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Review

A meta-analytic study on the effectiveness of comprehensive ABA-based early intervention programs for children with Autism Spectrum Disorders

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ABSTRACT

Excitement and controversy have surrounded the effectiveness of Early Intensive Behavioral Intervention (EIBI) for young children with autism. The purpose of this meta-analysis was to investigate the effectiveness of EIBI based on applied behavior analysis in young children with Autism Spectrum Disorders (ASD). There were 11 studies with 344 children with ASD. Quality of studies was assessed using the Downs and Black Checklist. Experimental groups who received EIBI outperformed the control groups on IQ, non-verbal IQ, expressive and receptive language and adaptive behavior. Differences between the experimental and control groups were 4.96–15.21 points on standardized tests. These results strongly support the effectiveness of EIBI.

Contents

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1. Introduction

Autism Spectrum Disorder (ASD) is characterized by severe and sustained impairment in communication and social interaction and restricted patterns of ritualistic and stereotyped behaviors manifested prior to age 3 years (APA, 1994). In approximately 26–40% of young children with ASD intellectual disability (ID) is also present (Baird et al., 2000; Chakrabarti & Fombonne, 2001). A range of behavior problems are also common, including self-injury, anxiety, compulsions, withdrawal, uncooperative behavior, aggression, and destruction of property (Gadow, DeVincent, Pomeroy, & Azizian, 2004; Lecavalier, 2006; McClintock, Hall, & Oliver, 2003). There are many intervention approaches including applied behavior analysis (ABA), diets and vitamins, floor time, holding, medication, options, Picture Exchange Communication System, sensory integration, speech and music therapy, special education and visual schedules (Green et al., 2006; Hess, Morrier, Heflin, & Ivey, 2008); however, there is little empirical evidence for the effectiveness of many of these approaches and available evidence shows mixed results (Foxx, 2008; Howlin, 1997; Schechtman, 2007; Smith, 1999).

Building on research from the 1960s, Early Intensive Behavioral Intervention (EIBI) is the most often studied type of intervention for children with ASD (Matson & Smith, 2008). It is based on principles of operant learning and focuses on remediation of deficient language, imitation, pre-academics, self-help and social interaction skills (Sturmey & Fitzer, 2007) which are broken down into discrete components and taught on a one-to-one basis in school and/or at home, typically using discrete trial teaching (with subsequent planned generalization), reinforcement, backward chaining, shaping, extinction, prompting and prompt fading (Duker, Didden, & Sigafoos, 2004). Parental participation is considered essential to achieve generalization and maintenance. EIBI is effective when it is both intensive (i.e. approximately 40 h per week) and extensive – minimally 2 years (Lovaas, 2003; Matson & Smith, 2008).

Studies have reported mixed outcomes (Eikeseth, 2009). Several descriptive reviews have concluded that, although EIBI generally has meaningful benefits for young children with ASD, there were large individual differences in treatment response and most children continued to require specialized services (Eikeseth, 2009; Howlin, Magiati, & Charman, 2009; Matson & Smith, 2008; Rogers & Vismara, 2008; Shea, 2004; Smith, 1999). Two meta-analyses (Eldevik et al., 2009; Reichow & Wolery, 2009) found an average medium to large effect size for IQ change despite using different effect sizes (standardized mean change effect size versus a standardized mean difference effect size) and differences in study selection criteria. Eldevik et al. (2009) also found a medium effect size on change of the adaptive behavior composite. Several studies have also reported supplementary measures of adaptive behavior; however, meta-analyses have not systematically analyzed full scale, verbal and performance IQ and measures of adaptive behavior. Thus, it is unclear if the effects of EIBI are robust across all these measures. Therefore, this meta-analysis synthesized the outcomes of comprehensive EIBI programs in which data were collected in group designs using full scale, verbal and performance IQs and measures of adaptive behavior.

2. Method

2.1. Search methods and selection of studies

There were three search strategies. First, computerised literature searches of MedLine, Psychinfo and Eric were conducted using the keywords "behavioral treatment" or "behavioral intervention" in combination with "autism", "autism spectrum disorder" or "pervasive developmental disorder". Second, a manual search of the following journals was performed: *American Journal on Mental Retardation/American Journal on Intellectual and Developmental Disabilities, Autism, Behavioral Interventions, Behavior Modification, Focus on Autism and Other Developmental Disabilities, Journal of Applied Behavior Analysis, Journal of Autism and Developmental Disorders, Journal of Intellectual Disability Research, Intellectual and Developmental Disabilities/Mental Retardation, Research in Autism Spectrum Disorders and Research in Developmental Disabilities*. Third, recent publications on EIBI were inspected to confirm the manual and computer searches. Each article on EIBI retrieved through the manual or computerised search was checked on relevant studies.

All EIBI studies in young children with ASD were selected and reviewed if: (1) interventions addressed all three core deficits in autism using ABA; (2) only studies with a pre-test post-test control group were included; (3) all participants had a diagnosis of Autism Spectrum Disorder, including DSM-III, DSM-III-R DSM-IV or ICD diagnosed Autistic Disorder (AD) and Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS); (4) children were aged 10 years or younger at treatment onset; (5) studies contained quantitative outcome data including means and standard deviations on standardized measures of IQ, language and adaptive behavior; and (6) the study was published in English in a peer-reviewed journal between 1980 and 2009. Fig. 1 gives an overview of the selection and exclusion process.

Eleven studies met inclusion criteria (see Table 1). Ten were retrieved by computer search and a manual search and reference tracking resulted in one additional study. Each study sample could contribute only one data point to the meta-analysis; therefore, since Eikeseth, Smith, Jahr, and Eldevik (2002, 2007) used the same participants, these two studies were treated as one study. Only Smith, Groen, and Wynn (2000) was a fully randomized control trial. Other studies used a pre-test post-test control group design, which was not fully randomized. A second reviewer examined the first 50 articles of the MedLine database. Agreement between the reviewer and the first author was 100%. Study quality was assessed by two independent reviewers using Downs and Black's (1998) checklist.

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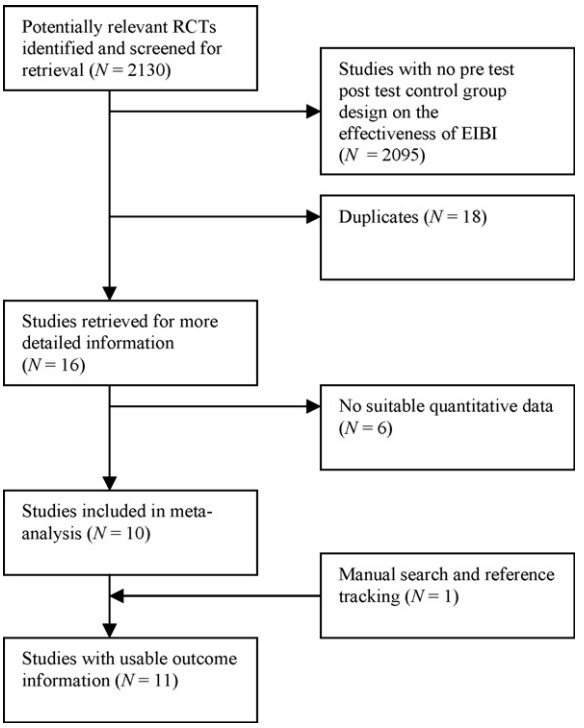

Fig. 1. Study identification, screening and selection.

2.2. Data extraction

Outcome variables were IQ and adaptive behavior. All means and standard deviations were obtained directly from published papers when available. When the study did not provide these data (Smith et al., 2000: Non-verbal IQ, Expressive and Receptive Language), the standard scores were calculated using the following formula: outcome in months/chronological age in months × 100. When studies did not report means and standard deviations of pre- and post-tests, the study was excluded. For each study, mean differences and standard deviations between baseline and treatment were calculated. When a study had two control groups, a weighted mean and standard deviation was calculated, since the similarity between both control groups and the experimental group and the control groups of the other studies made it problematic to select one control group over the other. The meta-analysis was conducted using meta-analysis with interactive explanations (MIX) (Bax, Yu, Ikeda, Tsuruta, & Moons, 2006, 2008).

3. Results

3.1. Study characteristics

Participants' average age ranged from 33.56 (Magiati, Charman, & Howlin, 2007) to 65.68 months (Eikeseth et al., 2002). Reported gender was 65.70% male, 10.47% female; 23.84% was not reported. All had an Autism Spectrum Disorder (47.09% autistic disorder; 12.79% PDD-NOS; 40.12% not specified) and average IQ ranged from 27.52 (Smith, Eikeseth, Klevstrand, & Lovaas, 1997) to 76.53 (Magiati et al., 2007).

Experimental groups received on average 12.5 (Eldevik, Eikeseth, Jahr, & Smith, 2006) to 38.6 h (Sallows & Graupner, 2005) of EIBI for 10 months to more than 2 years. Control groups consisted of less intensive EIBI (<10 h per week; Smith et al., 1997), 12.5–29.08 h per week eclectic treatment (Eikeseth et al., 2002; Eldevik et al., 2006; Howard, Sparkman, Cohen, Green, & Stanislaw, 2005), parent-directed ABA (Sallows & Graupner, 2005; Smith et al., 2000) or treatment as usual (e.g., public early intervention, nursery provision, Portage, school based intervention; Howard et al., 2005; Magiati et al., 2007; Reed, Osborne, & Corness, 2007; Remington et al., 2007; Sheinkopf & Siegel, 1998. Howard et al. (2005) and Reed et al. (2007) had two control groups. Table 1 shows the demographic characteristics.

3.2. Child outcomes

The EIBI group outperformed the control group on all dependent variables. Full scale and non-verbal IQ improved in the EIBI group 11.98 and 11.09 points more than in the control groups, respectively. In receptive and expressive language, the

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Table 1
Characteristics of included studies. N.B. EG = Experimental group; CG = Control Group; CA = Chronological Age in months at onset of treatment; NR. = not reported; AD = Diagnosis of Autistic Disorder by start of the treatment; PDD = Diagnosis of Pervasive Developmental Disorder-Not Otherwise Specified by start of the treatment; ASD = A diagnosis of Autism Spectrum Disorder; this include Autistic Disorder (AD) and Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS); Treatment hours are hours reported in the first year of treatment.

Study	Sample EG	Sample CG	Intervention EG	Intervention CG	Outcome
Eikeseth et al. (2002, 2007)	*N*: 13 (8 boys) CA: 66.31 (11.31) IQ: 61.92 (11.31) ASD: 13	*N*: 12 (11 boys) CA: 65.00 (10.95) IQ: 65.17 (14.97) ASD: 13	28.00 h per week 1–1 behavioral treatment based on Lovaas using a discrete trial format	29.08 h eclectic treatment per week.	The EG made significant larger gains than the CG on IQ, receptive and expressive language and adaptive behavior.
Eldevik et al. (2006)	*N*: 13 (10 boys) CA: 53.0 (9.5) IQ: 41.0 (15.2) AD: 13	*N*: 15 (14 boys) CA: 49 (16.9) IQ: 47.2 (14.7) AD: 15	12.5 h 1–1 behavioral treatment based on Lovaas using a discrete trial format; for 20.3 months	12 h eclectic 1;1 treatment for 21.4 months	The EG displayed significant more change than the CG on intellectual functioning, language and the communication domain of the VABS; no significant differences on other measurements.
Howard et al. (2005)	*N*: 29 (25 boys) CA: 30.86 (5.16) IQ: 58.54 (18.15) AD: 24 PDD-nos: 5	CG1 *N*: 16 (16 boys) CA: 34.56 (6.53) IQ: 59.88 (14.85) AD: 9 PDD-nos: 7 CG2 *N*: 16 (13 boys) CA: 37.44 (5.68) IQ: 53.69 (13.50) AD: 12 PDD-nos: 4	25 – 40 h per week 1–1 behavioral treatment based on ABA using a discrete trial format	CG1: 15 h per week public early intervention (eclectic treatment in small groups) CG2: 30 h per week 1:1 or 1:2 eclectic treatment	At follow-up the EG outperformed on intelligence, language and adaptive behavior.
Magiati et al. (2007)	*N*: 28 (27 boys) CA: 38.0 (7.2) IQ: 83.0 (27.9) AD: 19 PDD: 9	*N*: 16 (12 boys) CA: 42.5 (7.8) IQ: 65.2 (26.9) AD: 13 PDD: 3	32.4 h 1–1 behavioral treatment based on Lovaas using a discrete trial format; ≥2 years	25.6 h nursery provision using several developmental and behavioral approaches; ≥2 years	No significant differences in cognitive ability, language, play or severity of ASD. Large individual differences in IQ and language level.
Remington et al. (2007)	*N*: 23 (boys: n.r.) CA: 35.7 (4.0) IQ: 61.43 (16.43) ASD: 23	*N*: 21 (boys: n.r.) CA: 38.4 (4.4) IQ: 62.33 (16.64) ASD: 21	25.6 h 1–1 behavioral treatment based on ABA using a discrete trial format; ≥2 years	Standard provision for young children with autism	The EG outperformed the CG on intelligence, language, daily living skills and positive social behavior.
Reed et al. (2007)	*N*: 12 (11 boys) CA: 40 IQ: 55.6 (13.8) ASD: 12	*N*: 20 (18 boys) CA: 43 IQ: 51.9 (20.1) ASD: 20 CG2: N: 16 (n.r. boys) CA: 38 IQ: 53.3 (16.1) ASD: 16:	30.4 h per week 1–1 generic ABA programs (Lovaas, CABAS and Verbal behavior)	CG1: 12.7 h per special nursery placement in small classes CG2: 8.5 h per week portage, a home-based parent administered teaching program.	EG made greater intellectual and educational gains than children in CG1 and CG 2. CG1 made larger gains than CG2.
Sallows and Graupner (2005)	N: 13 (11 boys) CA: 35.00 (4.86) IQ: 50.85 (10.57) AD: 13	*N*: 10 (8 boys) CA: 37.10 (5.36) IQ: 52.10 (8.98) AD: 18	38.60 h per week Clinic directed 1–1 behavioral treatment based on Lovaas; ≥2 years	31.67 h per week parent-directed 1–1 behavioral treatment based on Lovaas; ≥2 years (6 h supervision per month).	After 4 years treatment no group differences existed. The IQ increased from 51 to 76 and 11 children had an IQ over 85.
Sheinkopf and Siegel (1998)	*N*: 11 (n.r. boys) CA: 33.8 (6.2) IQ: 62.8 (27.4) AD: 10 PDD-nos: 1	*N*: 11 (n.r. boys) CA: 35.2 (5.5) IQ: 61.7 (20.2) AD: 10 PDD-nos: 1	19.45 h per week 1–1 home-based behavioral treatment based on Lovaas for 15.36 months	10.70 h school based intervention and 0.44 h other one-to-one therapies.	Children in the EG had higher post treatment IQ scores and post treatment measurements displayed a modest group differences on autism severity.

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Table 1 (*Continued*)

Study	Sample EG	Sample CG	Intervention EG	Intervention CG	Outcome
Smith et al. (1997)	*N*: 11 (11 boys) CA: 36 (6.90) IQ: 28 (4.90) ASD: 11	*N*: 10 (8 boys) CA: 38 (5.40) IQ: 27 (5.40) ASD: 10	≥30 h 1–1 behavioral treatment based on Lovaas using a discrete trial format; ≥2 years	≤10 h 1–1 behavioral treatment based on Lovaas using a discrete trial format; ≥2 years	In follow-up the EG had higher IQ scores than the CG. 10/11 children in the EG used spoken words versus 2/11 in the CG.
Smith et al. (2000)	*N*: 15 (12 boys) CA: 36.07 (6.00) IQ: 50.53 (11.18) AD: 7 PDD: 8	*N*: 13 (11 boys) CA: 35.77 (5.37) IQ: 50.69 (13.88) AD: 7 PDD: 6	24.52 h 1–1 behavioral treatment based on Lovaas using a discrete trial format;≥2 years	3–9 months 5 h per week parent training in 1–1 ABA and 1 h supervision per week.	The EG outperformed the CG at follow-up on IQ, visual spatial skills, language and academic skills and had less restrictive school placements. No differences in behavior problems and adaptive functioning.

average increases were 13.94 and 15.21 points more, respectively. The EIBI groups surpassed the control groups on composite adaptive behavior, communication, daily living skills and socialization subscales the experimental groups surpassed the control groups by 5.92, 10.44, 5.48, and 4.96 points, respectively. Consistent with the results based on mean differences, Cohen's *D* indicates moderate (adaptive behavior: daily living skills subscale) to large effect sizes (IQ, non-verbal IQ, adaptive behavior, receptive and expressive language). Figs. 2–9 summarize the means, confidential intervals and standard deviations for each study and totals on each dependent variable. Table 2 displays Cohen's *D* for each study on each dependent variable.

The mean quality score (Downs & Black, 1998) was 24.65 out of 32 (*SD* = 1.29; range 23–27). Intraclass correlation (average measures, two-way random effects model using an absolute agreement definition) between the two reviewers was 0.70 ($p = 0.04$; 95% CI: −0.15 to 0.93).

As described in Bax et al. (2009) publication bias and statistical heterogeneity were attested with funnel plots, adjusted rank correlations, Galbraith plots and Tau-squared measures. Funnel plots indicated some publication bias; however, this was not confirmed by adjusted rank correlations which indicated that publication bias was absent (all *p*'s > 0.22). Galbraith plots showed there was statistical heterogeneity. IQ and the communication and daily living skills domains of the Vineland Adaptive Behavior Scale (VABS) had diverse variances. Tau-squared measures of heterogeneity showed rather high values for full scale IQ, expressive language and VABS communication domain (π^2: 56.30, 27.23 and 35.98, respectively; with

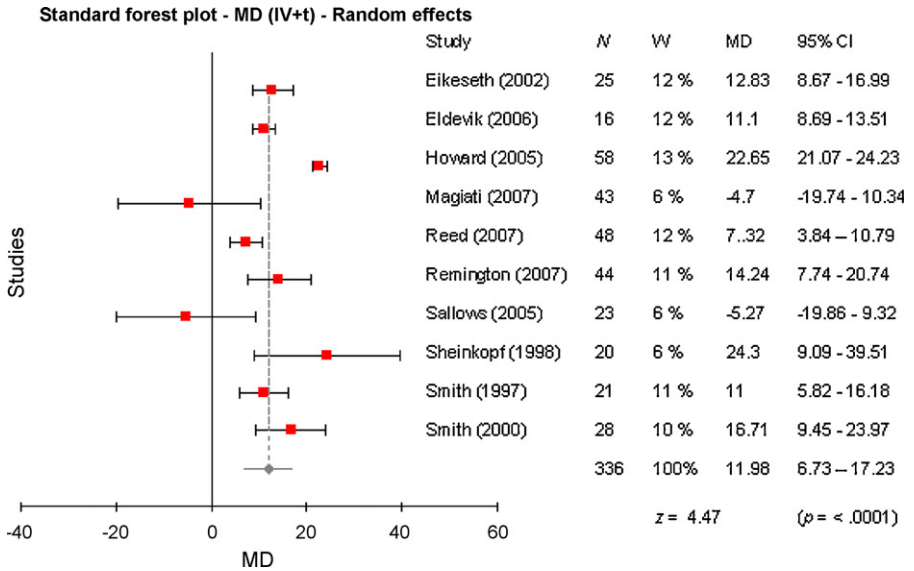

Fig. 2. Result of EIBI on IQ in individuals with ASD. MD = Mean Difference; IV = Inverse Variance; *T* = Estimate of the between study variance where the Weight given to each study is calculated by the inverse sum of the within study and between study variance estimates; *Z* = *z*-score. The *Z*-statistic determines the size of the effect of EIBI when all studies are combined.

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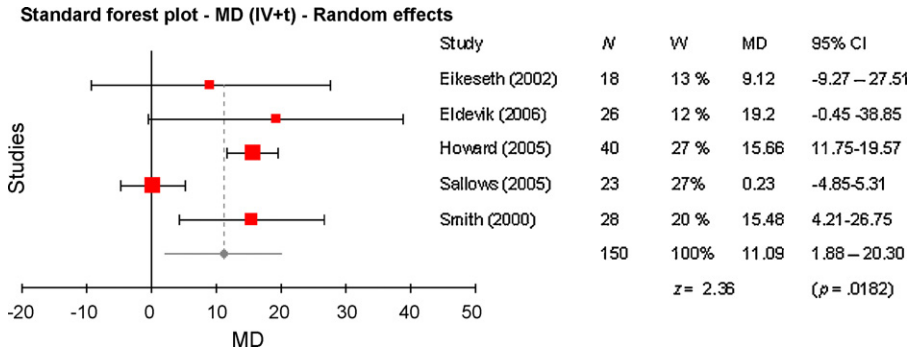

Fig. 3. Result of EIBI on non-verbal IQ in individuals with ASD. MD = Mean Difference; IV = Inverse Variance; *T* = Estimate of the between study variance where the Weight (*W*) given to each study is calculated by the inverse sum of the within study and between study variance estimates; *Z* = *z*-score. The *Z*-statistic determines the size of the effect of EIBI when all studies are combined.

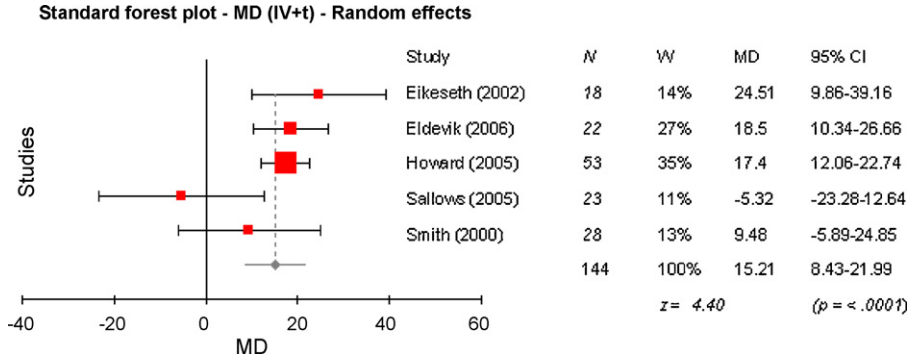

Fig. 4. Result of EIBI on expressive language in individuals with ASD. MD = Mean Difference; IV = Inverse Variance; *T* = Estimate of the between study variance where the Weight (W) given to each study is calculated by the inverse sum of the within study and between study variance estimates; *Z* = *z*-score. The *Z*-statistic determines the size of the effect of EIBI when all studies are combined.

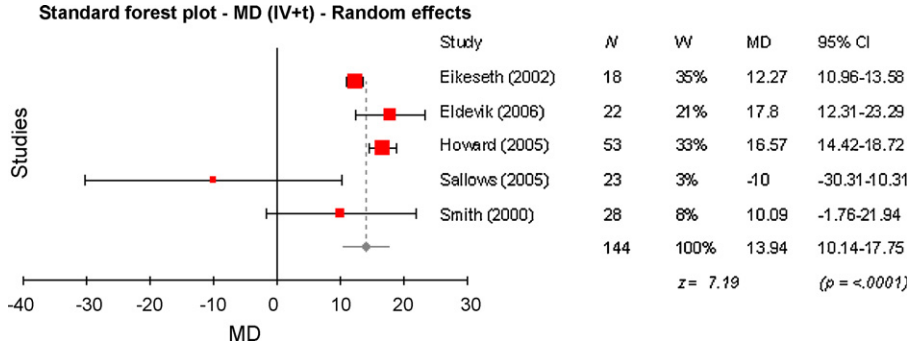

Fig. 5. Result of EIBI on receptive language in individuals with ASD. MD = Mean Difference; IV = Inverse Variance; *T* = Estimate of the between study variance where the Weight (*W*) given to each study is calculated by the inverse sum of the within study and between study variance estimates; *Z* = *z*-score. The *Z*-statistic determines the size of the effect of EIBI when all studies are combined.

theoretical range from 0 to 100) and low values for non-verbal IQ, the receptive language and the composite score, the daily living skills domain and the socialization domain of the VABS (π^2: 0.70, 0.75, 0.14, 1.30 and 0.75, respectively). Thus, the meta-analysis for EIBI contains statistically heterogeneous studies.

4. Discussion

Children with ASD participating in EIBI generally outperformed children receiving other treatments or treatment as usual on both IQ and adaptive behavior measures. This confirms findings from other studies on EIBI (Eikeseth, 2009; Howlin et al.,

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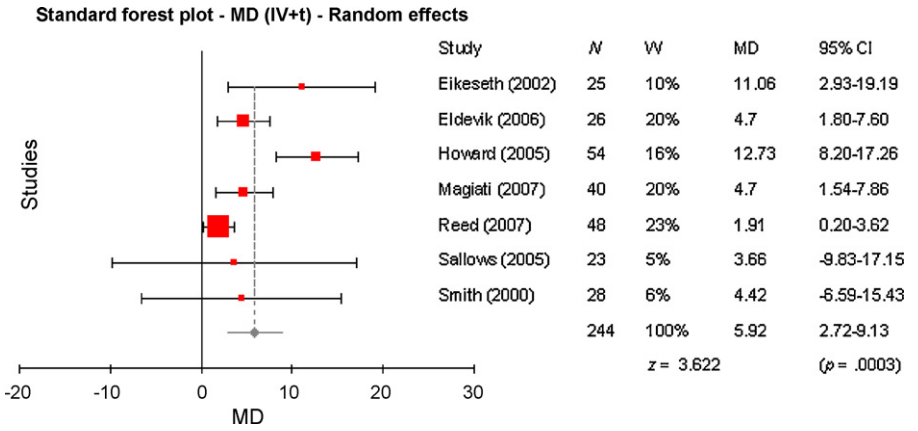

Fig. 6. Result of EIBI on adaptive behavior in individuals with ASD. MD = Mean Difference; IV = Inverse Variance; *T* = Estimate of the between study variance where the Weight (*W*) given to each study is calculated by the inverse sum of the within study and between study variance estimates; *Z* = *z*-score. The *Z*-statistic determines the size of the effect of EIBI when all studies are combined.

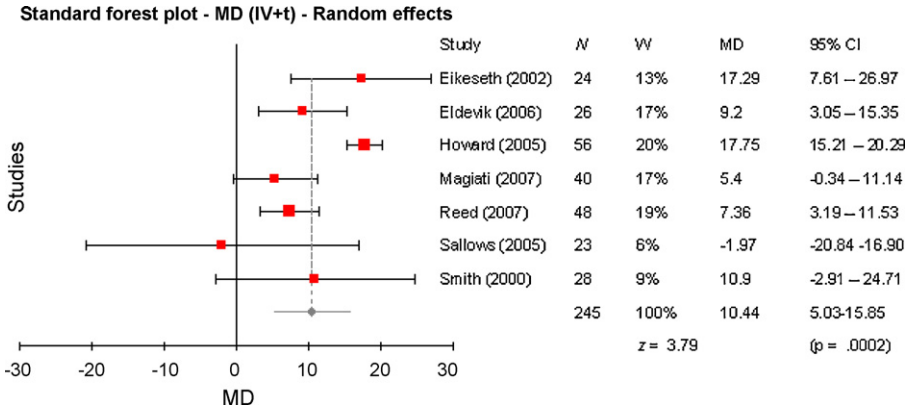

Fig. 7. Result of EIBI on adaptive behavior: communication subscale in individuals with ASD. MD = Mean Difference; IV = Inverse Variance; *T* = Estimate of the between study variance where the Weight (*W*) given to each study is calculated by the inverse sum of the within study and between study variance estimates; *Z* = *z*-score. The *Z*-statistic determines the size of the effect of EIBI when all studies are combined.

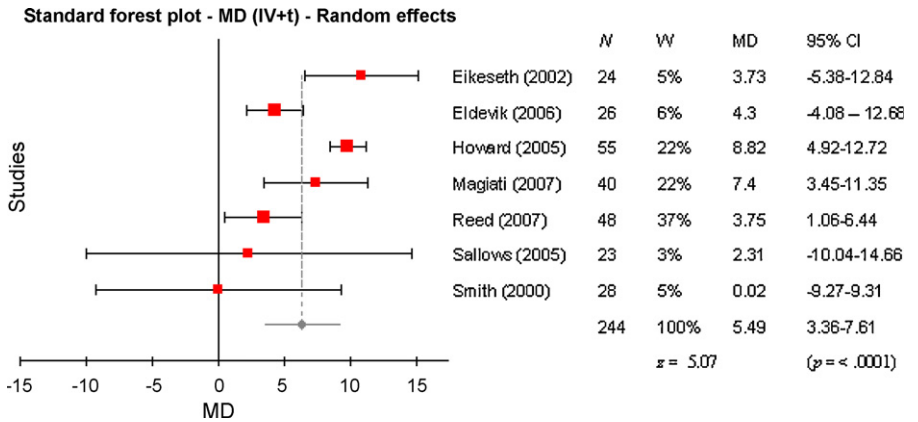

Fig. 8. Result of EIBI on adaptive behavior: daily living skills subscale in individuals with ASD. MD = Mean Difference; IV = Inverse Variance; *T* = Estimate of the between study variance where the Weight (*W*) given to each study is calculated by the inverse sum of the within study and between study variance estimates; *Z* = *z*-score. The *Z*-statistic determines the size of the effect of EIBI when all studies are combined.

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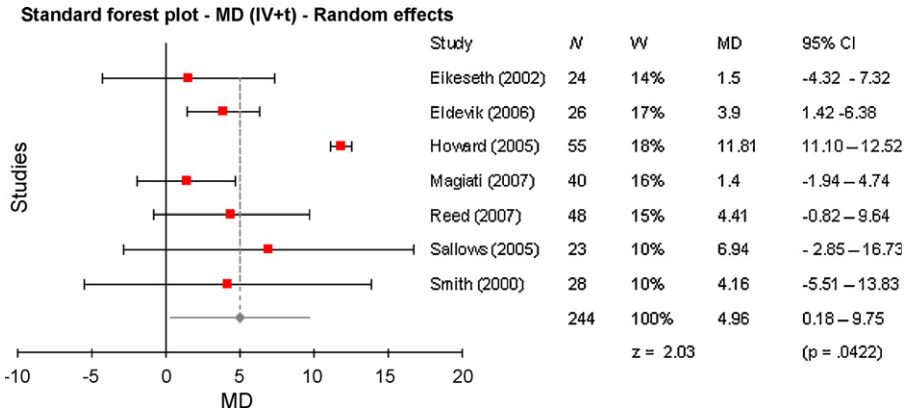

Fig. 9. Result of EIBI on adaptive behavior: socialization subscale in individuals with ASD. MD = Mean Difference; IV = Inverse Variance; *T* = Estimate of the between study variance where the Weight (*W*) given to each study is calculated by the inverse sum of the within study and between study variance estimates; *Z* = *z*-score. The *Z*-statistic determines the size of the effect of EIBI when all studies are combined.

Table 2
Cohen's *D* for each study on each dependent variable. NV-IQ = non-verbal IQ; EL = expressive language; RL = receptive language; ABC = adaptive behavior composite; Com = adaptive behavior: communication subscale; DLS = adaptive behavior: daily living skills; Soc = adaptive behavior: socialization subscale.

Studies	Cohen's *D* for each study on each dependent variable							
	IQ	NV-IQ	EL	RL	ABC	Com	DLS	Soc
Eikeseth et al. (2002)	2.36	0.39	1.73	9.50	1.09	1.51	0.35	0.19
Eldevik et al. (2006)	3.55	1.11	1.90	2.71	1.25	1.15	0.39	1.21
Howard et al. (2005)	7.24	2.29	1.76	4.20	1.62	3.66	1.10	8.12
Magiati et al. (2007)	−0.19				1.06	0.57	1.66	0.29
Reed et al. (2007)	2.06				0.72	1.91	0.91	0.97
Remington et al. (2007)	1.30							
Sallows and Graupner (2005)	−0.28	0.03	−0.23	−0.38	0.20	−0.08	0.14	0.52
Sheinkopf and Siegel (1998)	1.40							
Smith et al. (1997)	1.75							
Smith et al. (2000)	1.63	1.03	0.45	0.62	0.28	0.56	0.0015	0.31
Total	2.00	0.98	1.10	2.91	0.91	1.32	0.68	1.49

2009) and two other recent meta-analyses (Eldevik et al., 2009; Reichow & Wolery, 2009). The average differences of 11.09 to 15.21 standardized points in scores between the experimental and control groups on IQ, non-verbal IQ and receptive and expressive language and the large effect sizes may be considered clinically significant (Hojat & Gang, 2004).

Consistent with Eldevik et al. (2009), this study found smaller differences on adaptive behavior between the experimental and the control group (4.96–10.44 points) suggesting that future applied work might focus more intensively to improve child adaptive behavior. This might include a greater quantity of teaching and/or improved quality of teaching of skills in these domains.

Results varied considerable between studies and participants. Differences may be attributable to treatment intensity (Lovaas, 1987), EIBI quality, intensity of supervision (Eikeseth, Hayward, Gale, Gitlesen, & Eldevik, 2009), participant characteristics, and the control group's treatment, if any. Further research should determine which child characteristics, beside baseline IQ and age at start of treatment, are related to treatment outcome (Harris & Handleman, 2000). Children who do not make dramatic responses are often readily identifiable within a few weeks or months of EIBI (Sallows & Graupner, 2005). Future research might evaluate what strategies should be adopted to further improve outcomes for these children who may need even more intense EIBI or perhaps technically very precise teaching and a very high degree of treatment integrity to accelerate development. Perhaps these children enter EIBI with key deficits that are not readily remediable with routine EIBI. These might include acquisition of prerequisite skills such as sitting and attending, joint attention skills, and acquisition of praise as a secondary reinforcer or perhaps some of these children have interfering challenging behavior that routine EIBI does not address effectively in the first few months of intervention. An alternate explanation might be that the quality of the teaching that these children receive might be poor and staff and parents working with these children require more careful training and supervision than other staff.

Since a meta-analysis is only based on published studies, publication bias is a threat to validity (Torgerson, 2006). Funnel plots and rank correlation tests of expressive language suggested some evidence for publication bias. More studies with positive than non-significant or negative results are published (Torgerson, 2006); however, another explanation might be that behavioral treatment is indeed effective.

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Galbraith plots showed that there was indication of statistical heterogeneity. This could be explained in terms of differences in characteristics of the treatment (e.g., setting, amount of supervision provided, intensity) and the participants (age at treatment onset, IQ at treatment onset, diagnosis). This seems typical for the field and for autistic children.

As Reichow and Wolery (2009) and Eldevik et al. (2009) stated, results need to be interpreted cautiously, since studies in this area contain several methodological limitations including small sample sizes, non-randomized assignments to groups, non-uniform assessments protocols, use of quasi-experimental designs, lack of equivalent groups, lack of adequate fidelity measures, unknown characteristics of comparison conditions, and selection bias (Boyd, 1998; Eikeseth, 2009; Gresham & MacMillan, 1997; Levy, Kim, & Olive, 2006; Mundy, 1993; Schopler, Short, & Mesibov, 1989; Wheeler, Baggett, Fox, & Blevins, 2006); only one study (Smith et al., 2000) was a fully randomized control trial. Despite these potential limitations, this meta-analysis demonstrated that EIBI has a moderate to large effect in young children with autism on full scale and non-verbal IQ and adaptive behavior.

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