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Intervening in infancy: implications for autism spectrum disorders

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There is a scarcity of empirically validated treatments for infants and toddlers under age 3 years with autism spectrum disorders (ASD), as well as a scarcity of empirical investigation into successful intervention characteristics for this population. Yet early screening efforts are focused on identifying autism risk in children under age 3 years. In order to build ASD interventions for infants and toddlers upon a foundation of evidence-based characteristics, the current paper presents the results of a systematic literature search and effect size analysis of efficacious interventions for infants and toddlers with other developmental disorders: those who were born prematurely, have developmental impairments, or are at high risk for developmental impairments due to the presence of a biological or familial condition associated with developmental impairments. A review of 32 controlled, high-quality experimental studies revealed that the most efficacious interventions routinely used a combination of four specific intervention procedures, including (1) parent involvement in intervention, including ongoing parent coaching that focused both on parental responsivity and sensitivity to child cues and on teaching families to provide the infant interventions, (2) individualization to each infant's developmental profile, (3) focusing on a broad rather than a narrow range of learning targets, and (4) temporal characteristics involving beginning as early as the risk is detected and providing greater intensity and duration of the intervention. These four characteristics of efficacious interventions for infants and toddlers with other developmental challenges likely represent a solid foundation from which researchers and clinicians can build efficacious interventions for infants and toddlers at risk for or affected by ASD. **Keywords:** Early intervention, autism, ASD, parent coaching, infant, toddler, evidence-based intervention.

The primary purpose of early detection of autism spectrum disorders (ASD) is to prevent or mitigate the symptoms and severity of disability associated with ASD. Early detection science requires that early treatment science develop in parallel, so that tested treatments are ready for infants and toddlers identified by early detection. However, while there is considerable progress being made in early detection of ASD, thanks to the productive infant sibling studies and early screening studies under way, there is currently a scarcity of empirically validated treatments for infants and toddlers under age 3 years with ASD, and a scarcity of treatment studies for those under 18 months. While well-structured, data-based, long-term early intervention involving many hours per week of intervention (from staff and/or parents) is currently the most effective strategy for improving functioning for 2–5-year-olds with ASD (Lovaas, 1987; McEachin, Smith, & Lovaas, 1993; Rogers & Dawson, 2009), these models have been developed for preschoolers, and do not fit the lifestyle or learning patterns of infants and toddlers in the first and second years of life (Rogers & Vismara, 2008).

Given the importance of designing interventions for infants and toddlers with ASD on a foundation of evidence-based characteristics, we turned to rigorously designed intervention studies for infants and toddlers with other developmental disorders or developmental risks (i.e., those who were born prematurely, those with developmental delays including Down syndrome, and those at risk for intellectual disabilities due to parental poverty and intellectual impairment) to determine intervention characteristics that are associated with improved developmental functioning. The current paper provides the results of a systematic review of infant and toddler intervention research from these three clinical groups, including methodological investigation, effect size analyses, and extraction of key ingredients of the most efficacious interventions.

Method

Search criteria and study selection

Inclusion criteria for papers were as follows: (1) the article was published in a peer-reviewed journal, (2) the article described a well-designed, controlled intervention efficacy study involving infants or toddlers with developmental impairments or significant risk of such impairments; (3) study participants were in the age range of birth through 3 years, and (4) the paper reported sufficient data to calculate effect sizes (e.g., group sizes, means and standard deviations of core measure performance for each group; this inclusion criterion excluded papers such as Piper et al., 1986). We identified three clinical conditions: prematurity,

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developmental delay including Down syndrome, and risk of intellectual disability. We then conducted an internet search using PsycINFO and Pubmed, using a variety of groupings of keywords. For each condition, we searched condition name and early intervention, condition name and method and intervention, and condition name and intervention.

Following the internet search, we hand-searched through six texts focused on efficacy of early intervention, listed below.

- *From Neurons to Neighborhoods: The Science of Early Childhood Development* (Shonkoff & Phillips, 2000)
- *Handbook of Infant Mental Health* (Zeanah, 2005)
- *Handbook of Developmental Disabilities* (Odom, Horner, Snell, & Blacher, 2007)
- *The Effectiveness of Early Intervention for At-Risk and Handicapped Children* (Guralnick & Bennett, 1987)
- *Handbook of Early Childhood Intervention* (Meisels & Shonkoff, 1990)
- *Handbook of Early Childhood Intervention*, Second Edition (Shonkoff & Meisels, 2000)

Within each, we searched the Table of Contents and Index for keywords related to the topic areas, located all the papers referenced for the target conditions, and applied the inclusion criteria to them. Our search criteria may not have yielded every published intervention study for these topic areas, but our findings represent all those found by the search procedure described above. Given our interest in general interventions aimed to improve children's overall development, we excluded papers that focused on very specific intervention aims, such as improvement in language or motor functioning only.

Methodological investigation

These papers were then classified according to the criteria for establishing empirical support outlined by Nathan and Gorman (2002), which are as follows:

- **Type 1 Studies** are randomized, prospectively designed clinical trials which use randomly assigned comparison groups. They also utilize blind assessments, clear inclusion/exclusion criteria, treatment fidelity measures, treatment manuals (including use of structured curriculum), and state-of-the-art diagnosis. They have adequate sample sizes to power the analyses and clearly described statistical methods.
- **Type 2 Studies** are clinical trials using a comparison group to test an intervention. These have some significant flaws but not critical design flaws that would prevent one from using the data to answer a study question. This category also includes single-subject designs.
- **Type 3 Studies** have significant methodological flaws. These include uncontrolled studies using pre-post designs and studies using retrospective designs.
- **Type 4 and Type 5 Studies** are secondary analysis papers.
- **Type 6 Studies** are case reports.

Two independent raters evaluated each paper and inter-rater agreement regarding this classification was assessed via the examination of 20% of papers. Reliability for classifying randomization, inclusion and exclusion criteria, and use of standardized diagnostic batteries, comparison group, blind assessors, and treatment fidelity was 100%, and reliability for classifying use of a treatment manual was 87.5%. Any classification differences were resolved by discussion among the raters.

It is important to note that classification of a study as lacking a methodological characteristic refers to the published description of the method: it may not always indicate a true lack of the characteristic within that study. Authors may not have described methods they were using, such as use of blind assessors or treatment fidelity checks within their manuscripts.

Only papers classified as Type 1 or Type 2 using the Nathan and Gorman (2002) criteria were included in analyses. The efficacy of the interventions described within these papers was investigated as described below, and the methods used were examined in detail to determine key intervention features. All papers are presented in Table 1, including details regarding study sample, outcome measures, treatment procedures, findings, effect sizes, and Type classification.

Results

The literature search yielded 32 Type 1 or Type 2 papers across the three groups. Across all disability groups, 6 papers attained the highest classification (18.75%), while the remaining 26 were classified as Type 2 (81.25%). It is important to note that Type 2 criteria are quite strict—a study missing only one of randomization, use of blind assessors, inclusion and exclusion criteria, a standardized diagnostic battery, treatment fidelity, or a treatment manual would qualify that paper as a Type 2 as opposed to a Type 1.

There was great disparity in the range of studies for each disability group. Out of the 24 papers reporting early intervention for premature infants and toddlers, 6 papers were Type 1 (25%), while the remaining 18 were Type 2 (75%). Out of the 5 papers reporting early intervention for infants and toddlers with developmental delays including Down syndrome, all were classified as Type 2 (100%). Similarly, all 3 papers reporting early intervention for infants and toddlers at risk for or affected by intellectual disability were Type 2 (100%).We documented in Table 1 the presence or absence of seven methodological procedures involving scientific rigor as specified by the Nathan and Gorman (2002) criteria: randomization, assessments by raters blind to intervention group, use of inclusion/exclusion criteria, a standardized diagnostic battery, presence of a well-matched, nonrandomized comparison group, treatment fidelity procedures, and a treatment manual. Across all 32 studies, 23 randomized subjects (72%) and 6 did not (19%). Three studies utilized partial randomization procedures (9%). For example, in an early intervention study for premature infants, Zahr (2000) randomly assigned some participants to treatment or control groups,

Table 1 Type 1 and Type 2 intervention studies for children ages 0–3 with a variety of disabilities (gray highlighting represents a successful intervention study)

Author(s) and year	Sample	Outcome measures	Treatment procedures	Findings	Nathan and Gorman (2002) criteria
EARLY INTERVENTIONS FOR INFANTS AND TODDLERS WITH DEVELOPMENTAL DELAYS:					
Connolly, Morgan, Russell, & Richardson (1980)	20 ss, 53 control	Stanford–Binet Intelligence Scale or Cattell Infant Intelligence Scale; Vineland Social Maturity Scale	Early Intervention Program at the Child Development Center of the University of Tennessee Center for the Health Sciences; parent–child relationship and maximization of overall development of each child; 10 1-hr sessions during which professionals taught parents developmental interventions for individualized home use stimulation programs, 1-hr parent group, and .5-hr feeding skill development; 10 wks of individualized programs	At 3–6 yrs., ES = .48 (corrected, .49) for Stanford–Binet and .28 for social quotient	Type 2 study: –RCT, –Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, –Tx manual
Connolly, Morgan, Russell, & Fulliton (1993) (Follow-up of Connolly, Morgan, Russell, & Richardson (1980))	10 ss, 10 controls	Stanford–Binet Intelligence Scale; Vineland Social Maturity Scale; Bruininks–Oseretsky Test of Motor Proficiency	See Connolly, Morgan, Russell, & Richardson (1980)	At about 16 yrs., ES = .97 (corrected, .93) for IQ and 1.63 for social quotient	Type 2 study: –RCT, –Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, –Tx manual
Piper & Pless (1980)	21 ss, 16 controls	Griffiths Mental Developmental Scales; HOME	Center-based twice weekly, 1-hr sessions; activities designed to encourage normal development were demonstrated to parent, and written instructions sent home	At 15 mon., ES = –.11 (corrected, –.11) for total Griffiths score	Type 2 study: –RCT, +Blind assessments, –Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, –Tx manual
Seifer, Clark, & Sameroff (1991)	23 ss, 17 controls	Coding of videos of mother–child interaction; BSID; Uzgiris and Hunt Ordinal Scales of Development	6 sessions of interaction coaching; taught mothers about overstimulation	At 18 mon., ES = .70 (corrected, .69) for mental age	Type 2 study: –RCT, +/– (partial) Blind assessments, –Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, –Tx manual

Table 1 (Continued)

Author(s) and year	Sample	Outcome measures	Treatment procedures	Findings	Nathan and Gorman (2002) criteria
Sloper, Glenn, & Cunningham (1986)	12 ss, 12 controls	Scales of object permanence, attention span, and imitation every 3 wks; BSID; Stanford–Binet Intelligence Scale	Parents in tx group given exercises to carry out daily to development object permanence, attention span, imitation (parents were to practice 5 times per day and record data); parents in control group given general guidance on stimulation, discussed these and other areas of concern, and parent and clinician developed stimulation activities	At 4.5 yrs., ES = .19 (corrected, .18) for mental age, but sig. differences on later items of the checklists (example: ES = .87 for imitation of crayon stroke)	Type 2 study: –RCT, +/– (partial) Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, –Tx manual
EARLY INTERVENTIONS FOR INFANTS AND TODDLERS AT RISK FOR INTELLECTUAL DISABILITY:					
Breitmayer & Ramey (1986)	For optimal Apgar: 22 ss, 27 controls; For nonoptimal Apgar: 19 ss, 12 controls	McCarthy Scales of Children's Abilities; BSID; Stanford–Binet Intelligence Scale	Direct educational programming through the provision of systematic, developmental day-care; particular emphasis on language; began attending b/w 6 wks and 3 mon. of age; ran 7:45–5:30 each weekday for 50 weeks per yr.; up to 3rd birthday: Carolina Infant; up to school entry: systematic exposure to areas such as math, science, & music	At 54 mon., for optimal Apgar participants, ES = .24 for McCarthy Scales; At 54 mon., for nonoptimal Apgar participants, ES = 1.04 (corrected, 1.03) for McCarthy Scales	Type 2 study: +RCT, +/– (partial) Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, +Tx manual
Ramey & Campbell (1984)	54 ss, 53 controls	BSID, Stanford–Binet Intelligence Scale, or McCarthy Scales of Children's Abilities at 6, 12, 18, 24, 30, 42, 48, & 54 mon.	Carolina Abecedarian Project; child-centered, prevention-oriented tx program delivered in a daycare setting; infancy–5 yrs.; ran 7:45–5:30 each weekday for 50 weeks per yr.; infant curriculum: language, motor, social, and cognitive items; after age 3: standard preschool curricula; particular emphasis on language	At 54 mon., ES = 1.22 (corrected, 1.21) for Stanford–Binet	Type 2 study: +RCT, –Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, +Tx manual
Ramey & Smith (1976)	25 ss, 22 controls	Two-choice visual discrimination task; BSID	Daycare program designed to prevent developmental retardation; 8 hrs per day, 5 days per wk; began attending b/w 6 & 12 wks of age; curriculum individualized and focuses on perception and cognition, language, and social and motor development	At 18 mon., ES = 1.40 (corrected, 1.38) for Bayley	Type 2 study: +RCT, +/– (partial)Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, +Tx manual

Table 1 (Continued)

Author(s) and year	Sample	Outcome measures	Treatment procedures	Findings	Nathan and Gorman (2002) criteria
EARLY INTERVENTIONS FOR PREMATURE INFANTS AND TODDLERS:					
Avon Premature Infant Project (1998)	116 ss in developmental education group, 106 ss in parent advisor group, 106 controls	Griffiths Mental Development Scales	The Avon Premature Infant Project; ss randomized to developmental education group (using Portage, consisting of activities to introduce the parent to aspects of child's development; nurses served as interventionists), parent advisor group (seminars and individual and group work focused on parent support), or control; interventions delivered weekly from hospital discharge for a few months, 2–4 weekly for the next yr., and monthly until 2 yrs. of age	At 2 yrs., ES = .59 (corrected, .59) for Portage group and .27 (corrected, .27) for parent advisor group for children under 1250 grams at birth	Type 2 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, +Tx manual
Johnson, Ring, Anderson, & Marlow (2005) (Follow-up of Avon Premature Infant Project (1998))	63 ss in developmental education group, 61 ss in parent advisor group, 63 controls	British Ability Scales II; Movement ABC; CBCL	See Avon Premature Infant Project (1988)	At 5 yrs., ES = –.12 (corrected, –.12) for Portage group and –.05 (corrected, –.05) for parent advisor group	Type 2 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, +Tx manual
Bao, Sun, & Wei (1999)	52 ss, 51 preterm controls, 53 full-term controls	Child Development Center of China scale at 1.5 and 2 yrs.	Parent training of exercises to stimulate motor, cognitive, speech, and social behavior; monthly instruction for the first year and instruction every other month for the second year; at least half-hour meetings; occasional small parent classes, organized in didactic manner to teach about development and early intervention	At 2 yrs., ES = .58 for MDI in favor of intervention group over normal control group, and ES = 1.28 for MDI in favor of intervention group over premature control group	Type 2 study: +RCT, +Blind assessments, –Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, –Tx manual

Table 1 (Continued)

Author(s) and year	Sample	Outcome measures	Treatment procedures	Findings	Nathan and Gorman (2002) criteria
Barrera, Doucet, & Kitching (1990)	22 ss in parent–infant tx, 16 ss in developmental programming tx, 21 preterm controls, 24 full-term controls	Vineland Social Maturity Scale; Flint Infant Maturity Scale; BSID	12–28 1–2-hr home visits; DPI: specific activities designed to encourage infants' development in cognition, communication, fine and gross motor, socio-emotional & self-help; PII: improve parent-infant interaction, followed child's and parents' leads	For Vineland Social Maturity Scale, ES = .21 for DPI versus preterm controls and .06 for PII versus preterm controls	Type 2 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, +Tx manual
Bustan & Sagi (1984)	8 ss, 8 controls	At about 3 mon. of age: Broussard Scale; Infant Characteristic Questionnaire; interaction observations; Maternal Questionnaire	3 sessions of discussion with ICU staff regarding mother's feelings and provision of information about prematurity; provision of Prematurity Manual which elaborates on prematurity	No positive effect of intervention on maternal personal attitudes and feelings (ES = .24 for attitudes regarding maternal role), but some positive effects for mother–infant interactions (e.g., ES = .87 for close body contact)	Type 2 study: -RCT, +/– (partial)Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, +Tx manual
Gianni et al. (2006)	18 ss, 18 controls	Griffiths Mental Development Scale	An early post-discharge developmental mother–child tx program; 3–12 mon of age, mother–infant pairs attended 1.5-hr, twice monthly group sessions; focused on mother grief/guilt and infant's observation and promotion of perceptual and social-cognitive skills in mother–infant interaction	At 36 mon, ES = .79 for personal social, .32 for hearing and speech, .78 for hand and eye coordination, .58 for performance, and 1.00 for practical reasoning (corrected effect size of .67)	Type 2 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, –Tx manual
IHDP (1990)	377 ss, 608 controls	BSID; Stanford–Binet Intelligence Scale; PPVT; Beery Test of Visual Motor Integration	Home visits across 3 yrs, educational daycare beginning in yr 2, monthly parent group meetings, and case management; cognitive stimulation curriculum for low birth weight infants (Early Partners) and a cognitive stimulation curriculum for infancy and early childhood (Partners for Learning)	At 36 mon., ES = .83 for Stanford–Binet for the heavier participants, and .41 for the lighter participants (average corrected effect size of .62)	Type 2 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, +Tx manual

Table 1 (Continued)

Author(s) and year	Sample	Outcome measures	Treatment procedures	Findings	Nathan and Gorman (2002) criteria
Brooks-Gunn, Liaw, & Klebanov (1992) (Expansion of IHDP (1990))	377 ss, 608 controls	BSID; Stanford–Binet Intelligence Scale; PPVT; Beery Test of Visual Motor Integration	See IHDP (1990)	At 24 mon., ES = .46 for vocabulary, .49 for receptive language, 1.01 for visual-motor and spatial factors; at 36 mon., ES = .46 for vocabulary, .49 for receptive language, .55 for visual-motor and spatial factors, .42 for reasoning	Type 2 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, −Tx fidelity, +Tx manual
Kaaresen et al. (2008)	69 ss, 67 controls	At 2 yrs.: BSID; CBCL; PSI	Modified version of The Mother–Infant Transaction Program; emphasizes the transactional nature of development and seeks to enable parents to appreciate their infant's unique characteristics and respond appropriately to infant's cues; 1-hr daily sessions for a week, then four home visit follow-ups 3, 14, 30, and 90 days after hospital discharge	ES = .22 (corrected, .22) for MDI	Type 1 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, +Tx fidelity, +Tx manual
Kang et al. (1995)	64 ss in hospital experimental, 77 ss in home visit experimental, 70 ss in hospital control, 116 ss in home control	NCAFS; NCATS	Hospital experimental: State Modulation (program designed to promote infant behavioral responsiveness and interaction with mothers; 1-hr program); home visit experimental: Nursing Systems Toward Effective Parenting-Preterm (designed to promote parent adaptation to preterm infants; 9 visits across 5 mon.); hospital control: car seat instructional program (1-hr program); home control: standard public health nursing	For NCAFS, ES = .32 for hospital intervention and ES = −.20 for home intervention; For NCATS, ES = .61 for hospital intervention and ES = .41 for home intervention	Type 2 study: +/- (partial)RCT, -Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, -Tx fidelity, +Tx manual

Table 1 (Continued)

Author(s) and year	Sample	Outcome measures	Treatment procedures	Findings	Nathan and Gorman (2002) criteria
Kleberg, Westrup, Stjernqvist, & Lagercrantz (2002)	11 ss, 9 controls	BSID at 1 yr. corrected age	Newborn Individualized Developmental Care and Assessment Program (NIDCAP); involves sequential, formalized, naturalistic observations of the infant prior to, during, and after care-giving pro>cedures; observer assesses the infant's current ability to organize and modulate the 5 highly interactive subsystems categorized in the synactive theory – the autonomic physiological, motor, state organizational, attention interactive and self-regulatory systems – then recommendations for individualized care and changes in the environment are formulated	At 12 mon. corrected age, ES = 1.45 (corrected, 1.39) for MDI and .50 for PDI	Type 2 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, −Tx fidelity, +Tx manual
Melnyk et al. (2001)	20 ss, 22 controls	BSID; State-Trait Anxiety Inventory; Profile of Mood States; Parental Stressor Scale: Neonatal Intensive Care; Maternal-Infant Interaction Scale; NCAFS; HOME; Parental Belief Scale: NICU	COPE – a parent-focused tx; four-phase educational-behavioral program that began 2–4 days postbirth and continued through 1 week following discharge from the NICU; provided infant information and parent activities	At 6 mon., ES = .72 (corrected, .71) for MDI	Type 1 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, +Tx fidelity, +Tx manual
Newnham, Milgrom, & Skouteris (2009)	35 ss, 33 controls	Edinburgh Postnatal Depression Scale; collection of birth, medical, and SES information; Neonatal Medical Index; Short Temperament Scale for Infants; Synchrony Scale; PSI; Ages and Stages Questionnaire	Mother–Infant Transaction Program, focused on teaching parents to recognize infant disorganization and stress and responding to cues; 9 sessions across 3 mon.	At 6 mon., ES = 2.00 for mutual attention on Synchrony Scale	Type 2 study: +RCT, +/− (partial)Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, −Tx fidelity, +Tx manual

Table 1 (Continued)

Author(s) and year	Sample	Outcome measures	Treatment procedures	Findings	Nathan and Gorman (2002) criteria
Olafsen et al. (2006)	71 ss, 69 preterm controls, 75 full-term controls	Early Social Communication Scales	A modified version of the 'Vermont Intervention Program for Low Birthweight Infants;' aims were to (1) enable the parents to appreciate their baby's specific behavioral and temperamental characteristics, (2) sensitize parents to the infant's cues, and (3) teach parents to respond appropriately to those cues in order to facilitate mutually satisfying interactions; daily 1-hr sessions for 7 days, and 4 1-hr home visits	At 12 mon., ES = .49 for initiating joint attention	Type 1 study: +RCT, Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, +Tx fidelity, +Tx manual
Rauh et al. (1988)	25 ss, 29 LBW controls, & 28 NBW controls	Quality of Mothering and Degree of Receptivity to the Program; Seashore Self-Confidence Rating Paired Comparison Questionnaire; Taylor Manifest Anxiety Scale; Carey Infant Temperament Questionnaire; Satisfaction Scale; BSID; McCarthy Scales of Children's Abilities	Implemented by a NICU nurse; 11 1-hr sessions over 3 mon. (7 in hospital, 4 in home); followed mothers' leads; aimed to facilitate maternal adjustment to care of infant, and indirectly affect infant development; various topic areas such as maternal sensitivity and infant distress	ES = .80 (corrected, .79); cognitive diff. at age 4 yrs., maintained until age 9 yrs	Type 1 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, + Tx fidelity, +Tx manual
Achenbach, Phares, Howell, Rauh, & Nurcombe (1990) (Follow-up of Rauh et al. (1988))	24 ss, 32 LBW controls, & 37 NBW controls	At 7 yrs: Kaufman Assessment Battery for Children; PPVT	See Rauh et al., 1988	ES = .70 for total Kaufman score for LBW tx over LBW control	Type 1 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, +Tx fidelity, +Tx manual
Achenbach, Howell, Aoki, & Rauh (1993) (Follow-up of Rauh et al. (1988) and Achenbach et al. (1990))	24 ss, 31 LBW, & 36 NBW controls	At 9 yrs.: Kaufman Assessment Battery for Children; PPVT; CBCL for Ages 4–18; Teacher's Report Form of CBCL	See Rauh et al., 1988	ES = .65 for Kaufman total achievement (LBW treatment versus LBW control)	Type 1 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, +Tx fidelity, +Tx manual

Table 1 (Continued)

Author(s) and year	Sample	Outcome measures	Treatment procedures	Findings	Nathan and Gorman (2002) criteria
Resnick, Eyler, Nelson, Eitzman, & Bucciarelli (1987)	124 ss, 131 controls	BSI	Developmental interventions in the hospital and at home for first 2 yrs of life as well as counseling and parent education; water beds, visual stim, developmental exercises; individualized and updated frequently	At 24 mon., ES = .66 (corrected, .66) for MDI and .54 for PDI	Type 2 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, −Tx fidelity, +Tx manual
Sajaniemi et al. (2001)	49 ss, 51 controls	BSID at 2 yrs.; Wechsler Preschool and Primary Scale of Intelligence at 4 yrs.; Preschool Assessment of Attachment	Weekly 60-min. OT sessions at home from 6–12 mon. of age; goals: to promote normal sensorimotor development, development of play, and social-emotional development by promoting parent–infant relationship	ES = .42 (corrected, .42) for full-scale IQ at 4 yrs.	Type 2 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, −Tx fidelity, −Tx manual
Scarr-Salapatek & Williams (1973)	15 ss, 15 controls	Brazelton Cambridge Newborn Scales; Cattell Infant Intelligence Scale; ratings of maternal care	Visual, tactile, & kinesthetic stimulation during 6 wks in NICU; weekly home visits until 12 mon. of age	At 12 mon., ES = .71 for IQ	Type 2 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, −Tx fidelity, +Tx manual
Teti et al. (2009)	84 ss, 89 controls	At 3–4 mon. corrected age: Maternal Self-Efficacy Scale; Maternal Behavioral Q-Set; BSID; PSI-Short Form; Life Events Survey	Psychoeducational video about NICU environment, infants' development, and parent–child relationship; serial administration of Brazelton Neonatal Behavioral Assessment Scale; maternally-administered infant massage; 8 sessions over 20 wks	At 3 mon., ES = .72 (corrected, .72) for Bayley MDI for extremely low birthweight infants	Type 2 study: +RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Com parison group, −Tx fidelity, +/− (partial) Tx manual
van der Pal et al. (2008)	84 ss, 84 controls	Infant Behavior Questionnaire-Revised (at 9 mon.); Infant–Toddler Social and Emotional Assessment & Nijmegen Parenting Stress Index-Short Version (at 1 yr)	NIDCAP (behavior observations and guidance by a trained developmental specialist)	No sig. effects (e.g., ES = .36 for social relatedness)	Type 2 study: +RCT, −Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, −Tx fidelity, +Tx manual
Zahr (2000)	43 ss in extended-visitation group, 40 ss in short-visitation group, 40 controls (all Latino and low SES)	At 1, 4, 8, 12, 18, & 24 mon.: BSID; NCAFS; NCATS; Maternal Confidence Questionnaire; PSI; HOME; Arizona Social Support Interview Schedule	Home visits by public health nurses; extended-visitation received 19 visits across 12 mon. and short-visitation received 11 visits across 4 mon.; mothers were taught to identify cues of infants and about general caretaking skills; provision of support for mothers; goals: to enhance infant development and mother-infant interaction	ES = −.66 (corrected, −.65) for mental scores at 24 mon. in extended-visitation group, and −.43 (corrected, −.43) in short-visitation group	Type 2 study: +/− (partial)RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, +Tx fidelity, −Tx manual

Table 1 (Continued)

Author(s) and year	Sample	Outcome measures	Treatment procedures	Findings	Nathan and Gorman (2002) criteria
Zahr, Parker, & Cole (1992)	26 ss, 15 controls	Assessed weekly on Assessment of Preterm Infant Behavioral or neurobehavioral observation; BSID; Infant Characteristics Questionnaire; Mother–Infant Interaction; Maternal Confidence Questionnaire: HOME	Teaching sessions aimed to teach mothers about infants' behavioral cues; average 3.6 sessions, 60-90 min. each; individualized	At 8 mon., ES = 1.22 (corrected, 1.20) for MDI for infants <1500 grams at birth and .10 for infants >1500 grams at birth	Type 2 study: +/- (partial)RCT, +Blind assessments, +Incl/excl criteria, +Standardized dx battery, +Comparison group, –Tx fidelity, –Tx manual

Abbreviations used: ss = subjects; tx = treatment; sig. = significant; LBW = low birthweight; NBW = normal birthweight; DS = Down Syndrome; OT = occupational therapy; PT = physical therapy; BDI = Battelle Developmental Inventory; PSI = Parenting Stress Index; PPVT = Peabody Picture Vocabulary Test; CBCL = Child Behavior Checklist; BSID = Bayley Scales of Infant Development; NCAFS = Nursing Child Assessment Feeding Scale; NCATS = Nursing Child Assessment Teaching Scale; HOME = Home Observation for Measurement of the Environment.

while others were assigned by default to a specific group based on geographical factors.

Effect size calculations

As noted above, all papers included in the analyses reported sufficient statistics to calculate effect sizes. Effect sizes were calculated for primary outcome measures for each paper, and ranged from effect sizes representing changes in IQ scores to effect sizes representing changes in children's vocabulary. Effect sizes were calculated by subtracting comparison group mean outcome scores from treatment group mean outcome scores, and dividing that result by the average of standard deviations of scores for both groups. These are presented in Table 1.

We then identified those studies that used psychometrically sound, standardized measures of overall developmental ability: the Bayley Scales of Infant Development, the Stanford–Binet Intelligence Scale, the Griffiths Mental Development Scales, the McCarthy Scales of Children's Abilities, the Kaufman Assessment Battery for Children (one study), the Cattell Infant Intelligence Scale (one study), and the British Ability Scales II (all outcome measures are described in Table 1). This involved all but 11 of the total number of studies. Effect sizes generated from these instruments were then corrected for small sample size, following the methods reported in Reichow and Wolery (2009). Once these corrections were made, the standard error of the corrected effect size and the 95% confidence intervals were calculated, following Reichow and Wolery (2009). These corrected effect sizes are also included in Table 1, under the heading Findings. Papers reporting moderate to large effect sizes (.50 and above) are highlighted in gray. The corrected effect sizes and confidence intervals for studies using these instruments are plotted for each of the three diagnostic groups in Figures 1 and 2, with the Type 1 studies and the Type 2 studies grouped by type. Ages of the sample at the time of follow-up are noted in each entry. For studies in which there are multiple follow-up periods, the age of follow-up closest to age 29 months was selected, since that represented the mean age at first outcome study across all the studies.

Extraction of key ingredients

We identified the studies for each diagnostic group that were the most effective at changing child developmental outcomes based upon effect size analysis and we then examined the methodology of these intervention studies for similarities that might reflect the most powerful elements resulting in child change. In the following section, we describe these results.

Effective interventions for premature infants. A remarkable intervention study for premature infants

was carried out by the Infant Health and Development Program (IHDP; 1990), a consortium of eight sites that conducted randomized controlled trials involving 1000 infants who were followed up at age 3 years. Participants' mothers were primarily African American and Caucasian, and had attended some high school or had earned a high school diploma. Six of the seven methodological elements were described in the paper; the lack of a description of fidelity measures resulted in the Type 2 classification.

The program consisted of parent training in home visits across the first three years of life, with weekly visits for the first year and biweekly visits thereafter. Interventionists taught parents to use two cognitive stimulation curricula for low birthweight infants and toddlers, one emphasizing cognitive, linguistic, and social development via a program of games and activities, and the other involving a systematic approach to help parents manage self-identified problems. In the second year of life, infants began attending an educational daycare five days per week, in which teachers continued to utilize the stimulation curriculum, and this continued until 36 months of age. Children received 20+ hours in intervention per week, and bimonthly parent group meetings began when the infants were 12 months of age. Infants were assessed at 40 weeks and 4, 8, 12, 18, 24, 30, and 36 months of age. At age 36 months, the effect sizes for Stanford–Binet scores were .83 for heavier participants and .41 for lighter participants (resulting in an average corrected effect size of .62).

In terms of intervention characteristics, this intervention was both long-lasting and intensive. The intervention began in the home during infancy and transferred to a center-based program during the toddler period. It involved parent training in infancy during weekly home visits and through parent groups during toddlerhood. The intervention was individualized for each child. Parents were provided additional supports in terms of parent groups, case management, and transportation if needed.

Another remarkably effective intervention was reported by Rauh, Achenbach, Nurcombe, Howell, and Teti (1988), in a Type 1 study involving 25 premature infants (with an average maternal education of 14.1 years), 29 randomized comparisons, and 28 normal birthweight comparison infants followed up at age 7 years by Achenbach, Phares, Howell, Rauh, and Nurcombe (1990) and again at age 9 years by Achenbach, Howell, Aoki, and Rauh (1993). The intervention, focused on supporting maternal care, was implemented by an NICU nurse and consisted of 11 one-hour sessions over a 3-month period. Intervention began during the final week of infant hospitalization and extended into the home. Seven sessions occurred in the hospital, and four occurred in the families' homes. Nurses targeted topics related to maternal sensitivity and infant distress and fol-

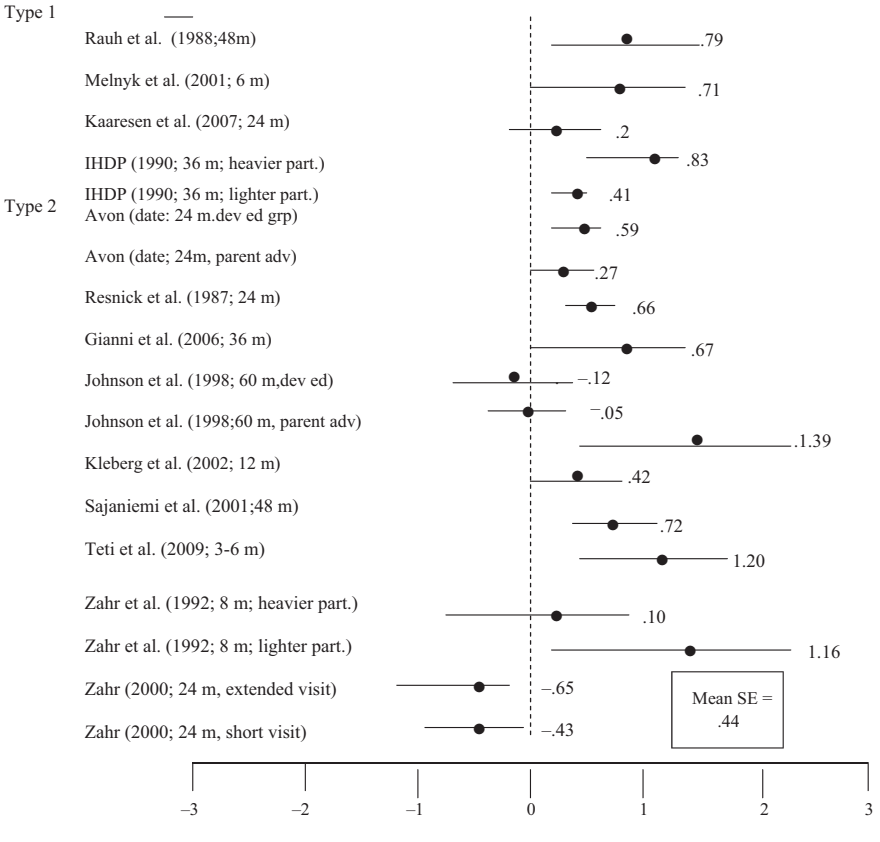

Figure 1 Corrected effet sizes, ages in months at outcome, and 95% confidence intervals of Type 1 and Type 2 interventions for premature infants

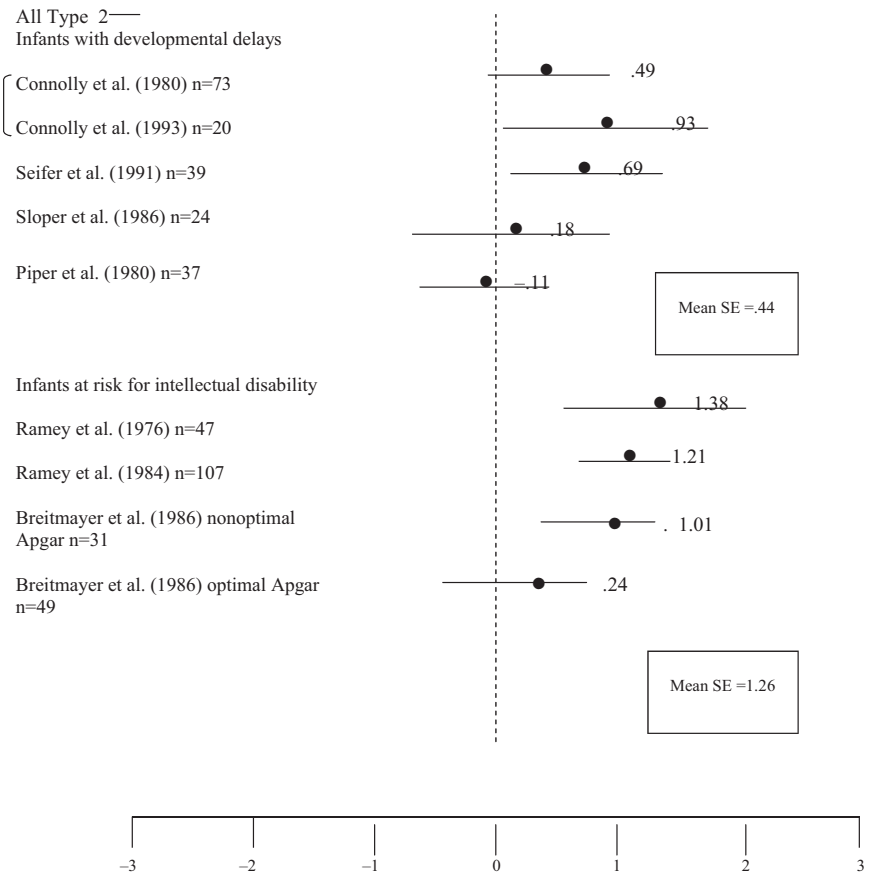

Figure 2 Corrected effect sizes, ages in months at outcome, and 95% confidence intervals of Type 1 and Type 2 interventions for infants with developmental delays and those at risk for intellectual disability

lowed the mothers' leads in terms of emphasis and pace.

Intervention outcomes were assessed with a multitude of measures administered to infants and to the mother–infant dyads every 6 months across a 4-year period. Mothers in the treatment group reported significantly higher self-confidence and satisfaction with mothering, as well as more favorable views of infant temperament than did the comparison group. Beginning at age 3 years, children in the treatment group progressively caught up to the normal birthweight comparison group on cognitive scores (Rauh et al., 1988). Further follow-up at age 7 years (Achenbach et al., 1990) and at age 9 years (Achenbach et al., 1993) continued to find the treatment groups' cognitive scores similar to those of normal birthweight children and significantly higher than the premature control group. Effect sizes for cognitive scores at age 4 years was .79 (corrected effect size), at age 7 years was .70, and at age 9 years was .65.

This intervention occurred over a short period of 3 months and involved contacts both in the community and at home. Parents were coached in techniques aimed to bolster the development of their infants. The intervention was broad-based, individualized, and provided one-on-one in homes by parents. Parents were not provided with additional support beyond the intervention.

These two randomized controlled studies demonstrate the largest effect sizes in this sample that were sustained well into early childhood and beyond. They stand out for two reasons: the IDHP (1990) study because of the enormous sample size and lengthy follow-up period, and the Rauh et al. (1988) study because of the sustained effects over a very long follow-up period. However, the interventions are quite different, with the former a very long-lasting and intensive intervention carried out for 36 months and the second a very brief intervention lasting only 3 months and carried out by a visiting nurse. Common elements include an individualized developmental curriculum for children, a strong focus on parent training and parent delivery of the intervention, and emphasis on supporting parents.

There was also a study that did not find any positive change due to intervention (Zahr, 2000). This study focused on low-income infants from minority families and involved a low-intensity intervention focused on general caretaking skills and sensitivity to infant cues. The intervention was delivered either for 19 visits across 12 months, or 11 visits across 4 months. Corrected effect sizes were –.65 for the extended period group and –.43 for the shorter period group.

In reviewing these studies as a group, and as demonstrated in Figure 1, there are overall moderate effects of these intervention strategies for premature

infants, though there is much variability. The mean effect size of this group of studies is .44, demonstrating that these intervention strategies, focused on parent coaching, are effective in improving developmental outcomes of the infants receiving the experimental treatments, at least within the time period assessed.

Infants with developmental delays. Connolly, Morgan, Russell, and Richardson (1980) examined the effects of treatment on children diagnosed with Down syndrome who had participated in the Early Intervention Program at the Child Development Center of the University of Tennessee Center for the Health Sciences when under the age of 3 years. This program's goals involved improving the parent–child relationship and maximizing the overall development of each child. For 10 weeks, families participated in weekly, 2.5-hour group sessions at the Center. During the first hour of each session, parents and children participated together while professionals taught and demonstrated to parents various developmental interventions. During the second hour, parents participated in a group therapy session, discussing their feelings and concerns, while the children were treated individually. Finally, a half-hour was spent dealing with feeding-skill development. In the winter and summer following this 10-week program, parents continued individualized home programs, and had occasional visits by staff of physical therapy and nursing departments.

At age 3–6 years, 20 children who completed this intervention were compared to 53 children who had not received it. There was a significant group difference on the Stanford–Binet favoring the children who received the intervention, with a corrected effect size of .49. At age 16 years, ten children who had received the intervention were again compared on the Stanford-Binet to ten who had not, with a corrected effect size of .93 favoring the intervention group. However, this study had a variety of methodological weaknesses, including lack of randomized assignment, lack of raters blind to intervention status, and lack of treatment manuals or fidelity measures. There was also considerable attrition in both groups at the age 16 assessment.

In terms of intervention characteristics, density and duration were moderate and mixed across participants. The intervention was delivered in the community and at home and involved parents heavily in terms of coaching and relying on them to practice developmental activities with their children. It was broad-based and individualized, and provided in a mixed one-to-one and group setting. Families were provided with additional support in the form of parent groups and therapy.

In reviewing these studies as a group, and as demonstrated in Figure 2, there are overall moderate effects of these intervention strategies for infants with a variety of significant developmental disorders, though, as above, there is much variability. The mean effect size of this group of studies is .44, demonstrating that these intervention strategies, most of them focused on parent coaching, are effective in improving developmental outcomes of the infants receiving the experimental treatments, at least within the time period assessed.

Children at risk for intellectual disability. The Carolina Abecedarian Project (Ramey & Campbell, 1984; Ramey & Smith, 1976) was one of several well-publicized studies that attempted to prevent intellectual disability in infants at risk due to poverty and intellectual impairments of their mothers. Fifty infants were randomized into intervention and comparison groups. The full-day intervention was delivered in specialized daycare centers beginning when the infants were 6–12 weeks of age and continued until age 5 years. The infant curriculum consisted of activities designed to stimulate language, motor, social, and cognitive skills and was delivered by the daycare staff. After the third birthday, the intervention became an excellent preschool curriculum with a particular emphasis on language development. Families were provided with additional support in the form of case management, nutrition, medical assistance, and transportation if needed.

Ramey and Campbell (1984) compared the scores of these children to 53 control children on the Bayley Scales of Infant Development, the Stanford–Binet Intelligence Scale, and/or the McCarthy Scales at 6, 12, 18, 24, 30, 42, 48, and 54 months of age. Beginning at 18 months and on every test thereafter, those in the treatment group outscored control children. The corrected effect size for Bayley scores at 18 months was 1.38, and for Stanford–Binet scores at 54 months of age was 1.21.

In terms of intervention characteristics, both density and duration were high, with 40 hours per week of intervention for a period of 60 months. Ratios were those of excellent daycare centers. The curriculum was broad-based and individualized, with special emphasis on language development. Methodological weaknesses included absence of blind assessors and treatment fidelity checks.

In reviewing these studies as a group, and as demonstrated in Figure 2, there are overall large effects of these intervention strategies for infants at risk for intellectual disability due to parental lower IQs and poverty, though there is much variability. The mean effect size of this group of studies is 1.26, demonstrating that these intervention strategies, most of them delivered in high-quality child care settings combined with parent coaching and support, are effective in markedly improving developmental outcomes of the infants receiving the experimental treatments, at least within the time period assessed.

For the purposes of comparison, we have also included a similar figure from Reichow and Wolery

(Figure 3; 2009), demonstrating effect sizes for young children with autism receiving intensive applied behavior analysis following Lovaas's (1981, 1987, 2003) model. For the children in these studies, interventions were carried out for 30–40 hours per week, in 1:1 ratios, mostly at home but a few in special group settings, using discrete trial teaching. While these studies are delivering more intensive intervention than most of the other studies cited in this paper, the mean corrected effect sizes reported are moderate, similar to those achieved by intervention studies for other infants with delays.

Taken as a group, the mean effect sizes across all these studies suggests a high degree of plasticity in developmental outcomes in infants and toddlers with known developmental impairments and a marked capacity to respond to carefully delivered infant interventions with developmental acceleration. The autism outcome data from the most intensive and carefully completed intervention studies is quite similar to the effect sizes achieved by the intensive interventions delivered of infants at risk of developmental impairment carried out for long periods of time at high intensity. To what extent the very large effect sizes gained in these two groups are due to the intense and long-lasting interventions, and to what extent they are due to child-specific characteristics in these two groups, is unknown and presents a very interesting question for future research.

Discussion

In all, 32 Type 1 or Type 2 Studies were identified that focused on infants and toddlers in the birth to 3-year chronological age range. In the previous sections, a sampling of the most efficacious studies was provided, focusing on their intervention characteristics and methodological rigor. The effect size analysis conducted on all 32 studies allows us to extract key intervention ingredients that appear to contribute to successful outcome. Four characteristics appear repeatedly in the efficacious interventions: (1) parent involvement in intervention, including ongoing parent coaching that focused both on parental responsivity and sensitivity to child cues and on teaching families to provide developmentally based, individualized infant interventions, (2) individualization of curriculum to each infant's developmental profile, (3) focusing on a broad range of learning targets, and (4) temporal characteristics involving beginning as early as the risk is detected and providing greater intensity and duration of the intervention. It is interesting that a large majority of the interventions were carried out in individual homes in regular home visits, coaching families. The only center-based interventions among these Type 1 and Type 2 papers were those for low-income infants, and these involved full time daycare in a language-rich, excellent setting, but group care began after the infants were 1 year old. Before that, the home visit and parent coaching methods involving parental sensitivity and infant development activities were also used. We did not find studies that compared efficacy of center-based to home-based intervention in this literature, but a multitude of carefully controlled studies of typically developing infants find very few meaningful differences between these two child-rearing environments on developmental profiles of preschoolers (e.g., National Institute of Child Health and Human Development Early Child Care Research Network, 2000).

Given these common ingredients among the most efficacious intervention studies, it is interesting to examine the non-efficacious interventions to determine which of these key ingredients were present. The intervention described by Zahr, Parker, and Cole (2000) compared home visitation for two lengths of

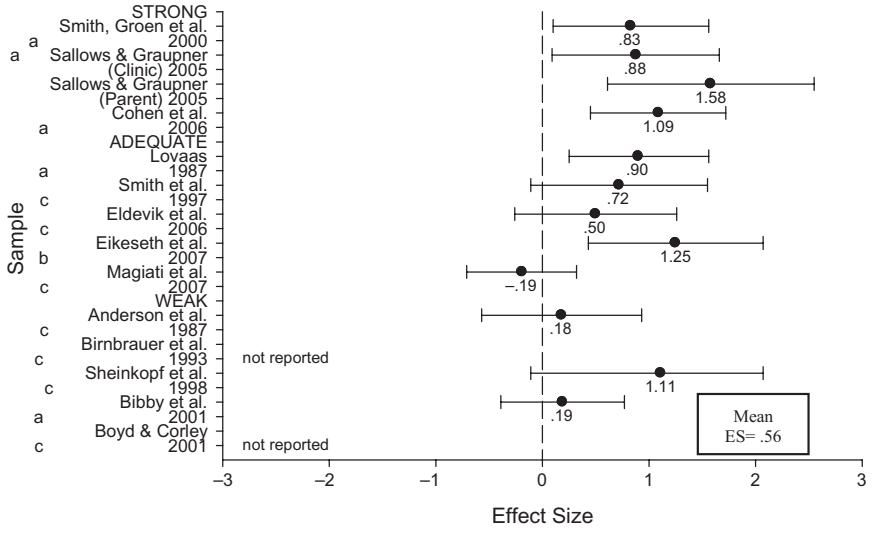

Figure 3 Corrected effect sizes, ages in months at outcome, and 95% confidence intervals of interventions for young children with ASD toddlers. Printed with permission of Springer

time – 4 months versus 12 months after hospital discharge – for impoverished Latino mothers and their premature infants. There were no gains in child developmental rates related to this intervention, though previous studies of the same intervention model by the same authors with other participant groups demonstrated positive intervention effects. The authors note that the caretaking environment in these families, as a group, differed from previous study groups, and that cultural differences in infant rearing patterns, combined with already existing social supports in these Latino communities, may support infant development in these families more strongly than other groups studied, resulting in less 'room' for improvements due to the intervention. The studies by Zahr and colleagues are good examples of the program of studies that are needed on a specific intervention approach in order to determine who will benefit and what intensity of intervention is needed. The common elements listed above are excellent candidates for manipulation within experimental designs in future studies to determine moderators and mediators of improved outcomes for children with developmental risks.

However, two words of caution are necessary. First, the results of the Avon Premature Infant Project (1998) point out the crucial importance of long-term follow-up. This very well done, randomized study delivered a developmental curriculum to a large group of parents and infants via nurse visits (n = 116) or via parent groups (n = 106). At age 2 years, children receiving the regular home visits and developmental curriculum showed much larger effects of the intervention (ES = .59) than did the parent group intervention (ES = .27). However, follow-up of two-thirds of the sample by Johnson, Ring, Anderson, and Marlow (2005) at age 5 years revealed no group differences (home visit group ES = −.12; parent group ES = −.05) compared to the controls.

Second, it is important to note that there are some exceptions to key ingredients pulled from the literature review (e.g., that those interventions which provide long-term, intensive, and comprehensive intervention are more efficacious than time-limited, focal interventions). For example, Teti et al. (2009) discuss a short-term focal intervention with impressive results. Nevertheless, the largest trials (e.g., IHDP, 1990; Resnick, Eyler, Nelson, Eitzman, & Bucciarelli, 1987) support the conclusion that long-term, intensive, and comprehensive interventions are highly efficacious. Future research may help to further parcel out the importance of intervention intensity, duration, and comprehensiveness.

To what extent infants and toddlers receiving these early interventions show long-lasting benefit is a seldom studied question. However, the question underscores a critically needed feature of future intervention studies for all groups of infants and toddlers: long-term follow-up. Documentation of long-term effects of early intervention will assist the public in making important decisions regarding funding for these services and in assessing the costs and benefits to individuals and to communities that come from high-quality infant intervention programs.

Implications for research in infant/toddler interventions for ASD

The age of early recognition of ASD or ASD risk is fast approaching 12 months and research groups are working hard to identify risk signs even earlier, for the express purpose of enabling treatment to begin as soon as possible in order to reduce or reverse signs and symptoms of autism. The large body of research in infant intervention for other clinical infant groups and their families suggests starting points for research on infant interventions for ASD. Given the amount of science that already exists in early intervention for ASD, it would be extremely helpful for ASD researchers to design comparative studies that allow for isolation of the 'active ingredients' for best outcomes for infants with ASD. Specific intervention variables to be examined when considering intervention for infants at risk for ASD include the following.

ASD-specific versus general developmental intervention. Some approaches to early ASD intervention, both from applied behavior analysis and from developmental approaches, target a broad range of learning targets (Maurice, Green, & Luce, 1996; Rogers & Dawson, 2009), similar to what has been described above in the infant literature from other groups. However, in the literature on ASD there has also been the focus on primary deficits, or core features that are impaired in ASD and that appear to prevent other areas of development from flourishing, resulting in secondary deficits. Core deficits suggested early in ASD have included joint attention (Whalen, Schreibman, & Ingersoll, 2006), imitation (Rogers & Williams, 2006), language, and symbolic play (Young, Brewer, & Pattison, 2003). While there is currently considerable controversy about whether there are such 'primary deficits' (Happé & Ronald, 2008), there is repeated evidence that targeting one or more of these core features does result in positive changes in other areas – 'collateral effects' is the term most often used. Furthermore, these collateral effects typically occur among the various core features of ASD listed above, suggesting that they are not independent of each other (Whalen et al., 2006). Intervention approaches for preschoolers with ASD that have focused on core skills rather than a broad array of skills include Pivotal Response Training, focused on communication (e.g., Koegel, Koegel, Harrower, & Carter, 1999), the work by Kasari and colleagues focused on joint attention and symbolic play (e.g., Kasari, Freeman, & Paparella, 2006; Kasari, Paparella, Freeman, & Jahromi, 2008),

imitation (e.g., Whalen et al., 2006), and social development (Odom & McConnell, 1996). The idea that targeting core developmental features results in downstream gains in other important developmental areas is an important tenet of developmental psychology.

Targeting intervention on core features may be a more economical approach to intervention, in terms of time, family involvement, and cost, than delivering global teaching based on every aspects of a child's development. Determining whether a targeted approach to a limited set of skills is as efficacious as a global approach to development in intervention is a critical research need, given the number of children who need intervention and the limited resources that communities have to provide it. A study design that would help to answer this question would involve assigning infants and toddlers with ASD randomly to either a comprehensive or a targeted set of treatment objectives within a given teaching approach, holding all other variables constant, and following the infants along with careful and frequent assessment of all developmental areas. This type of study would help us learn whether the approach that has been so effective in the other infant interventions – use of a broad developmental curriculum – is also optimal for ASD.

Intensity and delivery system for intervention. The examination of effect sizes reviewed in this paper suggest that treatment intensity, including beginning treatment as early as possible and providing that treatment for long durations, contributes to more efficacious interventions. Thus, a second question that arises in discussing autism early intervention is the intensity of treatment. The current national standard suggests 25 hours per week of intervention for young children with ASD (National Research Council, 2001). However, the only infant treatments for other clinical conditions delivering this many hours of intervention per week are the center-based approaches that focused on infants at socio-cultural risk for intellectual disability (e.g., Ramey & Campbell, 1984). Given the success of home visit formats for infants with other conditions and given the expense of all-day specialty center-based care for children, the use of a home visitation model with ongoing parent training and support is likely a viable model for infant and toddler ASD intervention. When parents incorporate specific techniques into their ongoing interactions with their children, and when they maintain a high rate of interactions with their children throughout the day, then child social learning is occurring throughout the infant's waking hours.

However, we have little information about the extent to which parents actually infuse their newly learned skills into their ongoing caretaking with their children from any of the infant intervention studies. Furthermore, few of the autism treatment manuals that could be used for toddlers and parents provide tested methods for examining parent implementation of intervention techniques during dressing, feeding, bathing, and other household routines (although see Prizant, Wetherby, Rubin, Laurent, & Rydell, 2006 and Wetherby & Woods, 2006 for a model for others in this area). Research needs for home-based autism intervention delivered by parents include: (1) developing interventions that are meant to be delivered by parents to infants during caretaking and play activities, (2) development of low-cost methods for measuring parental fidelity of implementation in ways that are acceptable to parents and unobtrusive, and (3) developing measurement approaches for yielding reliable data concerning parental intensity of implementation. Can new technologies that are becoming available, like LENA (LENA Foundation, 2010), assist researchers to examine fidelity and intensity of parent-delivered interventions? Until these methods are worked out, we lack good ways of measuring the independent variable. These issues are crucial for designing efficacious autism intervention for infants in the 6–18-month age range.

Transferring intervention skills from therapists to parents. A third question arises when parents are the sources of intervention. What are the best ways of transferring intervention skills from therapists to parents? Several different models for teaching parents to carry out interventions exist. Some models use didactic parent instruction and training (e.g., Nefdt, Koegel, Singer, & Gerber, 2010); others argue for the importance of a coaching versus a didactic relationship (e.g., Vismara & Rogers, 2008). Some approaches teach parents in groups (Coulter & Gallagher, 2001) and others teach parents individually (Hanft, Rush, & Shelden, 2004). Some rely extensively on therapist modeling (e.g., Chandler, Christie, Newson, & Prevezer, 2002); however, therapist modeling raises concerns about contributing to parents' feelings of inadequacy. There is a whole literature on adult versus child learning styles and on individual differences among adults in learning styles. Just as we need comparative studies of the effects of different intervention approaches on children and families who differ from each other (treatment-by-aptitude interactions), we also need such studies to determine the best ways to help and support parents to provide learning opportunities for their children with appropriate frequency and high fidelity.

However, like parents of infants with other developmental disorders, parents of infants and toddlers with ASD are not community intervention providers; they are parents of an infant or toddler just diagnosed with a serious chronic developmental disorder. They are experiencing a tragic and life-altering event, one with long-term effects on everyone in the family. They need information, support, and services

for their child. How do we support them in this part of their lives, and also pass on intervention skills? Mental health professionals must be part of intervention teams, and research projects that examine parents as therapists need to examine this dimension of parenting of an infant or toddler with ASD, as the intervention studies of other infants have demonstrated. Acceptability of a specific intervention for families, and its ability to provide needed support for the family as a whole, is an important aspect to be measured in infant–toddler intervention studies. Furthermore, no one intervention approach will meet the needs of all families. How to individualize, and what to individualize, for each family, within the structure of a manualized, empirically supported treatment, is a crucial research question, in order to meet the needs of diverse families and children. Whether intervention approaches that provide the most adequate family support also result in families which provide high-quality intervention at home is an empirical question, and it is an important one to study as we design and carry out interventions for infants and toddlers with ASD.

Conclusion

The goal of this paper was to provide researchers with a starting point for designing interventions for infants and toddlers with ASD, as well as to determine whether researchers designing intervention studies for infants and toddlers with ASD are on the right track. While intervention research typically follows a pyramid of designs, beginning with case studies, then moving to single-subject designs, then group designs with treatment as usual, and finally comparative designs (Lord et al., 2006; Smith et al., 2007; Uzgiris, 1973), this approach takes many years, as we clearly see in the general infant intervention literature reviewed above. ASD researchers can shorten the period of treatment development by building from this existing body of work instead of starting anew, by designing comparative studies to manipulate the key elements identified here, as well as others, and by testing specific features, rather than comprehensive interventions, so that efficacious interventions for infants at risk of ASD can be tested and ready for the infants identified by the early detection research that is moving so quickly.

Finally, determining the content of what is taught to parents needs to come from a research agenda. The evidence is mounting that assisting parents to learn to read and respond sensitively to their children's communications is helpful for child communication development, for infants and toddlers with typical development as well as those with clinical conditions, including ASD (Siller & Sigman, 2002, 2008). It may be that there are a few other general interaction skills in addition to responsivity and sensitivity that are crucial 'active ingredients' in beneficial parent-delivered interventions for infants and toddlers at risk of ASD. If studies can use careful empirical methods to isolate, test, and identify those core parent–child interaction skills that lead to maximal child progress, then we may be able to move quickly to develop, package, and transmit effective ASD curricula to parents.

However, it is quite likely that children with different patterns of development and behavior, and parents with different child-rearing styles, beliefs, and values, will benefit from different approaches. This touches on the need to identify mediators and moderators of outcome, involving both child and family characteristics. Designing studies with sufficient group sizes to allow for such analyses, and designing comparative studies that would allow for such analyses, will move us ahead farther than small controlled studies focused on one intervention and looking only for main effects. Identifying and disseminating effective interventions for infants and ever-younger toddlers with ASD depends on our ability to identify active ingredients and mediators and moderators of treatment effects. However, the infant intervention research already accomplished suggests that the appropriate starting place is at home, with families, focused on the child's developmental needs, sensitive, responsive parent–child interaction styles, and family support. For families who need center-based daycare, studies from other infants suggests that high-quality daycare can support development very well. We also have a few studies of children with autism as young as 2 years thriving in both inclusive day programs modeled on high-quality daycare centers (McGee, Morrier, & Daly, 1999; Stahmer & Ingersoll, 2004), and specialty groups providing intensive autism intervention (Owens, Granader, Humphrey, & Baron-Cohen, 2008). We need to understand the active ingredients and mediators and moderators of outcomes of infants and toddlers with ASD in center-based programs as well as those at home, from culturally diverse families, in order to have a group of effective ASD intervention models that can be fit to the huge variation in characteristics and needs of these children and of their families across the globe.

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Key points

- Early screening efforts are focused on identifying ASD risk in children under age 3 years, but there is a scarcity of empirical investigation into successful intervention characteristics for this population.
- With the aim of extracting successful intervention characteristics for infants and toddlers with developmental delays, the current paper presents a literature search and effect size analysis of early intervention studies for infants and toddlers with a variety of non-autism developmental delays or those at risk for such delays.
- Effect size analyses indicate that there are four key intervention characteristics used repeatedly in successful interventions: (1) parent involvement, (2) individualization, (3) focusing on a broad range of learning targets, and (4) providing early, intense interventions for a long duration.
- These characteristics represent a solid foundation from which researchers and clinicians can build efficacious interventions for infants and toddlers with ASD.

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