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RESEARCH PAPER

thinkSMART®: A pilot study of a transdiagnostic cognitive-behavioral treatment for adolescents with executive functioning weaknesses

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Abstract Executive functions are a broad term used to describe the cognitive functions necessary to help individuals complete tasks and achieve goals. Executive functioning weaknesses are a hallmark feature of psychopathology, particularly in youth. These weaknesses are associated with chronic impairment across academic, social and family domains and do not typically improve into adulthood. Despite these negative outcomes, few behavioral interventions have been successfully developed to target executive functioning outside of ADHD, particularly in adolescents with various types of psychopathology. The thinkSMART® program was created to target the broad heterogeneity of adolescents with executive function weakness. We discuss the rationale for the development of the program, as well as outline the primary skill areas addressed. We also present an open-trial pilot study using the program in adolescents ages 12—17 who identify as having executive functioning weaknesses. Preliminary findings highlight the acceptability and feasibility of the program, as well as the initial efficacy in improving adolescents' day-to-day executive functioning. We discuss the limitations and benefits of providing broad skills and compensatory strategies to improve adolescent executive functioning.

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Introduction

Executive functions (EF) are the complex, underlying processes driving the behaviors needed to accomplish and maintain goal-directed activities. They are controlled by circuits within the prefrontal cortex and continue to develop into early adulthood (Diamond, 2012; Diamond & Lee, 2011). Traditionally, EF is defined by three specific cognitive processes — working memory, cognitive flexibility, and inhibitory control — however, the term has expanded to include more processes that enable goal-direction action (Hughes, Graham, & Grayson, 2004). Broadly, EF can include processes involved with planning, problem solving, inhibition, organization, cognitive flexibility, fluency, time awareness/management, emotional control, working memory, and task initiation/completion. EFs develop throughout childhood and adolescence (Anderson, 2002; Zelazo & Carlson, 2012), and are critical for successful management of behavior, emotion, social relationships (Mischel, Shoda, & Rodriguez, 1989; Shoda, Mischel, & Peake, 1990). Moreover, early individual differences in EF are persistent across the life course, and also predict academic, occupational, and physical health outcomes in adulthood (Ayduk et al., 2000; Davis, Marra, Najafzadeh, & Liu-Ambrose, 2010; De Panfilis, Meehan, Cain, & Clarkin, 2013; Duncan et al., 2007; Foxall, 2014; Moffitt et al., 2011), underscoring the importance of targeted remediation of executive function deficits.

Executive dysfunction, or weakness in one or more EF domains, has been observed across both clinical and neurotypical populations (Vaidya et al., 2020). The presence of EF deficits in psychiatric populations specifically is well-documented, emerging as an associated feature of nearly all mental health problems (e.g., depression, anxiety, autism, addiction, schizophrenia) (Buckholtz & Meyer-Lindenberg, 2012), particularly ADHD (Bloemen et al., 2018; Millan et al., 2012; Snyder & Munakata, 2013; Barkley, 2001; Barkley & Fischer, 2011). Among youth with ADHD, executive dysfunction persists into adulthood, despite many individuals no longer meeting diagnostic criteria for ADHD as adults (Biederman, Petty, Evans, Small, & Faraone, 2010; Fischer, Barkley, Fletcher, & Smallish, 1993; Sibley, Pelham et al., 2012; Sibley, Swanson et al., 2017). In all populations, EFs are further vulnerable to transient stressors such as sadness, stress, loneliness, lack of exercise and poor sleep (Baler & Volkow, 2006; Diamond & Lee, 2011). Despite the demonstrable need for evidence-based executive function intervention for individuals with executive dysfunction, transdiagnostic interventions that aim to support executive function development do not exist.

Existing interventions that target executive function

Interventions targeting EF weaknesses span multiple delivery approaches, including pharmacology, neuromodulation, cognitive training, and behavioral (Caye, Swanson, Coghill, & Rohde, 2019; Diamond & Ling, 2016; Loo et al., 2021), and the vast majority of these interventions have focused solely on remediation of EF in individuals with ADHD. Outcome measures also vary across EF intervention efficacy studies, and often employ solely neurocognitive assessment of EF (performance-based measures) that are only marginally related to real-world EF (behavioral rating measures), and are less predictive of functional impairment (Barkley & Murphy, 2010; Biederman et al., 2008; Tan, Delgaty, Steward, & Bunner, 2018; Toplak, Bucciarelli, Jain, & Tannock, 2008). Indeed, few studies of EF intervention efficacy have successfully demonstrated significant improvement in real-world EFs, despite improvements across performance-based neurocognitive measures (Hosenbocus & Chahal, 2012).

For individuals with ADHD, medication is the first-line treatment recommendation to target the inattention, hyperactivity, and impulsivity symptoms that characterize the disorder (AACAP). However, the functional impairment in occupational, academic, and social domains observed among individuals with ADHD is also partially explained by EF deficits. Studies have successfully demonstrated improvement in some neurocognitive measures with medication, but few studies have shown efficacy in targeting real-world EFs that are more critical to academic, occupational, and psychosocial outcomes (Hosenbocus & Chahal, 2012).

Non-medication-based interventions designed to improve EFs in youth have also fallen short, often failing to sufficiently address the multiple components of EF needed for daily functioning. Specifically, computer-based learning programs generally focus on a single domain, often demonstrate a narrow transfer of skills, and show only minimal effects on clinical symptoms (Caye et al., 2019; Cortese et al., 2015). More recently, video game-based physical exercise in youth ages 8 to 12 with ADHD showed improvements across cognitive inhibition and switching performance-based tasks, as well as in overall psychopathology. However, changes in real-world EF was not examined, therefore tempering the conclusions made about the impact of the intervention on daily functioning (Benzing & Schmidt, 2019). Further, findings from a study examining the efficacy of a recently developed game-based computerized executive function training program for 8 to 12-year-olds suggested that real-world EF gains across placebo and active treatment conditions may be better explained by non-specific intervention components (e.g., use of an external standardized reward system, gamification of intervention delivery) than by active intervention components (Dovis, Maric, Prins, & Van der Oord, 2019).

Behavioral interventions that target multiple domains of EF can optimize effects on overall psychosocial and academic functioning (Cortese et al., 2015). Indeed, behavioral interventions have demonstrated the most success in improving real-world EFs associated with organization, time management, and planning in both children and adults and have shown the most robust generalizability across EF domains (Abikoff et al., 2013; Bikic, Reichow, McCauley, Ibrahim, & Sukhodolsky, 2017; Pelham & Fabiano, 2008; Shuai et al., 2017; Solanto et al., 2010). Behavioral interventions that target real-world executive function in youth with ADHD are designed to utilize developmentally appropriate intervention delivery strategies that vary depending on the age-appropriate needs of youth. For preschool and elementary-aged youth, substantial parent involvement is required to support acquisition of EF skills and to generalize these skills across contexts (e.g., school, home; Abikoff et al., 2013; Pfiffner et al., 2007). Behavioral interventions designed for adolescents emphasize greater personal responsibility for the adolescent, encouraging self-monitoring with decreased parental involvement (Sibley et al., 2016). Existing behavioral interventions to target real-world executive function in youth with ADHD are delivered over the course of 10 weeks to one year, have been delivered in school (Evans, Schultz, & DeMars, 2014; Evans et al., 2016; Langberg, Epstein, Urbanowicz, Simon, & Graham, 2008) and clinic-based contexts (Abikoff et al., 2013; Pfiffner et al., 2007; Sibley et al., 2016), by both clinical and school-based mental health professionals. For example, a 12-week skills-based training program delivered to 8-year old children by clinicians showed improvements in overall ADHD symptoms, real-world EF behaviors (i.e., BRIEF), and performance-based EF measures (e.g., processing speed, working memory, inhibition). Academic improvements were also observed suggesting generalizability of intervention gains to additional functional outcomes. The primary features of this behavioral intervention involved: 1) teaching the child specific skills and strategies associated with EF weaknesses; 2) helping to make changes to the child's environment through providing cues to help the child or by changing the nature of the task; 3) facilitating habit-formation through daily practice and homework; and 4) involving the parent by providing parent training on behavioral management skills and psychoeducation about ADHD (Shuai et al., 2017).

In one study of adolescents (age 11—15) with ADHD that examined efficacy of the Supporting Teens' Autonomy Daily (STAND) intervention, parents and teens participated in a behavioral ''family'' therapy that included motivational interviewing to enhance effects. This combination of behavioral intervention, plus parent involvement and motivational techniques showed improvements across teens' overall level of ADHD symptoms, their organization and time management skills, and their recording of daily homework. Parent reports also showed reductions in parenting stress, as well as improvements in contingency planning with teen to improve motivation and promote use of skills (Sibley et al., 2016).

Behavioral interventions to support EF development in youth with ADHD show clear efficacy, however, there exists no empirically-supported adolescent-specific, transdiagnostic interventions for improving daily EF. Given this, the thinkSMART® program was created to facilitate positive changes in clinical, academic, and social functioning, through targeted EF intervention during the extended developmental window of adolescence. The purpose of this paper is to describe the rationale behind the creation of the thinkSMART® program, outline the components of the program, and present initial efficacy from an open-trial of the program. To accomplish these goals, the term executive functioning will focus on *real-life behaviors* and skills displayed in the context of everyday environments (e.g., Cortese et al., 2015).

Method

thinkSMART®: a behavioral intervention

The thinkSMART® program was developed with two research-guided, initial goals in mind: 1) to improve the broad impairments in EF observed across psychiatric disorders through the targeting of multiple EF domains; 2) to teach skills and strategies across multiple EF domains to enhance transfer of skills. The thinkSMART® program is a 12-week group behavioral intervention to improve executive functioning in adolescents and target broad EF impairments, teach specific strategies and compensatory behaviors, and emphasizes daily practice. Sessions occur one time per week, and each session is 90-minutes. All sessions include mindfulness, psychoeducation, a didactic skill, in-session practice of the skill, and an at-home skill-building activity. Participants are encouraged to practice skills daily, as skill acquisition is strongly rooted in the daily practice.

The program features strategies that were adapted for adolescents from empirically-supported treatments for school-aged youth and adults focusing on organization, time awareness/management, planning, and task initiation/completion (Abikoff et al., 2013; Solanto et al., 2010), as well as numerous additional adolescent-focused domains including mindfulness (Lam & Seiden, 2020; Tang, Yang, Leve, & Harold, 2012; Schonert-Reichl & Lawlor, 2010), sleep hygiene, (Khor, McClure, Aldridge, Bei, & Yap, 2021; Blake & Allen, 2020; Lawless, Turner, LeFave, Koinis-Mitchell, & Fedele, 2020) effective communication, study strategies, (Geller et al., 2018; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; McDaniel, Agarwal, Huelser, McDermott, & Roediger, 2011) and emotional control (Hoffmann, Brackett, Bailey, & Willner, 2020; Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011). Sessions are considered iterative in that previously learned skills are continuously reviewed and used in conjunction with additional, new strategies. For example, time awareness skills are taught prior to planning and scheduling, given that it is a critical underlying component of the latter skill. Table 1 outlines the order of specific skills targeted with the program.

One particularly novel component of the program is that at least one primary caregiver is required to attend all group sessions with the adolescent, encouraging simultaneous skill learning. This is required so that parents can help with habit-formation of skill use in the home and also model the appropriate use of skills. Parental involvement is critical not only for intervention delivery, but also because parental involvement (e.g., conversations with child about daily activities, homework, friends) is associated with less overall impairment in adolescence, regardless of ADHD history (Howard et al., 2016) and also predicts social, academic, and behavioral functioning during the transition to adulthood (Masten, 2004). Increased parent involvement in adolescent's academic routines has also been shown to improve parent-adolescent communication and increase autonomy-granting (Sibley et al., 2014). Consistent with behavioral parent training programs, parents are encouraged to be warm, controlled, consistent, and to support autonomy in their teen (Ginsburg & Bronstein, 1993). Parents are taught to use prompts to engage the teen in skill use. A scaffolding approach is used, with a gradual reduction in support as the teen becomes more independent.

The thinkSMART® program has an overall attrition rate of < 2% (*zero* attrition among those included in the pilot study) and an overall attendance rate of less than 1 missed session per family over the 12 sessions for total participants

Table 1 Weekly session outline of the thinkSMART® program.

Session #	
1	Psychoeducation of executive functioning and goal setting - Defining EFs: the ''driver'' of the brain - Why are EFs important? Why is practice important? - Goal discussion using motivational interviewing techniques
2	Planner use and mindfulness - Mindfulness and EFs: awareness of the present moment - How to efficiently use a planner and catch your distraction
3	Organization and minimizing distractions - How to surf your urge and create a distraction free study spot - Steps to organizing: 1. Identify; 2. Categorize; 3. Sort
4	Time estimation and time awareness - How to estimate time - Time cracks: increasing productivity - How to use to-do lists
5	Scheduling and prioritizing - Steps to prioritizing: how to determine what should be done first - How to structure ''unstructured'' time
6	Skill review and problem solving - Review of skills and discussion of obstacles - How to identify problems/their root causes and generate solutions
7	Task Initiation and Breaking Down Tasks - How to improve inertia to get started on non-preferred tasks - Breaking large projects down into manageable parts
8	Motivation and rewards - When are rewards necessary? - Self-contingent rewards, privileges, and consequences
9	Long-term planning - Long-term planning with integration of other thinkSMART skills - Overcoming obstacles when planning for the future - How daily choices build habits and impact goals
10	Emotional control - How thoughts/feelings/behaviors are related - How to use grounding techniques and the opposite action reaction
11	Sleep hygiene, study skills, and communication - Environmental factors and healthy habits to improve sleep - Effective study strategies: active studying and the tree of knowledge - Active listening and making positive requests
12	Skill review

EF: executive functioning.

and those included here. This speaks to the acceptability and feasibility of the program. In addition, for the initial 3 years of the program, evaluations were given to all parents and teens at the end of treatment ($n = 74$). Combined, these evaluations rated the helpfulness of the program as 4.2/5 and the relevance/appropriateness of the content as 4.5/5. Given the deidentification of the data, as well as the shorter timeline of data collection, we were not able to exactly link these evaluations to the families included in the study. These results are presented here to highlight the acceptability of the program as a whole.

Participants

Adolescents ages 12—17 are eligible to participate in the thinkSMART® program. The following inclusion criteria are used for general program enrollment: 1) enrolled in 6th—12th grade; 2) IQ greater than 80; 3) ability of adolescent and parent to speak, read and understand English; 4) ability to tolerate a general classroom setting; 5) parental concern about their child's real-world executive function skills. Participants were not required to have a psychiatric diagnosis, and no assessment of executive function was required for program entry. Medication use was assessed, but not a criterion for eligibility.

Measures

Basic demographic information including age, sex, race/ethnicity, psychiatric diagnostic history, and ADHD medication use was assessed. The Behavior Rating Inventory of Executive Functioning (BRIEF) parent report form was

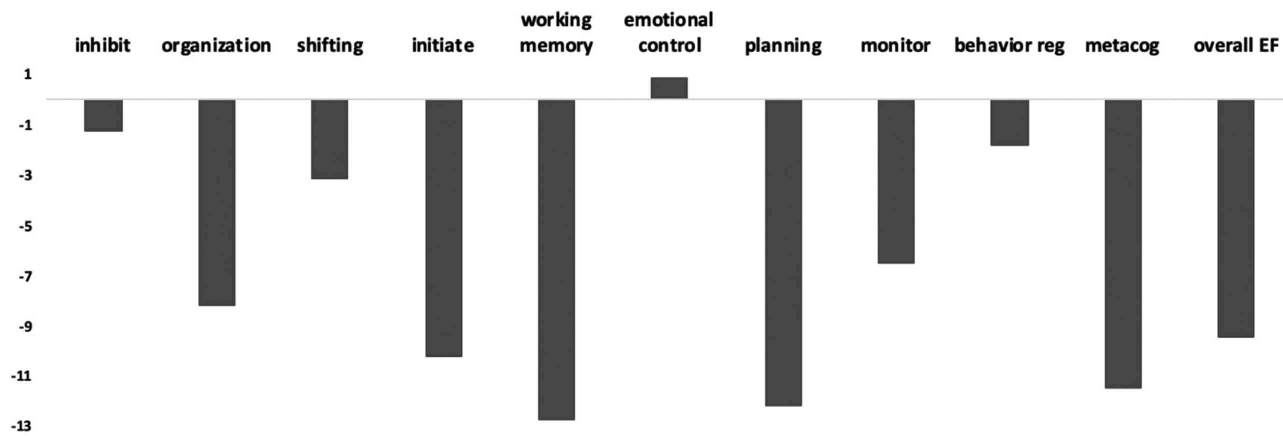

Figure 1 Percentage of Behavior Rating Inventory of Executive Functioning (BRIEF) T-score improvement from pre- to post-thinkSMART®, where negative percentiles indicate reduction in subscale T-score over time.

administered to parents to complete about their child's behaviors (Gioia, Isquith, Guy, & Kenworthy, 2000). Behavioral reports, such as the BRIEF, assess multiple components of EF (Clark et al., 2017; Nyongesa et al., 2019), are reflective of the general, daily behaviors displayed by teens in real-life situations, and provide information from outside informants who view the teen on a daily basis (Kamradt et al., 2021). Behavioral reports, as compared to neurocognitive measures of performance, have been shown to be more sensitive in detecting changes in EF (Cummings, Singer, Krieger, Miller, & Mahone, 2002). Dysfunctions in real-world EF, identified by the BRIEF, have been linked to academic outcomes, increased psychopathology, and more risk-taking behaviors (Clark et al., 2017; Langberg et al., 2011; Langberg, Dvorsky, & Evans, 2013; Pope et al., 2016). Given the utility of the BRIEF in predicting functional outcomes, it was the primary outcome measure used in this study.

The BRIEF is composed of 86 items that represent the following factors: initiate, working memory, plan/organize, organization of materials, monitor, inhibit, shift, and emotional control (combined to form the behavioral regulation index). The BRIEF also generates a metacognition index score (initiate, working memory, plan/organize, organization of materials, monitor) and a behavioral regulation index (inhibit, shift, emotional control) and an overall general EF score reflective of all factors. The BRIEF has demonstrated strong reliability and validity, as well as strong internal consistency ($\alpha = 0.8$-0.98). The test-retest for parent-rated BRIEF measures is also high (0.82) (Gioia et al., 2000).

Study design

This pilot study used a non-randomized, open-trial design whereby all families knew that they were participating in the active treatment. The data were solicited from families, and they used their own discretion on whether to participate. Given that data had been collected voluntarily as part of the clinical program, the study investigators received approval from the institutional review board at UCLA verifying the ethical nature of the study and to waive informed consent to obtain and analyze existing program data. Behavioral assessments of EF were conducted using the BRIEF before and after the 12-week intervention. Initial BRIEF assessments were administered prior to the beginning of the program and were required to be returned within the first week in order to be included. Completion of initial BRIEF assessments within the first week of the program and following the 12-week intervention. The intervention was delivered by a clinical neuropsychologist and co-lead by clinical and educational psychologists. It was delivered in an outpatient clinic within a psychiatry department. The delivery of the thinkSMART® intervention was given in-person using a group format. Group sizes ranged from 7—10 participants, with the majority meeting the 10 threshold. Given the need to pivot to a virtual format during the COVID pandemic, 18% of all thinkSMART® participants received remote sessions. Of the 34 participants discussed in this pilot study, 10 completed thinkSMART® virtually (~29% of participants). Of the subscales demonstrating clinical change from pre-to post-intervention noted below, a time × virtual/in-person repeated measures Anova showed that Organization was the only one that differed between in-person and virtual participants whereby the virtual participants showed greater improvements over time [$F(1, 32) = 9.27$, $p < .01$]. This demonstrates initial efficacy for thinkSMART® regardless of modality, where a stronger treatment effect for Organization was observed for the virtual mode.

Analyses

Descriptive data were examined for sample characteristics, as well as for acceptability analyses. First, to identify the clinical severity of the population, we calculated percentages of teens with clinically significant elevations on each subscale (i.e., T-scores on BRIEF subscales > 65). Percentages were also calculated following the program to determine the extent to which the program reduced the clinical severity of symptoms over time (see Table 3). We also calculated rates of change for each subscale, (i.e., post-intervention T-score divided by pre-intervention T-score) and present them here as a percentile to depict average slope change as a function of the intervention. Next, repeated measures anova were used to examine

Table 2 Demographic characteristics of participants in the open-trial.

Demographics *n* (%)	
Male/female	23 (69%)/11 (31%)
Age (mean years; SD)	14.15 (1.60)
Racial categories *n* (%)	
Non-Hispanic/Latino	29 (85%)
Hispanic/Latino	5 (15%)
Asian	7 (20.6%)
Black or African American	1 (2.9%)
White	19 (55.9%)
Mixed race	6 (17.6%)
ADHD and ADHD medication use *n* (%)	
ADHD diagnosed (self-report)	25 (73.5%)
ADHD diagnosed (male/female ratio)	17/8
ADHD medication (%)[a]	19 (56%)
ADHD medication (male/female ratio)	13/6
Reported other psychiatric conditions (*n*)	
Internalizing disorder (e.g., depression/anxiety)	5
Autism spectrum disorder	6
Other (ODD: [*n* = 1]; Tourettes: [*n* = 1]; specific learning disorder [*n* = 3])	5
None or unknown	6

[a] ADHD medication included stimulants, non-stimulants and alpha-agonists. Of those taking ADHD medication, 4 were also taking antidepressant/anxiety medications. 1 participant was on only antidepressant medication.

whether BRIEF subscale means differed as a function of time across pre- to post-thinkSMART®. Significant results suggest that participants experienced significant reductions in EF symptoms over time. Finally, as exploratory analyses, the effect of ADHD medication and ADHD diagnosis were examined as potential moderators of treatment efficacy and to determine whether effects of the thinkSMART® intervention may be specific to ADHD or may generalize across diagnoses.

Results

Of the 148 families who participated in the program over a period of 4.5 years (16 total groups), $n = 35$ parents agreed to complete additional measures of EF about their teen and themselves within a one week window of the program beginning, and within 1-week of program completion. One participant was dropped from analyses due to incomplete data, for a final $n = 34$. Participant characteristics are detailed in Table 2. Parent reported diagnoses were varied among participants, with families indicating that no diagnoses had ever been given ($n = 3$) or that the diagnosis was unknown ($n = 3$). Nearly three-quarters of participants ($n = 25$) had an ADHD diagnosis. Of those, 28% had been previously diagnosed with a comorbid disorder. Within participants, the following had also been reported by parents as diagnosed by a professional: Autism Spectrum Disorder ($n = 6$), Anxiety ($n = 4$), Depression ($n = 1$), ODD ($n = 1$), Tourettes ($n = 1$), and specific learning disability ($n = 3$).

Group characteristics and clinical cut-offs

The majority of participants were experiencing clinically significant levels of impairment across multiple domains of executive function as determined by the BRIEF prior to the start of intervention. BRIEF subscale pre- and post-treatment means, as well as percentage of participants above clinical threshold before and after the program, are reported in Table 3. On average, participants demonstrated clinically significant levels of impairment in each of the following subscales prior to intervention: task initiation, working memory, planning, metacognition, and general functioning (see Table 3). Following thinkSMART®, the overall means of *all* BRIEF executive functioning domains fell below the threshold for clinically significant impairment (T = 65).

Rates of change were calculated to show the percent decrease in T-score from baseline to post-thinkSMART®. Subscales of initiate (10.18%), working memory (12.71%), planning (12.18%), monitor (6.47%), metacognitive index (11.46%) and GEC (9.47%) showed the greatest rates of improvement, as compared to inhibition, shifting, emotional control, and behavior regulation index which all showed < 3.2% change over time (Fig. 1).

Changes in EF pre- and post-thinkSMART®

Repeated measures anova revealed significant changes in BRIEF subscale T-scores as a function of time. As shown in Fig. 2, significant improvement from pre- to post-intervention was observed in each of the following executive functioning domains: Task Initiation, $F(1,33) = 26.64$, $p < .01$, partial $\eta^2 = .45$, Working Memory, $F(1,33) = 37.63$, $p < .01$, partial $\eta^2 = .53$, Planning, $F(1,33) = 36.86$, $p < .01$, partial $\eta^2 = .53$, Organization, $F(1,33) = 13.59$, $p < .01$, partial $\eta^2 = .29$, Monitor, $F(1,33) = 7.36$, $p = .01$, partial $\eta^2 = .18$, Metacognitive Index, $F(1,33) = 45.46$, $p < .01$, partial $\eta^2 = .58$, and General EF Composite $F(1,33) = 25.98$, $p < .01$, partial $\eta^2 = .44$. Results highlight considerably large effect sizes across these domains, particularly when compared to those domains not showing significant change over time [shifting: partial $\eta^2 = .08$; inhibit: partial $\eta^2 = .03$, emotional control: partial $\eta^2 = .01$, and behavior regulation: partial $\eta^2 = .05$] (Fig. 2).

Moderator analyses

Results demonstrated that the interaction of ADHD diagnosis/ADHD medication status and time (pre-/post) was non-significant across all domains of executive functioning, indicating no impact of ADHD or ADHD medication use on intervention efficacy. Despite no interaction effect of ADHD diagnostic status on overall outcome across domains, the a priori hypothesis regarding the transdiagnostic nature of thinkSMART® was examined in post-hoc exploratory analyses within the non-ADHD group only ($n = 9$). Although the sample was small, across domains of working memory,

Table 3 BRIEF Subscale T-score means (standard deviation) and % of participants above clinical threshold (T > 65) Pre- and Post-thinkSMART®.

BRIEF Subscale	Pre mean (SD)	Pre % clinical	Post mean (SD)	Post % clinical
Inhibition	59.15 (14.17)	32.4	57.24 (12.91)	23.5
Shift	62.24 (14.96)	47.1	58.79 (12.01)	38.2
Emotional control	58.50 (13.62)	20.6	56.91 (10.90)	29.4
Initiation	67.82 (10.57)[a]	64.7	60.53 (10.07)	38.2
Working memory	73.35 (11.77)[a]	79.4	63.35 (10.01)	44.1
Planning	70.85 (10.54)[a]	73.5	61.68 (9.37)	32.4
Organization	60.38 (9.01)	38.2	55.21 (10.11)	20.6
Monitoring	64.68 (10.82)	47.1	60.29 (10.46)	35.3
BRI	61.38 (14.60)	35.3	58.74 (12.04)	32.4
MI	70.71 (10.86)[a]	73.5	62.32 (10.33)	35.3
GEC	68.79 (12.20)[a]	61.8	61.79 (10.65)	38.2

BRIEF: Behavior Rating Inventory of Executive Functioning.
[a] Mean falls within the clinically significant range (T > 65).

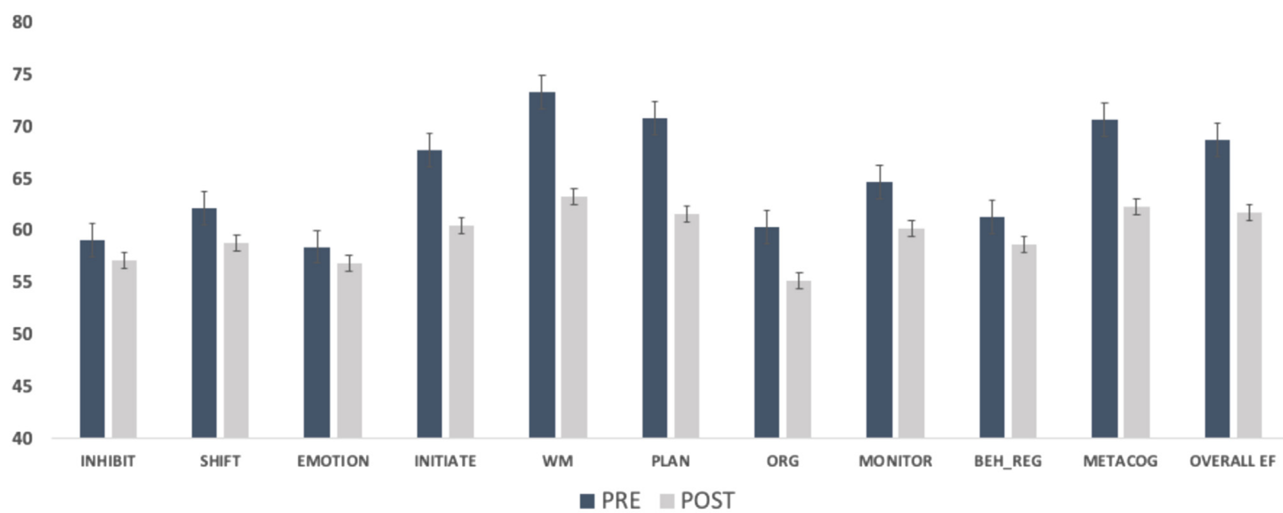

Figure 2 Behavior Rating Inventory of Executive Functioning (BRIEF) T-Scores before and after thinkSMART®.

task initiation, organization, planning, metacognition, and overall EF, large effect sizes were observed (partial $\eta^2 > .31$), suggesting initial efficacy of the program in non-ADHD adolescents.

Discussion

The present study evaluated a skills-based behavioral training program that aims to improve executive function in teens ages 12—17. Although the number of teens without ADHD is relatively small in this pilot study, thinkSMART® is one of the first behavioral group treatments for EF that exists for adolescents with executive dysfunction, with or without co-occurring psychopathology. These results provide initial support that it may be a viable transdiagnostic intervention. The program builds on the success of existing behavioral skills-based programs targeting EF in adolescents with ADHD. The program was well received by families, as indicated by the low attrition rate, high attendance ratios, and parent and teen ratings of program acceptability and perceived benefit. Additionally, preliminary data from the present study indicates that the thinkSMART® program, a skills-based cognitive-behavioral intervention, may be efficacious in improving executive functioning in teens ages 12—17 with diverse executive function support needs. Specifically, the thinkSMART® intervention produced large effect sizes, explaining 18—58% of the variance, across domains of task initiation, working memory, planning, and organization on the BRIEF as reported by parents. Large effects were also observed in both those diagnosed with ADHD and those without. Further, the use of psychostimulant medication to manage ADHD symptoms did not moderate the effect of thinkSMART® on EF, suggesting that thinkSMART® can be used as a non-medication alternative for adolescents seeking EF support or as a supplement to their current medication regimen.

Broad EF domain improvement to target youth with diverse support needs

The thinkSMART® program effectively targeted areas of executive function that are not addressed through existing cognitive-behavioral interventions for youth with ADHD (e.g., working memory, task initiation). Indeed, extant behavioral training programs that aim to remediate executive function were primarily designed to address the specific needs of youth with ADHD, including building organization, time management, and planning skills (e.g., Boyer, Geurts, Prins, & Van der Oord, 2015; Sprich, Safren, Finkelstein, Remmert, & Hammerness, 2016). The specificity of these interventions may not appropriately target the EF support needs of a more transdiagnostic group that include individuals with more global executive function impairment (Demetriou et al., 2018; Han et al., 2016).

The thinkSMART® program was successful in improving task initiation, working memory, organization, and planning; however, it did not improve domains of behavioral regulation such as inhibition, emotional control, and self-monitoring. The broad and skills-based focus of the program on metacognitive executive function domains thus resulted in generalizable improvement. Prior work emphasizes the potential importance of targeting multiple EF domains to maximize EF intervention efficacy (Cortese et al., 2015). The thinkSMART® program used this multi-domain approach and emphasized key features that may have enhanced intervention effectiveness and broadened impact. Psychoeducation was used to improve knowledge and insight, and individual EFs were targeted through session content and the teaching of multiple compensatory strategies within each area. The diversity of compensatory strategies presented allowed teens the autonomy to select and use one or all the presented skills to target their EF weaknesses. Use of this strategy to increase personal autonomy and decrease parental control among teens (Eccles et al., 1991), consistent with developmental milestones during this period, may have improved skill uptake and use. Content from session to session was also cumulative over the course of the intervention, where content learned in earlier sessions was frequently revisited in later sessions. The greatest intervention benefit was observed for EF domains that were covered early on in the program, as content was reinforced for the remaining weeks. Repeated exposure to content, and repeated practice of previously learned skills was likely essential to program efficacy.

Although each of the individual subscales comprising the metacognition domain showed significant improvement, self-monitoring showed the smallest effects from the program. Though use of self-monitoring skills was encouraged in the program due to the developmental importance, the use of self-monitoring was not explicitly practiced. This may suggest that for adolescents with executive dysfunction, even those who demonstrate improvement, targeted parent support may still be required to derive full benefit. Parents are able to not only influence their teen's behavior, but also supervise and reinforce skills that their child may struggle to execute independently. Teens with EF weaknesses are known to require additional support from caregivers and teachers to effectively navigate (Weisz & Hawley, 2002).

Indices of behavioral regulation from the BRIEF (i.e., inhibit, shift, emotional control) did not demonstrate change with the program. Emotional control was addressed explicitly during one of the intervention sessions. However, emotional control may have required more attention than a single session to yield benefit. The absence of significant improvement in emotional control supports the hypothesis that repeated exposure to session content over multiple sessions is likely critical to skill uptake. Modification to emotion regulation content to improve efficacy may include instruction in additional emotion regulation strategies, or earlier introduction of the emotion regulation module to allow for repeated exposure to session content and opportunities for practice. Given that emotional control is a primary area of concern for youth with diverse psychopathology (e.g., ADHD, internalizing disorders; Bodalski, Knouse, & Kovalev, 2019), future research should examine how altering the ''dosage'' of each session module may impact intervention component efficacy. The remaining two domains of behavioral regulation, inhibition and shifting, were not specified modules in the program, which may explain why there was no observable change. Inhibition and shifting represent two underlying cognitive processes that may be more difficult to modify with compensatory skill instruction and use. Lack of observed change in these underlying cognitive processes is consistent with prior work demonstrating lack of demonstrable improvement on neurocognitive tasks following behavioral intervention (e.g., Boyer et al., 2015).

Importance of parental involvement in intervention

The involvement of parents in each of the sessions was considered a critical component of the intervention, impacting continued skills practice at home and therefore intervention efficacy. Though the impact of parent involvement was not explicitly tested, anecdotal reports from parents underscored the importance of parents and teens learning the same skills and strategies to be implemented at home. Parents reported that they appreciated being ''in the loop'' and learning the same strategies as their teens, in addition to the perceived benefit to their own executive functions.

Parents also reported reduced conflict with their teens at home over executive function-related difficulties and strategy implementation. Parent-child conflict has been reported to interfere with intervention attendance and efficacy in prior behavioral training programs (Barkley et al., 2001). Parent involvement in sessions was also critical to teen's effective implementation of skills used at home. The majority of existing behavioral training programs designed to target executive function involve direct skill instruction to teens in clinic or school settings without parent involvement, or with a few concurrent parent-only sessions (Boyer et al., 2015; Sprich et al., 2016). Generalization of skills across contexts is unlikely to be effective without appropriate support (i.e., parent implementation of strategies; Stokes & Baer, 1977). A final benefit of including parents observed by group instructors was the social support experienced by the parents in the group. Many parents reported experiencing high levels of frustration with their teens prior to the start of the program, consistent with high rates of conflict among teens with ADHD and their parents about executive function-related difficulties (e.g., homework; Garcia, Medina, & Sibley, 2019). Group instructors observed that the group format facilitated the sharing of ideas, helped with brainstorming solutions for obstacles, and provided support in normalizing struggles with executive dysfunction.

Limitations and future directions

Given the pilot nature of the data presented here, limitations must be discussed. The data were collected using a single self-report measure given to parents prior to beginning and following the program. This open-trial design, in addition to minimal outcome variables, limits the conclusions that can be drawn from the results presented here. For example, future examination of the efficacy of the thinkSMART® program should involve an active control condition, as well as other symptom measures such as those assessing those present in the transdiagnostic sample (e.g., inattention, anxiety, depression). Assuming a pre-post design, $\alpha = .05$, $\beta = .80$, $f = .3$ (medium-large treatment effect), and $r = .5$ between repeated measures, a future Phase III trial would aim to complete $n = 34$ active treatment and $n = 34$ control participants.

Given this design, reporter bias must also be considered. All participants chose to participate in the program, and thus, may have been biased in their reporting. Interestingly, however, results did not show improvements across multiple domains of EF, suggesting a lack of a consistent positive response bias. Despite this, observer reports should be obtained from individuals outside the home (e.g., teachers), and data from the adolescents themselves should be included.

In addition to limitations of the data presented, limitations of the program itself should be noted. It has yet to be established whether the program leads to meaningful changes in daily functioning in areas of academics, social relationships, or emotional health, limiting the generalizability of the program. The sustainability of gains observed in thinkSMART® should also be examined through follow-up assessments. Booster sessions may be needed to reinforce skill use following the program. The program has also been offered as a ''fee for service'' program where participants pay to participate. While our observations suggest that the financial commitment to enroll in the program has contributed to increased compliance, it may also be true that using a financial investment to improve motivation may consequently serve as a barrier of dissemination. The fee structure, as well as alternative motivators should be explored. Relatedly, the socioeconomic profile and racial distributions of the groups have not captured the diversity seen in many large, urban cities. Future work should examine the effects of thinkSMART® in underserved communities where resources, parental involvement, and factors affecting consistency may be different than those of families who have participated.

Future research should examine motivation, attrition, and overall change as a function of whether participants are required to pay to participate.

Conclusion

Although additional evidence is needed through a randomized controlled trial, the initial preliminary findings suggest the viability of the thinkSMART® program as a successful intervention for improving adolescents' executive functioning. Through the use of concrete skill acquisition, adherent parental involvement, and dedicated at-home practice for habit building, the thinkSMART® program shows great promise for youth with and without ADHD.

Disclosure of interest

The authors declare that they have no competing interest.

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