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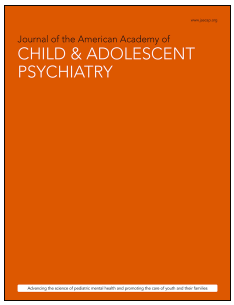

Meta-analysis: Which Components of Parent Training Work for Children With Attention-Deficit/Hyperactivity Disorder?

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PII: S0890-8567(21)00420-2

DOI: https://doi.org/10.1016/j.jaac.2021.06.015

Reference: JAAC 3469

To appear in: *Journal of the American Academy of Child & Adolescent Psychiatry*

Received Date: 26 October 2020

Revised Date: 2 June 2021

Accepted Date: 2 June 2021

Please cite this article as: Dekkers TJ, Hornstra R, van der Oord S, Luman M, Hoekstra PJ, Groenman AP, van den Hoofdakker BJ, Meta-analysis: Which Components of Parent Training Work for Children With Attention-Deficit/Hyperactivity Disorder?, *Journal of the American Academy of Child & Adolescent Psychiatry* (2021), doi: https://doi.org/10.1016/j.jaac.2021.06.015.

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Meta-analysis: Which Components of Parent Training Work for Children With Attention-Deficit/Hyperactivity Disorder?

RH = Working Elements in ADHD Parent Training

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Supplemental Material

Accepted June 25, 2021

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This research was funded by the Dutch Organization for Health Research and Development (ZonMw) under grant number 729300013 to Barbara J. van den Hoofdakker. The funder had no role in the design of this protocol, the collection of data, the data analysis, or the interpretation or publication of the study results.

This article is part of a special series devoted to the subject of child and adolescent attention-deficit/hyperactivity disorder (ADHD). The series covers a range of topics in the area including genetics, neuroimaging, treatment, and others. The series was edited by Guest Editor Jonathan Posner, MD along with Deputy Editor Samuele Cortese, MD, PhD.

This work has been prospectively registered:
https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42018096768

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The authors would like to thank Lieke Bruinsma, MSc and Simone Breider, PhD student, of the University of Groningen, for assistance in scoring the manuals, and gratefully acknowledge all authors who provided their data. The authors thank Nico Flierman, PhD student, of the University of Amsterdam, for assistance with the figures.

Disclosure: Dr. van der Oord has co-developed a planning-focused and solution-focused treatment, and other behavioral treatments, but has no financial interest in any of these. She has received research grants from ZonMw (The Netherlands Organization for Health Research and Development) and the FWO (The Flemish Organization for Scientific Research); she was an advisor of the Dutch ADHD guideline groups and is a member of a working group on ADHD of the health counsel of Belgium. Dr. Luman has co-developed a self-help teacher training, without financial interests. She has received research grants from ZonMw and was an advisor of the Dutch ADHD guideline groups. Dr. van den Hoofdakker has received royalties as one of the editors of "Sociaal Onhandig" (published by Van Gorcum), a Dutch book for parents that can be used in parent training. She has been involved in the development and evaluation of several parent and teacher training programs, without financial interests; she has been a member of Dutch ADHD guideline and practice standard groups. Drs. Dekkers, Hoekstra, Groenman and Ms. Hornstra have reported no biomedical financial interests or potential conflicts of interest.

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Abstract

Objective: Behavioral parent training is an evidence-based intervention for children with attention-deficit/hyperactivity disorder (ADHD), but it is unknown which of its components are most effective. This meta-regression analysis investigated which specific behavioral techniques that parents learn in parent training are associated with effects on parental outcomes.

Method: We searched for randomized controlled trials on parent training for children with ADHD, with positive parenting, negative parenting, parenting sense of competence, parent-child relation quality, and/or parental mental health as outcome measures. After screening 23,026 publications, 29 studies contributing 138 effect sizes were included (*N*=2345). For each study, the dosage of 39 behavioral techniques was derived from intervention manuals, and meta-regression determined which techniques were related to outcomes.

Results: Parent training had robust small-to-medium-sized positive effects on all parental outcomes relative to control conditions, both for unblinded and probably blinded measures. A higher dosage of techniques focusing on the manipulation of antecedents of behavior was associated with better outcomes on parenting sense of competence and parental mental health, and a higher dosage of techniques focusing on reinforcement of desired behaviors was related to larger decreases in negative parenting. Higher dosages of psycho-education were negatively related to parental outcomes.

Conclusion: Although techniques were not investigated in isolation, our results suggested that the manipulation of antecedents of behavior and reinforcement techniques are key components of parent training for children with ADHD in relation to parental outcomes. These exploratory findings may help to strengthen and tailor parent training interventions for children with ADHD.

Key words: attention-deficit/hyperactivity disorder (ADHD), Behavioral Parent Training, parenting, meta-analysis, children

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Introduction

Behavioral parent training is recommended as evidence-based intervention for children with attention-deficit/hyperactivity disorder (ADHD) in clinical practice guidelines (e.g.,[1,2]). The presumed working mechanism of behavioral parent training is to alter the child's behavior *via* parenting behaviors[3]. Several meta-analyses demonstrated effects of parent training on several parental outcomes (see [4] for a review of these meta-analyses), with largest and most robust effects on positive and negative parenting, smaller improvements in parenting sense of competence, but no effects on parental mental health[5]. Behavioral parent training consists of many different behavioral techniques that are being taught to parents, and it is yet unknown which of these techniques are most effective. In the current study, we investigated which behavioral techniques contribute to the effects of parent training on parental outcomes.

Several studies show that improvements in parenting behaviors mediate improvements in the behavior of children with ADHD. There is consistent evidence that parent training for children with ADHD is less likely to improve the child's behavior when negative parenting practices such as harsh and inconsistent discipline do not decrease[6–8]. Furthermore, increased parenting sense of competence and decreased parenting stress after parent training has repeatedly been found to be associated with behavioral improvements of children with ADHD[9,10].

Although the effectiveness of parent training on parenting outcomes is recognized by all major clinical practice guidelines on ADHD[1,2,11], there is surprisingly little research about which specific behavioral techniques that are being used in parent training contribute (most) to changes in parenting behaviors. Some examples of behavioral techniques are restructuring

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situations, offering rewards, and time-out procedures[12,13]. Most behavioral parent training programs are rooted in social learning theories[14], and the overarching aim of these programs is teaching parents to prevent and manage their child's behavior[15]. The content of existing behavioral parent training programs, however, differs substantially: some mainly consist of psycho-education (e.g., Sunshine Program for ADHD[16,17]), whereas others emphasize disciplinary communication (e.g., Helping the Noncompliant Child[18]), observation and monitoring (e.g., Family-School Success-Early Elementary[19]), or positive reinforcement (e.g., Incredible Years[20]).

Knowing which specific behavioral techniques are effective components of parent training is crucial as it could guide the development, improvement, and tailoring of interventions, and thereby benefits the well-being of children with ADHD and their families[21]. The current study is the first meta-analysis that disentangled the effects of these specific behavioral techniques of parent training for ADHD on parenting outcomes.

Two earlier endeavors examining the effectiveness of specific behavioral techniques of parent training are worth mentioning. First, for children with disruptive behavior disorders, the use of positive reinforcement (particularly praise) and natural/logical consequences was associated with stronger effects on disruptive child behavior[22]. Second, a meta-analysis including a broad range of parenting programs[23] suggested that techniques focusing on positive parent–child interactions and emotional communication skills, time-out, parenting consistency, and practicing skills during the sessions were associated with larger effectiveness, as measured by child and parenting outcomes. Despite the valuable contribution of these studies, their conclusions were limited for several reasons: (1) in Leijten et al.[22], only child outcomes were assessed, whereas the presumed working mechanism of parent training is to change parenting behaviors; (2) both studies only scored the presence or absence of specific behavioral techniques, which ignores crucial and more nuanced

information about the dosage of these techniques; (3) both studies only used information about the components of parent training that was provided in papers and supplements, which may be less detailed relative to information derived from treatment manuals; (4) both studies did not focus specifically on children with ADHD, and therefore the implications of these studies for children with ADHD are yet unclear, particularly as children with ADHD are suggested to have specific underlying instrumental learning deficits which potentially should be targeted with specific behavioral techniques[12]. Unique problems in intra-individual variability in responding (i.e., increased number of lapses of attention[24]) as well as aberrant motivational processes are documented for children with ADHD relative to children with disruptive behavior disorders[25–27]. Specifically, alterations in reward and punishment sensitivity may provide targets for behavioral parent training in this population (see [12] for a review on specific instrumental learning deficits in ADHD and the link with behavioral parent training).

The current meta-analysis took these limitations into account, by including only randomized controlled trials with samples in which all children were diagnosed with ADHD, and by scoring the dosage of behavioral techniques (i.e., the number and percentage of sessions in which a specific technique is being taught to parents). More specifically, we scored the behavioral techniques of all behavioral parent training manuals that were used in the included trials using a taxonomy consisting of 39 different behavioral techniques, grouped in 8 main categories (see Supplement 1, available online, for details).

In addition to the effects of the dosage of different techniques, we exploratively investigated whether other characteristics of the intervention (setting, delivery method, format, duration, collaboration with school, allowance of concurrent medication, and checking treatment integrity) or characteristics of the child (age, sex, comorbid disorders) were associated with the effectiveness of the intervention. So far, evidence for the possible

moderating effect of these characteristics is mixed. One meta-analysis showed that individual parent training was more effective than group training on parenting outcomes[28], whereas a meta-analysis on parent training in preschoolers with ADHD did not observe this effect[29]. Another meta-analysis on parent training in preschoolers with ADHD reported no moderation of age (within preschoolers) and duration of the intervention[30], but a meta-analytic review on behavioral interventions for children with a wider age range demonstrated larger effects on positive parenting for younger children[5]. Meta-analytic evidence for other moderator effects is scarce, but highly needed to establish who benefits most from behavioral parent training[31].

The primary aim of the current study was to investigate whether the behavioral techniques that were included in our taxonomy were associated with the effects of behavioral parent training for parents of children with ADHD on five different parental domains, i.e., positive parenting, negative parenting, parenting sense of competence, quality of the parent-child relationship, and parental mental health. A secondary aim was to investigate whether intervention and child characteristics influenced the training effects.

Method

Protocol and registration

This meta-analysis was preregistered at PROSPERO (https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42018096768), and PRISMA guidelines[32] were followed (see Supplement 2, available online, for the PRISMA checklist). Note that the preregistration also covers child outcomes, which is described in a separate article by the same research group (Hornstra et al., *under review*). Also, for this reason, some of the wording in the method sections of these articles may overlap.

In- and exclusion criteria

Randomized controlled trials were included when (i) behavioral parent training or a multimodal intervention (the latter only if >50% of intervention time was spent with the

parent) was compared to a control condition; (ii) the control condition consisted of (a) an active control treatment, (b) treatment as usual, or (c) no treatment/waitlist, and in case of multiple control conditions, the one with the highest quality was selected (a>b>c); (iii) participants were (on average) below 18 years old; (iv) participants met criteria for ADHD, either established by meeting DSM (any edition) criteria for ADHD measured by diagnostic interviews, or scoring above clinical cut-offs on questionnaires measuring ADHD. Studies were excluded if medication was used as control condition, or if medication was prescribed as part of the intervention. Behavioral parent training was defined as an intervention that teaches parents techniques to manipulate the antecedents of their child's behavior (i.e., stimulus control techniques) and/or techniques to manipulate behavioral contingencies (i.e., contingency management techniques), making children more likely to increase desired behaviors and to decrease unwanted behaviors[15].

Outcome variables

Five domains of outcome variables were selected: positive parenting, negative parenting, parenting sense of competence, parent-child relation, and parental mental health. Positive parenting includes parenting behavior such as reinforcement, monitoring, stimulating, and guiding the child. Negative parenting refers to behavior such as corporal punishment, harsh discipline, inconsistent parenting, and poor monitoring. Parenting sense of competence is defined as the extent to which parents perceive themselves as competent or efficacious when raising their child. Outcomes were classified as measuring the quality of the parent-child relation when measuring display of affect, support, sensitivity, and/or responsiveness. For parental mental health, measures included parenting stress and several indices of parental psychopathology (e.g., depression, anxiety, ADHD). Note that we performed a sensitivity analysis without parental ADHD symptoms as measure of parental mental health, as improvements in parental ADHD symptoms after parent training may be smaller than in other

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domains of parental mental health. The categorization of all instruments can be found in Table 1. When one measure tapped multiple outcome domains, we assigned this measure to the outcome domain which was reflected by most items of the measure. Measures were coded as either unblinded (parent-rated) or probably blinded (rated by independent coders).

Literature search

Literature was searched up to May 13th, 2020 (see Figure 1 for the PRISMA flowchart, Supplement 3, available online, for specific search terms per database). Selection and screening of the articles was performed by two authors (out of three: TJD, APG, RH) using Rayyan software[33]. Disagreement was solved by debate or by consulting the other authors (SvdO, BJvdH).

INSERT FIGURE 1 HERE

Data extraction

Included studies were independently rated by two out of three authors (TJD, APG, RH), disagreement was solved by debate or by consulting the other authors. Our taxonomy, which was based on several influential reviews[23,34–36], included eight categories (shaping knowledge; observation and monitoring; manipulating antecedents; positive consequences; negative consequences; combined techniques; practicing, generalization and maintenance; relationship building and communication skills). These categories cover a total of 39 behavioral techniques (for details on the taxonomy, see Supplement 1, available online; for operational definitions of other extracted variables, see Supplement 4, available online). For each technique, we established the dosage of these techniques by scoring the number and the percentage of sessions in which this technique was used. If not publicly available, the manuals of the interventions used in the included studies were requested from the authors.

The manual was unavailable for three studies[37–39], which were therefore excluded from the analyses on the effects of the dosage of behavioral techniques. Note that for [37], the manual of the traditional Behavioral Parent Training was unavailable. The same study also compares the STEPP (Strategies to Enhance Positive Parenting) program with a waitlist control, and this comparison is included in the analyses.

Risk of bias

We used GRADE (Grading of Recommendations Assessment, Development and Evaluation[40]) to assess the quality of the included studies, which was performed independently by two authors (APG and RH). GRADE uses six criteria to assess selection, detection, attrition, and reporting bias: random sequence generation, allocation concealment, blinding of outcome assessment, incomplete outcome data, vested interest, and selective outcome reporting. All studies were scored individually on these criteria.

Data-analytic approach

Effect sizes of every outcome were calculated in terms of standardized mean differences (Hedges' *g*), based on pre-post intervention differences standardized by the post-intervention standard deviation, using Comprehensive Meta-Analysis software[41] and, if applicable, recoded to ensure that positive effect sizes on that outcome indicate beneficial effects of the intervention relative to the control condition (i.e., increases in positive parenting, parenting sense of competence and parent-child relation quality, and decreases in negative parenting and parental mental health problems). The `metafor` and `dmetar` packages in R were used for further analyses[42,43]. Main effects of each outcome were calculated using multilevel meta-analyses. After main effects were estimated, a random effects meta-regression analysis was performed for each of the five outcome domains. Because several studies contributed multiple effect sizes, the analysis concerned three levels (i.e., participants, effect sizes, and studies; see [44] for background on multilevel meta-regression). This approach thereby

accounted for dependency between effect sizes within studies (e.g., when two different measures for positive parenting were used in one study, or when a study reported scores from two informants on one measure). Five studies compared two intervention arms with one control condition, we performed a sensitivity analysis to assess the potential influence of the dependency between these arms (see Supplement 5, available online). For meta-regression analyses we report $\hat{\beta}$ coefficients, with $\hat{\beta}_1$ indicating the change in the standardized mean difference when the moderating variable increases with one unit, and $\hat{\beta}_0$ indicating the intercept, which is equal to the standardized mean difference for a specific value of the reference category of the moderator[45].

Potential differences between probably blinded and unblinded measures were investigated in a categorical moderation analysis (probably blinded vs. unblinded), and differences based on the type of control condition were assessed with a similar analysis (active vs. waitlist control). Publication bias was assessed using Egger's test for funnel plot asymmetry[46], and Trim-and-Fill analyses were performed to estimate the number of studies that are needed to counter potential funnel plot asymmetry[47]. P-Curves were calculated to estimate evidential value and potential flexibility in data-analysis[48], and leave-one-out analyses were performed to assess the potential influence of single studies. For all analyses, I^2 statistics were used as indication of heterogeneity, separated for between-variables and between-studies heterogeneity (level 2 and 3, respectively). To estimate main effects and for continuous moderation analyses at least 10 effect sizes were required, and subgroups required at least 4 effect sizes for categorical moderation analyses[49].

For our primary aim, we assessed associations between behavioral techniques and outcomes using meta-regression analyses. To limit the number of analyses, we first tested whether the eight overall categories of behavioral techniques were associated with outcomes in two ways: by assessing the influence of (1) the percentage of sessions in which at least one

technique from a category occurs and (2) the number of sessions in which at least one of the techniques from a specific category occurs. If the percentage of sessions in which at least one technique from a category occurs was (borderline-)significantly (p<.10) related to an outcome domain, we conducted follow-up analyses for all specific techniques within that category. The same procedure was adopted when the number of sessions in which a certain category of techniques was represented was associated with the outcome.

For our secondary aim, we assessed the influence of the following factors on treatment effects on parenting outcomes: setting (home, clinic, school), delivery method (individual, group, mixed), format (parent training only versus parent training as part of multimodal treatment), the presence of home-school collaboration (yes/no), medication use at study entry (allowed versus not allowed) and the presence of integrity checks (yes/no) as intervention/study characteristics, and age (both continuously and categorical), sex (percentage boys), and comorbid externalizing disorders as child characteristics.

For all analyses, we did not control for multiple testing, as the analyses were hypothesis-generating, and not confirming.

Results

Study selection

In total, 29 studies with 35 interventions and 138 relevant effect sizes were included (see Figure 1). Study characteristics can be found in Table 1. The mean and the range of the dosage of all scored techniques are provided in Supplement 6, available online.

Risk of bias

Risk-of-bias analyses can be found in Supplement 7, available online (interrater reliability κ = .96). Few studies included blinded measures, most studies reported complete outcome data. Overall, the information in the published manuscripts of many studies was not

sufficient to determine the risk of bias for the categories random sequence generation, allocation concealment, vested interest, and selective outcome reporting.

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Main effects

Significant small-to-medium-sized main effects (ranging from .41 to .60, all *p*'s < .001) favoring parent training over control conditions were found for all outcome categories (see Table 2 and Figure 2).

Effect sizes were not significantly different for probably blinded and unblinded measures on positive parenting ($\hat{\beta}_1$ = .05, *p* = .82), negative parenting ($\hat{\beta}_1$ = -.15, *p* = .52) and parent-child relation ($\hat{\beta}_1$ = .02, *p* = .95) (see Table 2 for effect sizes). None or too few blinded measures were available for parenting sense of competence and parental mental health.

Visual inspection of the forest plot (Figure 2) depicted one outlying study with particularly high effect sizes on the outcome domain of parental mental health [50]. As noted in Table 2, the effect size decreased and the heterogeneity between studies dropped considerably after removing that study. For the forthcoming analyses on the parental mental health domain, we therefore decided to exclude that study from further analyses (analyses including this study were also performed and are described in Supplement 8, available online). A sensitivity check excluding one study measuring parental ADHD revealed highly similar results (see Supplement 9, available online).

A sensitivity check comparing studies with active control conditions and studies with waitlist control conditions demonstrated that—as expected—effect sizes for most of the outcome domains were smaller when parent training was compared to an active control condition than when it was compared to a waitlist. However, this difference in effect sizes was only significant for negative parenting (see Supplement 10, available online, for detailed results).

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INSERT FIGURE 2 HERE

Robustness analyses

Egger's test[46] indicated signs of funnel plot asymmetry (which potentially indicates publication bias) on negative parenting (t = 2.57, p = .02), parenting sense of competence (t = 2.17, p = .04), and parent-child relation (t = 2.46, p = .03), but not on positive parenting (t = 1.83, p = .08) and parental mental health (t = .55, p = .59). Note that Egger's test and trim-and-fill analyses were performed without modeling for dependency between effect sizes, as this is currently not possible.

Trim-and-fill analyses[52] demonstrated that, on the left side of the funnel plot, 9 studies were missing for negative parenting, 4 studies were missing for parental mental health, 4 for parent-child relation, 3 for positive parenting, and 1 for parenting sense of competence (see Supplement 11, Figure S1, available online, for funnel plots with estimated missing effect sizes). After taking into account these missing studies, the effect size slightly decreased (but remained significant) for positive parenting, negative parenting, parent-child relation, and parental mental health and remained similar for parenting sense of competence (effect sizes ranged between .29 and .54, all p's < .05; see Table 2).

P-curves[48] were created for all outcome categories. In all cases, p-curves were right-skewed and indicated evidential value (all p-values for the half p-curve < .05). See Supplement 11, Figures S2-S6, available online, for p-curves.

Sensitivity analyses (i.e., leave-one-out) indicated that effect sizes were not heavily dependent on single studies, as the minimum and maximum effect size calculated by the leave-one-out analyses did not differ substantially for all outcome domains, and all were within the range

of the confidence intervals of the main effects: for positive parenting (minimum SMD = .53, $p < .001$; maximum SMD = .64, $p < .001$), for negative parenting (minimum SMD = .53, $p < .001$; maximum SMD = .63, $p < .001$), for parenting sense of competence (minimum SMD = .49, $p < .001$; maximum SMD = .57, $p < .001$), for parent-child relation quality (minimum SMD = .45, $p < .001$; maximum SMD = .58, $p < .001$), and for parental mental health (minimum SMD = .32, $p < .001$; maximum SMD = .37, $p < .001$).

Additional sensitivity analyses were performed to assess the influence of dependency in studies that compared two intervention arms with one control condition. The influence was minimal (see Supplement 5, available online, for details).

In sum, although some analyses indicate the presence of publication bias (Egger's test, trim-fill analyses), the main effects are robust given the results of the trim-fill corrected analyses, p-curves and leave-one-out analyses.

Primary analyses: Does the dosage of behavioral techniques influence the effects of parent training?

All results regarding the association between the overall effect size and the dosage of technique categories or specific techniques (measured by both the percentage and the number of sessions in which a technique from a certain category/a specific technique occurs) can be found in Supplement 12, available online.

In Table 3, we summarized those categories/techniques that were significantly associated with outcomes. We found that (1) the dosage of psycho-education was negatively associated with treatment effects on positive parenting and the quality of the parent-child relation; (2) the dosage of teaching parents to manipulate antecedents, and in particular to anticipate misbehaviors, was positively associated with treatment effects on parenting sense of competence and parental mental health; (3) the dosage of teaching parents to work with positive consequences was

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associated with larger treatment effects on negative parenting; (4) the dosage of practicing/generalization techniques was negatively associated with the effect of treatment on the parent-child relation. Dosage was established by either the number or the percentage of sessions in which the techniques occur (see Table 3 for specific results). Most of the analyses, however, were not significant (see Supplement 12, available online).

Secondary analyses: Moderation by intervention and participant characteristics

Intervention characteristics

Secondary analyses of intervention characteristics on all outcomes were all non-significant except for two findings. First, on negative parenting, parent training only was associated with a larger effect than parent training as part of multimodal treatment. Second, interventions without integrity checks (although only 2 studies containing 6 effect sizes) were more effective than interventions with integrity checks on positive and negative parenting. See Table 3 for significant findings, see Supplement 13, Table S1-3, available online, for all results.

Child characteristics

Effects of parent training on negative parenting were higher when the child was younger, and effects on positive parenting were higher for preschoolers than for school-age children (the latter were more pronounced when two studies on adolescents were excluded, see Supplement 14, available online, for details on these sensitivity analyses). Sex of the child moderated the effect on negative parenting: the higher the percentage of boys in the sample, the higher the effects. Finally, the percentage of comorbid externalizing disorders in the sample did not moderate any

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outcomes. All analyses containing moderation by participant characteristics can be found in Supplement 13, Table S3, significant findings are also in Table 3.

Discussion

Behavioral parent training for children with ADHD consists of many different techniques that are being taught to parents. To enhance the development of more effective future parent training interventions, the primary aim of the current study was to investigate which behavioral techniques were associated with better or worse parental outcomes.

We found that higher dosages of behavioral techniques teaching parents to manipulate the antecedents of behavior (i.e., stimulus control techniques), in particular by explicitly anticipating potential misbehavior of the child (e.g., thinking ahead, prepare a plan before entering a problematic situation), were associated with positive effects on parenting sense of competence and parental mental health. Stimulus control techniques may be particularly relevant for children with ADHD, with their noted disorganization and executive functioning deficits[12,53–55]. These intervention components are (relative to for example techniques focusing on relationship building and teaching communication skills) relatively straightforward for parents and focus on the prevention of non-adaptive behavior, which may provide a sense of control. This may give parents immediate mastery of these skills. Also, it may well be that children respond quickly to these techniques and thereby reinforce parents, altogether leading to an increased sense of competence and a decrease of stress.

Additionally, stimulus control techniques such as applying more structure and clear rules may also be beneficial for parents themselves, as a significant proportion of the parents of children with ADHD has impairing ADHD symptoms[56]. This may well explain our finding that a higher

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dosage of stimulus control techniques was associated with improved parental mental health. This is an important finding, as parental ADHD symptoms have been found to attenuate effects of behavioral parent training[6,57].

Second, higher dosages of behavioral techniques teaching parents to provide children with positive consequences after showing desired behavior, in particular offering social rewards and responding in a consistent way, were associated with decreased negative parenting. The importance of the effects on negative parenting is emphasized by previous studies that consistently demonstrated that decreases in negative parenting mediated behavioral improvements in children: Decreases in negative parenting practices predicted improvements in child outcomes in the Multimodal Treatment of ADHD (MTA) study[8], and a recent telephone-assisted self-help parent training study found that changes in negative parenting mediated effects on children's ADHD symptoms[7]. Also, in response to behavioral parent training, changes in negative parenting mediated the link between maternal ADHD symptoms and the child's behavioral problems after parent training[6], and improved discipline techniques by parents predicted decreased disruptive behavior by the child[58]. This suggests that changing negative parenting is pivotal to ultimately improve the child's behavior.

Third, higher dosages of psycho-education were associated with *lower* effects on positive parenting and the quality of the parent-child relation. This seemingly surprising finding does not necessarily imply that psycho-education is ineffective, but suggests that other behavioral techniques such as manipulating antecedents and providing positive consequences deserve a higher dosage, given the limited time that is often available for behavioral parent training (usually between 8 and 12 sessions). On average, psycho-education occurred in 7 sessions, and in 69% of the total number of sessions, which was substantial. A limitation of the current approach, however, is that the content of the psycho-education

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was not scored. This could be relevant, as deterministic, biologically-based psycho-education potentially increases the perceived burden of the disorder by caregivers[59]. This could lead to more parental awareness of their child's problems and potentially also results in discouragement about the influence of parents on the problems of their children, ultimately resulting in lower effects of interventions. Future research should disentangle which specific forms of psycho-education are, and are not, useful in parent training for ADHD.

Fourth, higher dosages of techniques aimed at practicing, generalization and maintenance of learned skills (e.g., problem-solving techniques) were associated with lower effects on the quality of the parent-child relation, but there also was a trend towards a positive association between these techniques and positive parenting. Implications of these mixed findings with regard to practicing, generalization and maintenance techniques are not straightforward. Techniques from this category occurred in almost 90% of the sessions, with homework assignments as specific technique that was most frequently included in interventions (78% of the sessions). Potentially, the generally high rates of these techniques observed across studies may have obscured their effects. Earlier studies point towards the importance of these techniques, as assigning homework, for example, was associated with higher efficacy of behavioral treatment for ADHD[60].

Directly studying which techniques are related to the core mechanism of change of behavioral parent training—parenting—is the ultimate way of advancing our psychological treatments[61]. The main findings of our study therefore provide directions to better tailor behavioral parent training for children with ADHD, and to improve current interventions. This, however, does not imply that parent training in its current form is not effective: in correspondence with previous meta-analyses and reviews[4,5], we observed robust medium-sized effect sizes of parent training on all five outcome domains related to parenting. Effect sizes were lower when parent training was compared with active control conditions relative

to waitlists, but only the effect size for negative parenting dropped to non-significant when only including studies with active control conditions. A reassuring finding was that effect sizes on positive parenting, negative parenting, and the parent-child relation did not differ between probably blinded and unblinded measures, indicating that effects are not merely attributable to parents' investment affecting their assessment of outcome measures. This corresponds with an earlier meta-analysis of behavioral interventions for ADHD, which reported medium-sized effects on both positive and negative parenting, as measured by probably blinded assessments[5]. These robust effects of behavioral parent training on parenting outcomes are imperative, as improvements in parenting are a prerequisite to ultimately lead to improvements in child functioning, as these are the core mediators of change[6,8,9].

The secondary aim of this study was to investigate whether several child and intervention characteristics were associated with parenting outcomes. The most relevant finding was that effects of parent training on both positive and negative parenting were higher when children were younger, which is consistent with a previous meta-analysis on psychosocial interventions for ADHD [5]. Potentially, at an early age, not only the child's but also parenting behavior is less engrained and more prone to change relative to later ages. Together with observations that early onset of ADHD is associated with more severe long-term outcomes[29], these findings emphasize the need for early psychosocial interventions for children with ADHD[62]. Other secondary findings were more surprising. First, studies without integrity checks had higher effect sizes on positive and negative parenting than studies with integrity checks. The large majority of studies included integrity checks, and our findings on this variable were likely driven by two old studies[38,39] that did not report such checks and obtained medium-to-large effects on positive and negative parenting. Second, studies investigating parent training only had higher effect sizes on the reduction of negative parenting relative to studies on

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multimodal treatment. A likely explanation is that multimodal interventions focused less specifically on parenting (e.g., many of the multimodal interventions included in our study also involved school consultations), which could limit the impact of such interventions on parenting skills. Third, a higher proportion of boys was associated with stronger effects on negative parenting. A very tentative explanation for this finding could be that there is some evidence of higher (baseline) levels of negative parenting for boys relative to girls[63,64], which potentially leaves more room for improvement of negative parenting in parents of boys.

Although the current investigation has several strong aspects, including thorough investigation of the dosage of 39 behavioral techniques by scoring all original treatment manuals, inclusion of a large number of studies, and the use of state-of-the-art multilevel meta-regression analyses, a few limitations warrant mentioning. First, by using the current method we could not examine the effects of separate techniques, as these were not investigated in isolation. Therefore, potential effects of combinations of techniques, or sequencing of techniques, could not be ruled out and could have confounded the results. Correlations between dosages of different techniques (see Supplement 6, Table S2, available online, for the correlation matrix) further underline this issue: especially the dosage of positive consequences was associated with the dosage of several other techniques. Multicollinearity was not a problem as none of the correlations between technique categories was above .8.

Second, the current investigation should be primarily regarded as hypothesis-generating instead of confirming. For hypothesis-generating studies, correcting for multiple testing is not advised[65,66]. This implies that results should be interpreted with caution, and should be confirmed, or falsified, by future empirical studies.

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A third limitation is that only effects at the end of the intervention were taken into account. Potentially, some behavioral techniques are more effective on the longer term. For example, there were no direct post-treatment effects in a study particularly focusing on psycho-education, but substantial effects of psycho-education were observed after six months[16]. Similar mechanisms may apply for generalization techniques, as transfer of skills from therapy to daily life logically takes time.

Fourth, although our technique categories showed substantial variation, some of the separate techniques only occurred in a small number of studies (Supplement 6, Table S1, available online). This may have limited the power of our analyses on these techniques.

Fifth, we did not compute inter-rater reliability statistics about the coding of the intervention manuals. However, we do not believe this limitation affects our findings, as all manuals were independently scored by two raters, and senior authors were consulted in rare cases of disagreement.

Sixth, we scored the dosage of techniques in terms of number and percentage of sessions, but not the total amount of time spent on specific techniques within sessions. The latter may yield more definitive information for intervention optimization (e.g., how to best balance the time spent during sessions between homework review vs teaching a new skill).

Future studies are needed to test the hypothesis based on our current results that focusing on teaching parents to manipulate antecedents of behavior and to provide positive consequences for desired behavior is particularly effective to change child behavior in ADHD samples. Two recent micro-trials (one for parents and one for teachers) provided evidence in this direction: when provided in isolation, both stimulus control and contingency management techniques were found effective on improving the child's behavior[67,68]. Future studies should further test whether

the current findings also apply for child outcomes, as the ultimate goal of parent training is to change the child's behavior *via* parental behavior. These studies could also investigate associations between changes in parental outcomes and child outcomes.

The current study has several implications for clinical practice. First, the robust small-to-medium-sized main effects of parent training on all domains of parenting and parental well-being add to the evidence-base regarding parent training as an effective intervention for children with ADHD[4,5,15]. Second, this evidence, combined with our finding that parent training was particularly effective in ameliorating parenting for preschool-age children with ADHD, suggests that parent training should be delivered early in the potential chain of mental healthcare for children with ADHD (also see[69,70]). Third, although techniques were not investigated in isolation, our results suggest that the manipulation of antecedents of behavior and reinforcement techniques are key components of parent training for children with ADHD in relation to parental outcomes. These exploratory findings may help to strengthen and tailor parent training interventions for children with ADHD.

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Table 1. Study Characteristics

Study	Intervention (*N*)	Control (*N*)	Positive Parenting	Negative Parenting	Parenting Sense of Competence	Parent-Child Relation	Parental Mental Health	Setting/ Format/ Delivery	Duration in minutes	Age (cat.)	% Boys	% Ext. dis.	Home-school coll.	Med. All.	Integr. checks
Abikoff et al. 2015 [18]	HNC (63)	WL (34)	PPI-Total (N)	N/A	N/A	GIPCI-R-Total (Y), PSI-R & PPES Sum (N)	N/A	C/PT/I	480	3.6 (P)	74	42	N	N	Y
	NFPP (67)		PPI-Total (N)	N/A	N/A	GIPCI-R-Total (Y), PSI-R & PPES Sum (N)	N/A	H/PT/I	600	3.6 (P)	74	42	N	N	Y
Aghebati et al. 2014 [50]	Triple P (14)	WL (13)	N/A	PS (N)	N/A	PBI-Care, Overprot. (N)	DASS-42-Anx., Depr., Stress (N)	C/PT/G	667,5	8.0 (S)	59	N/A	N	Y	N/A
Au et al. 2014 [71]	Triple P (8)	WL (9)	N/A	N/A	PSOC Eff., Sat. (N)	N/A	SNQ-Stress (N)	M/PT/M	975	7.7 (S)	94	N/A	N	N	Y
Chacko et al. 2009 [37]	BPT (40)	WL (40)	DPICS-PP (Y)	DPICS-NP (Y)	N/A	IRS-Par. (N)	BDI (N), PSI (N)	C/MM/G	1350	7.9 (S)	71	71	N	Y	Y
	STEPP (40)		DPICS-PP (Y)	DPICS-NP (Y)	N/A	IRS-Par. (N)	BDI (N), PSI (N)	C/MM/G	1350	7.9 (S)	71	70	Y	Y	Y
Daley et al. 2013 [72]	NFPP SH (24)	WL (19)	GIPCI-Parent (Y)	N/A	PSOC Eff., Sat. (N)	N/A	GHQ (N)	H/PT/I	330	7.3 (S)	81	NA	Y	N	Y
DuPaul et al. 2018 [73]	F2F BPT (16)	WL (16)	N/A	N/A	PSI-SF-Dysf. Int. (N)	N/A	PSI-SF-Distress (N)	C/PT/G	900	4.4 (P)	64	60	Y	N/A	Y
	Online BPT (15)		N/A	N/A	PSI-SF-Dysf. Int. (N)	N/A	PSI-SF-Distress (N)	H/PT/I	900	4.4 (P)	64	60	Y	N/A	Y
Fabiano et al. 2012 [74]	Coaches (28)	WL (27)	DPICS-Total Praise (N)	DPICS-Total Com., Neg. Talk (N)	N/A	N/A	N/A	C/PT/G	960	8.5 (S)	87	69	N	Y	Y
Ferrin et al. 2014 [17]	Ps.-Ed. (43)	AC (37)	N/A	N/A	N/A	N/A	PSI-SF (N)	C/PT/G	1080	10.7 (S)	80	30	Y	Y	Y
Ferrin et al. 2016 [16]	Ps.-Ed. (35)	TAU (34)	N/A	N/A	N/A	N/A	PSI Total (N)	C/PT/G	720	10.7 (S)	87	97	Y	Y	Y
Franke et al. 2016 [75]	TPOL (27)	WL (26)	N/A	PS-Laxness, Overreact., Verb. (N)	PSOC Eff., Sat. (N)	PSDQ-Auth. (N)	DASS-21-Anx., Depr., Stress (N)	H/PT/I	480	4.0 (P)	72	N/A	N	N/A	Y

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Herbert et al. 2013 [76]	BPT (17)	WL (14)	CCNES-Supp. (N), Audiotape-Comm. Qual. (Y)	CCNES-Unsupp. (N), PS-Laxness, Overreact., Verb. (N)	N/A	Audiotape-Neg. Aff., Pos. Par. (Y)	Audiotape-Distress (Y)	C/PT/G	1260	4.6 (P)	74	N/A	N	Y	Y
Hoath et al. 2002 [77]	EGTP (9)	WL (11)	N/A	PS-Laxness, Overreact., Verb. (N)	PSBC (N)	N/A	DASS-Anx., Depr., Stress (N)	S/PT/G	574	7.7 (S)	80	NA	N	Y	Y
Jiang et al. 2018 [78]	CLAS (74)	TAU (51)	APQ/PCRQ-Pos. (N)	APQ/PCRQ-Neg. (N)	PSOC, PCEQ (N)	N/A	N/A	M/MM/M	1260	8.6 (S)	54	5	Y	Y	Y
	PFT (74)		APQ/PCRQ-Pos. (N)	APQ/PCRQ-Neg. (N)	PSOC, PCEQ (N)	N/A	N/A	C/PT/M	1080	8.6 (S)	62	6	N	Y	Y
Lange et al. 2018 [79]	NFPP (86)	TAU (75)	GIPCI (Y)	N/A	PSOC Eff., Sat. (N)	N/A	N/A	M/PT/I	600	5.1 (P)	73	8	N	N	Y
Matos et al. 2009 [80]	PCIT (20)	WL (12)	PPI (N)	N/A	N/A	N/A	BDI-S (N)	C/PT/I	1305	5.0 (P)	NA	98	N	N	Y
Mautone et al. 2012 [19]	FSS-EE (24)	CARE (29)	FIQ (N), DPICS-CU-DO (Y), DPICS-CP-DO (Y)	PCRS (N), DPICS-CU-DON'T (Y), DPICS-CP-DON'T (Y)	PES (N)	N/A	N/A	C/MM/M	980	NA (P)	72	30	Y	Y	Y
Mikami et al. 2010 [81]	PFC (28)	No tr. (29)	Observation-Praise (Y)	Observation-Crit. (Y)	N/A	Observation-Warmth (Y)	N/A	C/PT/G	720	8.3 (S)	68	32	Y	Y	Y
Pisterman et al. 1989 [38]	BPT (23)	WL (23)	% Alpha comm. (Y), % Pos. (Y), Freq. Alpha (Y)	% Dir. (Y), % Neg. (Y), Freq. Beta (Y)	N/A	N/A	N/A	C/PT/M	720	4.2 (P)	80	NA	N	Y	N
Pisterman et al. 1992a [39]	BPT (23)	WL (22)	% Alpha comm. (Y), % Pos. (Y), % Reinf. (Y)	% Dir. (Y), % Neg. (Y), Freq. Dir. (Y), Freq. Neg. Fb. (Y)	N/A	N/A	N/A	C/PT/G	720	4.1 (P)	84	NA	N	Y	N
Pisterman et al. 1992b [82]	BPT (46)	WL (45)	N/A	N/A	PSCS-S, PSCS-V (N)	N/A	PSI-PD (N_	C/PT/M	720	4.2 (P)	82	NA	N	Y	N
Power et al. 2012 [83]	FSS (92)	CARE (96)	N/A	PCRQ-N/ID (N)	PES (N)	PCRQ-PI (N)	N/A	M/MM/M	980	NA (S)	68	27	Y	Y	Y
Shimabukuro et al. 2020 [84]	WPJ (28)	WL (24)	N/A	PS-Laxness, Overreact., (N)	PSOC Eff., Sat. (N), PLOC-Resp., Control (N)	Pasta Task-Pos., Neg. (Y)	PSI (N), BDI (N)	C/PT/G	1560	8.4 (S)	83	NA	N	Y	N
Sibley et al. 2013 [85]	STAND (18)	TAU (18)	N/A	N/A	N/A	CBQ (N)	CSQ (N)	C/MM/M	740	12.4 (S)	72	78	Y	Y	Y
Sibley et al. 2016 [86]	STAND (67)	TAU (61)	PAMS-Contr., Privil. (N)	N/A	N/A	CBQ (N)	CSQ (N)	C/MM/I	740	12.7 (S)	65	58	Y	Y	Y
Sonuga-B. et al. 2001 [87]	BPT (30)	PC&S (28)	N/A	N/A	PSOC Eff., Sat. (N),	N/A	GHQ (N)	H/PT/I	480	3.5 (P)	62	NA	N	N	Y

Sonuga-B. et al. 2004 [88]	BPT (59)	WL (30)	N/A	N/A	PSOC Eff., Sat. (N),	N/A	GHQ (N)	H/PT/I	480	3.5 (P)	NA	NA	N	N	Y
Sonuga-B. et al. 2018 [20]	IY (131)	TAU (42)	GIPCI (Y)	N/A	N/A	N/A	GHQ (N)	C/PT/G	1620	3.5 (P)	71	73	N	N	Y
	NFPP (133)		GIPCI (Y)	N/A	N/A	N/A	GHQ (N)	H/PT/I	1080	3.6 (P)	75	74	N	N	Y
Thompson et al. 2009 [89]	NFPP (17)	TAU (13)	GIPCI (Y)	N/A	N/A	PFMSS-Neg., Pos., Gl. (Y)	GHQ (N), AARS (N)	H/PT/I	600	4.5 (P)	76	NA	N	N	Y
van den Hoofdakker et al. 2007 [90]	BPT (47)	RCC (47)	N/A	N/A	N/A	N/A	PSI-PD (N)	C/PT/I	1440	7.4 (S)	76	76	N	Y	Y

Note: Intervention: BPT = Behavioral Parent Training, CLAS = Child Life and Attention Skills, EGTP = Enhanced Group Triple P, F2F BPT = Face-to-face Behavioral Parent Training, FSS-EE = Family School Success Early Elementary, HNC = Helping the Noncompliant Child, IY = Incredible Years, NFPP = New Forest Parenting Program, NFPP-SH = New Forest Parenting Program Self Help, PCIT = Parent-Child Interaction Therapy, PFC = Parental Friendship Coaching, PFT = Parent Focused Treatment, Ps.-Ed. = Psycho-Education, STAND = Supporting Teens' Academic Needs Daily, TPOL = Triple P Online, WPJ = Well Parent Japan,. Control: AC = Active Control, , CARE = Coping With ADHD Through Relationships and Education, No tr. = No treatment, PC&S = Parent Counselling and Support, RCC = Routine Clinical Care, TAU = Treatment as Usual, WL = Waitlist. Outcomes (Positive Parenting, Negative Parenting, Parenting Sense of Competence, Parent-Child Relation, Parental Mental Health; in parentheses: probably blinded or not [Y/N]): AARS = Adult ADHD Rating Scale, APQ = Alabama Parenting Questionnaire, BDI = Beck Depression Inventory, CBQ = Conflict Behavior Questionnaire, CCNES = Coping with Children's Negative Emotion Scale, Comm. = Commands, Comm. Qual. = Command Quality, Contr. = Contracting, CP = child-led play, CSQ = Caregiver Strain Questionnaire, CU = clean-up, DASS = Depression Anxiety Stress Scale, Dir. = Directive, DPICS = Dyadic Parent–Child Interaction Coding System, Dysf. Int. = Dysfunctional Interactions, FIQ = Family Involvement Questionnaire, Freq. Neg. Fb. = Frequency of Negative Feedback, GHQ = General Health Questionnaire, GIPCI-R = Global Impressions of Parent-Child Interactions-Revised, Gl. = Global, IRS = Impairment Rating Scale, Neg. Aff. = Negative Affect, N/ID = Negative/Ineffective Discipline, NP = Negative Parenting, Overreact. = Overreactivity, PAMS = Parent Academic Management Scale, PBI = Parental Bounding Instrument, PCEQ = Parent Cognitive Error Questionnaire, PCRQ = Parent-Child Relationship Questionnaire, PES = Parent as Educator Scale, PFMSS = Pre-school Five Minute Speech Sample, PI = Positive Involvement, PLOC = Parental Locus of Control Scale, PP = Positive Parenting, PPES = Parent Perceptions of Parents Efficacy scale, PPI = Parenting Practice Interview, Priv. = Privileges, PSDQ-Auth. = Parenting Styles and Dimensions Questionnaire – Authoritative Parenting, PS = Parenting Scale, PSCS-S = Parenting Sense of Competence Scale - Skills, PSCS-V = Parenting Sense of Competence Scale - Valuing, PSI-PD = Parenting Stress Index – Parent Domain, PSI-R = Parenting Stress Index-Revised, PSI-SF = Parent Stress Index-Short Form, PSOC = Parenting Sense of Competence scale [Eff. = Efficacy (subscale), Resp. = Responsibility, Sat. = Satisfaction (subscale)], SNQ = Service Needs Questionnaire, Supp. = Supportive, Unsupp. = Unsupportive, Verb. = Verbosity,. Setting: C = Clinic, H = Home, M = Mixed, S = School,. Format: MM = Multimodal, PT = Parent Training,. Delivery: G = Group, I = Individual, M = Mixed. Duration: total duration of the intervention in minutes. Age: mean age of the children in the intervention condition in years. Age category: P = Preschool, S = School-age. % boys: Percentage of boys in the intervention condition. % ext. dis.: percentage of children with comorbid externalizing disorder in the intervention condition. Home-school coll.: Collaboration between home and school was actively encouraged in the intervention (Y= Yes, N = No). Med. all.: whether medication was allowed next to the intervention (Yes/No). Integr. checks: whether integrity checks were performed in the study (Yes/No). N/A = Not Available.

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Table 2. Main Effects per Outcome Domain

	k (n_es)	SMD	95% CI	I^2 (level 2, %)	I^2 (level 3, %)
Positive parenting	19 (27)	.60***	.39;.81	72.9	5.3
probably blinded	12 (17)	.58***	.30;.86	71.3	7.8
unblinded	9 (10)	.63**	.28;.98	71.3	7.8
after trim-fill correction	22 (30)	.49***	.24;.73		81.2
Negative parenting	15 (31)	.59***	.36;.82	56.3	18.1
probably blinded	6 (12)	.68***	.32;1.04	59.2	15.6
unblinded	10 (19)	.54***	.25;.83	59.2	15.6
after trim-fill correction	24 (40)	.35**	.12;.59		81.9
Parenting s/of competence	17 (29)	.54***	.35;.73	0.0	64.8
after trim-fill correction	18 (30)	.54***	.36;.72		63.1
Parent-child relation	13 (18)	.53***	.29;.77	44.5	19.6
probably blinded	6 (10)	.53**	.17;.88	43.8	23.5
Unblinded	7(8)	.54**	.18;.90	43.8	23.5
after trim-fill correction	17 (22)	.37*	.07;.67		72.2
Parental mental health	23 (33)	.41***	.20;.61	0.0	69.2
after trim-fill correction	29 (39)	.30*	.03;.57		75.1
without Aghebati study	22 (30)	.34***	.22;.45	3.1	16.6
without Aghebati study & after trim-fill correction	26 (34)	.29***	.17;.41		32.8

Note: Table presents overall main effects, main effects on probably blinded and unblinded measures separately, main effects after trim-fill correction. *k* represents the number of studies, with the number of effect sizes (*n_es*) in parentheses. The trim-fill correction calculates the effect size after correcting for funnel plot asymmetry. CI = confidence interval; I^2 represents "the proportion of variation in study estimates that is due to heterogeneity" [51], separately for heterogeneity between variables (level 2) and between studies (level 3); s/of = sense of; SMD = standardized mean difference in terms of Hedges' *g*.
* $p < .05$, ** $p < .01$, *** $p < .001$.

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Table 3. Significant Effects of Primary and Secondary Analyses

Primary analyses	*k (n_es)*	$\hat{\beta}_1$ (95% CI)	I^2 (2,3, %)
	Positive Parenting		
1. Shaping knowledge (#sessions)	16 (20)	-.05 (-.11;.01)****	69.2, 0.0
1. Shaping knowledge (%sessions)	16 (20)	-.01 (-.01;-.00)*	66.5, 0.0
1a. Psycho-education parent (%sessions)	16 (20)	-.01 (-.01;-.00)*	66.7, 0.0
7. Practicing/generalization/maintenance (%sessions)	16 (20)	.04 (-.00;.09)****	66.9, 0.0
	Negative Parenting		
4. Positive consequences (%sessions)	12 (23)	.01 (-.00;.02)****	65.4, 0.0
4d. Social reward (%sessions)	12 (23)	.01 (.00;.02)*	63.2, 0.0
4j. Consistent responding (%sessions)	12 (23)	.01 (.00;.03)*	64.6, 0.0
	Parenting Sense of Competence		
3. Manipulating antecedents (%sessions)	16 (27)	.01 (.00;.03)*	5.7, 53.2
	Parent-Child Relation		
1. Shaping knowledge (#sessions)	12 (17)	-.08 (-.15;-.00)*	54.8, 0.0
1a. Psycho-education parent (#sessions)	12 (17)	-.08 (-.16;-.00)*	54.8, 0.0
7. Practicing/generalization/maintenance (#sessions)	12 (17)	-.09 (-.17;-.01)*	52.8, 0.0
	Parental Mental Health		
3. Manipulating antecedents (#sessions)	20 (27)	.05 (.01;.09)*	0.0, 7.2
3b. Plan misbehavior (#sessions)	20 (27)	.03 (.00;.06)*	0.0, 11.8
3. Manipulating antecedents (%sessions)	20 (27)	.01 (.00;.01)*	4.8, 0.0
3b. Plan misbehavior (%sessions)	20 (27)	.00 (.00;.01)*	0.2, 10.1
Secondary analyses	*k (n_es)*	$\hat{\beta}_1$ (95% CI)	I^2 (2,3)
	Positive Parenting		
Age (categorical): preschool vs school-age	19(27)	-.42 (-.84;-.01)*	75.4, 0.0
Integrity checked vs not checked	19(27)	.58 (.10;1.07)*	73.9, 0.0
	Negative Parenting		
Age (continuous)	13(27)	-.12 (-.22;-.01)*	62.0, 5.5
Sex (% boys)	15(31)	.03 (.00;.05)*	62.6, 6.8
Parent Training vs Multimodal	15(31)	-.46 (-.91;-.00)*	67.2, 4.2
Integrity checked vs not checked	14(30)	.59 (.17;1.00)**	68.7, 0.0

Note: Significant effects of dosage of categories of behavioral techniques and specific techniques (primary analyses; upper panel) and significant effects of intervention and participant characteristics (secondary analyses; lower panels). *k* represents the number of studies, with the number of effect sizes (*n_es*) in parentheses. $\hat{\beta}_1$ denotes the change in standardized mean difference (in terms of Hedges' *g*) when the moderator increases with one unit (95% confidence intervals are depicted in parentheses). I^2 represents "the proportion of variation in study estimates that is due to heterogeneity" [51], separately for heterogeneity between variables (level 2) and between studies (level 3). Category numbers (and specific techniques within categories with numbers and letters) correspond with the taxonomy (see Supplement 1, available online).
* $p < .05$; ** $p < .01$; *** $p < .001$; **** $p < .10$.

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Figure 1. PRISMA Flowchart

Figure 2. Forest Plots With all Effect Sizes Sorted per Outcome Domain

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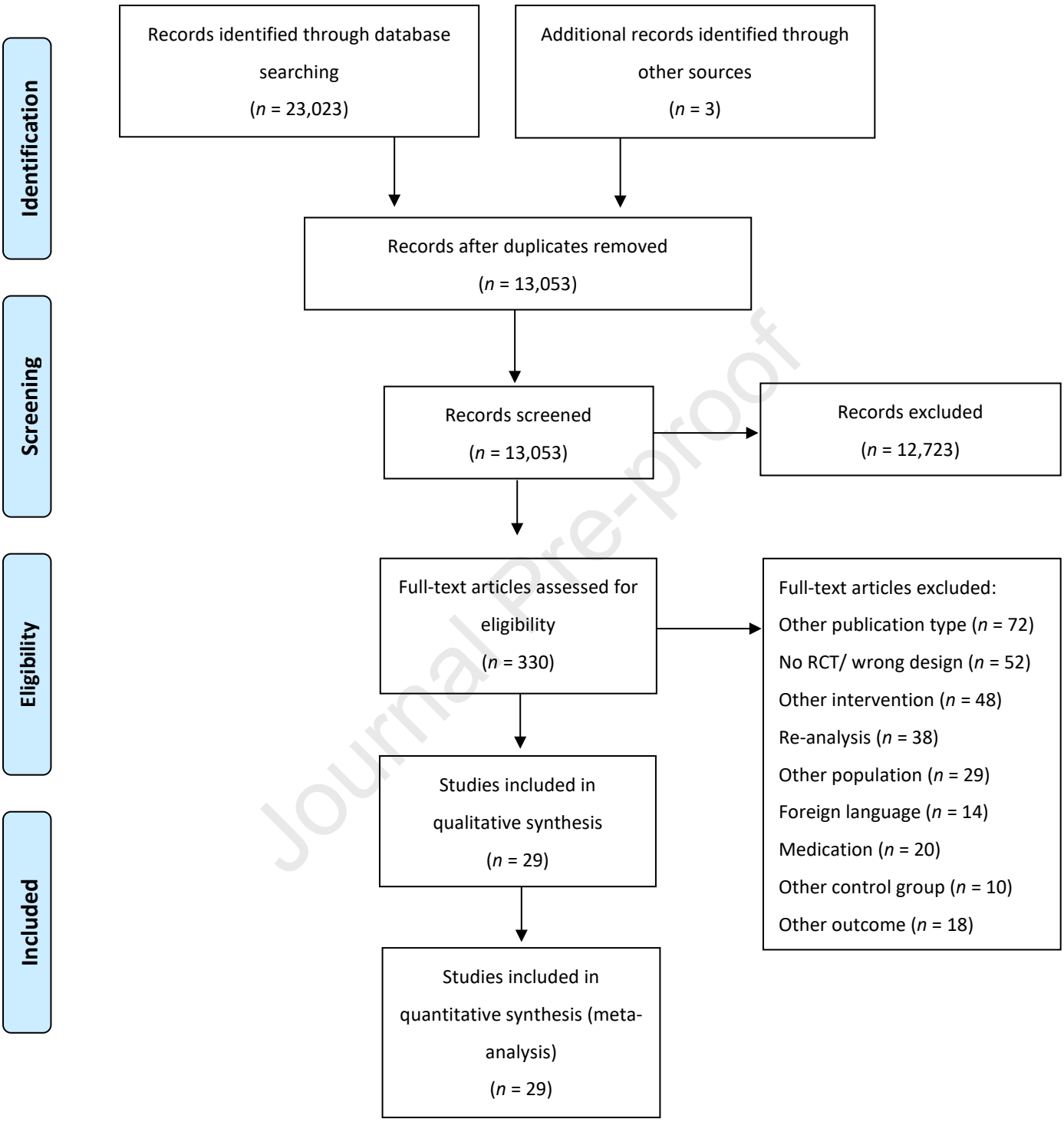

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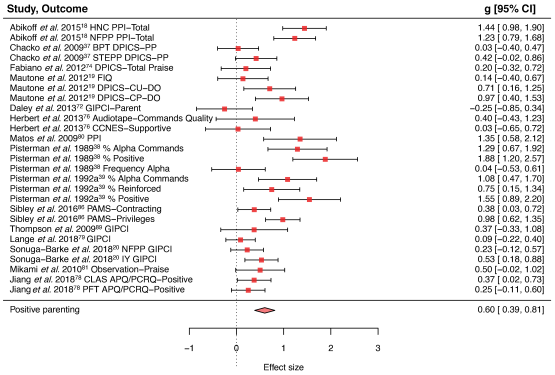
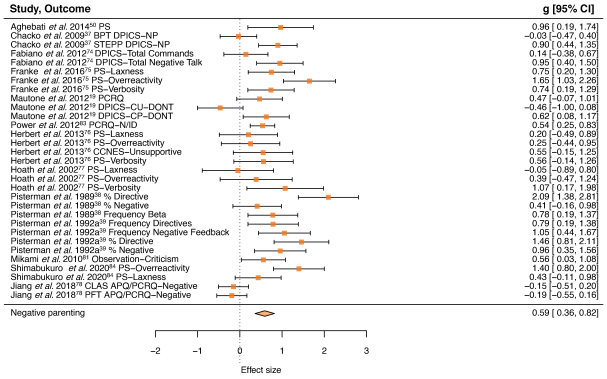
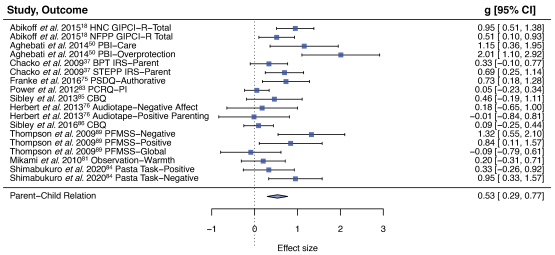
A. Positive parenting



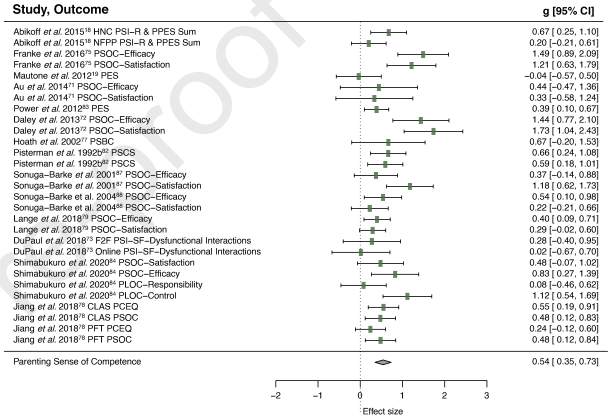
B. Negative parenting



C. Parent–Child Relation



D. Parenting Sense of Competence



E. Parental Mental Health

