Published in final edited form as:

Atten Defic Hyperact Disord. 2015 September ; 7(3): 183–190. doi:10.1007/s12402-014-0162-x.

Metacognitive Executive Function Training for Young Children with ADHD – A Proof of Concept Study

Leanne Tamm, Ph.D. and

Associate Professor Cincinnati Children's Hospital Medical Center, 3333 Burnet Avenue, ML 10006, Cincinnati, OH 45229; 513-803-3176

Paul A. Nakonezny, Ph.D.

Associate Professor University of Texas Southwestern Medical Center, 5323 Harry Hines Blvd. Dallas TX 75390-8828; 214-648-5289; Statistician

Abstract

Executive functions (EF) are impaired in children with Attention-Deficit/Hyperactivity Disorder (ADHD). It may be especially critical for interventions to target EF in early childhood given the developmental progression of EF deficits that may contribute to later functional impairments. This proof-of-concept study examined the initial efficacy of an intervention program on EF and ADHD. We also examined child performance on 3 neurocognitive tasks assessing cognitive flexibility, auditory/visual attention, and sustained/selective attention. Children with ADHD (ages 3–7) and their parents were randomized to receive an intervention targeting metacognitive EF deficits (n=13) or to a waitlist control condition (n=12). Linear model analysis of covariance compared groups on parent EF ratings, blinded clinician ratings of ADHD symptoms and improvement, and child performance on neurocognitive measures. Children who received the intervention significantly improved on parent ratings of attention shifting and emotion regulation in addition to clinician ratings of inattention. Moderate effect sizes showed additional intervention effects on parent ratings of inhibition, memory, and planning, and clinician ratings of hyperactivity/impulsivity and overall improvement. Small effect sizes were observed for improvement on child neurocognitive measures. Although replication with a larger sample and an active control group is needed, EF training with a metacognitive focus is a potentially promising intervention for young children with ADHD.

Keywords

ADHD; Executive Functioning; Intervention; Metacognition; Training; Preschool

Correspondence to: Leanne Tamm, Ph.D., Cincinnati Children's Hospital Medical Center, 3333 Burnet Avenue, ML10006, Cincinnati, OH 45229, 513-803-3176, 513-636-0755 fax, leanne.tamm@cchmc.org.

Conflict of Interest & Source of Funding: Dr. Tamm reports no biomedical financial interests or potential conflicts of interest. She receives research grant funding from NIH/NIMH & NICHD.

Dr. Nakonezny reports no biomedical financial interests or potential conflicts of interest.

Introduction

Young children with Attention-Deficit/Hyperactivity Disorder (ADHD) have difficulties with self-regulation, attention, working memory, cognitive flexibility, behavioral inhibition, and ability to sustain attention (American Psychological Association 2013; Byrne et al. 1998; Hughes et al. 2000; Mariani and Barkley 1997). These executive functioning (EF) deficits independently contribute to poorer outcomes in ADHD (Wahlstedt et al. 2008; Willcutt et al. 2005), and have been linked directly to impairments in academic (Raggi and Chronis 2006) and social functioning (Diamantopoulou et al. 2007). Yet most interventions for ADHD do not target the putative dysfunctions underlying ADHD nor address socio-developmental processes that promote development in EF (Sonuga-Barke et al. 2006).

Recently, investigations have examined whether EF can be trained in young children using a play based approach (Diamond and Lee 2011). It is hypothesized that such EF training interventions promote neural and social development and recent neuroimaging (Rueda et al. 2005; Schulz et al. 2005; Shaw et al. 2006; Suskauer et al. 2008) and neuropsychological (Halperin et al. 2008; Healey et al. 2011) data demonstrate that directed play EF interventions improve neural functioning. Directed play involves the use of games and activities that are specifically selected and designed to target skills such as inhibitory control, working memory, and motor coordination which are known to be impaired in children with ADHD and linked to behavioral challenges (Frazier et al. 2004). Research with typically developing preschoolers suggests some efficacy for EF training. For example, Diamond and colleagues evaluated a school-based EF intervention, Tools of the Mind, and found that typically developing children in the EF intervention group performed better on inhibition and cognitive flexibility tasks in comparison to children in a literacy intervention group (Diamond et al. 2007). Similarly, computerized games targeting sustained attention improved EF in 4 to 6 year old typically developing preschoolers (Rueda et al. 2005). Thus, play-based interventions targeting EF may provide an avenue for benefits for young children with ADHD (Halperin et al. 2012).

Few studies have addressed whether EF training is useful for young children with ADHD, however. One study reported that children with ADHD randomized to daily computerized EF training for up to 3 years demonstrated improved EF and reduced incidence of ADHD, based on parent-completed rating scales, compared to a group who did not receive daily intervention (Papazian et al. 2009). Three more recent studies examined non-computerized play-based interventions designed to improve EF in young children diagnosed with ADHD (Halperin et al. 2012; Healey and Halperin 2014; Tamm et al. 2012). These interventions required parents to learn and administer play-based activities targeting EF (e.g., inhibitory control, working memory, planning, attention, etc.) with their young child with ADHD. Non computerized play-based interventions might be particularly efficacious since they involve the parent who arguably spends the most time with the child, particularly in early childhood. There is clearly a potential benefit for improving parent-child relationships as a result of parents engaging with their children in a positive and encouraging manner on a frequent basis doing fun activities, as well as developing a shared language about what it means to pay attention. Having the key adult figure (e.g., parent) implement an intervention within the home setting dramatically intensifies the dose of intervention. Moreover, the intervention is

integrated into the home context and includes enjoyable activities that parents can readily support, which likewise makes the intervention more likely to be sustained. Indeed, initial evidence from open trials using directed-play targeting EF demonstrated an impact on parent-reported attention and hyperactivity symptoms (Halperin et al. 2012; Healey and Halperin 2014; Tamm et al. 2012), parent EF ratings (Tamm et al. 2012), functional impairment (Halperin et al. 2012), and child performance on visual/auditory attention cognitive flexibility (Tamm et al. 2012), working memory (Healey and Halperin 2014; Tamm et al. 2012), and visuomotor precision tasks (Healey and Halperin 2014). However, the lack of randomization and absence of a control group in these studies leaves open the possibility of effects being due to development and maturation as opposed to intervention per se.

Thus, we conducted a small randomized trial in a sample of young children carefully diagnosed with ADHD using the EF training program utilized by Tamm and colleagues (Tamm et al. 2012). Specifically, this proof-of-concept study examined whether EF training using directed-play activities impacted functioning related to ADHD symptomatology and EF/neurocognitive performance. We hypothesized that we would see improvements in EF ratings as well as ADHD symptomatology for the group that received training compared to a waitlist control group.

Material and Methods

The study was approved by the University Institutional Review Board and informed parental consent and participant assent were obtained from all participants prior to initiating any procedures.

Participants

Children and their parents were recruited from outpatient clinics, the community, and a private school for learning differences. Participants ranged in age from 3 to 7 years ($M = 5.0$, $SD = 1.3$), were all in a structured educational setting, predominantly Caucasian, and, consistent with the general ADHD population (American Psychological Association 2013), predominantly male with most meeting diagnostic criteria for the Combined Type of ADHD. All had a Clinical Global Impression (CGI) (Leon et al. 1993) severity score >3 (i.e., moderately impaired or worse). Table 1 reports the demographic characteristics of the sample. Exclusion criteria included: estimated Full Scale IQ <85 , history of head injury or prenatal drug exposure, diagnosis with congenital or acquired neurological conditions, pervasive developmental disorders, unknown developmental and family history, and participation in other treatments for ADHD (e.g., medication, neurofeedback). Of the 32 children who participated in a baseline evaluation, 24 met eligibility criteria and were randomized to the intervention ($n=13$) or the control group ($n=11$). Randomization was blocked by gender and allocations were determined by generating random number lists by computer.

Measures

Behavior Rating Inventory of Executive Function (BRIEF) (Gioia et al. 2000)—

Parents completed the age-appropriate version of this rating scale assessing executive function behaviors in the home and school environments, yielding *T*-scores on several subscales, including Inhibit, Shift, Working Memory, Emotion Regulation, and Planning, in addition to a General Executive Composite. Studies investigating psychometric properties report good convergent and discriminant validity between the BRIEF and other behavioral rating systems, test-retest reliability ranging from .79 to .88, and internal consistency ranging from .80 to .98 (Gioia et al. 2000).

Clinical Global Impressions (CGI) (Leon et al. 1993)—

Clinicians rated the severity of the child's impairment on an 7-point scale ranging from Not At All Ill to Very Severely Ill at baseline, and the level of improvement from baseline at outcome on an 7-point scale ranging from Very Much Worse to Very Much Improved. The scale has adequate reliability and validity (Leon et al. 1993).

Kiddie Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (K-SADS-PL) (Kaufman et al. 1997)—

The K-SADS-PL is a semi-structured diagnostic interview that has been used in a number of clinical and epidemiological studies of child psychiatric disorders. This measure consists of 82 screening items, and 5 diagnostic supplements, and is capable of generating 32 *DSM-IV* diagnoses. Reliability and validity for this measure are good to excellent (Kaufman et al. 1997).

Swanson, Nolan, and Pelham (SNAP-IV) DSM-IV ADHD Rating Scale (Swanson 1992)—

Clinicians rated how well each ADHD symptom described the child on a four-point Likert scale (0=Not at all, 1=Just a little, 2=Quite a bit, 3=Very much). The SNAP-IV measure shows adequate internal consistency (.94) and test-retest reliability (Bussing et al. 2008; Gau et al. 2008).

Wechsler Intelligence Scales (Wechsler 2002; Wechsler 2003)—

For children aged 6 years and older, IQ was estimated at baseline using established procedures for estimating IQ from 2 subtests (Sattler 2008) from the Block Design and Vocabulary subtests of the Wechsler Intelligence Scale for Children, 4th Edition (WISC). Children were also administered the Matrix Reasoning subtest of the WISC. For children younger than 6 years of age, the full version of the Wechsler Preschool Primary Scales of Intelligence (WPPSI) was used to assess IQ. The preschool and child versions of the Matrix Reasoning subtest have good internal consistency (.90 and .89 respectively), and are rated as having ample specificity at all age groups (Sattler 2008).

NEPSY-Visual Attention (Korkman et al. 1998)—

The Visual Attention subtest was included as a measure of selective and sustained attention and involves inhibition, vigilance, scanning, and impulse control. Reliabilities for this measure at ages 3 through 7 ranged from .68 to .76 (Korkman et al. 1998).

Clinical Evaluation of Language Fundamentals, Fourth Edition – Concepts and Following Directions (Semel et al. 2003)—The Concepts and Following Directions subtest was included as a measure of auditory and visual attention. Across ages, internal consistency ranged from .78 to .85 with an average of .82 (Semel et al. 2003).

Design and Procedure

Families meeting eligibility criteria by phone screen participated in a baseline evaluation which included the K-SADS-PL semi-structured interview and informal interview/behavioral observations with the child. With regards to the child informal interview, clinicians met with the child, asked questions about their home and preschool experiences (e.g., asking questions about if the child gets into trouble and why?, what sorts of things the child did and did not like to do, etc.), allowed them to select items to play with while conversing, observed the child's activity and attention level during this interaction, as well as how they separated and interacted with their parent in the waiting room, etc. The child was also administered the neurocognitive measures at this visit, and the child assessor shared behavioral observations such as how the child responded to frustration, attended to instructions, etc., with the clinician. Clinicians completed the SNAP-IV rating scale based on information obtained during the interviews with parent and child, as well as information provided by the child assessor, and provided CGI ratings, more heavily weighting information provided by the parent than the child interview/observations. In addition to the K-SADS-PL interview and clinical ratings, parents provided ratings of EF on the age-appropriate BRIEF (Gioia et al. 2000) at baseline and post-test.

Following the baseline evaluation and determination of inclusion/exclusion criteria, participants were randomly assigned to receive the EF intervention (n=13) or to a waitlist control (n=12) group. Participants assigned to the intervention (see below) attended 8 weekly sessions and completed interim homework assignments. Participants assigned to the wait list control group were asked to refrain from initiating any psychosocial or medical treatments for ADHD during the intervention period, and were offered the opportunity to receive the intervention following the post-test evaluation (i.e., ~3 months from baseline). Participants and their parents completed post-test measures approximately 12 weeks after baseline. At post-test, clinician's re-interviewed parents using the K-SADS-PL and met with the child separately to gather behavioral observations and informal interview data (as described for the baseline evaluation) to inform their SNAP and CGI Improvement ratings at the post-test evaluation. Of note, every attempt was made to keep clinicians blinded at post and families were advised not to reveal to the clinician whether they had attended the intervention or waited to receive the intervention.

Intervention (Treatment)—As described by Tamm and colleagues (Tamm et al. 2012), the intervention involved 8 weekly 60-minute sessions (with the exception of the first session which lasted 2 hours). Parents and children participated in separate groups offered concurrently.

Children met in small groups (4 to 6 children per group) with 2 interventionists (trained doctoral students and advanced research assistants) to expose them to the activities (4 new

activities per week). Training of the interventionists included a thorough overview of the manualized intervention, live observation, and debriefing and problem solving immediately following the intervention sessions. To aid in intervention implementation, children were grouped with children of similar ages (e.g., 3- and 4-year-olds together and 6- and 7-year-olds together) whenever possible. The program began by establishing a common framework of understanding by asking the children what they believe it means to pay attention, and then discussing what they already do to help them pay attention in other settings. Next, children participated in several activities designed to practice as many different aspects of EF and related skills as possible, e.g., (Diamond and Lee 2011; O'Neill et al. 2012), including attention, inhibition, memory, hand-eye coordination, balance, sensory awareness, listening skills, visual focusing. For example, to improve working memory, children played memory card games with increasing number of pairs of memory cards. To improve attention to detail, children did Highlight© search activities, again with increasing difficulty levels as they achieved mastery. The activities stand alone as enjoyable learning experiences, but are also crucial for bridging the metacognitive strategies emphasized across all activities in the program, thus nurturing generalization of the attention skills. Principles of behavior modification (e.g., preventing behavior before it occurs, setting up the environment, reinforcement for following group rules, ignoring, and timeout) were also implemented.

While children were participating in the small groups, parents met in a large group with a psychologist who explained and modeled the desired actions, such as how to implement the activities at home with an emphasis on well-timed attention, inhibition, and memory skill building, and how to use specific and labeled praise. To promote generalization, parents were asked to implement the metacognitive strategies prior to each activity, to brainstorm different activities that activate desired EF skills, and to identify different situations in which these skills are necessary. Parents also viewed a short videotaped segment of their child's group from a previous week as a demonstration of how to implement the activities. Between sessions, parents were asked to practice at least one of the activities with their child 3 times. Parents were explicitly instructed to try to practice at least one of the weekly activities in order to make the homework assignment realistic and feasible for parents to complete. Weekly phone calls were made by the child interventionists to coach parents and promote adherence.

Statistical Analysis

Data analyses were conducted on a final sample of 19 (i.e., 10 in the intervention group and 9 in the waitlist control group) due to attrition or to families not attending the outcome evaluation. Reasons for attrition in the intervention group varied. One family opted to pursue medication after attending one session. Two other families attended four sessions, with one opting to discontinue the intervention after four sessions, and the other not attending their scheduled outcome evaluation. One family assigned to the waitlist control group did not attend their scheduled outcome evaluation. Table 1 describes the demographic characteristics of the final sample included in the analyses. It should be noted that the individuals who did not complete an outcome evaluation did not significantly differ from the group retained for analysis on age, gender, grade, IQ, or baseline ADHD severity.

Independent sample *t*-tests (for continuous variables) and chi-square tests (for categorical variables) were used to compare the two groups (intervention vs. waitlist) on the various demographic and baseline clinical characteristics. Analysis of covariance (ANCOVA) was used to examine treatment group differences (intervention vs. waitlist control) on the BRIEF, SNAP-IV, CGI, and child neurocognitive measures at post-test, while controlling for baseline scores and child age linked to expected changes in development and maturation such as age-related changes in EF (e.g., (Pauli-Pott and Becker 2011)).

All analyses were carried out using SAS software, version 9.2 (SAS Institute, Inc., Cary, North Carolina, USA). The level of significance for all tests was set at $\alpha = .05$ (two-tailed). Because of the exploratory nature of the study, *p*-values were not corrected for multiple tests. We also include Hedge's *g* (Hedges 1981) effect sizes for the between-subjects intervention effect to aid with interpretation of results given the small sample size. We considered effect sizes ranging from .20 to .49 as small, .50 to .79 as moderate, and $>.8$ as large (Cohen 1998).

Results

As shown in Table 1, children in the intervention or waitlist condition did not differ in their demographic characteristics, indicating that randomization worked as intended. Specifically, no group differences were observed for age, gender, ethnicity/race, ADHD subtype, comorbidities, grade, IQ, or ADHD severity at baseline. Attendance was good with individuals assigned to the intervention attending an average of 6.8 ($SD = 1.3$) sessions, and retention was adequate (79% of participants completed post-test evaluation). It should also be noted that parents were compliant with the request that they practice the activities at home between sessions, and every family reported practicing at least 1 activity between sessions.

The ANCOVA analyses revealed significant group differences at post-test on the parent-rated BRIEF Emotion Regulation and Shift subscales and clinician ratings of inattention (Table 2), which were lower at post-test for the intervention group than the waitlist control group. Examination of effect sizes revealed a large effect at posttest on parent-rated BRIEF Inhibit, Shift, Working Memory, and General Executive Composite subscales and medium effect for BRIEF Planning and clinician ratings of hyperactivity/impulsivity suggesting better performance for the intervention group than waitlist controls (Table 2). Results for the CGI Improvement ratings at outcome were not significant, however, at post 6 children in the intervention group were rated as at least minimally improved (i.e., very much improved $n=1$, much improved $n=4$, minimally improved $n=1$, no change $n=2$), while only 2 children in the waitlist control group were rated as at least minimally improved (i.e., minimally improved $n=1$, no change $n=4$, minimally worse $n=2$). Effect sizes were small for normed child EF measures, but children who received the intervention improved more than controls (Table 2).

Discussion

The current study investigated the initial efficacy of an intervention program designed to train EF in young children at risk for ADHD. Retention was adequate and families randomized to the intervention attended more than 75% of the scheduled sessions and reported practicing the activities at home between sessions 100% of the time. This suggests the intervention was palatable to parents, which is important since the intervention was largely designed to be administered by parents. Significant effects were observed for parent BRIEF Shift and Emotion Regulation ratings, and blinded clinician inattention ratings. We also observed moderate to large effect sizes for the intervention group compared to the waitlist group on the BRIEF Inhibit, Working Memory, and Planning subscale ratings, clinician hyperactivity/impulsivity ratings, and the CGI improvement measures. Results were not significant for the child EF performance measures although the intervention group did have greater gains on the normed EF measures than the waitlist control group. Thus, we have preliminary evidence that EF training with a metacognitive focus may be a promising intervention for young children with ADHD.

Our significant findings for the parent rated BRIEF Shift and Emotion Regulation scales are highly relevant for ADHD. The Shift scale assesses the ability to move freely from one situation, activity, or aspect of a problem to another as the circumstances demand. Key aspects of shifting include the ability to make transitions, tolerate change, problem-solve flexibly, and alternate attention. The Emotional Control scale measures the impact of EF difficulties on emotional expression and assesses a child's ability to modulate or control his emotional responses. Clearly these are domains we would anticipate as problematic for young children with ADHD, and it is encouraging that the Shift and Emotion Regulation scores were in the normal range ($T < 60$) following the intervention. In addition to these EF effects, significant improvements were also observed for clinician inattention ratings, thus demonstrating the potential of the intervention to also impact ADHD symptoms. It should be noted that we did not specifically select a sample with EF deficits at baseline; future studies selecting samples with low EF are warranted, particularly given findings that children with the poorest EF typically gain the most from programs targeting EF (Diamond and Lee 2011).

Our findings are consistent with a previous open trial that tested the same intervention in an open trial (Tamm et al. 2012). As in the present study, reductions on parent BRIEF ratings and clinician ratings of inattention were also observed, as well as improvements in visual attention, matrix reasoning, and concepts and following directions. One new finding emerging in this trial was a significant and strong intervention effect on emotion regulation which was not observed in the open trial. It may be that children in the current study presented with more emotion regulation difficulties than those in the open trial and therefore were more likely to benefit from the intervention. A review of means is consistent with this hypothesis. Specifically, baseline means for Emotion Regulation in the open trial were 58.3 (Tamm et al. 2012) and in the current study 64 for the intervention group and 63.8 for the waitlist control group. Our findings are also consistent with an open trial conducted on a very similar intervention which reported effects of the EF intervention on parent ratings of inattention (Halperin et al. 2012) and attention problems (Healey and Halperin 2014).

Importantly, the Halperin et al. (Halperin et al. 2012) study included a longer follow-up period and showed that gains were maintained for 3 months post-treatment, though improvements on impairment ratings were observed at the follow up visits but not at the immediate post-test. Given that parents in that study continued to engage in the activities after the active intervention period, the benefits from this type of intervention may be durable and some benefits may not be apparent until well after the initial intervention delivery. Unfortunately, we were not able to investigate what gains were maintained or emerged after the current training as we did not conduct a follow-up assessment.

It is encouraging that we observed changes on the BRIEF which focuses on everyday behaviors associated with EF. The BRIEF is thought to provide a picture of idiographic cognitive functioning of an individual (McCandless and O' Laughlin 2007), which differs notably from laboratory-based tasks of EF that may lack real-world ecological validity (Barkley and Fischer 2011; Toplak et al. 2013). Further, the BRIEF has been shown to measure unique constructs related to ADHD-like behaviors (Jarratt et al. 2005; Mahone et al. 2002), to correlate with child performance on a continuous performance task (i.e., has ecological validity) (McCandless and O' Laughlin 2007), and to predict later diagnosis with ADHD (Gioia et al. 2000; McCandless and O' Laughlin 2007). Thus, improvements on this measure are meaningful and relevant for the child's overall functioning.

Limitations

One of the most important limitations of our study was the small sample size. An active control group is necessary to rule out the potential concomitant effects of parental attention and practice and expectancy effects. It has been reported that simply informing parents that they will receive an intervention may lead to reductions in parent ratings of problem behaviors (Patterson and Forgatch 1995). Thus additional research with an active control group is critical. Additionally, although the clinicians were blind to treatment condition and families were requested not to reveal their group assignment, it is possible that the blind was broken accidentally potentially affecting the clinicians' ratings. We did not include teacher ratings or measures of school readiness or other domains of functional impairment in ADHD (e.g., social skills) which would be critical secondary effects of the intervention. We also did not have measures of brain functioning to assess the mechanism of action – it may be that an improved parent child relationship is the primary effect of the intervention. For example, it has been shown that parents just spending time with their child can impact behavior (Gardner et al. 2003). Relatedly, we could not examine whether frequency of intervention in the home setting by parents correlated with outcomes as this data was not collected quantitatively. There is also the possibility that the individuals who completed the intervention and outcome evaluation differed in some way from those who started the intervention but did not complete the intervention potentially affecting the generalizability of this study's results.

Conclusion

The results of this trial and of previous studies using similar interventions (Halperin et al. 2012; Healey and Halperin 2014; Tamm et al. 2012) suggest the potential of early developmentally appropriate interventions targeting EF to improve aspects of everyday

functioning and ADHD symptomatology. Specifically, it appears that a program utilizing play-based activities targeting aspects of EF, when administered in a structured way by parents, is a promising approach for improving cognition and inattention in young children with ADHD. A larger randomized trial is warranted to assess the feasibility of a design in which the active intervention is compared to a placebo condition that will serve as an attention control. Longer term follow ups will be important with an emphasis on investigating functional outcomes including diagnosis, impairment, and school readiness.

Acknowledgments

We gratefully thank the interventionists, Peter Stavinoha, Jarrette Moore, Laure Ames, Tabatha Melton, Amanda Gray, Aleksandra Foxwell, Jeanne Rintelmann, Jessica Castrejana, Stephanie Weatherford, Gina Bolanos, and Amanda Moates, and data manager, Conrad Barnes. We thank Scott Klein and Helen Neville for their permission to utilize and modify the EF training program described in this study, and Joyce Pickering for providing space in which to administer the intervention.

This study was a collaborative effort of the Center for Advanced ADHD Research, Treatment, and Education (CAARTE). We are grateful to the Sparrow Foundation for funding this research and the CAARTE collaboration.

References

- American Psychological Association. Diagnostic and statistical manual of mental disorders. 5. Author; Washington, D.C.: 2013.
- Barkley RA, Fischer M. Predicting impairment in major life activities and occupational functioning in hyperactive children as adults: self-reported executive function (EF) deficits versus EF tests. *Dev Neuropsychol*. 2011; 36:137–161.10.1080/87565641.2010.549877 [PubMed: 21347918]
- Bussing R, Fernandez M, Harwood M, Wei H, Garvan CW, Eyberg SM, Swanson JM. Parent and teacher SNAP-IV ratings of attention deficit hyperactivity disorder symptoms: psychometric properties and normative ratings from a school district sample. *Assessment*. 2008; 15:317–328.10.1177/1073191107313888 [PubMed: 18310593]
- Byrne JM, DeWolfe NA, Bawden HN. Assessment of attention-deficit hyperactivity disorder in preschoolers. *Child Neuropsychol*. 1998; 4:49–66.
- Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*. Second. Lawrence Erlbaum Associates; Hillsdale: 1998.
- Diamantopoulou S, Rydell AM, Thorell LB, Bohlin G. Impact of executive functioning and symptoms of attention deficit hyperactivity disorder on children's peer relations and school performance. *Dev Neuropsychol*. 2007; 32:521–542. [PubMed: 17650992]
- Diamond A, Barnett WS, Thomas J, Munro S. Preschool program improves cognitive control. *Science*. 2007; 318:1387–1388.10.1126/science.1151148 [PubMed: 18048670]
- Diamond A, Lee K. Interventions shown to aid executive function development in children 4 to 12 years old. *Science*. 2011; 333:959–964.10.1126/science.1204529 [PubMed: 21852486]
- Frazier TW, Demaree HA, Youngstrom EA. Meta-analysis of intellectual and neuropsychological test performance in attention-deficit/hyperactivity disorder. *Neuropsychology*. 2004; 18:543–555.10.1037/0894-4105.18.3.543 [PubMed: 15291732]
- Gardner F, Ward S, Burton J, Wilson C. The role of mother–child joint play in the early development of children's conduct problems: A longitudinal observational study. *Social Development and Psychopathology*. 2003; 12:361–378.10.1111/1467-9507.t01-1-00238
- Gau SS, Shang CY, Liu SK, Lin CH, Swanson JM, Liu YC, Tu CL. Psychometric properties of the Chinese version of the Swanson, Nolan, and Pelham, version IV scale – parent form. *Int J Methods Psychiatr Res*. 2008; 17:35–44.10.1002/mpr.237 [PubMed: 18286459]
- Gioia, GA.; Isquith, PK.; Guy, SC.; Kenworthy, L. *Behavior Rating Inventory of Executive Function Professional Manual*. Psychological Assessment Resources, Inc; Lutz: 2000.

- Halperin JM, Marks DJ, Bedard AC, Chacko A, Curchack JT, Yoon CA, Healey DM. Training executive, attention, and motor skills: A proof-of-concept study in preschool children with ADHD. *J Atten Disord*. 2012;10.1177/1087054711435681
- Halperin JM, Trampush JW, Miller CJ, Marks DJ, Newcorn JH. Neuropsychological outcome in adolescents/young adults with childhood ADHD: profiles of persisters, remitters and controls. *J Child Psychol Psychiatry*. 2008; 49:958–966.10.1111/j.1469-7610.2008.01926.x [PubMed: 18573145]
- Healey DM, Halperin JM. Enhancing Neurobehavioral Gains with the Aid of Games and Exercise (ENGAGE): Initial open trial of a novel early intervention fostering the development of preschoolers' self-regulation. *Child Neuropsychol*. 2014;1–16.10.1080/09297049.2014.906567
- Healey DM, Marks DJ, Halperin JM. Examining the interplay among negative emotionality, cognitive functioning, and Attention Deficit/Hyperactivity Disorder symptom severity. *J Int Neuropsychol Soc*. 2011;1–9.10.1017/S1355617711000294
- Hedges LV. Distribution theory for Glass' estimator of effect size and related estimators. *Journal of Educational Statistics*. 1981; 6:107–128.10.3102/10769986006002107
- Hughes C, White A, Sharpen J, Dunn J. Antisocial, angry, and unsympathetic: "Hard to manage" preschooler's peer problems and possible cognitive influences. *J Child Psychol Psychiatry*. 2000; 41:169–179. [PubMed: 10750543]
- Jarratt KP, Riccio CA, Siekierski BM. Assessment of attention deficit hyperactivity disorder (ADHD) using the BASC and BRIEF. *Appl Neuropsychol*. 2005; 12:83–93.10.1207/s15324826an1202_4 [PubMed: 16083397]
- Kaufman J, Birmaher B, Brent D, Rao U, Flynn C, Moreci P. Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): Initial reliability and validity data. *J Am Acad Child Adolesc Psychiatry*. 1997; 36:980–987. [PubMed: 9204677]
- Korkman, M.; Kirk, U.; Kemp, S. NEPSY: A Developmental Neuropsychological Assessment: Manual. Harcourt Assessment Inc.; San Antonio: 1998.
- Leon AC, Shear MK, Klerman GL, et al. A comparison of symptom determinants of patient and clinician global ratings in patients with panic disorder and depression. *J Clin Psychopharmacol*. 1993; 13:327–331. [PubMed: 8227491]
- Mahone EM, et al. Validity of the behavior rating inventory of executive function in children with ADHD and/or Tourette syndrome. *Arch Clin Neuropsychol*. 2002; 17:643–662. [PubMed: 14591848]
- Mariani MA, Barkley RA. Neuropsychological and academic functioning in preschool boys with attention deficit hyperactivity disorder. *Dev Neuropsychol*. 1997; 13:111–129.
- McCandless S, O' Laughlin L. The Clinical Utility of the Behavior Rating Inventory of Executive Function (BRIEF) in the diagnosis of ADHD. *J Atten Disord*. 2007; 10:381–389.10.1177/1087054706292115 [PubMed: 17449837]
- O'Neill S, Rajendran K, Halperin JM. More than child's play: the potential benefits of play-based interventions for young children with ADHD. *Expert Rev Neurother*. 2012; 12:1165–1167.10.1586/ern.12.106 [PubMed: 23082729]
- Papazian O, Alfonso I, Luzondo RJ, Araguez N. Training of executive function in preschool children with combined attention deficit hyperactivity disorder: a prospective, controlled and randomized trial. *Rev Neurol*. 2009; 48(Suppl 2):S119–122. doi:rn2009053 [pii]. [PubMed: 19280566]
- Patterson GR, Forgatch MS. Predicting future clinical adjustment from treatment outcome and process variables. *Psychological Assessment*. 1995; 7:275–285.10.1037/1040-3590.7.3.275
- Pauli-Pott U, Becker K. Neuropsychological basic deficits in preschoolers at risk for ADHD: a meta-analysis. *Clin Psychol Rev*. 2011; 31:626–637.10.1016/j.cpr.2011.02.005 [PubMed: 21482321]
- Raggi VL, Chronis AM. Interventions to address the academic impairment of children and adolescents with ADHD. *Clin Child Fam Psychol Rev*. 2006; 9:85–111. [PubMed: 16972189]
- Rueda MR, Rothbart MK, McCandliss BD, Saccomanno L, Posner MI. Training, maturation, and genetic influences on the development of executive attention. *Proc Natl Acad Sci U S A*. 2005; 102:14931–14936. [PubMed: 16192352]
- Sattler, J. *Assessment of Children: Cognitive Foundations*. 5. Jerome M. Sattler, Publisher, Inc; San Diego: 2008.

- Schulz KP, Newcorn JH, Fan J, Tang CY, Halperin JM. Brain activation gradients in ventrolateral prefrontal cortex related to persistence of ADHD in adolescent boys. *J Am Acad Child Adolesc Psychiatry*. 2005; 44:47–54.10.1097/01.chi.0000145551.26813.f9 [PubMed: 15608543]
- Semel, E.; Wiig, EH.; Secord, WA. Examiner's Manual. 4. Harcourt Assessment Inc.; San Antonio: 2003. CELF-4: Clinical Evaluation of Language Fundamentals.
- Shaw P, et al. Longitudinal mapping of cortical thickness and clinical outcome in children and adolescents with attention-deficit/hyperactivity disorder. *Arch Gen Psychiatry*. 2006; 63:540–549.10.1001/archpsyc.63.5.540 [PubMed: 16651511]
- Sonuga-Barke EJ, Thompson M, Abikoff H, Klein R, Brotman LM. Nonpharmacological interventions for preschoolers with ADHD: The case for specialized parent training. *Infant Young Child*. 2006; 19:142–153.
- Suskauer SJ, Simmonds DJ, Caffo BS, Denckla MB, Pekar JJ, Mostofsky SH. fMRI of intrasubject variability in ADHD: anomalous premotor activity with prefrontal compensation. *J Am Acad Child Adolesc Psychiatry*. 2008; 47:1141–1150.10.1097/CHI.0b013e3181825b1f [PubMed: 18724253]
- Swanson, JM. School based assessments and interventions for ADHD students. KC Publishing; Irvine, CA: 1992.
- Tamm L, Nakonezny PA, Hughes CW. An open trial of a metacognitive executive function training for young children with ADHD. *J Atten Disord*. 2012;10.1177/1087054712445782
- Toplak ME, West RF, Stanovich KE. Practitioner review: do performance-based measures and ratings of executive function assess the same construct? *J Child Psychol Psychiatry*. 2013; 54:131–143 d. oi:10.1111/jcpp.12001. [PubMed: 23057693]
- Wahlstedt C, Thorell LB, Bohlin G. ADHD symptoms and executive function impairment: early predictors of later behavioral problems. *Dev Neuropsychol*. 2008; 33:160–178. [PubMed: 18443975]
- Wechsler, D. Administration Manual. Third. Harcourt Assessment Inc.; San Antonio: 2002. Wechsler Preschool and Primary Scale of Intelligence.
- Wechsler, D. The Wechsler Intelligence Scale for Children. Fourth Edition. Psychological Corporation; New York: 2003.
- Willcutt EG, Doyle AE, Nigg JT, Faraone SV, Pennington BF. Validity of the executive function theory of attention-deficit/hyperactivity disorder: a meta-analytic review. *Biol Psychiatry*. 2005; 57:1336–1346. [PubMed: 15950006]

Table 1

Demographics

		Intervention n=10	Waitlist n=9	Statistical Comparison
Mean age (SD)		4.9 (1.1) years	5.2 (1.4) years	t (17) = .56
% Male		n=8	n=6	χ^2 (1) = .43
Ethnicity	Caucasian	n=9	n=6	χ^2 (2) = 2.55
	Hispanic	n=0	n=2	
	Biracial	n=1	n=1	
ADHD Subtype	Combined	n=8	n=7	χ^2 (2) = 1.4
	Inattentive	n=2	n=1	
	Not Otherwise Specified	n=0	n=1	
Comorbid Diagnosis	ODD	n=1	n=3	n/a
	Enuresis	n=1	n=1	
	Anxiety Disorder	n=1	n=0	
Grade	Preschool	n=1	n=1	χ^2 (5) = 2.4
	Pre-K	n=5	n=4	
	Kindergarten	n=3	n=1	
	1 st	n=1	n=2	
	2 nd	n=0	n=1	
Estimated Full Scale IQ ^a (SD)		104.8 (9.7)	98.8 (12.3)	t (16) = 1.1
Clinician SNAP ADHD baseline rating (SD)		2.3 (0.4)	2.2 (0.4)	t (17) = 0.5

Note: SD = standard deviation; NOS = not otherwise specified; ODD = oppositional defiant disorder; IQ = intelligence quotient; n/a = not applicable

^aIQ data missing for one child in the intervention group.

Table 2

Executive Functioning and Behavior Ratings

	EFI	EFI	Waitlist	Waitlist	ANOVA		Effect size Hedges g
	M (SD) Baseline	M (SD) Post-test	M (SD) Baseline	M (SD) Post-test	(post-test, controlling for age and baseline performance)		
<i>BRIEF T-Scores</i>							
Inhibit	74.0 (11.5)	69.1 (11.2)	75.1 (11.6)	73.6 (11.7)	F (3,14) = 3.53		.85 ^L
Shift	57.8 (9.9)	55.7 (12.3)	56.6 (8.0)	59.3 (9.2)	F (3,14) = 4.96*		1.01 ^L
Emotion Regulation	64.0 (17.5)	58.1 (20.3)	63.8 (12.8)	65.0 (20.0)	F (3,14) = 4.65*		.97 ^L
Working Memory	77.2 (7.2)	71.2 (10.7)	78.3 (7.8)	78.3 (8.9)	F (3,14) = 2.88		.76 ^M
Planning	70.9 (7.9)	64.4 (10.9)	71.3 (9.2)	69.9 (8.0)	F (3,14) = 1.90		.62 ^M
General Executive Composite	74.3 (10.0)	67.7 (12.8)	75.5 (7.9)	74.1 (11.2)	F (3,14) = 2.65		.74 ^M
<i>SNAP-IV ratings</i>							
Inattention	2.3 (0.5)	2.0 (0.4)	2.3 (0.3)	2.4 (0.4)	F (3,15) = 6.26*		1.10 ^L
Hyperactivity/Impulsivity	2.3 (0.5)	1.9 (0.5)	2.2 (0.7)	2.2 (0.7)	F (3,15) = 2.03		.61 ^M
CGI Improvement rating	n/a	2.8 (1.1)	n/a	3.6 (1.5)	F (2,17) = 1.44		.53 ^M
<i>Neurocognitive Measures</i>							
Concept. Foll. Dir.	9.7 (3.1)	10.0 (2.6)	9.1 (2.9)	8.9 (2.5)	F (3,14) = 0.44		.30 ^S
Matrix Reasoning	12.6 (2.2)	13.0 (3.2)	11.2 (1.6)	11.3 (2.1)	F (3,14) = 0.39		.29 ^S
Visual Attention	9.2 (1.1)	10.7 (1.9)	11.3 (2.7)	11.3 (2.7)	F (3,12) = 0.62		.38 ^S

*
=p<.05

EFI = Executive Functioning Intervention; M = mean; SD = standard deviation; BRIEF = Behavior Rating Inventory of Executive Function; SNAP-IV = Swanson Nolan and Pelham ADHD Rating Scale; CGI = Clinical Global Impressions; Concept. Foll. Dir. = Concepts and Following Directions

^S = small effect size (.20 to .49)

$M =$ medium effect size (.50 to .79)
 $L =$ large effect size (>.8)

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript