseline social engagement scores predicted better IQ and adaptive functioning outcomes 1 and 2 years later (Smith et al., 2015). Similarly, Gulsrud et al. (2014) found that the frequency of IJA production at pre-school-age was associated with the degree of expressive language gains in expressive language between ages 8–10 years in children who received EIBI, with and without a supplemental developmental intervention targeting play or joint attention at pre-school-age. In this same sample, frequency of IJA production at pre-school-age was associated with gains in expressive language at ages 8–10 years. Children with the mildest ASD symptoms at follow-up exhibited the steepest growth curves in frequency of triadic gaze and greatest overall gains in expressive language. In another follow-up examination of the children in Kasari et al.'s (2006) study, Kasari, Gulsrud, Freeman, Paparella, and Hellemann, (2012) identified baseline play level and play diversity as predictors of spoken language and cognitive scores, respectively. Production of spoken language at baseline is reportedly associated with greater spoken language improvement in augmentative and alternative communication (AAC)-focused intervention (Ganz et al., 2014).

Age at intervention enrollment has repeatedly been identified as a predictor of social-communication outcomes (Rogers et al., 2012). In their systematic examination of treatment outcome predictors for children receiving community-based EIBI, Smith et al. (2015) also identified age at entry into the intervention as a predictor of functioning 1–2 years after baseline. Younger children made the greatest gains in IQ and adaptive domains, sometimes attaining greater reduction in ASD symptom severity (Smith et al., 2015). The most rapid gains in development and greatest reduction in symptom severity appear to occur in the first 2 years of intervention, most notably in the first year (Dawson et al., 2010; Howlin, Magiati, & Charman, 2009; Smith et al., 2015). Rate of learning in the early stages of intervention predicts later gains (Hayward, Eikeseth, Gale, & Morgan, 2009; Sallows & Graupner, 2005).

Greater intervention intensity (hours and duration in months) is associated with greater child gains (e.g. Eldevik et al., 2010; Magiati, Charman, & Howlin, 2007; Virués-Ortega, Rodriguez, & Yu, 2013). Related to dosage is fidelity of implementation, which is associated with improved child behaviour and reduced parent stress (Aldred et al., 2004; Shire et al., 2016; Strauss et al., 2012). Some researchers did not identify dosage effects, but instead

reported that interventionist characteristics (e.g. expertise) are associated with child outcomes (Fernell et al., 2011; Strauss et al., 2012; Vivanti, Dissanayake, Zierhut, Rogers, & Victorian ASELCC Team, 2013). For example, intervention delivered by community providers yielded less than half the gains achieved by university-delivered intervention (Dawson et al., 2010; Smith et al., 2015). Considering the multi-system nature of ASD impairments and limited generalization ability of children with ASD, providing sufficient training to intervention providers and dosage of intervention to the child in EI process is of great importance.

Summary

There are numerous predictors of child outcome, and these are likely to differ depending on the intervention approach, fidelity, and consistency of intervention delivery, parent buy-in, and so forth. As indicated in many studies, early enrollment in intervention is important, and multiple intervention approaches may be needed to maximize child outcomes.

Recommendations for clinical practice

Currently available evidence supports the following recommendations.

1. Initiate intervention early, when signs of ASD risk appear (Rogers et al., 2012).
2. Address all developmental domains in intervention (Gulsrud et al., 2014; Landa et al., 2011; Smith & Iadarola, 2015).
3. Shift strategies and targets as children show increasing expressive language skills (Siller et al., 2013).
4. Provide coaching to parents for at least 9–12 months at a frequency greater than once per month to promote consolidation of learning (e.g. Carter et al., 2011; Drew et al., 2002; Rogers et al., 2012; Wetherby et al., 2014).
5. Provide video feedback to parents to support understanding of intervention strategies and facilitate insights into their child's social and communication signals, and the contingency between their own and their child's behaviour.
6. Provide direct hands-on coaching of parents rather than psychoeducation provided without, or with few, hands-on coaching sessions (Carter et al., 2011; Kasari et al., 2015).
7. Provide at least part of the training in structured contexts with minimal distractions to achieve more focused training on intervention session (higher dosage) and more opportunities for parents to practice implementation of strategies (e.g. Ingersoll & Gergans, 2007; Wallace & Rogers, 2010).
8. Coach parents in a few child-responsive engagement strategies at a time to promote learning consolidation (Ingersoll & Gergans, 2007; Koegel et al., 2013).
9. Provide parent coaching in multiple settings to promote parent and child generalization (Wetherby et al., 2014).

10. Provide parents with booster sessions to support ongoing use and adaptation of intervention strategies after coaching support ends (Carter et al., 2011; Green et al., 2017).

11. Consider aided AAC (speech generating device or Picture Exchange Communication System (Frost & Bondy, 2002)), when speech does not emerge early; AAC will not impede spoken language acquisition (Schlosser & Wendt, 2008).

12. Combine professional-delivered intervention with parent-mediated intervention (Hampton & Kaiser (2016); Rickards et al., 2007; Roberts et al. (2011); Rogers et al. (2012); Stahmer et al., 2015).

13. Train intervention providers to fidelity in implementation of intervention approaches.

Conclusions

ASD is a complex, multi-system neurobiological disorder with no medical cure or pharmacologic treatment for core social and communication impairments. Meta-analyses and systematic reviews have shown that EI has moderate-to-large effects on child outcomes, with effect size depending on a variety of factors. Equipping parents to implement development-enhancing strategies while engaged with their children is a vital intervention component. However, methods of preparing parents to adopt such strategies, implement them with fidelity, adapt them to the child's changing skills and behaviours, and sustain use of the strategies have not been adequately defined. Child outcomes are enhanced when both clinician- and parent-implemented intervention components are included.

Considerably more high quality research, particularly with large sample sizes, is needed to understand the impact of prodromal interventions, improve personalization of interventions, determine what is needed to sustain treatment effects, define active ingredients of intervention approaches, examine timing of targeting specific types of skills, and establish adaptive treatment pathways for low responders. In the meantime, NDBI, EIBI/ABA, and aided AAC interventions are efficacious. Such information would support clinical decision-making for the heterogeneous population of young children with ASD.

Acknowledgments

Special appreciation is extended to Dr Julie Feuerstein for her comments on this manuscript during preparation, and to Chelsea Homa and Erin McAuliffe for their help with preparing the reference document.

Funding This work was supported by Maternal and Child Health Bureau [R40 MC26193] and National Institute on Deafness and Other Communication Disorders [R21 DC015846].

References

Aldred CR, Green J, Adams C. A new social communication intervention for children with autism: Pilot randomised controlled treatment study suggesting effectiveness. Journal of Child Psychology and Psychiatry. 2004; 45:1420–1430. DOI: 10.1111/j.1469-7610.2004.00338.x [PubMed: 15482502]

American Psychiatric Association. Diagnostic and statistical manual fifth edition. Washington DC: American Psychiatric Association; 2013.

Baranek GT. Autism during infancy: A retrospective video analysis of sensory-motor and social behaviors at 9–12 months of age. Journal of Autism and Developmental Disorders. 1999; 29:213–224. DOI: 10.1023/A:1023080005650 [PubMed: 10425584]

Baranek GT, Watson LR, Turner-Brown L, Field SH, Crais ER, Wakeford L, Reznick JS. Preliminary efficacy of adapted responsive teaching for infants at risk of autism spectrum disorder in a community sample. Autism Research and Treatment. 2015; 2015:386951.doi: 10.1155/2015/386951 [PubMed: 25648749]

Beaudoin AJ, Sébire G, Couture M. Parent training interventions for toddlers with autism spectrum disorder. Autism Research and Treatment. 2014; 2014:839890.doi: 10.1155/2014/839890 [PubMed: 24895534]

Bhat AN, Galloway JC, Landa RJ. Social and non-social visual attention patterns and associative learning in infants at risk for autism. Journal of Child Psychology and Psychiatry and Allied Disciplines. 2010; 51:989–997. DOI: 10.1111/j.1469-7610.2010.02262.x

Bhat AN, Galloway JC, Landa RJ. Relation between early motor delay and later communication delay in infants at risk for autism. Infant Behavior and Development. 2012; 35:838–846. DOI: 10.1016/j.infbeh.2012.07.019 [PubMed: 22982285]

Cannon EN, Yoo KH, Vanderwert RE, Ferrari PF, Woodward AL, Fox NA. Action experience, more than observation, influences mu rhythm desynchronization. PloS One. 2014; 9:e92002.doi: 10.1371/journal.pone.0092002 [PubMed: 24663967]

Carter AS, Messinger DS, Stone WL, Celimli S, Nahmias AS, Yoder P. A randomized controlled trial of Hanen's 'More Than Words' in toddlers with early autism symptoms. Journal of Child Psychology and Psychiatry. 2011; 52:741–752. DOI: 10.1111/j.1469-7610.2011.02395.x [PubMed: 21418212]

Casenhiser DM, Shanker SG, Stieben J. Learning through interaction in children with autism: Preliminary data from a social-communication-based intervention. Autism. 2013; 17:220–241. DOI: 10.1177/1362361311422052 [PubMed: 21949005]

Charman T, Young GS, Brian J, Carter A, Carver LJ, Chawarska K, Zwaigenbaum L. Non-ASD outcomes at 36 months in siblings at familial risk for autism spectrum disorder (ASD): A baby siblings research consortium (BSRC) study. Autism Research. 2017; 10:169–178. DOI: 10.1002/aur.1669 [PubMed: 27417857]

Chawarska K, Macari S, Shic F. Decreased spontaneous attention to social scenes in 6-month-old infants later diagnosed with autism spectrum disorders. Biological Psychiatry. 2013; 74:195–203. DOI: 10.1016/j.biopsych.2012.11.022 [PubMed: 23313640]

Christensen DL, Bilder DA, Zahorodny W, Pettygrove S, Durkin MS, Fitzerald RT, Yeargin-Allsopp M. Prevalence and characteristics of autism spectrum disorder among 4-year-old children in the Autism and developmental disabilities monitoring network. Journal of Developmental and Behavioral Pediatrics. 2016; 37:1–8. [PubMed: 26651088]

Darcy-Mahoney A, Minter B, Higgins M, Guo Y, Williams B, Head Zauche LM, Birth K. Probability of an autism diagnosis by gestational age. Newborn and Infant Nursing Reviews. 2016; 16:322–326. DOI: 10.1053/j.nainr.2016.09.019 [PubMed: 28989329]

Dawson G, Rogers S, Munson J, Smith M, Winter J, Greenson J, Varley J. Randomized, controlled trial of an intervention for toddlers with autism: The early start denver model. Pediatrics. 2010; 125:e17–e23. DOI: 10.1542/peds.2009-0958 [PubMed: 19948568]

Division for Early Childhood (DEC). DEC recommended practices in early intervention/early childhood special education 2014. 2014. Retrieved from http://www.decsped.org/recommendedpractices

Drew A, Baird G, Baron-Cohen S, Cox A, Slonims V, Wheelwright S, Charman T. A pilot randomised control trial of a parent training intervention for pre-school children with autism: Preliminary findings & methodological challengers. European Child and Adolescent Psychiatry. 2002; 11:266–272. DOI: 10.1007/s00787-002-0299-6 [PubMed: 12541005]

Eikeseth S, Klintwall L, Jahr E, Karlsson P. Outcome for children with autism receiving early and intensive behavioral intervention in mainstream preschool and kindergarten settings. Research in Autism Spectrum Disorders. 2012; 6:829–835. DOI: 10.1016/j.rasd.2011.09.002

Eikeseth S, Smith T, Jahr E, Eldevik S. Outcome for children with autism who began intensive behavioral treatment between ages 4 and 7: A comparison controlled study. Behavior Modification. 2007; 31:264–278. DOI: 10.1177/0145445506291396 [PubMed: 17438342]

Eldevik S, Hastings RP, Hughes JC, Jahr E, Eikeseth S, Cross S. Meta-analysis of early intensive behavioral intervention for children with autism. Journal of Clinical Child and Adolescent Psychology. 2009; 38:439–450. DOI: 10.1080/15374410902851739 [PubMed: 19437303]

Eldevik S, Hastings RP, Hughes JC, Jahr E, Eikeseth S, Cross S. Using participant data to extend the evidence base for intensive behavioral intervention for children with autism. American Journal on Intellectual and Developmental Disabilities. 2010; 115:381–405. DOI: 10.1352/1944-7558-115.5.381 [PubMed: 20687823]

Eldevik S, Hastings RP, Jahr E, Hughes JC. Outcomes of behavioral intervention for children with autism in mainstream pre-school settings. Journal of Autism and Developmental Disorders. 2012; 42:210–220. DOI: 10.1007/s10803-011-1234-9 [PubMed: 21472360]

Elison JT, Paterson SJ, Wolff JJ, Reznick JS, Sasson NJ, Gu H. IBIS Network. White matter microstructure and atypical visual orienting in 7-month-olds at risk for autism. The American Journal of Psychiatry. 2013; 170:899–908. [PubMed: 23511344]

Fernell E, Hedvall A, Westerlund J, Carlsson LH, Eriksson M, Olsson MB, Gillberg C. Early intervention in 208 Swedish preschoolers with autism spectrum disorder. A prospective naturalistic study. Research in Developmental Disabilities. 2011; 32:2092–2101. DOI: 10.1016/j.ridd.2011.08.002 [PubMed: 21985993]

Flanagan JE, Landa RJ, Bhat A, Bauman M. Head lag in infants at risk for autism: A preliminary study. American Journal of Occupational Therapy. 2012; 66:577–585. DOI: 10.5014/ajot.2012.004192 [PubMed: 22917124]

Frost, L., Bondy, A. The Picture Exchange Communication System (PECS) training manual. 2. Newark, DE: Pyramid Publications; 2002.

Ganz JB, Mason RA, Goodwyn FD, Boles MB, Heath AK, Davis JL. Interaction of participant characteristics and type of AAC with individuals with ASD: A meta-analysis. American Journal on Intellectual and Developmental Disabilities. 2014; 119:516–535. DOI: 10.1352/1944-7558-119.6.516 [PubMed: 25354122]

Green J, Charman T, McConachie H, Aldred C, Slonims V, Howlin P. The PACT Consortium. Parent-mediated communication-focused treatment in children with autism (PACT): A randomised controlled trial. The Lancet. 2010; 375:2152–2160. DOI: 10.1016/s0140-6736(10)60587-9

Green J, Charman T, Pickles A, Wan M, Elsabbagh M, Slonims V. The BASIS team. Parent-mediated intervention versus no intervention for infants at high risk of autism: A parallel, single-blind, randomised trial. The Lancet Psychiatry. 2015; 2:133–140. DOI: 10.1016/S2215-0366(14)00091-1 [PubMed: 26359749]

Green J, Pickles A, Pasco G, Bedford R, Wan MW, Elsabbagh M. The BASIS Team. Randomised trial of a parent-mediated intervention for infants at high risk for autism: longitudinal outcomes to age 3 years. Journal of Child Psychology and Psychiatry. 2017; 58:1330–1340. Advance Online Publication. DOI: 10.1111/jcpp.12728 [PubMed: 28393350]

Green J, Wan MW, Guiraud J, Holsgrove S, McNally J, Slonims V. The BASIS Team. Intervention for infants at risk of developing autism: A case series. Journal of Autism and Developmental Disorders. 2013; 43:2502–2514. DOI: 10.1007/s10803-013-1797-8 [PubMed: 23532347]

Gulsrud AC, Hellemann GS, Freeman SFN, Kasari C. Two to ten years: Developmental trajectories of joint attention in children with ASD who received targeted social communication interventions. Autism Research. 2014; 7:207–215. DOI: 10.1002/aur.1360 [PubMed: 24550145]

Hampton LH, Kaiser AP. Intervention effects on spoken-language outcomes for children with autism: A systematic review and meta-analysis. Journal of Intellectual Disability Research. 2016; 60:444–463. DOI: 10.1111/jir.12283 [PubMed: 27120988]

Hardan AY, Gengoux GW, Berquist KL, Libove RA, Ardel CM, Phillips J, Minjarez MB. A randomized controlled trial of pivotal response treatment group for parents of children with

autism. Journal of Child Psychology and Psychiatry. 2014; 56:884–892. DOI: 10.1111/jcpp.12345 [PubMed: 25346345]

Hayward D, Eikeseth S, Gale C, Morgan S. Assessing progress during treatment for young children with autism receiving intensive behavioural interventions. Autism. 2009; 13:613–633. DOI: 10.1177/1362361309340029 [PubMed: 19933766]

Howlin P, Magiati I, Charman T. Systematic review of early intensive behavior interventions for children with autism. American Journal on Intellectual and Developmental Disabilities. 2009; 114:23–41. DOI: 10.1352/2009.114:23-41 [PubMed: 19143460]

Ingersoll B. Brief report: Pilot randomized controlled trial of reciprocal imitation training for teaching elicited and spontaneous imitation to children with autism. Journal of Autism and Developmental Disorders. 2010; 40:1154–1160. DOI: 10.1007/s10803-010-0966-2 [PubMed: 20155309]

Ingersoll B, Gergans S. The effect of a parent-implemented naturalistic imitation intervention on spontaneous imitation skills in young children with autism. Research in Developmental Disabilities. 2007; 28:163–175. DOI: 10.1016/j.ridd.2006.02.004 [PubMed: 16603337]

Johnson MH, Griffin R, Csibra G, Halit H, Farroni T, De Haan M, Richards J. The emergence of the social brain network: Evidence from typical and atypical development. Developmental Psychopathology. 2005; 17:599–619. DOI: 10.1017/S0954579405050297

Juffer, F.Bakermans-Kranenburg, MJ., van IJzendoorn, MH., editors. Promoting positive parenting: An attachment-based intervention. New York, NY: Taylor and Francis Group/Lawrence Erlbaum Associates; 2008.

Kaale A, Smith L, Sponheim E. A randomized controlled trial of preschool-based joint attention intervention for children with autism. Journal of Child Psychology and Psychiatry. 2012; 53:97–105. DOI: 10.1111/j.1469-7610.2011.02450.x [PubMed: 21883204]

Kaplan G, McCracken JT. Psychopharmacology of autism spectrum disorders. Pediatric Clinics of North America. 2012; 59:175–187. DOI: 10.1016/j.pcl.2011.10.005 [PubMed: 22284801]

Karmiloff-Smith A. An alternative to domain-general or domain-specific frameworks for theorizing about human evolution and ontogenesis. AIMS Neuroscience. 2015; 2:91–104. DOI: 10.3934/Neuroscience.2015.2.91 [PubMed: 26682283]

Karmiloff-Smith A, Casey BJ, Massand E, Tomalski P, Thomas MS. Environmental and genetic influences on neurocognitive development: The importance of multiple methodologies and time-dependent intervention. Clinical Psychological Science: A Journal of the Association for Psychological Science. 2014; 2:628–637. DOI: 10.1177/2167702614521188 [PubMed: 26682092]

Kasari C, Freeman S, Paparella T. Joint attention and symbolic play in young children with autism: A randomized controlled intervention study. Journal of Child Psychology and Psychiatry. 2006; 47:611–620. DOI: 10.1111/j.1469-7610.2005.01567.x [PubMed: 16712638]

Kasari C, Gulsrud A, Freeman S, Paparella T, Hellemann G. Longitudinal follow-up of children with autism receiving targeted interventions on joint attention and play. Journal of the American Academy of Child Adolescent Psychiatry. 2012; 51:487–495. DOI: 10.1016/j.jaac.2012.02.019 [PubMed: 22525955]

Kasari C, Gulsrud A, Paparella T, Hellemann G, Berry K. Randomized comparative efficacy study of parent-mediated interventions for toddlers with autism. Journal of Consulting and Clinical Psychology. 2015; 83:554–563. DOI: 10.1037/a0039080 [PubMed: 25822242]

Kasari C, Gulsrud AC, Wong C, Kwon S, Locke J. Randomised controlled caregiver mediated joint engagement intervention for toddlers with autism. Journal of Autism and Developmental Disorders. 2010; 40:1045–1056. DOI: 10.1007/s10803-010-0955-5 [PubMed: 20145986]

Klintwall L, Eikeseth S. Number and controllability of reinforcers as predictors of individual outcome for children with autism receiving early and intensive behavioral intervention: A preliminary study. Research in Autism Spectrum Disorders. 2012; 6:493–499. DOI: 10.1016/j.rasd.2011.07.009

Koegel LK, Singh AK, Koegel RL, Hollingsworth JR, Bradshaw J. Assessing and improving early social engagement in infants. Journal of Positive Behavior Interventions. 2013; 16:69–80. DOI: 10.1177/1098300713482977

Koegel, R., Koegel, L. Pivotal response treatments for autism. Baltimore, MD: Brookes Publishing Co; 2006.

Kolb B, Gibb R. Brain plasticity and behaviour in the developing brain. Journal of the Canadian Academy of Child & Adolescent. 2011; 20:265–276. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=68628446&site=ehost-live&scope=site.

Landa RJ, Kalb LG. Long-term outcomes of toddlers with autism spectrum disorders exposed to short-term intervention. Pediatrics. 2012; 130:S186–S190. DOI: 10.1542/peds.2012-0900Q [PubMed: 23118250]

Landa RJ, Gross AL, Stuart EA, Faherty A. Developmental trajectories in children with and without autism spectrum disorders: The first 3 years. Child Development. 2013; 84:429–442. DOI: 10.1111/j.1467-8624.2012.01870.x [PubMed: 23110514]

Landa RJ, Holman KC, Garrett-Mayer E. Social and communication development in toddlers with early and later diagnosis of autism spectrum disorders. Archives of General Psychiatry. 2007; 64:835–864. DOI: 10.1001/archpsyc.64.7.853

Landa RJ, Holman KC, O'Neill AH, Stuart EA. Intervention targeting development of socially synchronous engagement in toddlers with autism spectrum disorder: A randomized controlled trial. Journal of Child Psychology and Psychiatry. 2011; 52:13–21. DOI: 10.1111/j.1469-7610.2010.02288.x [PubMed: 21126245]

Lane JD, Lieberman-Betz R, Gast D. An analysis of naturalistic interventions for increasing spontaneous expressive language in children with autism spectrum disorder. Journal of Special Education. 2016; 50:49–61. DOI: 10.1177/0022466915614837

Lovaas OI. Behavioral treatment and normal educational and intellectual functioning in young autistic children. Journal of Consulting and Clinical Psychology. 1987; 57:3–9. DOI: 10.1037/0022-006X.55.1.3

Magiati I, Charman T, Howlin P. A two-year prospective follow-up study of community-based early intensive behavioral intervention and specialist nursery provision for children with autism spectrum disorders. Journal of Child Psychology and Psychiatry. 2007; 48:803–812. DOI: 10.1111/j.1469-7610.2007.01756.x [PubMed: 17683452]

Mahoney G, Solomon R. Mechanism of developmental change in the PLAY project home consultation program: Evidence from a randomized control trial. Journal of Autism and Developmental Disorders. 2016; 46:1860–1871. DOI: 10.1007/s10803-016-2720-x [PubMed: 26830414]

Oono IP, Honey EJ, McConachie H. Parentmediated early intervention for young children with autism spectrum disorders (ASD). Evidence-Based Child Health. 2013; 8:2380–2479. DOI: 10.1002/ebch.1952

Oosterling I, Visser J, Swinkels S, Rommelse N, Donders R, Woudenberg T, Buitelaar J. Randomized control trial of the focus parent training for toddlers with autism: 1-year outcome. Journal of Autism and Developmental Disorders. 2010; 40:1447–1458. DOI: 10.1007/s10803-010-1004-0 [PubMed: 20440639]

Ozonoff S, Young GS, Carter A, Messinger D, Yirmiya N, Zwaigenbaum L, Stone WL. Recurrence risk for autism spectrum disorders: A baby siblings research consortium study. Pediatrics. 2011; 128:e488–e495. DOI: 10.1542/peds.2017-2954 [PubMed: 21844053]

Ozonoff S, Young GS, Landa RJ, Brian J, Bryson S, Charman T, Iosif AM. Diagnostic stability in young children at risk for autism spectrum disorder: A baby siblings research consortium study. Journal of Child Psychology and Psychiatry. 2015; 56:988–998. DOI: 10.1111/jcpp.12421 [PubMed: 25921776]

Peters-Scheffer N, Didden R, Mulders M, Korzilius H. Low intensity behavioral treatment supplementing preschool services for young children with autism spectrum disorders and severe to mild intellectual disability. Research in Developmental Disabilities. 2010; 31:1678–1684. DOI: 10.1016/j.ridd.2010.04.008 [PubMed: 20627451]

Pickles A, Le Couteur A, Leadbitter K, Salomone E, Cole-Fletcher R, Tobin H, Green J. Parent-mediated social communication therapy for young children with autism (PACT): Long-term follow-up of a randomised controlled trial. The Lancet. 2016; 388:2501–2509. DOI: 10.1016/S0140-6736(16)31229-6

Piven J, Elison JT, Zylka MJ. Toward a conceptual framework for early brain and behavior development in autism. Molecular Psychiatry. 2017; 22:1385–1394. DOI: 10.1038/mp.2017.131 [PubMed: 28937691]

Poslawsky IE, Naber FBA, Bakermans-Kranenburg MJ, van Daalen E, van Engeland H, van IJzendoorn MH. Video-feedback intervention to promote positive parenting adapted to autism (VIPP-AUTI): A randomized controlled trial. Autism. 2015; 19:588–603. DOI: 10.1177/1362361314537124 [PubMed: 24919961]

Reichow B. Overview of meta-analyses on early intensive behavioral interventions for children with autism spectrum disorders. Journal of Autism and Developmental Disorders. 2012; 42:512–520. DOI: 10.1007/s10803-011-1218-9 [PubMed: 21404083]

Reichow B, Barton EE, Boyd BA, Hume K. Early intensive behavioral intervention (EIBI) for young children with autism spectrum disorders (ASD). Cochrane Database of Systematic Reviews. 2012; 10:CD009260.doi: 10.1002/14651858.cd009260.pub2 [PubMed: 23076956]

Rickards AL, Walstab JE, Wright-Rossi RA, Simpson J, Reddihough D. A randomized, controlled trial of a home-based intervention program for children with autism and developmental delay. Journal of Developmental & Behavioral Pediatrics. 2007; 28:308–316. DOI: 10.1097/DBP.0b013e318032792e [PubMed: 17700083]

Roberts J, Williams K, Carter M, Evans D, Parmenter T, Silove N, Warren A. A randomised controlled trial of two early intervention programs for young children with autism: Centre-based with parent program and home-based. Research in Autism Spectrum Disorders. 2011; 5:1553–1566. DOI: 10.1016/j.rasd.2011.03.001

Rogers SJ, Vismara LA. Evidence-based comprehensive treatments for early autism. Journal of Clinical Child and Adolescent Psychology. 2008; 37:8–38. DOI: 10.1080/15374410701817808 [PubMed: 18444052]

Rogers SJ, Estes A, Lord C, Vismara L, Winter J, Fitzpatrick A, Dawson G. Effects of a brief Early Start Denver Model (ESDM)-based parent intervention on toddlers at risk for autism spectrum disorders: A randomized controlled trial. Journal of the American Academy of Child & Adolescent Psychiatry. 2012; 51:1052–1065. DOI: 10.1016/j.jaac.2012.08.003 [PubMed: 23021480]

Rogers SJ, Vismara L, Wagner AL, McCormick C, Young G, Ozonoff S. Autism treatment in the first year of life: A pilot study of Infant Start, a parent-implemented intervention for symptomatic infants. Journal of Autism and Developmental Disorders. 2014; 44:2981–2995. DOI: 10.1007/s10803-014-2202-y [PubMed: 25212413]

Sallows GO, Graupner TD. Intensive behavioral treatment for children with autism: Four-year outcome and predictors. American Journal on Mental Retardation. 2005; 110:417–438. DOI: 10.1352/0895-8017(2005)110[417:IBTFCW]2.0.CO;2 [PubMed: 16212446]

Salmond CH, Vargha-Khadem F, Gadian DG, De Haan M, Baldeweg T. Heterogeneity in the patterns of neural abnormaility in autistic spectrum disorders: Evidence from ERP and MRI. Cortex. 2007; 43:686–699. DOI: 10.1016/S0010-9452(08)70498-2 [PubMed: 17710821]

Schertz HH, Odom SL. Promoting joint attention in toddlers with autism: A parent-mediated developmental model. Journal of Autism and Developmental Disorders. 2007; 37:1562–1575. DOI: 10.1007/s10803-006-0290-z [PubMed: 17096190]

Schertz HH, Odom SL, Baggett KM, Sideris JH. Effects of joint attention mediated learning for toddlers with autism spectrum disorders: An initial randomized controlled study. Early Childhood Research Quarterly. 2013; 28:249–258. DOI: 10.1016/j.ecresq.2012.06.006

Schlosser RW, Wendt O. Effects of augmentative and alternative communication intervention on speech production in children with autism: A systematic review. American Journal of Speech-Language Pathology. 2008; 17:212–230. DOI: 10.1044/1058-0360(2008/021) [PubMed: 18663107]

Schriebman L, Dawson G, Stahmer AC, Landa R, Rogers SJ, McGee GG, Halladay A. Naturalistic developmental behavioral interventions: Empirically validated treatments for autism spectrum disorder. Journal of Autism and Developmental Disorders. 2015; 45:2411–2428. DOI: 10.1007/s10803-015-2407-8 [PubMed: 25737021]

Shire SY, Gulsrud A, Kasari C. Increasing responsive parent-child interactions and joint engagement: Comparing the influence of parent-mediated intervention and parent psychoeducation. Journal of Autism and Developmental Disorders. 2016; 46:1737–1747. DOI: 10.1007/s10803-016-2702-z [PubMed: 26797940]

Siller M, Hutman T, Sigman M. A parent-mediated intervention to increase responsive parental behaviors and child communication in children with ASD: A randomized clinical trial. Journal of

Autism and Developmental Disorders. 2013; 43:540–555. DOI: 10.1007/s10803-012-1584-y [PubMed: 22825926]

Smith, T. Applied behavior analysis and early intensive intervention. In: Amaral, DG.Dawson, G., Geschwind, DH., editors. Autism spectrum disorders. New York, NY: Oxford University Press; 2011. p. 1037-1055.

Smith T, Groen AD, Wynn JW. Randomized trial of intensive early intervention for children with pervasive developmental disorder. American Journal on Mental Retardation. 2000; 105:269–285. DOI: 10.1352/0895-8017(2000)105<0269:RTOIEI>2.0.CO;2 [PubMed: 10934569]

Smith T, Iadarola S. Evidence base update for autism spectrum disorder. J Clin Child Adolesc Psychol. 2015; 44:897–922. DOI: 10.1080/15374416.2015.1077448 [PubMed: 26430947]

Smith T, Klorman R, Mruzek D. Predicting outcome of community-based early intensive behavioral intervention for children with autism. Journal of Abnormal Child Psychology. 2015; 43:1271–1282. DOI: 10.1007/s10802-015-0002-2 [PubMed: 25778537]

Solomon R, Van Egeren LA, Mahoney G, Quon Huber MS, Zimmerman P. PLAY project home consultation intervention program for young children with autism spectrum disorders: A randomized controlled trial. Journal of Developmental and Behavioral Pediatrics. 2014; 35:475–485. DOI: 10.1097/DBP.0000000000000096 [PubMed: 25264862]

Stahmer AC, Rieth S, Lee E, Reisinger EM, Mandell DS, Connell JE. Training teachers to use evidence-based practices for autism: Examining procedural implementation fidelity. Psychology in the Schools. 2015; 52:181–195. DOI: 10.1002/pits.21815 [PubMed: 25593374]

Steiner AM, Gengoux GW, Klin A, Chawarska K. Pivotal response treatment for infants at-risk for autism spectrum disorders: A pilot study. Journal of Autism and Developmental Disorders. 2013; 43:91–102. DOI: 10.1007/s10803-012-1542-8 [PubMed: 22573001]

Strain P, Bovey EH. Randomized, controlled trial of the LEAP model of early intervention for young children with autism spectrum disorders. Topics in Early Childhood Special Education. 2011; 31:133–154. DOI: 10.1177/0271121411408740

Strauss K, Vicari S, Valeri G, D'elia L, Arima S, Fava L. Parent inclusion in early intensive behavior intervention: The influence of parental stress, parent treatment fidelity and parent-medicated generalization of behavior targets on child outcomes. Research in Developmental Disabilities. 2012; 33:688–703. DOI: 10.1016/j.ridd.2011.11.008 [PubMed: 22188793]

Twardzik E, Cotto-Negrón C, MacDonald M. Factors related to early intervention Part C enrollment: A systematic review. Disability and Health Journal. 2017; 10:467–474. DOI: 10.1016/j.dhjo.2017.01.009 [PubMed: 28187953]

Virués-Ortega J. Applied behavior analytic intervention for autism in early childhood: Meta-analysis, meta-regression and dose–response meta-analysis of multiple outcomes. Clinical Psychology Review. 2010; 30:387–399. DOI: 10.1016/j.cpr.2010.01.008 [PubMed: 20223569]

Virués-Ortega J, Rodriguez V, Yu CT. Prediction of treatment outcomes and longitudinal analysis in children with autism undergoing intensive behavioral intervention. International Journal of Clinical and Health Psychology. 2013; 13:91–100. DOI: 10.1016/S1697-2600(13)70012-7

Vivanti G, Dissanayake C, Zierhut C, Rogers SJ. Victorian ASELCC Team. Brief report: predictors of outcomes in the early start denver model delivered in a group setting. Journal of Autism and Developmental Disorders. 2013; 43:1717–1724. DOI: 10.1007/s10803-012-1705-7 [PubMed: 23124361]

Wallace KS, Rogers SJ. Intervening in infancy: Implications for autism spectrum disorders. J Child Psychol Psychiatry. 2010; 51:1300–1320. DOI: 10.1111/j.1469-7610.2010.02308.x [PubMed: 20868374]

Warren ZE, McPheeters ML, Sathe NA, Foss-Feig JH, Glasser A, Veenstra-VanderWeele J. A systematic review of early intensive intervention for autism spectrum disorders. Pediatrics. 2011; 127:e1303–e1311. DOI: 10.1542/peds.2011-0426 [PubMed: 21464190]

Watson LR, Crais ER, Baranek GT, Turner-Brown L, Sideris J, Wakeford L, Nowell SW. Parent-mediated intervention for one-year-olds screened as at-risk for autism spectrum disorder: A randomized controlled trial. Journal of Autism and Developmental Disorders. 2017; 47:3520–3540. [PubMed: 28861651]

Weisen S, Watkins RM, Needham A. Active motor training has long-term effects on infants' object exploration. Frontiers in Psychology. 2016; 7:599.doi: 10.3389/fpsyg.2016.00599 [PubMed: 27199833]

Wetherby AM, Guthrie W, Woods J, Schatschneider C, Holland RD, Morgan L, Lord C. Parent-implemented social intervention for toddlers with autism: An RCT. Pediatrics. 2014; 134:1084–1093. DOI: 10.1542/peds.2014-0757 [PubMed: 25367544]

Yoder P, McDuffie A. Teaching young children with autism to talk. Seminars in Speech and Language. 2006; 27:161–172. DOI: 10.1055/s-2006-948227 [PubMed: 16941287]

Zachor DA, Ben-Itzchak E. Variables affecting outcome of early intervention in autism spectrum disorder. Journal of Pediatric Neurology. 2017; 15:129–133. DOI: 10.1055/s-0037-1601444