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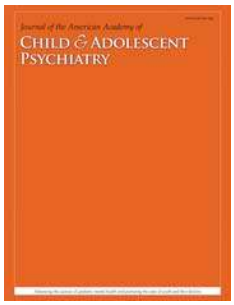

Behavioral Interventions in Attention-Deficit/Hyperactivity Disorder: A Meta-Analysis of Randomized Controlled Trials across Multiple Outcome Domains

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<LRH>Daley *et al.*

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<ARTFN>This article is discussed in an editorial by Dr. Linda Pfiffner on page xxx.

Supplemental material cited in this article is available online.

<BEGIN ABSTRACT>Objective: Behavioral interventions are recommended as attention-deficit/hyperactivity disorder (ADHD) treatments. However, a recent meta-analysis found no effects on core ADHD symptoms when raters were probably blind to treatment allocation. The present analysis is extended to a broader range of child and parent outcomes. Method: A systematic search in PubMed, Ovid, Web of Knowledge, ERIC, and CINAHAL databases (up to February 5, 2013) identified published randomized controlled trials measuring a range of patient and parent outcomes for children and adolescents diagnosed with ADHD (or who met validated cutoffs on rating scales). Results: Thirty-two of 2,057 nonduplicate screened records were analyzed. For assessments made by individuals closest to the treatment setting (usually unblinded), there were significant improvements in parenting quality (standardized mean difference [SMD] for positive parenting 0.68; SMD for negative parenting 0.57), parenting self-concept (SMD 0.37), and child ADHD (SMD 0.35), conduct problems (SMD 0.26), social skills (SMD 0.47), and academic performance (SMD 0.28). With probably blinded assessments, significant effects persisted for parenting (SMD for positive parenting 0.63; SMD for negative parenting 0.43) and conduct problems (SMD 0.31). Conclusion: In contrast to the lack of blinded evidence of ADHD symptom decrease, behavioral interventions have positive effects on a range of other outcomes when used with patients with ADHD. There is blinded evidence that they improve parenting and decrease childhood conduct problems. These effects also may feed through into a more positive parenting self-concept but not improved parent mental well-being. J. Am. Acad. Child Adolesc. Psychiatry, 2014;16(x):xx–xx. Key Words: ADHD, parenting, intervention, conduct<END ABSTRACT>

Attention-deficit/hyperactivity disorder (ADHD) is characterized by age-inappropriate, persistent, and pervasive inattention and/or overactivity/impulsiveness that impairs daily functioning[1] and is associated with substantial long-term burden on patients, families, and health and educational services.[2,3] Multimodal treatment approaches are recommended.[4] Medication is typically used as the first-line intervention, especially for severe cases.[5] Despite robust evidence of medium-term symptom control,[6] medication has some limitations. A proportion of patients shows partial or no response.[6] Long-term effectiveness remains to be established.[7,8] Important aspects of functioning may not improve (e.g., academic achievement[9]). Adverse effects on sleep, appetite, and growth, although rarely serious and generally manageable, are common and may not be well tolerated.[10] Treatment compliance can be low, especially during adolescence.[11] Parents and clinicians can have reservations about medication use[12] and may prefer nonpharmacologic approaches.[13]

Interventions using behavioral techniques also are recommended and commonly used as ADHD treatments.[14] Systematic reviews of treatment trials have provided evidence to support their efficacy.[15-17] However, these reviews can be difficult to interpret, because they sometimes include nonrandomized controlled trials (RCTs), mix individuals with and without ADHD, and have not always drawn clear boundaries between ADHD-specific and other outcomes. Furthermore, outcome assessment is often made unblinded by individuals taking an active part in the intervention (e.g., parents receiving parent training), which is likely to inflate efficacy estimates.[18] Sonuga-Barke *et al.*[19] published a meta-analysis of RCTs of behavioral interventions. Stringent inclusion and exclusion criteria addressed some limitations of previous meta-analyses. There was a moderate, statistically significant, positive effect on ADHD core symptoms for assessments made by individuals most proximal to the therapeutic setting—typically unblinded parent ratings. However, these effects were not corroborated by probably blinded measurements made by observers or raters unaware of treatment allocation when the effect size decreased to near 0 and became nonsignificant. A similar, although less marked, decrease was found for neural feedback and cognitive training. There are some possible explanations for these findings. First, that unblinded raters are biased and overestimate treatment effects.[20] Second, that interventions increase parental tolerance for ADHD or their ability to cope with its negative impact rather than decreasing symptom levels.[19] Third, that probably blinded measurements were less valid than most proximal measurements.[21] Fourth, that intervention effects did not generalize from the therapeutic setting (e.g., the home) to other settings (e.g., school).[22] The authors concluded that more evidence from studies with blinded assessments is required before behavioral interventions can be supported as treatments for core ADHD symptoms.

The limited effects of behavioral approaches on blinded core ADHD measurements may be explicable if one considers the treatment models on which many are based. For instance, although most treatments in the trials included in the meta-analysis of Sonuga-Barke *et al.*[19] were implemented to target

ADHD symptoms, they were initially developed and have been used extensively for children with oppositional and conduct problems.[23-25] For many of these, the rationale is that children's challenging behavior develops because of coercive interactional cycles that, over time, co-reinforce noncompliant and oppositional behaviors in the child and negative and inappropriate responses from significant adults (usually the parent but also potentially teachers and other caregivers).[26] During intervention, the adult is taught to apply behavior modification techniques to reinforce appropriate and discourage inappropriate child behaviors, enhance effective and enjoyable adult–child interactions,[27] and so transform negative into positive interactional cycles. Such interventions, it could be argued, are unlikely to be effective as treatments for core ADHD symptoms because ADHD does not emerge along a similar environmentally mediated route as conduct problems and therefore is less likely to respond to the modification of environmental contingencies.[28]

However, the value of behavioral interventions does not rest exclusively on their potential effects on ADHD symptoms. Patients with ADHD often have conduct problems[29] and other comorbidities[30] in addition to poor social and organizational skills and low academic achievement. Their parents can have poor parenting self-concept and mental health problems.[31] These associated features of the disorder are important treatment targets in and of themselves, because each is associated with substantial burden to the child, the child's family, and society through the criminal justice, social, and health systems.[22,32] Behavioral interventions may have an important role in treating these problems whether or not they decrease core ADHD symptoms. Indeed, behavioral treatments used with patients with ADHD have targeted ADHD-related but nonspecific aspects of impairment rather than ADHD symptoms themselves (e.g., social skills,[33] organizational skills,[34] and academic achievement[35]).

In this article, the authors build on the previous meta-analysis[19] to address the broader impact of behavioral interventions for children with ADHD. They address 3 related questions. First, given that most, although not all, interventions are implemented by changes in the behavior of responsible adults (typically parents or teachers), do behavioral interventions improve adult responses to children with ADHD? Second, do they improve the sense of efficacy and competence and decrease the mental health problems of adults working with children with ADHD? Third, do they decrease levels of child oppositional behavior and other comorbidities and other aspects of impairment such as social skills and academic performance? To address these questions, *most proximal* and *probably blinded* assessments were contrasted.

<H1>Method

Please see the registered protocol CRD42011001393 (link deleted to blind the identity of the authors) for more details.

<H2>Inclusion Criteria

Only published peer-reviewed RCTs were included, although the authors acknowledge that many well-designed studies using single-subject research designs examining the effects of behavioral interventions have been published. Following the recommendation of the Cochrane group, the search was limited to published trials to ensure a level of methodologic adequacy and rigor among included trials and to avoid the inevitable problems with securing access to a full set of unpublished trials and the bias that this would introduce.[36] Participants needed to be 3 to 18 years old and have an ADHD diagnosis (any subtype) or have met accepted cutoffs on validated ADHD rating scales. Trials involving only rare comorbid disorders (e.g., fragile X syndrome) were excluded. Acceptable control conditions were "treatment as usual," "wait list," or "active" controls. "Treatment as usual" could include medication, but trials were excluded if the behavioral intervention was an adjunct to medication or if pharmacologic and behavioral interventions were combined into 1 therapeutic arm as part of the study design. For the present extended review, trials could be included despite not having an ADHD-related outcome (as required in the original protocol).

<H2>Search Strategy

The search was updated to February 5, 2013. Drs. Cortese and Ferrin blindly conducted and cross-checked the updated search using the same databases, search strategy, and search terms as used previously[19] (see protocol). The searches were conducted for records included from the inception of the databases. Behavioral interventions were defined as those interventions directed at changing behaviors (increasing desired and decreasing undesired behaviors). They encompass classic contingency management, behavior therapy (mainly through mediators such as parents or teachers), and cognitive behavior therapy (such as verbal self-instruction, problem-solving strategies, or social skills training). The treatment search terms covered a wide variety of intervention types with the aim of including trials involving any form of behaviorally based therapies, implemented in any setting (home or school), and indirectly by an adult or directly to the child (see protocol).

<H2>Outcome Measurements

To increase analytical robustness, outcome domains were only considered if at least 5 RCTs were available. Outcome measurements meeting this criterion were pre- to post-treatment changes in positive and negative parenting, parent mental health (e.g., anxiety, depression) and parenting self-concept (e.g., sense of competence and efficacy), child ADHD, conduct problems (i.e., negative and noncompliant behavior including symptoms of oppositional defiance and conduct disorders), social skills, and academic achievement. There were too few RCTs ($n < 5$) to examine changes in teacher behavior and well-being,

child impairment, internalizing problems, executive/organizational skills, or more general measurements of family functioning.

<H2>Study Selection

Article titles and abstracts were screened. Final inclusion was based on the full text. Trials were blindly double-coded for eligibility. Study quality was assessed by 2 independent raters according to the criteria of Jadad *et al.*[37] (Table 1).[24,25,33-35,40-66] These provide a rating for each trial in terms of standard definitions for randomization, blinding, and treatment of missing data defined by Jadad*et al.*[37] Jadad scores for blinding were adapted for use with multiple outcomes so that studies with at least 1 blinded outcome yielded a score of 1 on this dimension. A score of at least 3 is regarded as indicating acceptable quality. Initial disagreements (n = 4) were resolved by the coders through discussion without recourse to an independent arbitrator.

<H2>Data Extraction and Statistical Analysis

Trial information was entered into RevMan 5.1 (http://ims.cochrane.org/revman).[38] Data extraction was independently rated by 2 authors. The standardized mean difference (SMD), namely the mean pre- to post-treatment change minus the mean pre- to post-treatment control group change divided by the pooled pretest standard deviation with a bias adjustment, was calculated.[39] SMDs for trials in each domain were combined using the inverse-variance method.[36] Given the inherent heterogeneity of studies, random-effects models were used. The I^2 statistic was calculated, a posteriori, to estimate between-trial SMD heterogeneity. Most proximal and probably blinded analyses were performed for all domains except parent mental health, parenting self-concept, child social skills, and academic outcomes for which insufficient trials with probably blinded measurements were available. When multiple measurements were available for an outcome, the one most frequently reported across included trials was included. For the most proximal analysis, parent ratings, if available, were used, except for teacher-based interventions, when teacher ratings or direct observations were preferred. Probably blinded assessments were made by an individual likely to be blind to allocation. In trials in which more than 1 such measurement was available, the best blinded measurement was selected. This affected only trials with a home-based element where direct observations by an independent researcher and teacher ratings were the probably blinded measurement. In such cases, direct observation was selected over teacher ratings. Sensitivity analyses examined the impact of background ADHD medication use in trial samples for which at least 3 trials had fewer than 30% of participants receiving medications (i.e., were no-/low-medication trials) and the effects of outliers identified using funnel plots within RevMan 5.1.[38] Meta-regression tested whether effect sizes were larger in lower-quality trials according to Jadad *et al.*[37] For 1 study,[34] 2 active treatment arms were suitable for analysis. Parents and Teachers Helping Children Organize and Organizational Skills

Treatment yielded similar results; so only 1 arm, Parents and Teachers Helping Children Organize, which was considered the more standard behavioral intervention, was included in the final analysis. For another study,[40] outcomes were taken from 3 publications.[40-42]

<H1>Results

Thirty-two studies met the entry criteria and had data amenable to analysis. Eight had a Jadad study quality rating of at least 3.[33] Thirty-one studies had a parent-based component implemented at home. Four had an additional school-based, teacher-focused element. Fourteen included direct intervention with the child. Although most used standard behavioral principles and targeted children's externalizing behaviors (ADHD, oppositional defiance disorder, conduct disorder), some implemented specialized social (n = 3), organizational (n = 3), or academic (n = 1) skills. Figure 1 presents the trial selection flowchart. Tables 1 and 2 present information about included trials and the measurements used in each analysis, respectively.

<H2>Do Behavioral Interventions Improve Adult Responses to Children with ADHD?

No trials measured responses to children with ADHD by adults other than parents (i.e., no teachers). Nine trials measured positive parenting. Three most proximal measurements were parent rated; 5 were observational. Eight trials had probably blinded measurements, all observational. For positive parenting, most proximal effects were significant (SMD 0.68; 95% confidence interval [CI] 0.27-1.09; Figure 2 shows forest plots). Effects were similar for probably blinded outcomes (SMD 0.63, 95% CI 0.47-0.78). Heterogeneity was significant in the 2 analyses (χ^2 for most proximal = 63.55, $I^2 = 87\%$, $p < .01$; χ^2 for probably blinded = 40.58, $I^2 = 83\%$, $p < .01$). Effects were unaffected by limiting the analyses to no-/low-medication trials (n = 5, SMD for most proximal 1.23, 95% CI 0.26-2.20; n = 4, SMD for probably blinded 0.89, 95% CI 0.65-2.13), although heterogeneity remained high (χ^2 for most proximal = 28.35, $I^2 = 89\%$, $p < .01$; χ^2 probably blinded = 23.29, $I^2 = 87\%$, $p < .01$). Removing outliers decreased effect sizes (n = 2, SMD most proximal 0.32, 95% CI −0.06 to 0.58; n = 1, SMD probably blinded 0.44, 95% CI 0.14-0.75). Heterogeneity was no longer significant (χ^2 most proximal = 3.46, $I^2 = 0\%$, $p = .48$; χ^2 for probably blinded = 0.83, $I^2 = 0\%$, $p = .66$). Fourteen trials measured negative parenting. The 9 most proximal measurements were parent ratings (4 observations and 1 speech sample). Eight studies met criteria for probably blinded assessments (7 observations and 1 speech sample). For negative parenting, effects were significant for the 2 analyses (SMD for most proximal 0.57, 95% CI 0.37-0.78; SMD for probably blinded 0.43, 95% CI 0.24-0.62). Heterogeneity also was significant (χ^2 for most proximal = 32.7, $I^2 = 60\%$, $p < .01$; χ^2 for probably blinded = 19.8, $I^2 = 65\%$, $p < .01$). Most proximal effects were unchanged when no-/low-medication trials were analyzed (n = 7, SMD 0.57, 95% CI 0.22-0.92, $\chi^2 = 7.81$, $I^2 = 49\%$, $p < .01$), but effects became nonsignificant for probably blinded outcomes (n = 6, SMD 0.42,

95% CI −0.07 to 0.91, $\chi^2 = 14.25$, $I^2 = 72\%$, $p < .01$). When outliers were excluded, effects remained significant for the 2 outcomes (n = 2, SMD for most proximal 0.45, 95% CI 0.31-0.58; n = 1, SMD for probably blinded 0.36, 95% CI 0.12-0.60). Heterogeneity was decreased for one (χ^2 for most proximal = 15.45, $I^2 = 35\%$, $p = .12$) but not the other (χ^2 for probably blinded = 15.03, $I^2 = 73\%$, $p < .01$).

<H2>Do Behavioral Interventions Improve the Self-Concept and Mental Health of Adults Working with Children with ADHD?

No trials measured the self-concept and mental health of adults other than parents. Seven trials included self-ratings of parental self-concept (6 parenting efficacy/sense of competence, 1 parenting self-esteem). There was a small but significant improvement in self-concept after treatment (SMD 0.37, 95% CI 0.03-0.70). Heterogeneity was significant ($\chi^2 = 19.03$, $I^2 = 68\%$, $p < .01$). Effects increased slightly in no-/low-medication trials (n = 5, SMD 0.68, 95% CI 0.22-0.92), whereas heterogeneity decreased substantially ($\chi^2 = 0.99$, $I^2 = 0\%$, $p = .61$). When outliers were removed (n = 1), effects and their heterogeneity were decreased to nonsignificant levels (SMD 0.30, 95% CI −0.07 to 0.65, $\chi^2 = 5.24$, $I^2 = 4\%$, $p = .39$). Measurements of self-rated parent mental health were included in 9 studies (7 depression/anxiety, 2 more general well-being). There were no significant effects of treatment (SMD 0.09, 95% CI −0.09 to 0.23; no-/low-medication analysis, n = 6, SMD 0.09, 95% CI −0.19 to 0.37, $p = .13$; $\chi^2 = 5.63$, $I^2 = 47\%$, $p < .01$). No outliers were identified.

<H2>Do Behavioral Interventions Decrease Child Psychopathology and Improve Functioning?

Nineteen studies had most proximal ADHD measurements (4 in addition to the trials included in the study by Sonuga-Barke *et al.*[21]). The treatment effect was significant (SMD 0.35, 95% CI 0.19-0.50). Heterogeneity was significant ($\chi^2 = 32.63$, $I^2 = 45\%$, $p < .05$). Restricting the analysis to no-/low-medication enhanced the effect (n = 11, SMD 0.50, 95% CI 0.24-0.76), but heterogeneity remained significant ($\chi^2 = 20.33$, $I^2 = 51\%$, $p < .05$). Effects were decreased when outliers (n = 3) were removed but remained significant (SMD 0.23, 95% CI 0.12-0.35). Heterogeneity was no longer significant ($\chi^2 = 16.86$, $I^2 = 23\%$, $p = .21$). None of the trials added since the study by Sonuga-Barke *et al.*[19] had a probably blinded measurement, so the prior finding of no treatment effect for ADHD remained unchanged (overall SMD 0.02, 95% CI −0.30 to 0.34).

Fifteen trials had most proximal measurements of conduct problems (10 parent ratings, 3 teacher ratings, and 2 clinic observations). Eight trials had probably blinded measurements (1 teacher rating and 7 observational ratings). Most proximal and probably blinded effects were significant (SMD for most proximal 0.26, 95% CI 0.14-0.37; SMD for probably blinded 0.31, 95% CI −0.05 to 0.57). Heterogeneity was significant for most proximal ($\chi^2 = 25.87$, $I^2 = 46\%$, $p = .03$) but not for probably blinded ($\chi^2 = 14.28$, $I^2 = 51\%$, $p = .05$) effects. Low-/no-medication studies yielded significant effects for the 2 analyses

(n = 7, SMD for most proximal 0.54, 95% CI 0.32-0.76; n = 6, SMD for probably blinded 0.27, 95% CI = 0.02-0.51). Heterogeneity was not significant for either of these analyses (χ^2 for most proximal = 5.96, I^2 = 37%, p = .43; χ^2 for probably blinded = 3.77, I^2 = 0%, p = .44). Most proximal effects remained significant when outliers (n = 2) were removed (SMD 0.26, 95% CI = 0.12-0.46, χ^2 = 14.16, I^2 = 22%, p = .22). There were no probably blinded outliers.

Nine trials included most proximal social skills outcomes (4 parent and 5 teacher ratings). Four of these included a core specialized social skills training component. The effect was significant (SMD 0.47, 95% CI 0.15-0.78), as was heterogeneity (χ^2 = 22.98, I^2 = 65%, p < .01). Restricting the analysis to the no-/low-medication studies increased heterogeneity (n = 5, χ^2 = 22.08, I^2 = 86%, p < .01), so that although the effect size increased, it was no longer significant (SMD 0.67, 95% CI −0.20 to 1.55). When outliers (n = 1) were removed, the effect remained (SMD 0.30, 95% CI 0.07-0.52) and heterogeneity was nonsignificant (χ^2 = 4.04, I^2 = 0%, p = .54).

Academic achievement was measured in 9 trials (6 parent or teacher questionnaire-based measurements and 3 objective assessments). Seven studies had a specialized component to specially target this aspect of impairment. Most proximal effects were significant, and heterogeneity was nonsignificant (SMD 0.28, 95% CI 0.06-0.50, χ^2 = 14.55, I^2 = 45%, p = .07) and persisted when outliers (n = 2) were removed (SMD 0.16, 95% CI 0.01-0.31) and heterogeneity was nonsignificant (χ^2 = 7.95, I^2 = 37%, p = .16). There were insufficient no-/low-medication studies to conduct a sensitivity analysis (Figure 3).

There was no association between larger effect sizes and lower Jadad ratings. In fact, for most proximal ADHD (t = 2.52, p = .02), higher-quality trials yielded larger effects. Meta-regression did show larger effect sizes in trials with younger children for most proximal positive parenting (t = −2.63, p = .03), most proximal ADHD (t = −2.09, p = .05), and most proximal conduct problems (t = −2.46, p = .03).

<H1>Discussion

The present meta-analyses found blinded evidence that behavioral interventions used to treat children and adolescents with ADHD had beneficial effects on important aspects of child and parent functioning. This finding contrasts with the lack of blinded evidence relating to ADHD symptoms reported by Sonuga-Barke *et al.*[19] Specifically, in this analysis, behavioral interventions improved parenting, decreasing negative and increasing positive parenting, and decreased children's comorbid conduct problems.

Although improving parent functioning was rarely their primary therapeutic goal, nearly all behavioral interventions included parent training as a core therapeutic mechanism. Positive effects on these outcomes are therefore expectable and, in some ways, a necessary condition for subsequent impacts on children's behavior. Given the need to pool across very diverse and often rather general parenting

assessments, a fine-grained analysis of these effects was not possible. For instance, positive parenting analyses pooled studies with general assessments of overall increases in positive behaviors/strategies (e.g., praise, encouragement[61]), together with measurements of their appropriate use,[25] according to therapeutic models. This is important because, according to most models,[28] simply increasing levels of positive parenting may not be sufficient to produce positive changes in children's behavior. Objective effects on parenting were reflected in improved parenting self-concept: an empowering effect important in the process of breaking negative parent–child interaction cycles.[31] Increased parenting confidence could come from working with experienced therapists who validate parents' approaches and/or implementing behavioral strategies and seeing their positive effects. It also may be an effect of psychoeducation that emphasizes the power parents have to influence developmental outcomes.[67] Given these parenting-specific positive effects, it was perhaps surprising that no beneficial effects were seen on parent mental health more generally. It would seem that the high levels of mental health problems that often affect parents of children with ADHD are not solely the result of issues around parenting morale, but rather reflect a more deep-seated, pervasive psychological aspect, perhaps reflecting shared genetic risk for mental health problems within families.[68,69] There also was blinded evidence that behavioral interventions decreased conduct problems in children with ADHD; benefits of behavioral interventions for children seen with conduct disorder extend to those with a full ADHD diagnosis.[25] Given the limited number of studies with probably blinded measurements and the fact that few had objective measurements of child behavior measured at home and school, the authors were unable to assess the generalization of child effects across settings. According to most proximal measurements, children's academic performance and social skills also were improved—an effect that is perhaps not surprising, because trials included in these analyses often specifically targeted these aspects of impairment with specialized packages. If these effects could be corroborated with blinded ratings, this would be encouraging given the inconsistent evidence regarding the effects of medication on these outcomes.[44,55]

When interpreting the present analysis, it is important to take some factors into account; all meta-analyses are constrained by the quality and diversity of the studies available for inclusion. First, for nearly all analyses, there was significant SMD heterogeneity among studies that may reflect the variety of intervention and outcome types analyzed. In most, although not all, cases, removing outliers identified using funnel plots decreased this heterogeneity while leaving treatment effects significant. Second, the authors could not establish how many parents had definite parenting or mental health problems, or how many children had clinical levels of conduct problems. Because participants were specifically selected for ADHD in childhood, it is likely that substantial numbers of individuals were unaffected by these additional problems. As a consequence, effect sizes seen for these outcomes, given the smaller room for improvement, are likely to be an underestimate of the true effects of behavioral interventions. Third,

Sonuga-Barke *et al.*[19] raised questions about the status of the probably blinded measurements as valid outcomes. This is because they were often based on relatively small snapshots of behavior or a rating by a teacher who may not know the child well. However, in the present study, these measurements proved to be sensitive to treatment-related change. Fourth, this evaluation did not explore the impact on long-term outcomes, where one might predict a more robust impact of behavioral interventions. Fifth, although the authors established that parenting improved on rather artificial trial-based assessments, these may not have been able to capture improvements in everyday life situations. Sixth, there were insufficient studies to explore whether interventions specifically tailored for ADHD[64] were more effective than parenting interventions designed to treat more general childhood behavior problems or other aspects of impairment (social and academic skills). Seventh, the pool of trials meeting inclusion criteria was dominated by parenting interventions. This meant that the present analysis says little specifically about the value of child- or teacher-focused interventions. Eighth, in a related manner, no trials included measurements of changes in adult responses to children with ADHD other than parents. Ninth, the authors decided not to conduct or report an analysis of publication bias using techniques such as funnel plots because their interpretation is equivocal when based on a small number of studies, with difficulty in particular distinguishing between the effects of study heterogeneity and publication bias with sparse data.[36]

In summary, although more evidence is required before behavioral interventions can be supported as a front-line treatment for core ADHD symptoms, the authors found evidence that they do have beneficial effects on parenting and parents' sense of empowerment and independently corroborated effects on conduct problems in children with ADHD. Initial evidence from proximal outcomes relating to academic achievement and social skills needs to be confirmed by probably blinded analyses and greater exploration is needed on the moderating impact of child age on intervention outcome.

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Figure 1 Flowchart showing the selection of trials. See Supplement 1 (available online) for specific reasons for exclusion.

Figure 2 Parental outcomes. Note: CI = confidence interval; MPROX = most proximal rating; MTA = National Institute of Mental Health Multimodal Treatment Study of Attention-Deficit/Hyperactivity Disorder; PBLIND = probably blinded rating; SMD = standardized mean difference.

Figure 3 Child outcomes. Note: ADHD = attention-deficit/hyperactivity disorder; CI = confidence interval; MPROX = most proximal rating; MTA = National Institute of Mental Health Multimodal Treatment Study of Attention-Deficit/Hyperactivity Disorder; PBLIND = probably blinded rating; SMD = standardized mean difference.

Table 1 Characteristics of Included Studies

Trial	Treatment		Control	Jadad Rating	Sample Size		Age Range (y)	Boys, %	Medicated for ADHD, %
	Delivery	Type			T	C			
Abikoff *et al.* (2012)[34]	parent and teacher	behavioral training	wait list	2	61	33	8-11	69	36
Antshel and Remer (2003)[43]	child and parent	social skills training	wait list	2	80	40	8-12	75	93
Bloomquist *et al.* (1991)[44]	child, parent, and teacher	CBT	wait list	2	20	16	8.58 mean	69	0 in analysis
Bor *et al.* (2002)[24]	parent	behavioral training	wait list	3	26	37	3.6 mean	73	0
Brown *et al.* (1986)[45]	child	self-control training	attention control	2	10	8	5-13	85	0
Chacko *et al.* (2009)[46]	parent	behavioral training	wait list	2	40	40	5-12	73	38.75
Evans *et al.* (2011)[47]	parent and child	behavioral and social skills training	TAU	1	31	18	11-13	71	57
Fabiano *et al.* (2010)[48]	children	daily report card	TAU	2	33	30	6-12	86	52
Fabiano *et al.* (2012)[49]	parent	behavioral training	wait list	2	27	28	6-12	87	54
Fehlings *et al.* (1991)[50]	parent and child	CBT	attention control	2	13	13	8-11	100	0

Hoath and Sanders (2002)[51]	parent	behavioral training	wait list	1	9	11	5-9	76	70
Horn *et al.* (1991)[52]	parent and child	behavioral and self-control training	placebo	2	16	16	7-11	no info	0
Jones *et al.* (2008)[53]	parent	behavioral training	wait list	3	50	29	3.8 mean	68	0
Kapalka (2005)[54]	parent	behavioral training	wait list	0	45	41	5-10	100	no info
Langberg *et al.* (2008)[55]	child and parent	organizational skills training	wait list	1	24	13	grades 4-7	83	43
Langberg *et al.* (2012)[35]	child and parent	organizational skills training	wait list	2	23	24	grades 6-8	74	66
Mikami *et al.* (2011)[56]	parent	parent coaching on social skills	wait list	2	32	30	6-10	68	64.5
Molina *et al.* (2008)[57]	child and parent	organizational skills training	community	2	11	9	grades 6-8	75	31
MTA (1999, 2000, 2006)[40-42]	child, parent, and teacher	Multicomponent: home, school, and camp	TAU	4	144	146	8.33 mean	80	47
Pfiffner and McBurnett (1997)[33]	child and parent	behavioral training and CBT	wait list	2	9	9	8-10	72	44
Pfiffner *et al.* (2007)[58]	child and parent	behavioral training and CBT	wait list	2	36	33	7-11	66	3
Pisterman *et al.* (1989)[59]	parent	behavioral training	wait list	3	23	23	4.1 mean	80	11
Pisterman *et al.* (1992)[60]	parent	behavioral training	wait list	3	23	22	4.1 mean	91	9
Power *et al.* (2012)[61]	child and parent	behavioral and academic skills training	attention	2	100	99	grades 2-6	68	43
Sonuga-Barke *et al.* (2001)[62]	parent	behavioral training	counseling	3	30	28	2-4	62	0
Sonuga-Barke *et al.* (2004)[63]	parent	behavioral training	wait list	2	59	30	2-4	no info	0
Thompson *et al.* (2009)[64]	parent	behavioral training	wait list	4	21	20	2-6	73	0
Tracey and Tripp (2005)[65]	parent	stress management	wait list	2	20	20	6-15	88	88

Van den Hoofdakker *et al.* (2007)[66]	parent	behavioral training	TAU	2	48	48	4-12	76	40
Webster-Stratton *et al.* (2011)[25]	parent and child	behavioral training	wait list	3	49	50	6.4 mean	75	13

Note: ADHD = attention-deficit/hyperactivity disorder; C = control; CBT = cognitive behavioral therapy; grade = school year; MTA = National Institute of Mental Health Multimodal Treatment Study of Attention-Deficit/Hyperactivity Disorder; no info = no information provided in article; T = treatment; TAU = treatment as usual.

Table 2 Measurements Used in Each Trial for the Different Outcomes

		Child				Parent			
		ADHD	CP	SS	AS	MH	SC	PP	NP
Abikoff *et al.*[34]	MPROX PBLIND				APRS[a]				COSS[a]
Antshel and Remer[43]	MPROX PBLIND			SSRS[a]					
Bloomquist *et al.*[44]	MPROX PBLIND	CTRS[b]		SSCSA[a]					
Bor *et al.*[24]	MPROX PBLIND	ECBI[a]	ECBI[a] FOSR[c]			DASS[a]	PSOC[a]		PS[a] FOSR[c]
Brown *et al.*[45]	MPROX PBLIND	CPRS[a] ACRS[b]	ACTeRS[b]	ACTeRS[b]	WRAT[d]				
Chacko *et al.*[46]	MPROX PBLIND	DBD[a]	DBD[a]	IRS[a]		BDI[a]		DPICS[c]	DPICS[c]
Evans *et al.*[47]	MPROX PBLIND	ADHDRS[a]		IRS[b]	IRS[b]			DPICS[c]	DPICS[c]
Fabiano *et al.*[48]	MPROX PBLIND	DBD[b]	DBD[b]		APRS[a]				
Fabiano *et al.*[49]	MPROX PBLIND		ECBI[a]					DPICS[c]	DPICS[c]
Fehlings *et al.*[50]	MPROX PBLIND	WWAS[a]						DPICS[c]	DPICS[c]
Hoath and Sanders[51]	MPROX PBLIND	CAPS[a] CAPS[b]	ECBI[a] SESBI[b]			DASS[a]	PSBC[a]		PS[a]
Horn *et al.*[52]	MPROX PBLIND	CPRS[a]							
Jones *et al.*[53]	MPROX PBLIND	CPRS[a]							

Kapalka[54]	MPROX		SSQ[b]						
	PBLIND								
Langberg *et al.*[55]	MPROX				APRS[a]				
	PBLIND								
Langberg *et al.*[35]	MPROX	VADPRS[a]			HPC[a]				COSS[a]
	PBLIND								
Mikami *et al.*[56]	MPROX			SSRS[a]				PBIPC[c]	PBIPC[c]
	PBLIND							PBIPC[c]	PBIPC[c]
Molina *et al.*[57]	MPROX		ACPS[a]		SGR				
	PBLIND								
MTA[40-42]	MPROX	SNAP[a]	SNAP[a]		WIAT[d]	BDI[a]		PCRQ[a]	PCRQ[a]
	PBLIND	classob[c]	classob[c]					OBS	
Pfiffner and McBurnett[33]	MPROX			SSRS[a]					
	PBLIND								
Pfiffner *et al.*[58]	MPROX			SSRS[a]					
	PBLIND								
Pisterman *et al.*[59]	MPROX		clinob[c]					clinob[c]	clinob[c]
	PBLIND		clinob[c]					clinob[c]	clinob[c]
Pisterman *et al.*[60]	MPROX	clinob[c]	clinob[c]					clinob[c]	clinob[c]
	PBLIND	clinob[c]	clinob[c]					clinob[c]	clinob[c]
Power *et al.*[61]	MPROX	SNAP[a]	SNAP[a]		APRS[b]		PES[a]	PCRQ[a]	PCRQ[a]
	PBLIND								
Sonuga-Barke *et al.*[62]	MPROX	PACS[a]	PACS[a]			GHQ[a]	PSOC[a]		
	PBLIND	homeob[c]							
Sonuga-Barke *et al.*[63]	MPROX	PACS				GHQ[a]	PSOC[a]		
	PBLIND								
Thompson *et al.*[64]	MPROX	PACS	PACS			GHQ[a]		GIPCI[c]	EE[e]
	PBLIND	homeob[c]	GIPCI[c]					GIPCI[c]	EE[e]
Tracey and Tripp[65]	MPROX					BDI[a]	PLOC[a]		PS[a]
	PBLIND								
Van den Hoofdakkar *et al.*[66]	MPROX	CPRS[a]				PSI[a]	PSI[a]		
	PBLIND								
Webster-Stratton *et al.*[25]	MPROX	CPRS[a]	CPRS[a]	SCS[a]				PPI[a]	PPI[a]
	PBLIND	COCA-R						DPICS[c]	DPICS[c]

,
DPICS[1]
[7]-OBS

Note: Superscript letter codes who provided the assessment; superscript number gives full name of test. ACPS = Aggression and Conduct Problem Scale; ACRS = Abbreviated Conners Rating Scale; ACTeRS = ACTeRS ADD-H Comprehensive Teachers Rating Scale; ADHD = attention-deficit/hyperactivity disorder; ADHDRS = Attention Deficit Hyperactivity Disorder Rating Scale; APRS = Academic Performance Rating Scale; AS = academic skills; BDI = Beck Depression Inventory; CAPS = Child Attention Problem Rating Scale; classob = classroom observation; clinob = clinic observation; COCA-R = Coder Observation of Classroom Adaption–Revised: Cognitive Concentration; COSS = Children's Organizational Skills Scale; CP = conduct problems; CPRS = Conners Parent Rating Scale–Hyperactivity; CTRS = Conners Teachers Rating Scale; DASS = Depression Anxiety and Stress Scale; DBD = Disruptive Disorders Rating Scale; DPICS = Dyadic Parent–Child Interaction Coding System; ECBI = Eyberg Child Behavior Inventory; EE = Expressed Emotion measured using the Pre-school Five Minute Speech Sample; FOSR = Family Observation Schedule; GHQ = General Health Questionnaire; GIPCI = Global Impressions of Parent Child Interaction Revised; homeob = home observation of on-task behavior; HPC = Homework Problem Checklist; IRS = Impairment Rating Scale; MH = mental health; MPROX = most proximal rating; MTA = National Institute of Mental Health Multimodal Treatment Study of Attention-Deficit/Hyperactivity Disorder; NP = negative parenting; OBS = observed constructive parenting; PACS = Parent Account of Childhood Symptoms Interview; PBIPC = Parental Behavior in Parent–Child Interaction; PBLIND = probably blinded rating; PCRQ = Parent Child Relationship Questionnaire; PES = Parent as Educator; PLOC = parents locus of control; PP = positive parenting; PPI = ??; PS = Parenting Scale; PSBC = Problem Setting and Behavior Checklist; PSI = Parenting Stress Inventory; PSOC = Parenting Sense of Competence Scale; SC = self-concept; SCS = Social Competence Scale; SESBI = Sutter-Eyberg Student Behavior Inventory Revised; SGR = school grade records; SNAP = Pelham Swanson and Nolan Questionnaire; SS = social skills; SSCSA = Walker-McConnel Scale of Social Competence and School Adjustment; SSQ = Social Situations Questionnaire; SSRS = Social Skills Rating Scale; VADPRS = Vanderbilt ADHD Diagnostic Parent Rating Scale; WIAT = Wechsler Individual Achievement Test; WRAT = Wide Range Achievement Test; WWAS = Werry Weiss Activity Scale.
[a]Parent.
[b]Teacher.
[c]Observation.
[d]Academic skills test.
[e]Speech sample.

Supplement 1 Information on Excluded Studies

Study	Reasons for Exclusion
Abikoff and Gittelman (1985)[1]	not a behavioral intervention; study explores cognitive training
Abikoff *et al.* (2004)[2]	no appropriate control group; behavioral intervention adjunctive to medication
Abikoff *et al.* (2004)[3]	no appropriate control group; behavioral intervention adjunctive to medication
Altemeier and Horwitz (1997)[4]	not randomized
Anastopolos *et al.* (1993)[5]	not randomized
Arnold *et al.* (2003)[6]	MTA study that did not add additional outcomes to the included studies
Barkley *et al.* (1992)[7]	no appropriate control group; this study is a comparison of 3 active therapies
Barkley *et al.* (1996)[8]	reports violation of randomization
Barkley *et al.* (2000)[9]	reports violation of randomization in 8 children
Barkley *et al.* (2001)[10]	no appropriate control group; this study compares 3 different combinations of intervention but does not have a control condition
Carlson *et al.* (1992)[11]	not randomized
Chacko *et al.* (2003)[12]	not a behavioral intervention; this is a medication study
Christensen and Sprague (1973)[13]	not randomized
Christensen (1975)[14]	no appropriate control group; this is a within-subject design
Cohen *et al.* (1981)[15]	not randomized

Cunningham *et al.* (1995)[16]	not a specific ADHD sample
Döpfner *et al.* (2004)[17]	no appropriate control group; this study applies an adaptive and individually tailored approach to treatment
Dubey and O'Leary (1983)[18]	randomization unclear; groups were assigned so that age and gender were evenly distributed
Epstein *et al.* (2007)[19]	not a behavioral intervention
Evans *et al.* (2005)[20]	not randomized
Fabiano *et al.* (2009)[21]	no appropriate control group; this study is a comparison of 2 behavioral interventions
Firestone *et al.* (1981)[22]	no control group
Firestone *et al.* (1986)[23]	no control group and follow-up of a previously excluded study
Frankel *et al.* (1997)[24]	children with and without ADHD included in sample
Gerber-von Müller *et al.* (2009)[25]	no appropriate treatment control group
Gonzalez and Sellers (2002)[26]	ADHD status of children unclear
Hanisch *et al.* (2010)[27]	not a specific ADHD sample
Hantson *et al.* (2012)[28]	not randomized
Hechtman *et al.* (2004)[29]	no appropriate control group; behavioral intervention adjunctive to medication
Hechtman *et al.* (2004)[30]	no appropriate control group; behavioral intervention adjunctive to medication
Hinshaw *et al.* (1984)[31]	no appropriate control group; behavioral intervention adjunctive to medication
Hinshaw *et al.* (1984)[32]	no appropriate control group; behavioral intervention adjunctive to medication
Hinshaw *et al.* (2000)[33]	MTA study that did not add any additional outcomes
Horn *et al.* (1987)[34]	no appropriate control group; this study is a comparison of 2 behavioral interventions
Horn *et al.* (1990)[35]	no appropriate control group; this study is a comparison of 2 behavioral interventions
Hupp *et al.* (2002)[36]	case study
Iolango *et al.* (1993)[37]	same dataset as Horn *et al.*,[35] which was excluded
Jensen *et al.* (2001)[38]	MTA study that did not add additional outcomes
Jensen *et al.* (2004)[39]	MTA study that did not add additional outcomes
Jensen *et al.* (2007)[40]	MTA study that did not add additional outcomes
Kapalka (2004)[41]	not a behavioral intervention
Kapalka (2005)[42]	weak randomization procedure
Kern *et al.* (2007)[43]	no appropriate control group; this study is a comparison of 2 behavioral interventions
Kienle *et al.* (2009)[44]	not randomized
Klein and Abikoff (1997)[45]	no appropriate control group; this study explores combinations of medication and behavioral intervention
Klein *et al.* (2004)[46]	methodology article on design of study by Hechtman[29,30]; no control group
Lerner *et al.* (2011)[47]	randomization unclear
Lloyd *et al.* (2010)[48]	not a behavioral intervention
McGrath *et al.* (2011)[49]	study met criteria for inclusion, but data were not amenable to analysis, and the investigators were unable to provide the data
McNeil *et al.* (1991)[50]	randomization unclear
Meyer and Kelley (2007)[51]	no appropriate control; this study compares parent with self-monitoring for homework problems
Mikami *et al.* (2013)[52]	no appropriate control; this study compares 2 behavioral interventions
Miranda *et al.* (2002)[53]	randomization unclear
Odom (1996)[54]	randomization unclear
Osterberg and Rydell (2012)[55]	randomization unclear; not an entirely ADHD sample
O'Leary *et al.* (1976)[56]	insufficient detail in summary statistics to allow calculation of SMD
Papazian *et al.* (2009)[57]	not a behavioral intervention
Pariseau *et al.* (2010)[58]	no appropriate control group; this is a within-subject design
Pelham (1977)[59]	case study
Pelham *et al.* (1993)[60]	no appropriate control group; this is a within-subject design
Pelham (1999)[61]	review article; no data
Pelham and Gnagy (1999)[62]	review article; no data
Pelham *et al.* (2000)[63]	no control group; same sample as MTA comparing behavioral and combined groups

Pfeiffer *et al.* (2008)[64]	not a specific ADHD sample and not a behavioral intervention
Pfeiffer *et al.* (2007)[65]	not fully randomized
Poulsen *et al.* (2010)[66]	not fully randomized
Presentación Herrero *et al.* (2010)[67]	not randomized
Rapport *et al.* (1982)[68]	case study (2)
Rieppi *et al.* (2002)[69]	MTA study that did not add additional outcomes
Rosén *et al.* (1984)[70]	not randomized
Rutter and Sroufe (2000)[71]	review article; no data
Sanders *et al.* (2007)[72]	not a specific ADHD sample
Sayal *et al.* (2010)[73]	not a behavioral intervention
Shafto and Sulzbacher (1977)[74]	case study
Schumann *et al.* (1998)[75]	not a specific ADHD sample
Scott *et al.* (2010)[76]	not a specific ADHD sample
Shaffer *et al.* (2001)[77]	not a behavioral intervention
So *et al.* (2008)[78]	no appropriate control group; behavioral intervention adjunctive to medication
Springer and Reddy (2010)[79]	not randomized
Strayhorn and Weidman (1989)[80]	not a specific ADHD sample
Strayhorn and Bickel (2002)[81]	no appropriate control group; comparison of 2 behavioral approaches
Storebø *et al.* (2012)[82]	behavioral intervention adjunctive to medication
Swanson *et al.* (2001)[83]	reanalysis of MTA study; no new outcomes added
Thorell (2009)[84]	not adequately randomized; allocation to condition influenced by other factors
Thurston (1979)[85]	randomization unclear
Tutty *et al.* (2003)[86]	no appropriate control group; behavioral intervention adjunctive to medication
Van der Oord *et al.* (2007)[87]	no appropriate control group; behavioral intervention adjunctive to medication
Waxmonsky *et al.* (2008)[88]	no appropriate control group; behavioral intervention adjunctive to medication
Waxmonsky *et al.* (2010)[89]	no appropriate control group; behavioral intervention adjunctive to medication
Wolraich *et al.* (1978)[90]	no appropriate control group
Wulbert and Dries (1977)[91]	case study

Note: ADHD = attention-deficit/hyperactivity disorder; MTA = National Institute of Mental Health Multimodal Treatment Study of Attention-Deficit/Hyperactivity Disorder; SMD = standardized mean difference.

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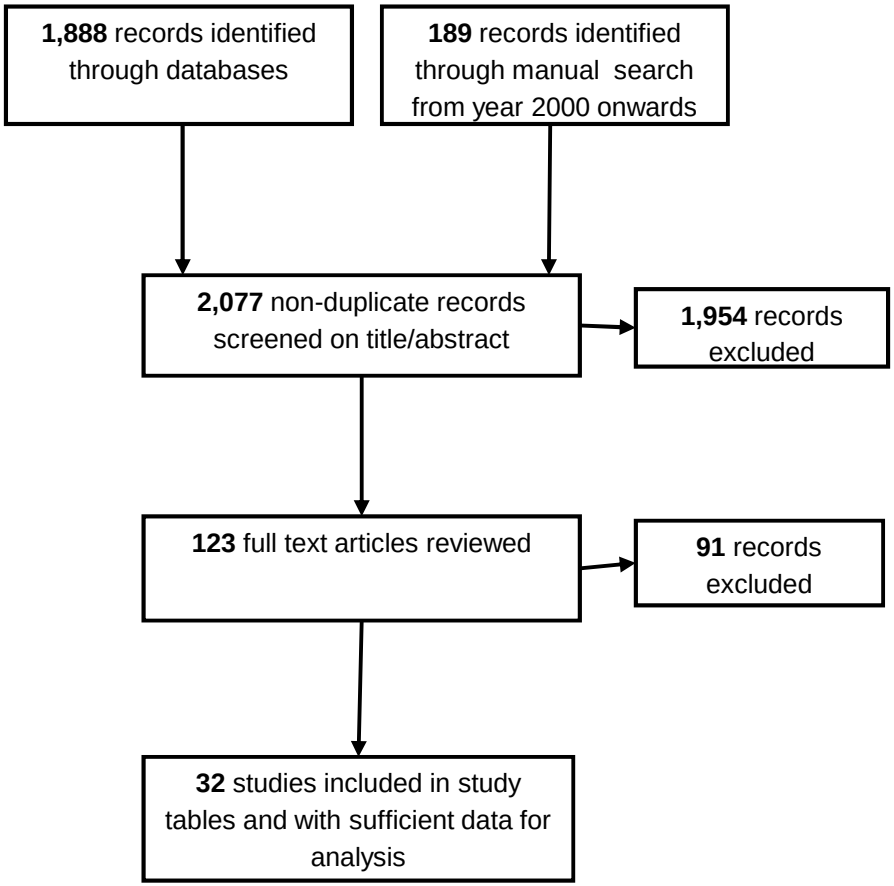
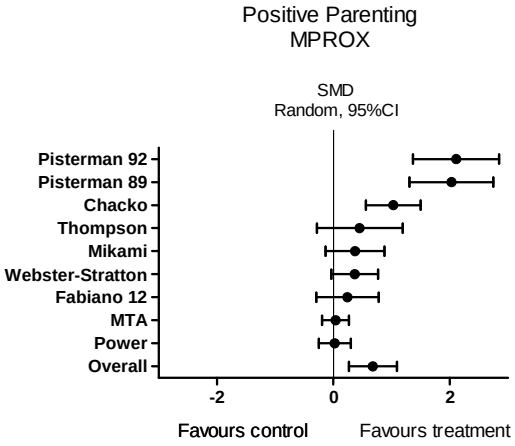
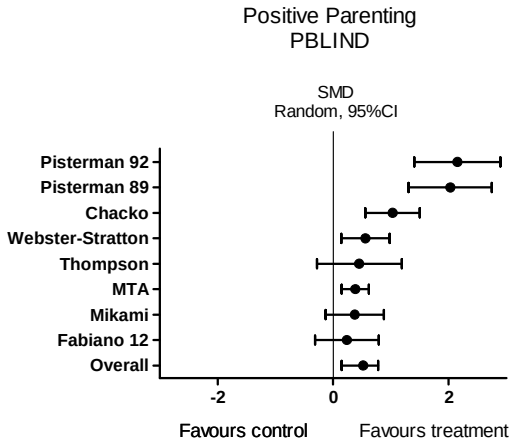
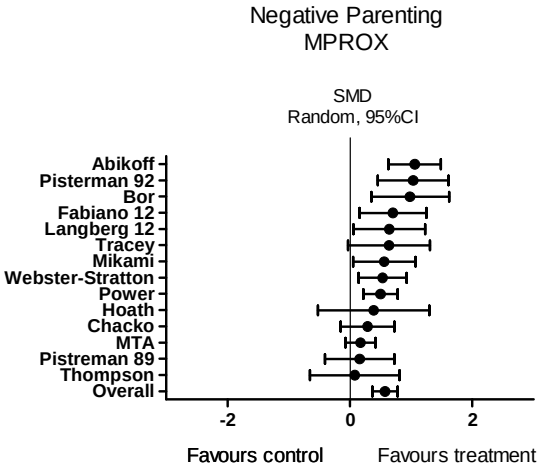




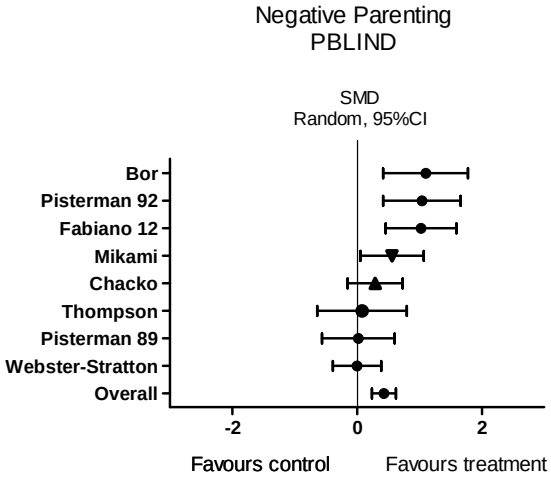
Overall SMD=0.68:95%CI=0.27-1.09



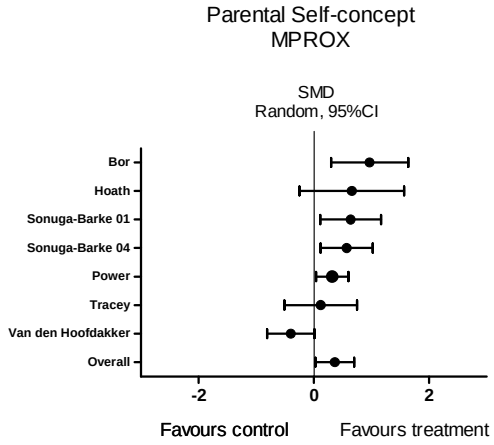
Overall SMD=0.63:95%CI=0.47-0.7



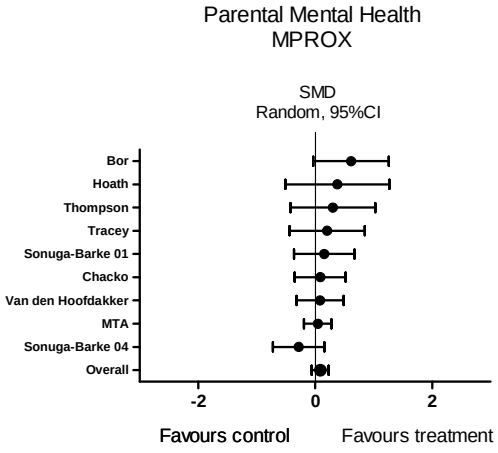
Overall SMD=0.57;95%CI=0.37-0.78



Overall SMD=0.43:95%CI=0.24-0.62

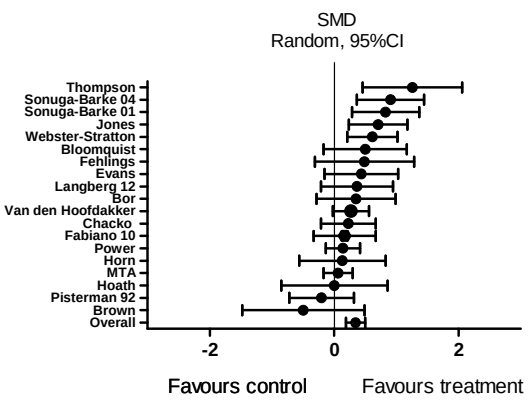


Overall SMD=0.37;95%CI=0.03-0.7



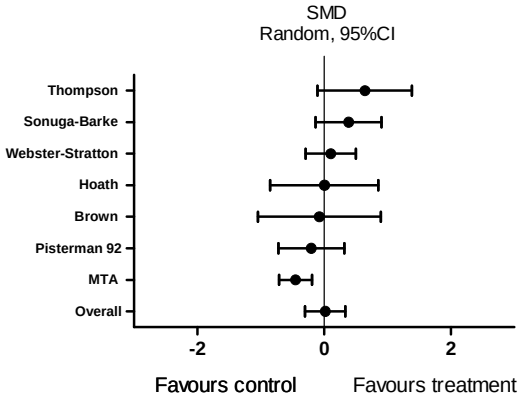
Overall SMS=0.09:95%CI=0.06-0.23

ADHD
MPROX



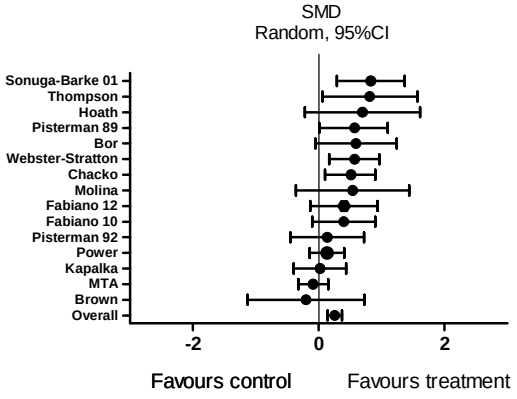
Overall SMD=0.35;95%CI=0.19–0.50

ADHD
PBLIND



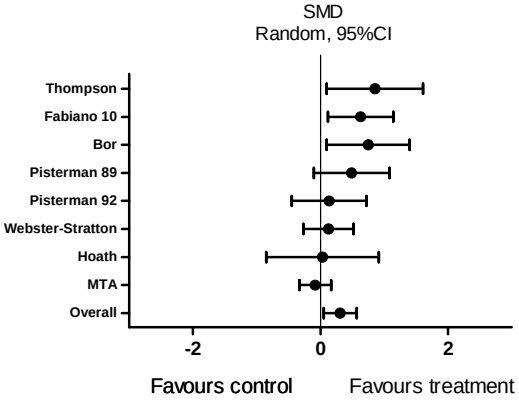
Overall SMD=0.0.02;95%CI=-0.30-0.34

Conduct Problems
MPROX



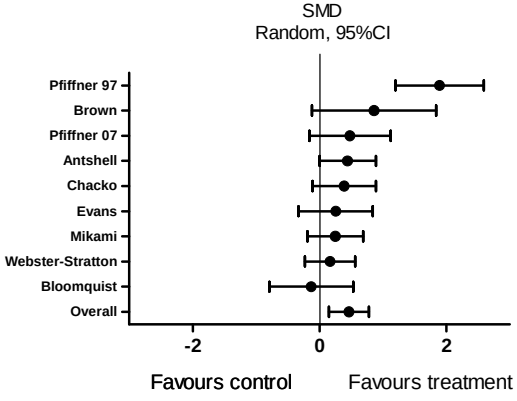
Overall SMD=0.26;95%CI=0.14-0.37

Conduct Problems
PBLIND



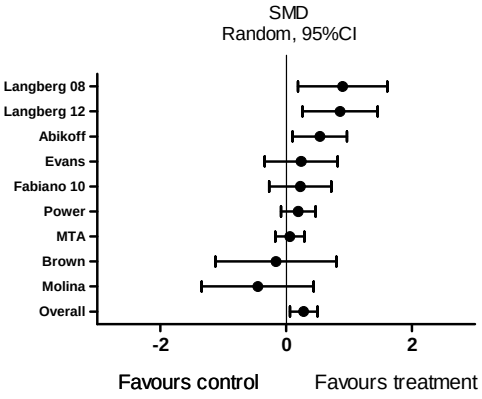
Overall SMD=0.31;95%CI=0.05–0.57

Social Skills
MPROX



Overall SMD=0.47;95%CI=0.15-0.78

Academic Achievement
MPROX



Overall SMD=0.0.28; 95%CI=0.06-0.59