School-based interventions for attention-deficit/hyperactivity disorder: a systematic review with multiple synthesis methods

Abstract

Non-pharmacological interventions for attention-deficit/hyperactivity disorder are effective treatments, but it is unclear how effective school-based interventions are for a range of outcomes and which features of interventions are most effective. This paper systematically reviews randomized controlled trial evidence of the effectiveness of interventions for children with ADHD in school settings. Three methods of synthesis were used to explore the effectiveness of school-based interventions, whether certain types of interventions are more effective than others and which components of interventions lead to effective academic outcomes. After comprehensive searching and study selection, twenty-eight studies (n=1,807) were included in the review. Eight types of interventions were evaluated and a range of different ADHD symptom, school outcomes and associated ADHD difficulties outcomes assessed across studies. Meta-analysis demonstrated beneficial effects for interventions that combine multiple features (mean effect size g=0.43) and suggest some promise for daily report card interventions (g=0.69). Meta-regression analyses did not give a consistent message regarding which types of interventions were more effective than others across different outcomes. Finally, qualitative comparative analysis demonstrated that aiming to improve self-regulation and intervention delivery one-to-one were important components of interventions that were effective for academic outcomes. These two components were not sufficient though; when they were seen with personalisation for individual recipient and delivery in the classroom or when interventions did not aim to improve child relationships, interventions were effective. This review provides updated information about the effectiveness of non-pharmacological interventions specific to school settings and the QCA gives tentative messages about important features of these interventions for academic outcomes.

Keywords: ADHD, school, intervention, review

Introduction

ADHD

Attention deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder with a prevalence in childhood community samples of between 1.5% and 7.2% worldwide, (American Psychiatric Association, 2013; Russell et al., 2014; Sayal et al., 2017; Thomas et al., 2015). It is widely reported to be more common in males (e.g. Hire et al., 2018). ADHD is diagnosed when an individual displays impairing levels of hyperactivity, impulsivity and/or inattention across settings that persist for longer than six months (American Psychiatric Association, 2013). The cause of ADHD is complex: both genetic and environmental risk factors interact to produce the core symptoms, although the severity of expression of the core symptoms is distributed throughout the population. Some children who do not meet full diagnostic criteria for ADHD can still be impaired by high symptom levels (Faraone et al., 2015). Diagnostically, ADHD has three subtypes: primarily inattentive (approximately 30% of diagnosed individuals), primarily hyperactive/impulsive (<10%), and combined (approx. 60%) where the individual has both inattentive and hyperactive/impulsive symptoms (Reale et al., 2017).

Although ADHD is clinically conceptualised as one disorder, children with the core symptoms have different underlying neuropsychological profiles. The extent of symptoms and other difficulties vary widely under the same diagnostic umbrella. The theoretical understanding of ADHD has evolved over the past three decades. Barkley (1997) posited that symptoms were the result of an underlying core deficit in executive functions e.g. working memory, planning and attentional flexibility, in particular a deficit in inhibitory control processes that manifest as a lack of self-control and inability to self-regulate. A second theory, characterised by "delay aversion" (Sonuga-Barke, 2003), was based on observations that children with ADHD prefer smaller-sooner rewards, rather than waiting for a larger

reward (Marco et al., 2009). The delay aversion theory posits that the function of the smaller-sooner preference is to avoid delay, and that the core symptoms of ADHD are expressed (in essence) as a time-passing mechanism when delay cannot be escaped or avoided: such as in classroom situations. These theories were tested "head to head" in a sample of children with ADHD and it was found that both were true to different extents: thus a dual pathway model of ADHD has been proposed (Sonuga-Barke, 2003).

Children with ADHD have symptoms that persist throughout adolescence and into adulthood in between 30 and 70% of cases (Caye et al., 2016). Individuals who have ADHD are more likely to have cognitive impairments (Kuntsi et al., 2014), socio-emotional difficulties (Wehmeier et al., 2010), problems regulating their behaviour (Barkley, 1997) and high levels of co-occurring disorders and mental health difficulties including emotional disorders such as depression and anxiety (Reale et al., 2017). Children with ADHD are also more likely than their peers to have low educational attainment, substance use, vehicle accidents, involvement in crime, antisocial behaviour and experience socioeconomic disadvantage (Able et al., 2007; Faraone et al., 2015; Shaw et al., 2012; Tarver et al., 2014).

ADHD has a substantive impact on education: high levels of ADHD symptoms in early childhood independently predict poor UK General Certificate of Secondary Education (GCSE) results (Washbrook et al., 2013). Poor outcomes attributable to ADHD incur huge cost to society, including costs to the National Health Service (NHS), education system, judicial system, social services and economic loss both for parents of children with ADHD and the children themselves as they enter the workforce (Le et al., 2014; Telford et al., 2013). Based on 2010 data, the average annual cost of treating a child with ADHD was estimated at £5,493 across health, education and social services. Of this, the largest cost (57%) was to

mainstream education. This equates to an annual cost in the UK of £670 million (Telford et al., 2013).

School-related difficulties

As the vast majority of children in the UK are in mainstream school settings, challenging behaviour arising from the difficulties associated with ADHD can cause problems in the classroom, for the child, the teacher and for other children (Abikoff et al., 2002; Greene et al., 2002). The classroom context, as well as teachers' attitudes and behaviour towards children with ADHD, impact on children's outcomes (Gwernan-Jones et al., 2015a; Sherman et al., 2008). The nature of the school setting in the UK, where children are often taught by one teacher, in large seated groups, is clearly at odds with the challenges experienced by children with ADHD in the domains of social and peer interactions, regulation of impulsive behaviour and verbal expression, and difficulty keeping on task and focussing attention. Unsurprisingly, tensions between parents and school are common (Harborne et al., 2004; Gwernan-Jones et al., 2015b), and there is a need both for schools to be better able to support children with ADHD and children to be better able to cope with school. In the mainstream setting, this would reduce the need and cost for special educational provision in addition to having benefits for the child, and potentially their teachers, peers and parents.

Treatment for children and young people with ADHD

ADHD is categorised under the social and emotional mental health category of special educational needs (Department for Education and Department of Health and Social Care, 2015). The recently-updated National Institute for Health and Care Excellence (NICE) guideline for ADHD diagnosis and management advises that when consent is given the clinician should contact the school to discuss the impact of the symptoms and "reasonable adjustments and environmental modifications" (1.4.12), and share the child's treatment plan with the school. NICE also recommends that multi-agency groups "start and coordinate local

training initiatives, including the provision of training and information for teachers about the characteristics of ADHD and its basic behavioural management" (NICE, 2018, 1.1.3). Schools are therefore expected to put in place environmental modifications for the child as well as complying with treatment plans that may or may not include medication. As such, up to date knowledge of the evidence base for interventions for children with ADHD in the school setting is needed.

Treatments for ADHD can be broadly categorised into pharmacological and non-pharmacological. Pharmacological treatments have small to medium effects on academic productivity (number of tasks completed), but evidence for long term improvement in academic outcomes and improvement in accuracy (number of correct answers) is lacking (Kortekaas-Rijlaarsdam et al., 2018).

Non-pharmacological treatments have been implemented and researched in school, home and clinical settings (Bikic et al., 2017; Catala-Lopez et al., 2017; Sonuga-Barke et al., 2013). It could be argued that non-pharmacological treatments for ADHD delivered in any setting may have impacts on outcomes relevant to school. The assumption cannot, however, be made that effects of an intervention will transfer across settings i.e. an intervention that is effective in the home setting may not be effective in the school setting (Abikoff, 2009). Indeed, Purdie and colleagues (2002) reported that school-based interventions had larger effects on behavioural outcomes than non-school based and parent training interventions (but smaller than pharmacological or multimodal interventions), and the largest effect on "general cognitive" outcomes. Given that ADHD is associated with poor academic attainment, school-based interventions that focus on academic outcomes are crucial. Furthermore, behaviour management interventions typically do not produce effects that generalise across settings (Evans et al., 2018), and as such interventions for ADHD that aim to impact on outcomes that

occur in the school setting ought to be implemented in this setting. The current study will therefore focus on interventions delivered in the school setting.

A number of reviews have assessed the effectiveness of non-pharmacological interventions for ADHD. They tend to indicate that non-pharmacological interventions for ADHD have beneficial effects on core ADHD symptoms and other outcomes (Bikic et al., 2017; Daley et al., 2014; Fabiano et al., 2009; Fabiano et al., 2015; Pelham & Fabiano, 2008; Sonuga-Barke et al., 2013; Zwi et al., 2011). Sonuga-Barke and colleagues (2013) reported statistically significant treatment effects for core ADHD symptoms assessed by the individual most proximal to the therapeutic setting – typically un-blinded parent ratings (Sonuga-Barke et al., 2013). Given the wide-ranging negative impacts of ADHD, Daley and colleagues examined a broader range of child outcomes for 'behavioural' interventions and reported statistically significant effects of interventions for improving conduct problems, social skills and academic performance (Daley et al., 2014). A meta-analysis of organisational skills training for ADHD reported modest improvements on inattentive symptoms and academic performance (Bikic et al., 2017).

School-based non-pharmacological interventions

DuPaul and colleagues' (2012) review explored the efficacy of 'academic', 'contingency management' and 'cognitive behavioural' interventions in school settings on child symptom and academic outcomes (DuPaul et al., 2012). Beneficial effects were reported for both symptoms and academic outcomes for studies with within-subject and single-subject designs, but not for the between-subject controlled trials, which were severely limited by the small number of included studies (n=3). Effectiveness on academic outcomes was limited to interventions conducted in public school settings rather than summer treatment programmes or private school settings (DuPaul et al., 2012). An earlier review reports short-term effectiveness

of a range of school-based treatments for ADHD on decreasing disruptive and increasing on-task behaviour, and improving academic performance (Miranda et al., 2006).

There have been many randomised controlled trials (RCTs) of non-pharmacological interventions for ADHD in school settings, but there is no clear review evidence that supports use of a particular package of treatment for specific target outcomes (Richardson et al., 2015). The pragmatic challenges of conducting randomised controlled trials (RCTs) of non-pharmacological treatments to the standards of pharmacological trials often confer methodological limitations on studies, that translate into results being tentative or studies being considered at risk of bias. There remains optimism that effective interventions can and are being developed, as there is broad evidence that non-pharmacological treatments for ADHD are efficacious and importantly may have broader benefits than medication (Pfiffner, 2014). There is, however, clear evidence from existing systematic reviews and meta-analyses that psychosocial and behavioural treatments for ADHD in the school setting can be effective (Miranda et al., 2006); the challenge is in identifying which intervention components lead to sustained improvement in the target outcomes.

The current study

The current study updates the evidence base on the effectiveness of non-pharmacological treatments for ADHD in the school setting and develops a deeper understanding of the components of effective interventions. We build on a systematic review conducted on this topic that reported statistically significant evidence of beneficial effects for symptoms of inattention, hyperactivity/impulsivity, externalising problems, perceptions of school adjustment and standardised academic achievement (Richardson et al., 2015). This review will also include additional studies conducted between 2013 and 2018 and focus efforts on understanding the types of interventions and components of them that are shown to be effective.

A systematic review was undertaken in order to identify and assess RCTs of non-pharmacological interventions for ADHD conducted in the school setting for a broad range of child outcomes. Multiple methods of synthesis were used to appropriately address the different research questions and therefore elucidate the effectiveness of different types of school-based interventions, consider which type of intervention might be more effective and also begin to consider the components (or combination of components) of interventions that lead to beneficial outcomes for children and young people with ADHD.

Meta-analyses were used to consider the effects of different types of interventions for particular outcomes and raters. Meta-regression was used where applicable to consider how the type of intervention moderates effectiveness. In order to further investigate how different combinations of intervention components of school-based non-pharmacological interventions lead to different outcomes, we undertook qualitative comparative analysis (QCA). We focused on academic outcomes in the QCA reported here as they were frequently reported across included studies and are considered important by children with ADHD, teachers, parents and schools (Loe & Feldman, 2007).

The research questions are:

1. What is the effectiveness of school-based interventions for students with attention-deficit/hyperactivity disorder (ADHD)?
2. Are some types of school-based interventions for students with ADHD more effective?
3. What components of the interventions reviewed are effective for academic outcomes?

Systematic Review Methods

The methods used to identify and select evidence followed the methodological approach recommended by the University of York's Centre for Reviews and Dissemination (2009). This work is an extension of a previously published systematic review (Richardson et al., 2015) for which a protocol was registered on the International Prospective Register of Systematic Reviews (PROSPERO) (CRD42011001716). The systematic review is reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher et al., 2009).

Inclusion criteria

The following inclusion and exclusion criteria were used to determine eligibility of articles and inform the search for literature.

Population

All participants needed to have a diagnosis of ADHD and/or be shown to be experiencing ADHD difficulties at a diagnosable level according to established cut-offs of an existing ADHD scale (e.g. above the 90th percentile on the Inattention or Hyperactivity-Impulsivity factor of the ADHD Rating Scale-IV School Version (DuPaul et al., 1998)). Participants needed to be aged between four and 18 years, attending a preschool or school (including kindergarten, infant/elementary; middle/primary; high/secondary; further education). Participants described as having intellectual difficulties (i.e., IQ<70) or brain damage were excluded.

Interventions

Non-pharmacological interventions delivered primarily in an educational setting (e.g. general education, special education). Included interventions had to target ADHD symptoms or difficulties that challenge children and young people with ADHD in school settings (e.g.

social interaction and study skills). All other intervention settings were excluded (including laboratory classrooms and summer treatment programs).

Outcomes

A minimum of one child-focused outcome was required for inclusion. Such outcomes include ADHD symptoms (e.g. inattention, hyperactivity-impulsivity or a combination of both), academic outcomes (e.g. test scores or productivity) and classroom behaviour (e.g. off task behaviour).

Methods

Randomised controlled trials where participants were randomly allocated to either a treatment group or a comparator/control group receiving education and/or other treatment as usual or no treatment.

Location, date and language

No restrictions on location of study. Only English language studies were included and only studies published from 1980 onwards given the significant changes to the diagnosis of ADHD that year (American Psychiatric Association, 1980).

Search strategy

The database search strategy consisted of three elements; 1) terms related to ADHD, 2) terms related to school, 3) terms related to interventions. Search strategies used a mixture of subject headings (controlled vocabulary) and free text terms. Twenty electronic databases were searched, including several that index grey literature: MEDLINE, Embase, PsycINFO, Health Management Information Consortium, Social Policy and Practice (via OvidSP); ASSIA, ProQuest Dissertations & Theses, Australian Education Index (via ProQuest); ERIC, Education Research Complete, British Education Index (via EBSCOhost); and Social Sciences Citation Index, Conference Proceedings Citation Index; Conference Proceedings Citation Index –

Social Science & Humanities (via ISI Web of Science); The Cochrane Library [Cochrane Database of Systematic Reviews (CDSR), Database of Abstracts of Reviews of Effects (DARE), Cochrane Central Register of Controlled Trials (CENTRAL), Cochrane Methodology Register (CMR), Health Technology Assessment (HTA), NHS Economic Evaluation Database (NHS EED)]; and The Campbell Library. Searches were initially undertaken in May 2012 and then updated in February 2013, November 2014 and January 2018. An example search strategy used for the PsycINFO/OvidSp database is shown in Appendix 1. Forward citation chasing of included papers and backward citation chasing of included papers' and relevant systematic reviews' reference lists was completed to identify additional relevant work. EndNote X8 reference management software was used to organise the search results and title and abstract screening.

Study selection

Relevant studies were identified in two stages based on the inclusion criteria given above. First, two reviewers conducted title/abstract screening independently for each record and disagreements were resolved through discussion with referral to a third reviewer if necessary. Full texts of records that could not be excluded on the basis of their titles and abstracts were then obtained wherever possible. Full texts were screened independently by two reviewers for final inclusion and exclusion. Disagreements were resolved through discussion with referral to a third reviewer if necessary.

Data extraction

A data extraction form was developed and piloted. Data on the study design, participants, interventions, outcome measures, findings and risk of bias for each included article were extracted into Microsoft Office Excel 2010 by one reviewer and checked by another reviewer. Authors were contacted to obtain missing data necessary for meta-analysis.

Quality appraisal

The quality and risk of bias of included studies was assessed using criteria adapted from the Cochrane risk of bias tool (Higgins et al., 2011). The 11 criteria assessed selection bias (randomisation and allocation concealment); detection bias (blinding of outcome assessors); attrition bias (intention to treat analysis (ITT), response rate and reporting of attrition); use and length of follow-up(s); reporting of outcomes (missing data explained and full reporting of outcomes assessed) and whether there was a manual for the intervention. Items were assigned a response of 'yes', 'no', 'not reported' or not applicable ('n/a') as appropriate for each paper. A trial was defined as meeting the ITT criteria when all participants remained in the intervention groups to which they were randomised or where data for all randomised participants were included in the analysis. Quality appraisal was conducted alongside data extraction and was used as a means to raise awareness of a range of relevant factors for each paper, rather than as a basis for exclusion.

Categorisation of interventions and outcomes

In order to facilitate reporting of meta-analyses, i.e. the pooling of comparable outcomes across studies, we categorised interventions and outcome measures for each included study. We considered it inappropriate to pool different interventions, outcomes and raters into one overall effect size for school-based interventions, this would invite clinical heterogeneity (Fletcher, 2007). So we reported meta-analyses when these study features were comparable and heterogeneity would therefore be more likely to be methodological. We developed eight intervention categories based on the primary focus of the intervention and included a combined category for interventions that combined more than one main part (e.g. social skills, study skills and rewards). The intervention categories were: combined interventions, cognitive training, daily report card, neurofeedback, relaxation, self-monitoring, study and organisational skills training, task modifications.

We developed eight outcome categories based on categories used in previous systematic reviews (e.g. Purdie et al., 2002; Sonuga-Barke et al., 2013) The eight categories featured symptoms (ADHD combined, hyperactivity/impulsivity and inattention), school outcomes (academic and classroom behaviour) and associated ADHD difficulties (social, personal/emotional and conduct). Outcomes in included studies were often completed by different raters. Because of their different perspectives and potential biases (Wolraich et al., 2004), meta-analyses were reported for these different raters (child self-reports, teacher-reports, parent-reports, independent observer) as well as intervention and outcome category. Child self-reports included both self-report measures of behaviour, for example the Aggression and Conduct Problems Scale (Molina et al., 2008) and child completed assessments, for example the Woodcock-Johnson III Tests of Achievement (Fabiano et al., 2010).

Synthesis methods

Meta-analysis methods

The principal summary measures used to compare included studies were differences in means. Differences between intervention and control groups on post-test means were analysed. Hedges effect size (g), the standardised mean difference, was reported for each outcome measure category and rater dyad used in the study (Hedges & Olkin, 1995). The effect sizes and 95% confidence intervals were calculated using the mean, standard deviation and the sample size for the intervention and control groups or, if any were not reported or available from the study authors, statistics that could be used to derive these (e.g. t statistic). When two or more measures that assessed the same outcome category were reported in a study, the effects were combined into one composite effect for that outcome; we calculated the standard error for this effect using the correlation between the measures, obtained from the paper itself or other research (Borenstein et al., 2009). In studies with more than one intervention group, categorised as the same intervention type, we pooled the data prior to any meta-analysis so as not to double-

or triple-count the control group in the analysis (Borenstein et al., 2009). In all cases, a positive effect size indicates the intervention improves the outcome.

Random effects meta-analysis models were fitted to pool effect sizes across the studies where multiple studies had calculable effect sizes for the same intervention-outcome-rater category triad. For instance, only one study reported findings for a task modification intervention, for an academic outcome rated by the child participant. Therefore the effect size for the study is reported and no meta-analysis was possible. For cognitive training intervention effects on inattention outcomes measured by teachers, three studies provided measures, so a random effects meta-analysis was conducted. For each pooled effect size estimate from random effects meta-analysis, we calculated 95% confidence intervals. The I^2 statistic was used to quantify heterogeneity. The calculation of effect sizes and meta-analyses used the software environment R 3.2.3. Hattie's (2009) guidelines were used to interpret effect sizes. Classifications for what are considered to be 'small', 'medium' and 'large' effect sizes are g = 0.2, g = 0.4 and g = 0.6, respectively.

We planned to assess publication bias by examining funnel plots for asymmetry. However, we were unable to assess funnel plots properly or use more advanced regression-based assessments to assess publication bias owing to insufficient numbers of included studies and the substantial heterogeneity identified across them (Sterne et al., 2011).

Meta-regression methods

Tests of interaction were performed using meta-regression to examine research question 2 - whether there was evidence that the pooled intervention effects differed across intervention categories. Although a minimum of ten studies is often cited as necessary (Borenstein, 2009), in light of the data collated, we adopted a lower threshold of eight studies. Meta-regression models were fitted using the *metafor* software package in R 3.2.3. We report

Q_M, the statistic for an omnibus test of parameters that the effect sizes of the different intervention categories are equal, and its p-value, where the same outcome category and rater is reported by at least eight studies, as well as I^2, the proportion of residual between-study variation attributable to heterogeneity.

Qualitative comparative analysis methods

Qualitative comparative analysis (QCA) is a method that takes a "case" rather than "variable" approach to analysis. Here a case is an intervention that has been evaluated as part of an included study in the current systematic review. It has been developed by Charles Ragin and others (Ragin, 1987) and has been used frequently in social science research, more so in primary research in political science and sociology than in systematic reviews (Schneider & Wagemann, 2012). QCA can identify complex (non-linear and non-additive) causal patterns and is appropriate in situations where there are limited cases and a large number of factors that may explain differences in findings. It is therefore particularly appropriate for systematic reviews of complex interventions where there is heterogeneity that might be explained by a number of intervention or contextual features.

QCA uses set relations and formal Boolean logic to find commonalities between different cases with the same outcome (Rihoux & Ragin, 2008). In the current QCA the outcome related to effectiveness of a case (or intervention) for academic outcomes. It is through the use of set theoretic principles that QCA seeks to transcend the qualitative/quantitative divide (Thomas et al., 2014). QCA considers the necessity and sufficiency of conditions for an outcome, with 'condition' in this case denoting a particular intervention component or contextual factor. A necessary condition is one that must be present to trigger an outcome, but may still not trigger an outcome in isolation. A sufficient condition triggers the occurrence of an outcome, although other pathways to triggering the outcome may also exist.

The focus of investigation is not the individual study or intervention trialled, but the different configurations of intervention or contextual conditions that together are responsible for interventions leading (or not) to the effective academic outcomes. The method also allows for equifinality (Kahwati et al., 2016), meaning that QCA allows for multiple pathways to causality. Because QCA is focused on whether the presence or absence of conditions are important to trigger an outcome, a crisp-set QCA analysis sees conditions coded as 1 for present and 0 for absent for each case (Thomas et al., 2014). In fuzzy-set QCA, as will be used here, greater flexibility in categorisation is possible. Here a value of 1 indicates full membership of a condition or set, and 0 indicates full non-membership. Values between 0.5 and 1 are used to denote partial membership of a condition or set, and values between 0 and 0.5 used for non-membership (Lee, 2014).

Given the research question "What aspects of the interventions reviewed are effective for academic outcomes?", this QCA considers features of the interventions (or conditions) tested in the RCTs (or cases) included in the systematic review that together may predict the outcome of interest – here effectiveness for academic outcomes. QCA sits within causal chain analysis as a method and therefore a hypothesised causal chain between intervention and outcome should be considered ahead of analysis. Reviewers began by drawing a logic model that theorised the types of condition that might together impact academic outcomes for children with ADHD (see Figure 1). The logic model shows the links between underlying causes of ADHD and core symptoms and the associated manifestation of ADHD in the classroom context that is hypothesised to lead to poor academic outcomes for these children. Conditions of interventions that are likely to impact on academic outcomes include A: those that may ameliorate school-based difficulties for the children with ADHD, B: the needs of children with ADHD, and C: the need for regular education setting and structure.

INSERT FIGURE 1 ABOUT HERE

Identifying specific conditions that might impact on academic outcomes according to the logic model involved consulting a previous qualitative systematic review of ADHD interventions in school settings (Moore et al., 2016), an overarching synthesis of school-based interventions for ADHD (Moore et al., 2015) and other features of studies included in this systematic review that previous research predicts would impact academic outcomes. Although this initially suggested over 50 conditions (when 4-6 final conditions is advised (Berg-Schlosser & De Meur, 2005)), these were reduced according to the theorised importance of the condition in predicting academic outcomes, the availability of data in the included studies and the spread of presence and absence of the condition in the included studies (Rihoux 2006). The conditions taken forward are indicated in the logic model.

In the QCA analysis we followed the steps outlined by Thomas and colleagues (2014) in their worked example of a QCA in a systematic review of interventions for public health and health promotion. Six stages of analysis are outlined:

1. building the data table

2. constructing a 'truth table'

3. checking the truth table

4. Boolean minimisation,

5. consideration of the 'logical remainders' cases

6. interpretation.

We examined pathways both to effectiveness and to least effectiveness for the QCA model (Thomas et al., 2014). Here we briefly outline the analytic steps. The truth table gives all the possible configurations of the conditions tested. Each configuration will have a number of cases (interventions testes) that are members. The truth table also gives the consistency – a metric that shows the extent the configuration is necessary to conclude effective academic outcomes for that configuration. We set the cut-off level as 0.8 after Ragin (2009).

A truth table should be checked for a good spread of studies across different configurations. Contradictory configurations are sets of cases in which identical configurations of conditions lead to both effective and ineffective outcomes. These need to be resolved before the QCA can proceed. Boolean minimisation gives solution sets that identify pathway/s to effectiveness. Ragin (2008) suggests that an intermediate solution, one that incorporates logical remainders and theoretical predictions for the direction of effect for each condition, is preferable. Logical remainders are those configurations without any cases, meaning no included intervention represents the configuration of those conditions. All analysis was performed in R software, using the software package *QCA*.

Once a simplified solution has been identified, the final stage of the analysis involves interpretation. The solution is explained with reference to the studies informing the configurations, the research question "What aspects of the interventions reviewed are effective for academic outcomes?" and the logic model which guided the QCA.

Systematic Review Findings

Our searches identified 21,532 records for title and abstract screening after the removal of duplicates. A total of 20,845 of these records were excluded after title and abstract screening determined that they did not meet the inclusion criteria. The full text of the remaining 687

records were retrieved for closer examination. A further 657 articles were excluded at this stage. Thirty articles (28 studies) included were included in the systematic review. The flow of studies through the selection process (and the reasons for exclusion at full text) is shown in Figure 2.

INSERT FIGURE 2 AROUND HERE

Description of included studies

The study details of included studies can be seen in Table 1. Studies were conducted from 1980 to 2017 and the majority took place in the United States of America (n=25/28). A total of 1,807 participants were included, with a mean of 65 participants per study. Most (n=26) articles were from peer reviewed journals, two were dissertations and one was a report from the Appalachia Education Laboratory. Five studies included more than one includable treatment group, all studies included one control group only. The most frequently used type of control group was treatment as usual (n=10), although many studies employed waitlist controls that would have functioned as treatment as usual at the time of the comparison (n=7). The majority of studies focused on elementary or primary school level participants (n=17), with just one trial including only secondary or high school level participants.

INSERT TABLE 1 AROUND HERE

Where reported, a mean of 25% of participants were female, which is a little higher than recent prevalence estimates (Hire et al., 2018). Only six studies excluded participants taking medication. More typically around a third of participants were taking medication (mean 31% where reported). Thirteen studies did not report the subtypes of ADHD represented by their sample. Where this was reported, or where measures used at baseline indicated particular ADHD difficulties, there tended to be less combined subtype participants than one would expect from prevalence studies (Reale et al., 2017). More than half the participants in four

studies had inattentive subtypes. Despite hyperactive/impulsive being the least common subtype, six studies included only participants who scored above a cutoff on an established measure of hyperactivity.

Interventions

Thirty-five interventions were assessed across the 28 included studies. See Table 2 for details of these interventions. Eight categories were used to organise the interventions as described in the methods section. The most frequently observed intervention categories were combined interventions (interventions with multiple different main components) (n=8), neurofeedback interventions (n=8) and study and organisational skills training (n=6). Study and organisational skills often made up part of combined interventions (n=5). Thirteen interventions involved some element of delivery or practice at home. The majority of interventions did not fully describe the setting within school (n=20). Most interventions took place during school hours (n=25) and children were the only recipients (n=27). There were a mix of intervention formats, with 18 interventions delivered to individuals, 11 interventions delivered to groups and the remaining six being a mix of the two formats. Teachers were involved in the delivery of 11 interventions, school mental health practitioners were involved in the delivery of 10 interventions. Those who delivered interventions were often reported as having received training (n=20). The mean hours of treatment was 20.2 hours, although this ranged from less than an hour to over 120 hours. Fidelity was assessed for 20 of the 35 interventions.

INSERT TABLE 2 AROUND HERE

Outcomes

There were 265 individual outcomes across the 28 studies for which effect sizes could be calculated. Eight categories were used to organise the outcomes as described in the methods

section. Academic outcomes were most frequently observed, featuring in 17 studies. Raters for academic outcomes were either child self-reports, teacher- or parent-reports. Inattentive symptoms and hyperactivity/impulsivity symptoms were outcomes for 15 and 14 studies respectively, more than ADHD combined type symptoms (n=8). For each of these symptom outcome categories, teachers were more likely to be raters than parents or children. Classroom behaviour was the only outcome where independent observers were the most frequently observed rather, appearing in six of the eight studies with this outcome type. Personal/Emotional outcomes were observed in 11 studies, conduct problem outcomes in nine studies and social outcomes in seven studies. Teachers and parents typically rated conduct and social outcomes, but there was a mix of all four raters for personal/emotional outcomes.

Quality Appraisal

Table 3 reports the quality and risk of bias for the included studies. All but one of the studies was free of any sign of selective reporting, only five studies failed to explain missing data when this was applicable and the majority of studies had a response rate of over 85% (n=24). Half of the studies either used intention-to-treat analysis or there was no change to participant numbers analysed compared to allocation. While ten studies specified their method of randomisation, only two studies reported detail that indicated adequate concealment of allocations prior to assignment. Nine studies included a follow-up assessment, but only five of these had follow-ups of six months or more (one of these was reported in an additional article (Steiner 2014b)). Finally, five studies included measures where the assessor was blinded to treatment group. This was typically the case where independent observers measured classroom behaviour.

INSERT TABLE 3 AROUND HERE

None of the studies were rated positively for all nine criteria. Egeland (2014) was rated positively for all criteria except intention-to-treat analysis and blinding of outcome assessors. Four studies were rated positively for six out of nine criteria (Evans 2016; Chacona 2007; Looyeh 2012; Steiner 2014). Evans (2011) was only free from bias in relation to selective reporting and the study by Jurbergs and colleagues (Jurbergs et al., 2010; Palcic et al., 2009) was only free from bias on selective reporting and response rate. Overall the RCTs included were of low study quality according to criteria typically used in health research.

Meta-analysis

Although this section is named meta-analysis, we also give effect sizes (Hedge's g) and corresponding 95% confidence intervals when only one study provided data for an intervention-outcome-rater triad, to enable comparison across the available data. Table 4 shows how many studies contributed to effect sizes across the different interventions, outcomes and raters.

INSERT TABLE 4 ABOUT HERE

Effectiveness of Combined Interventions

Combined interventions were assessed in eight studies (Evans et al., 2011, 2014, 2016; Looyeh, 2012; McGraw et al., 2004; Molina et al., 2008; Pfiffner 2016; Seeley, 2009). Four of these interventions were versions of the Challenging Horizons Programme (Evans et al., 2011, 2014, 2016; Molina et al., 2008). Elements of combined interventions that were seen in more than one studies included, study and organisational skills training, social skills training, behaviour modification techniques, parent training, self-monitoring and daily report card. A statistically significant large effect size indicated improvement for ADHD combined symptoms rated by both teachers and parents ($g=0.79$, 95% confidence interval (CI): 0.45 to 1.12, $p<0.001$,

number of studies (k)=2; g=0.97, 95% CI: 0.62 to 1.33, p<0.001, k=1). Beneficial effect sizes whose confidence intervals ranged from no effect to medium effect sizes were reported for teacher- and parent-rated academic outcomes (g=0.30, 95% CI: 0.12 to 0.47, p=0.001, k=6; g=0.37, 95% CI: 0.19 to 0.55, p<0.001, k=3).

Two studies measured classroom behaviour; Seeley's (2009) First Step to Success programme used independent observers and reported a large beneficial effect with wide confidence intervals (g=0.83, 95% CI: 0.20 to 1.47, p=0.01), whereas the other study reported a negligible effect for teacher-rated classroom behaviour (g=0.09, 95% CI: -0.49 to 0.67, p=0.77). Mixed results were also seen for conduct outcomes across different raters. For child raters in Molina and colleagues' (2008) evaluation of the Challenging Horizons Programme, a large effect size with wide confidence intervals was reported (g=1.13, 95% CI: 0.18 to 2.08, p=0.02). Beneficial effects ranging from no effect to large effects were reported for parent raters (g=0.44, 95% CI 0 to 0.87, p=0.05, k=4) with high heterogeneity (I^2=68%) suggesting differences between the four studies. Effect sizes for teacher rating of conduct outcomes ranged from no effect to large effects (g=0.3, 95% CI: -0.02 to 0.61, p=0.07, k=3).

Small beneficial effects were seen for inattention outcomes (teacher-reported g=0.33, 95% CI: -0.06 to 0.73, p=0.1, k=4; parent reported g=0.27, 95% CI: 0.01 to 0.54, p=0.05, k=4). Whilst a medium sized beneficial effect was seen for teacher ratings of hyperactivity, confidence intervals were large (g=0.42, 95% CI: -0.13 to 0.97, p=0.13, k=4) and was characterised by higher heterogeneity (I^2=70%). While a large beneficial effect was reported by one study for child ratings of personal and emotional outcomes, confidence intervals were wide (g=0.62, 95% CI: -0.28 to 1.52, p=0.18) multiple studies including teacher- and parent-ratings reported minimal effects. Social skills outcomes for teacher ratings gave a medium, but not statistically significant beneficial effect (g=0.45, 95% CI: -0.04 to 0.94, p=0.07, k=3), but

parent ratings indicated no effect. Other effect sizes were small or indicated no effect and were not statistically significant.

Overall there is some good evidence of beneficial effects for combined interventions in several outcome categories across raters. We can be quite confident of small effects for parent- and teacher-rated academic outcomes and large effects for ADHD combined symptoms. However, the evidence is less certain for inattention and hyperactivity/impulsivity symptom outcomes. Considering associated ADHD outcomes, there is evidence of beneficial effects for conduct problems, although the size of effects are uncertain. There is little evidence for the effects of combined interventions on personal/emotional and social outcomes.

Effectiveness of cognitive training interventions

Across all outcomes for the three studies reporting on cognitive training interventions (Egeland et al., 2013; Steiner et al., 2011; Steiner et al., 2014) only one statistically significant beneficial effect was found, this was a small effect on parent-rated inattention with confidence intervals indicating an effect in the range from no effect to a large effect (g=0.36, 95% CI: 0.02 to 0.7, p=0.4, k=3). Inattention was also measured by child and teacher raters and effect sizes were smaller (g=0.19, 9%% CI: -0.22 to 0.59, p=0.36, k=2; g=0.18, 95% CI: -0.15 to 0.51, p=0.29, k=3) and not statistically significant. A similar trend was seen for hyperactivity/impulsivity outcomes, where a small but uncertain effect was for parent-rating (g=0.21, 95% CI: -0.13 to 0.55, p=0.22, k=3), but child- and teacher-rated hyperactivity/impulsivity reported effects as likely to be negative as beneficial (g=-0.17, 95% CI: -0.7 to 0.36, p=0.53, k=2; g=-0.07, 95% CI: -0.4 to 0.27, p=0.69, k=3). Across all outcomes there were no medium or large sized beneficial effects (g>0.4) thus suggesting a lack of evidence of beneficial effect for these interventions.

Effectiveness of daily report card interventions

While only two studies reported effects for daily report cards interventions, one study did assess three different interventions: Jurbergs and colleagues had intervention groups where parents provided rewards (traditional daily report card) and two others with either teacher delivered rewards or no rewards (Jurbergs et al., 2010; Palcic et al., 2009). Effect sizes tended to be large and beneficial in this study, which is also the case for the meta-analysed outcomes that included the study by Fabiano and colleagues (2010). While effect sizes were often large across outcomes, only teacher-rated academic outcomes were also statistically significant for Fabiano and colleagues (2010): g=0.68, 95% CI: 0.17-1.19, p=0.01. The large beneficial effect sizes in the meta-analyses that were not statistically significant for child-rated academic outcomes, teacher-rated ADHD Combined symptoms and observer classroom behaviour ratings were characterised by wide confidence intervals and high levels of heterogeneity (I^2: 68-97%). There was only weak evidence for beneficial effects (g=0.49, 95% CI:-0.02 to 1.01, p=0.06, k=1) for both teacher-rated conduct and social skills outcomes. As a whole daily report cards were characterised by medium to large beneficial effects with a lack of confidence in the precision of these effects.

Effectiveness of neurofeedback interventions

Eight studies assessed neurofeedback interventions (Denkowski et al., 1983, Denkowski & Denkowski, 1984; Omizo, 1980a, 1980b; Omizo & Michael, 1982; Rivera & Omizo, 1980; Steiner et al., 2011, 2014). Unlike the eight combined intervention studies, effect sizes here were typically small or negligible. Only two statistically significant large effects were found for child-reported academic outcomes (g=0.72, 95% CI: 0.27 to 1.17, p=0.002, k=2) and inattention symptoms (g=0.82, 95% CI: 0.39 to 1.26, p<0.001, k=3). However, when inattention symptoms were rated by teachers and parents there was weak evidence of small

beneficial effects (g=0.28, 95% CI: -0.19 to 0.74, p=0.24, k=2; g=0.28, 95% CI: -0.22 to 0.78 p=0.27, k=2). Indeed, across all symptom outcomes children's ratings were medium to large, but teachers were minimal. When personal and emotional outcomes were rated by children and observers, large effect sizes were reported but confidence intervals were very wide (g=0.86, 95% CI: -0.46 to 2.19, p=0.2, k=3; g=0.65, 95% CI: -0.7 to 1.99, p=0.35, k=2) and heterogeneity was large (I^2: 84% to 96%). Overall there may be some promise for the effect of neurofeedback on academic and personal and emotional outcomes, but effects reported have wide confidence intervals were exclusively from studies conducted in the 1980s and have not been replicated since.

Effectiveness of relaxation interventions

Two studies reported the effects of relaxation interventions (Khilnani et al., 2003; Denkowski & Denkowski, 1984). Where meta-analyses could be conducted for teacher-rated conduct and observer personal and emotional outcomes effects were small and not statistically significant (g=0.34, 95% CI:-0.23 to 0.9, p=0.24, k=2; g=0.3 95% CI: -0.35 to 0.94, p=0.37, k=2). Confidence intervals for all effects reported are wide, given the small sample sizes in the two studies. Large statistically significant beneficial effects were seen for teacher-rated personal and emotional (g=0.91, 95% CI: 0.23 to 1.58, p=0.01) and social outcomes (g=0.82, 95% CI: 0.08 to 1.57, p=0.03) in one study (Khilnani et al., 2003). Effect sizes were typically larger for this study than Denkowski and Denkowski (1984), with teacher-rated hyperactivity/impulsivity symptoms (g=0.6, 95% CI: -0.13 to 1.33, p=0.11) and inattention symptoms (g=0.41, 95% CI: -0.32 to 1.13, p=0.27) giving medium to large beneficial effects, although with wide confidence intervals. Only the massage intervention in Khilnani and colleagues' (2003) relatively small study suggests promise for relaxation interventions at this time, but with a lack of precision for the true effect of the intervention..

Effectiveness of self-monitoring interventions

Two studies assessed self-monitoring interventions (Bloomquist et al., 1991; Cassar, 2010). Effect sizes reported were typically medium or very large, but with wide confidence intervals, owing to the very small samples in these studies. Meta-analysis was only possible for teacher-rated inattention symptoms resulting in an effect size range from very large harm to very large benefits (g=1.03, 95% CI: -1.15 to 3.22, p=0.35). There was substantial heterogeneity for this analysis (I^2=77%) highlighting differences between the two studies. For effect sizes reported by Cloward (2002), only observer classroom behaviour showed a statistically significant large beneficial effect (g=2.89, 95% CI: 0.75 to 5.03, p=0.01). A large effect for teacher-rated ADHD combined symptoms (g=1.55, 95% CI: -0.21 to 3.31, p=0.08) and medium effects for teacher-rated hyperactivity/impulsivity (g=0.47, 95% CI: -0.31 to 1.25, p=0.24) and social skills outcomes (g=0.45, 95% CI: -0.36 to 1.26, p=0.28) were not statistically significant. Very wide confidence intervals indicate the small sample sizes of both study and therefore the lack of clarity regarding the effects of self-monitoring interventions at this time.

Effectiveness of study and organisation skills training

Five studies reported the effects of study and organisation skills training (Evans et al., 2016; Iseman et al., 2011; Langberg et al., 2008, 2012, 2017). Only parent-rated academic outcomes provided a statistically significant large beneficial effect (g=0.69, 95% CI: 0.24 to 1.14, p=0.002, k=4). However, high heterogeneity (I^2=87%) suggests differences between the four studies. Furthermore, child- and teacher-rated academic outcomes showed weak evidence of beneficial effects, with the three teacher-rated studies indicating confidence in no effect (g=0.26, 95% CI: -0.38 to 0.91, p=0.42, k=1; g=0.05, 95% CI: -0.08 to 0.17, p=0.45, k=3). It was not the case that teacher and parent ratings came from different studies, indicating the trend

for parent-reports of larger effects for school-based interventions than teachers, although for study and organisation skill training parents were often rating the effects seen at home regarding homework. All other effect sizes for symptom, conduct and personal and emotional outcomes were small or negligible. Overall findings do not indicate effectiveness of study and organisational skills interventions when they are the main focus of interventions.

Effectiveness of task modification interventions

Finally two studies assessed effects of task modification interventions, game-based and music curriculums respectively (Cassar 2010; Chacona 2007). Meta-analysis was not possible as no common outcome was assessed by both studies. Only two outcome categories were reported for each study. A statistically significant and large beneficial effect was found for teacher-rated classroom behaviour by Cassar (2010): $g=0.97$, 95% CI: 0.44 to 1.5, $p<0.001$. That the confidence interval is not wider is surprising given this study has the smallest sample size of included studies (n=6). No evidence for other effects was found. Overall there is a lack of evidence for beneficial effects of these curriculum-based interventions, or task modifications more generally at this time.

Summary of meta-analysis findings

Eight categories of school-based interventions for ADHD were analysed for effectiveness according to different outcomes and raters. There is strongest evidence of beneficial effects for combined interventions, although there was heterogeneity across different types of outcomes, these interventions may be more effective for ADHD combined symptoms, academic outcomes and conduct problems, than other outcomes. The question remains as to which components of combined interventions might be more effective and whether there is an additive effect, the QCA analysis can help to explore this.

There was also some promise of beneficial effects of daily report cards. Pooled effects from two studies were large for all outcomes, but imprecise with large statistical heterogeneity reported. There were mixed findings for neurofeedback, relaxation and self-monitoring interventions. Findings were characterised by beneficial effects only indicated across some outcomes and raters assessed and imprecision in the effects reported. Despite a lack of clear evidence of benefit across a wider range of outcomes and raters available, there was a beneficial effect for neurofeedback on academic outcomes. There was a lack of evidence of effect for cognitive training, study and organisation skills training and task modification.

Meta-regression of intervention types

To test the type of intervention as a moderator, a meta-regression model was fitted to each outcome/rater dyad when there were at least eight studies that provided relevant effect size data. The omnibus test of moderators statistic, Q_M, was calculated for the different outcomes. Analysis for nine different outcome/rater dyads was possible. Only teacher-rated academic (Q_M=18.4, df=3, p<0.001), teacher-rated ADHD-combined (Q_M=28.9, df=5, p<0.001) and parent rated inattention (Q_M=12.5, df=4, p=0.01) showed a statistically significant result. For teacher-rated academic outcomes Daily Report Cards showed large effects (g=0.68, 95% CI: 0.17 to 1.19), Combined interventions showed a small effect (g=0.3, 95% CI:-0.02 to 0.61) and study skills and organisation training a negligible effect (g=0.05, 95% CI: -0.08 to 0.17). Confidence intervals indicate effects are likely to be more beneficial for Daily Report Cards than Study Skills and Organisational Training.

For teacher-rated ADHD combined symptoms Combined, Daily Report Card and Self-monitoring interventions revealed larger effects (g=0.62, 95% CI: -0.11 to 1.35; g=1.55, 95% CI: -0.21 to 3.31)) than Neurofeedback and Cognitive Training (g=0.12, 95% CI: -0.38 to 0.61; g=0.06, 95% CI: -0.29 to 0.40). Finally, for parent-rated inattention it appears that cognitive training (g=0.36, 95% CI: 0.02 to 0.70) had a larger effect size, despite being small in

magnitude, than Combined (g=0.27, 95% CI: 0.01 to 0.54), Neurofeedback (g= 0.28, 95% CI: -0.22 to 0.78) and Study skills and organisation training interventions (g=0.29, 95% CI: -0.04 to 0.62). Child-rated academic outcomes, teacher-rated conduct, hyperactivity/impulsivity rated by both teachers and parents, teacher-rated social skills and teacher-rated inattention all indicated no moderation effect by type of intervention. It is of note that meta-regression was also possible for child-rated academic outcomes and teacher-rated inattention and with data for more intervention categories there was no moderation by intervention type for these raters.

Overall, for a small amount of outcomes and raters there were statistically significant differences in effects across intervention types. Often this was in line with the general trends for the meta-analytic result. That parent-rated inattention had higher effect for cognitive training than combined interventions is surprising, but this was not the case for teacher-rated inattention, so calls into question whether cognitive training is actually more effective than other intervention categories for inattention outcomes.

Qualitative Comparative Analysis Findings

Building the data table

As seventeen RCTs included in the systematic review reported academic outcomes, they were included in the QCA. There were actually 22 "cases", as one study included three intervention groups (Jurbergs et al., 2010; Palcic et al. 2009) and three studies included two intervention groups (Evans 2016; Langberg 2017; Denkowski & Denkowski, 1984). Coding of the conditions according to fuzzy set logic was agreed by two reviewers after discussion with the review team. One reviewer extracted data from original studies and this was checked by another reviewer with any disagreements resolved through discussion. The codes 0, 0.33, 0.67, 1 were used as necessary to refer to partial or full membership of the condition for each case. The effect sizes for academic outcomes were also converted to fuzzified values using the calibrate command in the R 3.2.3 software package QCA. Thresholds of Hedge's g of 0.1, 0.4

and 1.0 were used given the spread of effect sizes for the cases and 0.4 as a medium effect size (Hattie 2008).

The data extraction and coding gave us a "data table", i.e. a table consisting of rows that represent the cases (interventions tested in studies) and columns representing the conditions and outcome coded between 0 and 1. The nine conditions appearing in the data table were whether: 1. study and organisational skills were trained, 2. Behaviour modification was used, 3. Intervention aimed to improve self-regulation 4. Intervention is personalised to individual recipient, 5. Intervention is delivered in the classroom, 6. Intervention is delivered one-to-one, 7. Teacher delivers intervention, 8. Intervention aims to improve relationships for child, 9. Total intervention hours were over 10 hours (see Appendix 3 for data table and criteria for coding).

Constructing and checking a 'truth table'

Because four to six conditions would usually be advised (Berg-Schlosser & De Meur, 2009) given the inclusion of 22 cases in the QCA, an iterative process was followed when constructing the truth table and determining the final conditions used. We initially considered the four conditions that fit the support school-based difficulties category depicted in the logic model (see Figure 1): behaviour modification, study skills, self-regulation and relationships. Self-regulation and relationships appeared to be conditions that together could explain effectiveness, but behaviour modification and study skills were not conditions that helped to distinguish more effective interventions from less effective ones. We then added the needs of children with ADHD conditions to the draft truth table: personalisation, delivery one-to-one and total hours of intervention. It became clear that self-regulation and delivery one-to-one were features of interventions that often were present in effective configurations, with personalisation and relationships (sometimes the absence of relationships) also featuring, but total hours did not seem to hold much explanatory power. Finally, we added the regular

education conditions: delivered in classroom and teacher delivers, which both helped explain the configurations that were effective (<0.8 sufficiency). However, there was considerable overlap between delivery in the classroom and by the teacher, so delivery in the classroom was prioritised given that theorising suggested this condition would respond to the difficulties faced when students with ADHD are withdrawn from their regular classroom. This meant that five conditions appeared in the final truth table: Personalisation, delivered one-to-one, self-regulation, relationships, and delivered in classroom (see Table 5).

INSERT TABLE 5 ABOUT HERE

Because self-regulation and delivery one-to-one were always present in configurations that gave effective academic outcomes, we considered whether one or both of these conditions would be enough to clearly explain the causal path to effectiveness, but found that the other three conditions were also important. Indeed, it was not enough to say that the presence of self-regulation and/or delivery one-to-one gave effective outcomes as for some studies the outcome was ineffective when these conditions were present. Note that there are a range of configurations that are effective and ineffective according to the sufficiency inclusion score of 0.8 and that 9 of 22 cases appear in the effective configurations. Such a spread is desirable.

Boolean minimisation

This stage aims to simplify the five effective configurations from the data table. The intermediate solution that accounts for remainders – those configurations (n=19) where no cases provide information – and predicts that the presence of the five conditions should lead to effectiveness, as per the logic model, gave two pathways to effectiveness (see Figure 3). The solution coverage of 0.606 indicates the proportion of cases with an effective intervention that fit either pathway. Checks of this model indicated no contradictory configurations and the

model does not also explain ineffective academic outcomes, which suggests a good fit for the solution.

Turning to the pathways to effectiveness for academic outcomes, both include the presence of self-regulation and one-to-one delivery as part of the intervention. The first pathway also includes the absence of improving relationships. This implies that when interventions targeted self-regulation and were delivered by an individual to the child recipient, but there is no sign that child relationships are targeted, the intervention is effective for academic outcomes. In the second pathway the presence of classroom delivery and personalisation replaces the absence of relationships. So this causal pathway suggests that interventions that include: self-regulation, personalisation, and are delivered one-to-one in the classroom are effective for academic outcomes.

INSERT FIGURE 3 HERE

Logical remainders

Although there were 19 configurations out of a possible 32 that were remainders (meaning no cases provided evidence for effectiveness or ineffectiveness), some of these configurations would not be expected to fit an intervention. It would be useful to have further data on configurations where interventions are delivered in the classroom, one-to-one and improved relationships were targeted, as three remainders include this as part of the configuration. Aside from this, there were no notable configurations that were not seen frequently in the cases available.

Interpretation

The first causal pathway was unexpected given the prediction that the conditions might all increase academic outcomes, as is seen in the truth table for the case Fabiano (2010). But it is found that when interventions target self-regulation skills, are delivered one-to-one, but do

not aim to improve relationships, academic outcomes are effective. The nine interventions that provided evidence for this pathway were categorised as neurofeedback, study skills and organisation training and daily report card interventions. The daily report card interventions here often featured rewards delivered by parents or teachers, but were not indicative of improved relationships between provider and recipient or targeting relationships more generally (Jurbergs et al., 2010; Palcic et al., 2009). For study skills and organisation training interventions, the meta-analysis provided mixed effectiveness results for academic outcomes. The inclusion of self-regulation targets that both encourage the student with ADHD to monitor and self-control behaviour and in particular one-to-one delivery, appears to distinguish effective study skills and organisation training from less effective examples.

Interpretation of the second causal pathway is relatively straightforward. The logic model would predict that each condition could together increase effectiveness for academic outcomes and in this causal pathway, four of the five conditions are present. In isolation we might speculate that "relationships" is not a necessary condition because elements of personalisation, one-to-one delivery and a classroom setting may indirectly improve relationships. The three interventions that provide evidence for this pathway were all the daily report card interventions that included rewards for meeting targets (Fabiano et al., 2010; Jurbergs et al., 2010; Palcic et al., 2009). Self-regulation and one-to-one delivery are common features of both causal pathways. We can conclude that self-regulation and one-to-one delivery are important for academic outcomes to improve, although they are not sufficient alone. In the discussion section we consider the fit of this outcome with previous literature and the logic model.

Discussion

Summary of findings

This review synthesised RCTs on the effectiveness of non-pharmacological interventions for children with ADHD in school settings. Twenty-eight studies were included that reported effects across eight different types of interventions. Outcomes were categorised according to eight types and the rater type was also distinguished. Included studies were most often published in peer-reviewed journals, took place in the United States of America and included primary or elementary school-aged children with ADHD. The quality and risk of bias of included studies was assessed. The included studies were of low study quality according to criteria typically used to assess RCTs in health research (Higgins et al., 2011). They rarely reported how they concealed allocations prior to assignment, tended not to use raters blinded to treatment group and a small number of studies assessed intervention effects beyond treatment, with a six month follow up rare.

Research question one was addressed through calculation of effect size and meta-analysis methods. Consideration across the eight categories of school-based intervention indicate evidence of beneficial effects for combined interventions, those that include more than one main intervention part, for outcomes including ADHD combined symptoms, academic outcomes and conduct problems. There was also some indication of large beneficial effects for daily report card interventions, but the confidence of the true effect was very wide. For other types of interventions, there is less evidence of beneficial effects, although neurofeedback interventions may improve academic outcomes.

Research question two was also addressed more directly through meta-regression methods, to consider which types of school-based interventions for students with ADHD are more effective than others. There was some evidence of moderation of effectiveness by type

of intervention for three outcomes and raters. For teacher-rated academic outcomes, daily report cards appear more likely to be beneficial than study skills and organisation training. However, there were no differences between intervention types for child self-reported academic outcomes, which may call into question this finding. There was also evidence that for teacher-rated ADHD combined symptoms outcomes, daily report card and self-monitoring interventions were more effective than neurofeedback and cognitive training. For parent-rated inattention, cognitive training had a larger effect size than combined interventions, neurofeedback and study skills and organisation training. However, this was not the case for teacher-rated inattention. The limited number of studies that could be included in each meta-regression analysis meant that other variables were not able to be explored in the model, such as participant characteristics and school setting. Had there been clearer indication of certain intervention types being more effective than others, this would have been considered further.

QCA was undertaken to explore which components of interventions might be necessary for effective academic outcomes. Seventeen RCTs provided data for this analysis. An iterative process of selecting potential conditions according to a logic model was followed, with nine conditions considered during the analysis and five used in the final truth table and solution: intervention aimed to improve self-regulation; intervention is personalised to individual recipient; intervention is delivered in the classroom; intervention is delivered one-to-one; intervention aims to improve relationships for child.

The simplified solution gave two causal pathways to effective academic outcomes. One configuration showed interventions that aimed to improve self-regulation and were delivered one-to-one, but did not aim to improve relationships improved academic outcomes. A second configuration included presence of conditions where the intervention aimed to improve self-

regulation, was personalised to the individual recipient and was delivered one-to-one in the classroom, which together improved academic outcomes.

Relation to previous literature

The meta-analysis findings hold differences to systematic reviews of non-pharmacological interventions for children and young people with ADHD across settings. Evans and colleagues (2018) conclude that organisation training met criteria for a well-established treatment, but combined training programs only met criteria for a probably efficacious treatment. We found more evidence for the effects of combined training programs and no effect of study and organisational training. Bikic and colleagues (2017) reported only modest improvements in symptoms of inattention and academic performance for organisation skill training, so the current findings are more in line with their focused review, although their work suggests that these types of interventions may be more effective when delivered in clinical settings. We found similar findings to Evans and colleagues (2018) in relation to two other types of intervention; according to evaluation criteria (Silverman & Hinshaw, 2008), they considered neurofeedback only possibly efficacious and cognitive training to be an experimental treatment.

The current study provides a more nuanced picture of interventions effects than previous reviews of school-based interventions. It considers intervention types with more specificity than DuPaul and colleagues (2014) who found that contingency management, academic intervention and cognitive-behavioural interventions all were associated with positive effects for academic and behavioural outcomes, although this was across study designs, rather than for higher quality research designs (e.g. RCTs). Miranda and colleagues (2006) concluded that school-based interventions as a whole were effective in the short-term for classroom behaviour and academic performance and interventions with multiple components were particularly effective. We find support for the latter conclusion. The QCA responds to the

need identified in this previous review to determine which specific techniques of multimodal interventions produce improvements (Miranda et al. 2006). It is notable that these two previous reviews focus on school outcomes, namely academic outcomes and behaviour. Our review also considers ADHD symptoms and associated difficulties in the school setting. This is important given the call for the treatment of mental ill health in schools (Fazel et al., 2014) and the lack of evidence for school-based treatment recommendations in the latest NICE treatment guidelines for children and young people with ADHD (NICE, 2018).

Iznardo and colleagues (2017) reviewed the effectiveness of daily report cards for children with ADHD, finding medium effects for teacher rated ADHD symptoms in a wider range of study designs than RCTs. This lends support to the beneficial effects reported in the current review, which were large but imprecise given the limited amount of RCTs (n=2). The tentative findings regarding the effectiveness of school-based neurofeedback for academic outcomes, appears to be novel. Several previous reviews (e.g. Willis et al., 2011) investigate the effectiveness of neurofeedback in broader settings and do not include school outcomes.

It is noteworthy, given the focus on academic outcomes in the QCA performed in the current study, that a previous review focused on academic outcomes (Trout et al., 2007). However, we find rather different information in the current review, with participants being more representative of the ADHD population and comparison across methodologically similar studies feasible. Unlike Trout and colleagues (2007), we were able to draw conclusions about effects of interventions on academic outcomes and saw application of neurofeedback and relaxation interventions in school settings, therefore extending this previous work.

Richardson and colleagues (2015) reported that moderator analyses were not able to clarify which intervention features were linked with effectiveness for school-based interventions for ADHD in their systematic review. Meta-regression analyses of intervention

type as moderating variables and in particular the QCA for academic outcomes, provide more suggestions regarding components of interventions that are linked with effectiveness. As the meta-regression uses unique categories of interventions in this study and we are not aware of any previous QCA on the topic, these elements cannot be directly compared to previous findings in the literature.

The QCA can be considered in relation to the logic model, drawn from previous literature, to theorise how conditions of interventions may impact academic outcomes. Previous literature can also help further interpret the configuration of intervention components shown to lead to beneficial academic outcomes. As a previous review informed the selection of conditions, it is not surprising that Moore and colleagues (2016) review of attitudes towards and experience of interventions can help to interpret the QCA findings. One-to-one delivery and personalising interventions respond to the differing needs of children with ADHD. Delivery of interventions in the classroom avoids issues of stigma, strain on peer relationships and, of particular relevance to academic outcomes, mean children in regular education miss less curriculum content. Other previous work stresses the importance of self-regulation as a key challenge for children with ADHD in school settings (Barkley, 1997; Gwernan-Jones et al., 2015a). Furthermore, Purdie and colleagues (2002) reported strong effects for self-regulation interventions both in and out of school settings for children with ADHD. Therefore support is found for the importance of self-regulation components of interventions for academic outcomes.

It was surprising that relationships are a component that should not appear in the configuration with self-regulation and one-to-one intervention delivery for effective academic outcomes. Teachers see relationships that children with ADHD hold as key to their success in school (Moore et al., 2017). Perhaps with focus specifically on academic outcomes after often

relatively short interventions (mean 20.2 hours), self-regulation and one-to-one delivery needs to focus on schoolwork, rather than relationships.

The second causal pathway includes the presence of conditions where the intervention aimed to improve self-regulation, was personalised to the individual recipient and was delivered one-to-one in the classroom. The implication is that the presence of these conditions would be predicted to also lead to effective academic outcomes in a different type of intervention. However, all the cases (interventions) providing evidence for this configuration were daily report card interventions with rewards. Thus, it would be naïve not to suggest that this pathway might simply be further evidence for the effectiveness of daily report cards for ADHD when they include rewards for meeting targets given at home or in school.

Strengths and limitations

This systematic review of school-based interventions for children with ADHD extends the most recent previous reviews (DuPaul et al., 2012; Richardson et al., 2015), by categorising interventions in a way that allowed for comparison between different types of similar interventions. The review followed best practice guidelines for systematic reviews (CRD 2009) and was inclusive with regard to date and publication status, in order to consider as much relevant, comparable evidence as possible. The review included relatively strict inclusion criteria, so that all participants in studies were either diagnosed with ADHD and/or showing symptoms at a diagnosable level at baseline and RCT design. This differs from several previous reviews that make claims about treatment for ADHD (e.g. Fabiano et al., 2009; Richardson et al., 2015). While this is a strength of the current review, evidence from other studies with sub-clinical samples and lower quality designs may be of relevance to teachers considering the evidence for the use of interventions with students who have ADHD-related difficulties, regardless of diagnosis (e.g. DuPaul et al., 2006; Owens et al., 2012; Rabiner et al., 2010; Sayal et al., 2015; Tymms & Merrell, 2006).

Limitations of this systematic review include the applicability of findings. Most studies were conducted in the United States of America and only one study had participants who were all of secondary/high school age. Future research should explore different populations, and in particular, whether interventions are effective across age groups. Although the categorisation of interventions and outcomes was clear, the wide range of school-based treatments and measures of impact, meant that relatively small numbers of studies provided evidence that could be pooled in meta-analysis or assessed in meta-regression.

QCA as an analytical method for systematic review data is iterative and should be theoretically informed. Analysis of other outcomes would therefore require a new logic model, conditions and data extraction. While the QCA arguably provides a clearer response to research question 3 than the other methods of synthesis provide for the other research questions, there are a number of caveats to consider. Firstly, we have attempted to carefully report meta-analysis results with references to magnitude of the effect size, statistical significance and confidence intervals. For a fuzzy-set QCA the outcome needs to be on a scale from 0 to 1. We calibrated the effect sizes for academic outcomes to the binary scale, rather than select arbitrary categories, but they do not consider confidence intervals.

QCA is limited to using conditions that are reported in included studies. While, we consulted previous literature to theorise how conditions might impact academic outcomes, not all conditions that might be relevant will be reported in a journal article or have the necessary spread of membership and non-membership of a condition. For instance, we would have been interested in whether there was a home element of interventions, but this was present for only five cases, so did not have the necessary spread of membership to be tested.

The two causal pathways from the QCA give clear implications for components of interventions that are predicted to improve academic outcomes. However, the utility of the two

pathways as currently expressed can be questioned. Not seeking to improve relationships is identified as an important part of interventions in the first pathway. It may be that the interventions that do not target relationships in their one-to-one delivery have something else in common. If rather than not focusing on relationships, these interventions did include other features that have not been considered in the analysis, this would be a more palatable message, rather than recommending not to include something in an intervention that is widely considered to be important for wider school success (Moore et al., 2017).

The second pathway is evidenced by cases that are all the daily report card interventions that involve rewards given to children who meet their targets. While, the implication is that there would be benefit to the inclusion of self-regulation, personalisation and delivery one-to-one in the classroom for other interventions if this was implemented, a simplified solution, would be to say that the QCA finds that one pathway to academic outcomes is to have an intervention that is a daily report card with rewards.

The focus of the current research questions were on ADHD generally, rather than including any analysis by further participant characteristics. As for previous systematic reviews (e.g. Richardson et al., 2015), we found that important details such as subtype of ADHD, severity of ADHD and participant age were rarely reported in included studies and they were even less likely to provide data for subgroups or analyse this. In relation to subtype, previous research suggests that there are differences in the long-term outcomes of children with different subtypes of ADHD. For example, the inattentive subtype is associated with poorer academic performance and impulsivity may actually be associated with positive academic outcomes for some children with ADHD difficulties (Merrell et al., 2017). None of the seven studies that reported multiple ADHD subtypes amongst their sample, explored how this moderated intervention effects. Few of these studies would have been powered for such an analysis, but

this suggests future research ought to have sufficient power to report by ADHD subtype when an intervention intends to improve all ADHD symptoms.

The 2018 NICE guideline for the diagnosis and management of ADHD, recommends that any treatment plan should take into account the severity of ADHD symptoms and the impairment of the condition (NICE, 2018). Although included studies had samples that were all at a level of severity to indicate diagnosis, none provided details of which participants would be considered mild, moderate or severe according to DSM-5 recommendations (APA, 2013). Previous research has found that symptom severity is associated with academic underachievement (Barry et al., 2002) and therefore may moderate the effectiveness of school-based interventions. Future research should explore this, as it may suggest that certain types of school-based intervention (e.g. study skills and organisational training) may be inappropriate or need to be tailored to children with more severe ADHD.

Implications for practitioners
Need a paragraph or twoConclusion

This systematic review that used multiple methods to synthesise data provides a comprehensive review of RCTs assessing the effectiveness of school-based interventions for ADHD. Meta-analysis demonstrates some beneficial effects for interventions that combine multiple components and some promise for daily report cards and neurofeedback for academic outcomes. We are however, unable to confidently pinpoint certain interventions that will work for children and young people with ADHD. The QCA method of synthesis takes this further and provides implications for intervention design, indicating the importance of components including self-regulation and one-to-one delivery for academic outcomes.

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Table 1. Description of included studies

Study details	Country	Publication status	Relevant treatment groups (n)	Type of control	Sample size	School level	Percentage of female participants	Percentage on medication for ADHD	ADHD subtype
Bloomquist (1991)	USA	Journal article	1	WLC	24	Elementary/primary	31%	0%	NR
Cassar (2010)	Canada	Journal article	1	TAU	6	Elementary/primary	50%	NR	NR
Chacona (2007)	USA	Thesis	1	TAU	60	Elementary/primary	30%	NR	100% Inattentive
Cloward (2003)	USA	Thesis	1	TAU	8	Elementary/primary	38%	NR	NR
Denkowski (1984)	USA	Journal article	1	PLCB	45	Elementary/primary	NR	NR	100% Hyperactive
Denkowski (1983)	USA	Journal article	1	PLCB	48	Middle school	0%	0%	100% Hyperactive
Egeland (2014)	Norway	Journal article	1	TAU	75	Elementary/primary	27%	69%	100% Combined
Evans (2011)	USA	Journal article	1	CC	49	Middle school	29%	31%	NR

Evans (2014)	USA	Journal article	1	CC	36	Secondary/High School	17%	50%	81% Inattentive, 19% Combined
Evans (2016)	USA	Journal article	2	CC	326	Middle School	29%	47%	51% Inattentive, 49% Combined
Fabiano (2010)	USA	Journal article	1	TAU	63	Elementary/primary	14%	52%	87% Combined, 11% Inattentive, 2% Hyperactive/ Impulsive
Iseman (2011)	USA	Journal article	1	TAU	29	Combination of school levels	28%	66%	NR
Jurbergs (2010)	USA	Journal article	3	TAU	56	Elementary/primary	26%(of 43)	23%(of 43)	NR
Khilnani (2003)	USA	Journal article	1	WLC	30	Combination of school levels	20%	NR	NR
Langberg (2008)	USA	Journal article	1	WLC	37	Elementary/primary	16%	43%	NR
Langberg (2012)	USA	Journal article	1	WLC	47	Middle School	23%	66%	NR
Langberg (2018)	USA	Journal article	2	WLC	280	Middle School	26%	54%	62% inattentive, 38% combined
Looyeh (2012)	Iran	Journal article	1	WLC	14	Elementary/primary	100%	0%	NR

McGraw (2004)	USA	Report	1	TAU	53	Middle School	30%	NR	NR
Molina (2008)	USA	Journal article	1	CC	23	Middle School	25%	30%	50% combined, 50% inattentive
Omizo (1980a)	USA	Journal article	1	PLCB	56	Middle School	0%	0%	100% Hyperactive
Omizo (1980 b)	USA	Journal article	1	PLCB	52	Elementary/primary	0%	0%	100% Hyperactive
Omizo (1982)	USA	Journal article	1	PLCB	32	Elementary/primary	0%	NR	100% Hyperactive
Pfiffner (2016)	USA	Journal article	1	TAU	135	Elementary/primary	24%	8%	58% combined, 39% inattentive, 3% hyperactive/impulsive
Rivera (1980)	USA	Journal article	1	PLCB	36	Elementary/primary	0%	0%	100% Hyperactive
Seeley (2009)	USA	Journal article	1	TAU	42	Elementary/primary	7%	10%	52% combined, 24% Inattentive, 24% Hyperactive/Impulsive
Steiner (2011)	USA	Journal article	2	WLC	41	Elementary/primary	48%	60%	NR
Steiner (2014)	USA	Journal article	2	CC	104	Elementary/primary	33%	49%	NR

TAU = treatment as usual; WLC = waitlist control PLCB = Placebo; CC = Community control; NR = not reported

Table 2. Intervention details of included studies

Study details	Intervention category	Intervention name	Involves home?	School setting	During school hours?	Who receives the intervention?	Group or individual	Who delivers?	Were they trained?	Total hours of treatment	Fidelity assessed?
Bloomquist (1991)	Self-monitoring	Multicomponent CBT	Yes	Classroom	Yes	Children	Group	SMHP, teacher, student	Yes	20	Yes
Cassar (2010)	Task Modification	game-based instructional intervention	No	NR	Yes	Children	Group	Student	NR	12	No
Chacona (2007)	Task Modification	World Music Drumming Curriculum	No	Other school room	Yes	Children	Group	Teacher	NR	7	No
Cloward (2003)	Self-monitoring	Self-Monitoring	No	Classroom	Yes	Children	Group	Teacher	Yes	NR	No
Denkowski (1983)	Neurofeedback	EMG Assisted Relaxation Training	No	NR	Yes	Children	Individual	SMHP	NR	2.5	No

Denkowski (1984)1	Neurofeedback	EMG Biofeedback Training	No	NR	Yes	Children	Individual	Student	NR	3.3	No
Denkowski (1984)2	Relaxation	Progressive Relaxation	No	NR	Yes	Children	Group	Student	NR	3.3	No
Egeland (2013)	Cognitive Training	Cogmed's RoboMemo program	No	NR	Yes	Children	Individual	Teacher	NR	18.75	No
Evans (2011)	Combined	Challenging Horizons After-School Program	Yes	NR	No	Children	Both	Student	Yes	86	Yes
Evans (2014)	Combined	Challenging Horizons Program - Coaching	Yes	Other school room	Yes	Children	Both	SMHP, other practitioner	Yes	39.87	Yes
Evans (2016)1	Combined	Challenging Horizons After-School Program	No	NR	No	Children	Both	Student	Yes	121.05	Yes
Evans (2016)2	Study Skills	Challenging Horizons Program - Mentoring	No	NR	No	Children	Individual	Teacher	Yes	5.46	Yes

Fabiano (2010)	Daily Report Card	Daily Report Card	Yes	Classroom	Yes	Children	Individual	Teacher	Yes	NR	Yes
Iseman (2011)	Study Skills	Cognitive Strategy Instruction	No	Classroom	Yes	Children	Group	Teacher	Yes	1.66	Yes
Jurbergs (2010)1	Daily Report Card	DRC with parent consequences	Yes	Classroom	Yes	Children	Individual	Teacher	Yes	NR	Yes
Jurbergs (2010)2	Daily Report Card	DRC without parent consequences	No	Classroom	Yes	Children	Individual	Teacher	Yes	NR	Yes
Jurbergs (2010)3	Daily Report Card	DRC with teacher consequences	Yes	Classroom	Yes	Children	Individual	Teacher	Yes	NR	Yes
Khilnani (2003)	Relaxation	Massage Therapy	No	Other school room	Yes	Children	Individual	Other	NR	2.66	No
Langberg (2008)	Study Skills	organization and homework management interventions	Yes	NR	No	Children, parents	Both	Student	Yes	20	Yes

Langberg (2012)	Study Skills	Homework, Organization, and Planning Skills (HOPS)	Yes	NR	Yes	Children, parents	Individual	SMHP	Yes	5.18	Yes
Langberg (2018)1	Study Skills	Homework, Organization, and Planning Skills (HOPS)	Yes	NR	NR	Children, parents	Individual	SMHP	NR	5.33	Yes
Langberg (2018)2	Study Skills	Completing Homework by Improving Efficiency and Focus (CHIEF)	Yes	NR	NR	Children, parents	Individual	SMHP	NR	6.53	Yes
Looyeh (2012)	Combined	Narrative Therapy	No	NR	No	Children	Group	SMHP	NR	12	No
McGraw (2004)	Combined	Dance Dance Revolution	No	NR	Yes	Children	Group	Student	NR	NR	No
Molina (2008)	Combined	Challenging Horizons Program	Yes	NR	No	Children	Both	Student	Yes	40	No

Omizo (1980 a)	Neurofeedback	Biofeedback-induced Relaxation Training	No	Other school room	NR	Children	Individual	SMHP	NR	0.85	No
Omizo (1980 b)	Neurofeedback	Biofeedback-induced Relaxation Training	No	Other school room	Yes	Children	Individual	NR	NR	NR	No
Omizo (1982)	Neurofeedback	Biofeedback-induced Relaxation Training	No	Other school room	Yes	Children	Individual	SMHP	NR	1.66	No
Pfiffner (2016)	Combined	Collaborative Life Skills	Yes	NR	No	Children, teachers, parents	Both	SMHP	Yes	21	Yes
Rivera (1980)	Neurofeedback	Biofeedback-induced Relaxation Training	No	Other school room	Yes	Children	Individual	NR	NR	0.4	No
Seeley (2009)	Combined	First Step to Success	Yes	Classroom	Yes	Children, parents	Group	Teacher, other practitioner	Yes	NR	Yes

Steiner (2011)1	Neurofeedback	Neurofeedback	No	NR	Yes	Children	Group	Student	Yes	24	Yes
Steiner (2011)2	Cognitive Training	Standard Computer Format	No	NR	Yes	Children	Group	Student	Yes	24	Yes
Steiner (2014)1	Neurofeedback	Neurofeedback	No	NR	Yes	Children	Individual	Researcher	Yes	30	Yes
Steiner (2014)2	Cognitive Training	Cognitive Training	No	NR	Yes	Children	Individual	Researcher	Yes	30	Yes

NR = not reported, SMHP = School Mental Health Practitioner

Table 3. Quality appraisal of included studies

Study details	Randomisation Specified	Allocation Concealment	Intention to Treat	Blinding	Response rate	Follow Up	6m Follow Up	Missing data	Selective reporting
Bloomquist (1991)	N	N	N	Y	<70%	Y	N	Y	Y
Cassar (2010)	N	N	Y	N	85%+	N	N	NA	Y
Chacona (2007)	Y	Y	Y	N	85%+	N	N	NA	Y
Cloward (2003)	N	N	Y	N	85%+	N	N	NA	N
Denkowski (1983)	Y	N	Y	N	85%+	N	N	NA	Y
Denkowski (1984)	N	N	N	Y	85%+	N	N	Y	Y
Egeland (2014)	Y	Y	N	N	85%+	Y	Y	Y	Y
Evans (2011)	N	N	N	N	NR	N	N	N	Y
Evans (2014)	N	N	Y	N	70-84%	N	N	Y	Y

Evans (2016)	N	N	Y	N	85%+	Y	Y	Y	Y
Fabiano (2010)	N	N	N	Y	85%+	N	N	Y	Y
Iseman (2011)	N	N	N	N	<70%	Y	Y	N	Y
Jurbergs (2010)	N	N	N	N	85%+	N	N	NA	Y
Khilnani (2003)	N	N	Y	N	85%+	N	N	N	Y
Langberg (2008)	N	N	Y	N	85%+	Y	N	NA	Y
Langberg (2012)	N	N	Y	N	85%+	Y	N	N	Y
Langberg (2018)	Y	N	N	N	85%+	Y	Y	N	Y
Looyeh (2012)	N	N	Y	Y	85%+	Y	N	NA	Y
McGraw (2004)	Y	N	N	N	85%+	N	N	Y	Y
Molina (2008)	N	N	N	N	85%+	N	N	Y	Y

Omizo (1980a)	Y	N	Y	N	85%+	N	N	NA	Y
Omizo (1980 b)	Y	N	Y	N	85%+	N	N	NA	Y
Omizo (1982)	Y	N	Y	N	85%+	N	N	NA	Y
Pfiffner (2016)	N	N	N	N	85%+	N	N	Y	Y
Rivera (1980)	Y	N	N	N	85%+	N	N	NA	Y
Seeley (2009)	N	N	N	N	85%+	N	N	NA	Y
Steiner (2011)	N	N	N	N	85%+	N	N	Y	Y
Steiner (2014)	Y	N	Y	Y	85%+	Y	Y	Y	Y

Y=Yes, N=No, NA=Not applicable, NR=Not reported

Table 4. Number of studies providing data for each intervention/outcome/rater

	Combined intervention	Neuro-feedback	Cognitive Training	Study and organisational Skills Training	Self-monitoring	Daily Report Card	Relaxation	Task Modifications
Academic outcome	C=1 T=6 P=3	C=2	C=1	C=1 T=3 P=4		C=2 T=1	C=1	C=1
Classroom Behaviour	T=1 O=1	O=1	O=1		O=1	O=2		T=1
Symptoms: Hyperactive/ Impulsive	T=4 P=3	C=3 T=2 P=2	C=2 T=3 P=3	T=2 P=1	T=1		T=1	T=1
Symptoms: Inattention	T=4 P=3	C=3 T=2 P=2	C=2 T=3 P=3	T=2 P=1	T=2		T=1	T=1
Symptoms: ADHD Combined	T=2 P=1	C=1 T=2 P=1	C=1 T=3 P=2		T=1	T=2 P=1		
Conduct problems	C=1 T=3 P=4	T=2 P=1	T=1 P=1	T=1 P=1	T=1	T=1	T=2	
Personal/ Emotional	C=1 T=2 P=3	C=3 P=1 O=2	P=1	T=1 P=1	C=1		O=2 T=1	
Social	T=3 P=3	T=1 P=1	T=1 P=1		T=1	T=1	T=1	

C = child self-report, T = teacher-report, P = parent-report, O = independent observation

Table 5. QCA Truth Table

Conditions					Outcome			
Self-regulation	Classroom delivery	One-to-one delivery	Personalised	Relationships	EFFECTIVE	n of cases	sufficiency inclusion score	proportional reduction in inconsistency
1	**1**	**1**	**1**	**0**	**1**	**2**	**1**	**1**
1	**0**	**1**	**1**	**0**	**1**	**1**	**1**	**1**
1	**1**	**1**	**0**	**0**	**1**	**1**	**1**	**1**
1	**0**	**1**	**0**	**0**	**1**	**4**	**0.905**	**0.816**
1	**1**	**1**	**1**	**1**	**1**	**1**	**0.902**	**0.763**
1	1	0	1	1	0	1	0.665	0
1	0	1	1	1	0	3	0.65	0.346
0	1	1	0	0	0	1	0.64	0.613
1	0	0	1	1	0	3	0.535	0.137
0	0	1	1	0	0	1	0.464	0.057
0	0	0	0	0	0	2	0.426	0
1	0	0	0	0	0	1	0.391	0
0	1	0	0	0	0	1	0.274	0

Appendix 1. PsycINFO Search Strategy:

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1   exp attention deficit disorder with hyperactivity/ (11098)
2   ADHD.ti,ab. (14279)
3   ADHS.ti,ab. (46)
4   ADDH.ti,ab. (129)
5   attention deficit.ti,ab. (16587)
6   hyperactiv*.ti,ab. (23610)
7   (hyper adj1 activ*).ti,ab. (69)
8   (Conduct adj3 (problem* or difficult* or disorder* or issue*)).ti,ab. (7625)
9   (Attention adj3 (problem* or difficult* or disorder* or issue*)).ti,ab. (20840)
10   hyperk*.ti,ab. (1471)
11   minimal brain.ti,ab. (686)
12   inattenti*.ti,ab. (4334)
13   impulsiv*.ti,ab. (13115)
14   restless*.ti,ab. (2497)
15   overactiv*.ti,ab. (1461)
16   or/1-15 (54049)
17   school*.ti,ab. (220799)
18   college*.ti,ab. (85771)
19   nurser*.ti,ab. (2859)
20   preschool*.ti,ab. (26400)
21   kindergarten*.ti,ab. (10621)
22   classroom*.ti,ab. (50276)
23   elementary.ti,ab. (29135)
24   education* setting*.ti,ab. (3690)
25   ((education* or behavio?r*) adj unit*).ti,ab. (311)
26   education* establishment*.ti,ab. (112)
27   education* system*.ti,ab. (4486)
28   learning environment*.ti,ab. (7200)
29   learning establishment*.ti,ab. (4)
30   teaching environment*.ti,ab. (210)
31   teaching establishment*.ti,ab. (6)
32   teacher*.ti,ab. (105288)
33   early years.ti,ab. (2190)
34   foundation stage.ti,ab. (67)
35   summer treatment program*.ti,ab. (48)
36   breakfast club*.ti,ab. (13)
37   holiday club*.ti,ab. (2)
38   pupil*.ti,ab. (13914)
39   student*.ti,ab. (306201)
40   or/17-39 (519640)
41   intervention*.ti,ab. (187941)
42   strateg*.ti,ab. (185305)
43   program*.ti,ab. (234366)
44   project*.ti,ab. (82197)
45   train*.ti,ab. (185259)
46   support*.ti,ab. (360119)
47   therap*.ti,ab. (235922)
48   (Behavio?r* adj2 (management or modification* or medicine or treatment*)).ti,ab. (19574)
49   (education* adj2 (management or modification* or treatment*)).ti,ab. (2943)
50   (classroom adj2 (management or modification* or treatment*)).ti,ab. (1537)
51   (playground adj2 (management or modification*)).ti,ab. (1)
52   (psychosocial adj2 (management or modification* or treatment*)).ti,ab. (2405)
53   (cognitive adj2 (management or modification* or treatment*)).ti,ab. (5790)

54   behavio?r change technique*.ti,ab. (75)
55   bct*.ti,ab. (195)
56   exercise*.ti,ab. (34126)
57   (social adj2 play).ti,ab. (1451)
58   (free adj2 play).ti,ab. (2026)
59   (physical adj2 (education or activit*)).ti,ab. (16433)
60   meditat*.ti,ab. (4434)
61   class* size*.ti,ab. (854)
62   seating.ti,ab. (596)
63   incredible years.ti,ab. (106)
64   Triple P.ti,ab. (141)
65   good behavio?r game.ti,ab. (62)
66   123 magic.ti,ab. (0)
67   place2be.ti,ab. (3)
68   reinforcement.ti,ab. (27920)
69   punishment*.ti,ab. (10232)
70   response cost.ti,ab. (449)
71   time out.ti,ab. (1242)
72   reward*.ti,ab. (30548)
73   prize*.ti,ab. (1481)
74   privilege*.ti,ab. (6354)
75   teacher pupil relationship*.ti,ab. (66)
76   teacher student relationship*.ti,ab. (445)
77   (Family adj2 school adj (partnership* or relationship* or involvement)).ti,ab. (221)
78   (Parent adj2 school adj (partnership* or relationship* or involvement)).ti,ab. (118)
79   (school adj2 parent adj (partnership* or relationship* or involvement)).ti,ab. (118)
80   (home adj2 school adj (partnership* or relationship* or involvement)).ti,ab. (201)
81   rule*.ti,ab. (36823)
82   (routine or routines).ti,ab. (18697)
83   contingent attention.ti,ab. (34)
84   daily report*.ti,ab. (248)
85   think* time.ti,ab. (44)
86   extra time.ti,ab. (201)
87   quiet.ti,ab. (3201)
88   indoor pass.ti,ab. (0)
89   verbal correction*.ti,ab. (14)
90   instruct*.ti,ab. (82292)
91   clear commands.ti,ab. (3)
92   social stor*.ti,ab. (142)
93   (weigh* adj2 (jacket* or vest* or belt*)).ti,ab. (31)
94   (lesson adj2 structure*).ti,ab. (50)
95   (goal* adj3 setting).ti,ab. (4304)
96   (target* adj3 setting).ti,ab. (231)
97   behavio?r book.ti,ab. (2)
98   (peer adj2 (support or tutor*)).ti,ab. (2862)
99   champion*.ti,ab. (1581)
100   mentor*.ti,ab. (8142)
101   counsell*.ti,ab. (8376)
102   coach*.ti,ab. (7875)
103   cwpt.ti,ab. (47)
104   computer*.ti,ab. (59337)
105   ICT.ti,ab. (1444)
106   (information adj2 technology).ti,ab. (3789)
107   social skills.ti,ab. (8876)
108   social problem solving.ti,ab. (1149)
109   life skills.ti,ab. (1179)

110   (anger adj2 (strateg* or manag* or modification*)).ti,ab. (1099)
111   CBT.ti,ab. (5834)
112   cognitive behavio?r*.ti,ab. (23399)
113   worksheet*.ti,ab. (815)
114   timer*.ti,ab. (499)
115   break*.ti,ab. (20036)
116   headphone*.ti,ab. (453)
117   music.ti,ab. (15813)
118   timetable*.ti,ab. (425)
119   ((individual or screen*) adj3 (desk* or table*)).ti,ab. (60)
120   traffic light*.ti,ab. (119)
121   whole class.ti,ab. (512)
122   breakfast club*.ti,ab. (13)
123   holiday club*.ti,ab. (2)
124   workshop*.ti,ab. (9658)
125   ((self or personal) adj2 organis*).ti,ab. (309)
126   selfmanage.ti,ab. (0)
127   self manage.ti,ab. (141)
128   role play.ti,ab. (1841)
129   roleplay.ti,ab. (39)
130   multimodal.ti,ab. (4515)
131   multi agency.ti,ab. (394)
132   (chunk* or chunking).ti,ab. (1068)
133   brain gym.ti,ab. (15)
134   (stress adj2 (toy* or ball*)).ti,ab. (4)
135   circle time.ti,ab. (69)
136   transition.ti,ab. (26001)
137   cube box.ti,ab. (1)
138   curriculum.ti,ab. (26474)
139   remedial teaching.ti,ab. (89)
140   or/41-139 (1296528)
141   16 and 40 and 140 (6584)
142   limit 141 to yr="1980 -Current" (6235)

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Appendix 3. QCA data table and criteria for coding

Case	Study skills	Behaviour modification	Self-regulation	Personalised	Classroom delivery	One-to-one delivery	Teacher delivers	Relationships	Total Hours	Effective academic
Jurbergs 2010 NPC	0	0	0.67	0	1	1	1	0.33	0	0.992
Jurbergs 2010 PC	0	0.67	0.67	0.67	1	1	1	0.33	0	0.983
Palcic Jurbergs 2009 TC	0	0.67	0.67	0.67	1	1	1	0.33	0	0.982
Langberg 2012	1	0.67	1	0	0	1	0	0.33	0.33	0.977
Denkowski 1983	0	0	0.67	0	0	1	0	0	0	0.882
Langberg 2018 CHIEF	1	0.67	0.67	0.67	0	1	0	0.33	0.33	0.702
Molina 2008	1	1	1	0.67	0	0.67	0	1	1	0.697
Evans 2014	1	0.67	1	0.67	0	0.67	0	1	1	0.609
Denkowski 1984 Neurofeedback	0	0	0.67	0	0	1	0	0	0	0.585
Pfiffner 2016	1	1	0.67	0.67	0.33	0.33	0	1	0.67	0.585
Fabiano 2010	0	1	0.67	0.67	1	1	0.67	1	0.67	0.475
McGraw 2004	0	0	0	0	0	0	0	0	0	0.475
Langberg 2018 HOPS	1	0.67	1	0	0	1	0	0.33	0.33	0.439
Langberg 2008	1	1	0.67	0	0	0.33	0	0.33	0.67	0.346
Seeley 2009	1	1	1	0.67	1	0.33	0.67	1	1	0.335
Iseman 2011	0	0	0.33	0	1	0	1	0	0	0.202
Evans 2016 CHP after school	1	0.67	1	0.67	0	0.33	0	1	1	0.179
Egeland 2013	0	0.67	0	0.67	0	1	0.67	0	0.67	0.134
Cassar 2010	0	0	0	0	1	0.67	1	0.33	0.67	0.072
Denkowski 1984 Relaxation	0	0	0.33	0	0	0	0	0	0	0.046

Evans 2016 CHP mentoring	1	0.33	0.67	1	0	1	0.67	1	0.33	**0.043**
Evans 2011	1	0.67	1	0.67	0	0.33	0	1	1	**0.003**

Condition	Coding	Criteria
Study Skills Trained	1	Study skills component of intervention, including homework/school material organisation
	0	No study skills component
Behaviour Modification	1	Major behaviour modification part of intervention
	0.67	Rewards etc as part of intervention adherence
	0	No behaviour modification component
Self-regulation	1	The intervention has participants both monitor and control their behaviour
	0.67	The intervention only includes monitoring or control of behaviour (students aim to control behaviour in response to monitoring by staff/deliverer)
	0.33	Unclear if intervention involves self-regulation, but aims to improve this type of outcome. Or optional self-monitoring.
	0	The intervention does not involve any self-regulation
Personalised intervention	1	Intervention is delivered in different ways in response to the individual recipient
	0.67	Intervention can be tailored to individual needs
	0	No personalisation, everyone receives the same
Delivered in classroom	1	Delivered in regular classroom during class time
	0.67	Delivered in classroom, not a regular class
	0.33	Only part of school-based part of intervention in classroom
	0	Not delivered in classroom (or after school programme)
Delivered 1-1	1	Intervention deliverer and recipient meet 1-1
	0.67	Much of intervention 1-1
	0.33	Less than half 1-1
	0	None 1-1
Teacher delivers	1	Teacher delivers intervention

	0.67	Teacher delivers some of intervention, or "teacher or other staff member" delivers
	0	Teacher does not deliver
Relationships	1	At least some of intervention directly intends to improve recipient's relationship with school staff or peers
	0.67	It is clear that indirectly the intervention is going to strengthen relationships with school staff or peers
	0.33	As part of the intervention the recipient works with a member of school staff or peers, but there is no sign that relationships improve (or getting along with peers target on DRC)
	0	No relationships in school are likely to be improved by the intervention
Total hours	1	30+ hours
	0.67	10+ hours
	0.33	5+ hours
	0	< 5 hours

NPC = No parent consequences, PC = Parent consequences, TC = teacher consequences, HOPS = Homework, Organization, and Planning Skills, CHIEF = Completing Homework by Improving Efficiency and Focus