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Exploring the potential of Braingame Brian for executive function improvement in Spanish-speaking children with ADHD: A pilot study

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ABSTRACT

Considering the implications of executive function (EF) in the core symptoms of attention deficit hyperactivity disorder (ADHD), further research is required on strategies such as therapies, treatments, and rehabilitation programs focused on improving EF. This study aimed to assess the potential of an EF training program called "Braingame Brian" in improving working memory, inhibition, and cognitive flexibility in children with ADHD. The programme was developed in the Netherlands and has been shown to be effective in pilot studies of ADHD populations conducted in this country. However, it has not been used before in the Spanish-speaking population. A total of 41 children (aged 8–12 years) were assigned to the EF training or waitlist control groups. The intervention consisted of a 25-session training programme of approximately 45 min per day for nine consecutive weeks. Treatment outcomes were assessed using cognitive tasks of the trained EF, as well as evaluations of EF behaviors by parents and teachers. The initial findings suggest that the implementation of the Braingame Brian programme may be associated with improvements in working memory, inhibition, and cognitive flexibility. These preliminary results also indicate the potential for enhancements in parents' and teachers' perceptions of EF difficulties in children with ADHD.

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ADHD; child; computer gaming; executive function; training

Introduction

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental condition that is commonly diagnosed during childhood. ADHD is one of the most prevalent chronic medical conditions in school-aged children, with

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impulsivity, hyperactivity, and inattention being the main symptoms (American Psychiatric Association, 2013; Levitt & Felt, 2022).

Epidemiological samples that are representative of the general population indicate that the prevalence of ADHD in school-aged children is 5.3%, with no significant variation by geographical region (Faraone et al., 2024). The prevalence rates have been on the rise over time (London & Landes, 2021), resulting in significant challenges in various domains, including social, academic, personal, and familial spheres (American Psychiatric Association, 2013; Lopera, 2008). This increases the risk of lifelong difficulties for children with ADHD, due to their symptoms, including deficits in neurocognitive abilities, academic difficulties, social isolation, risk-taking behaviors, and psychiatric comorbidities (Coghill et al., 2014b; Faraone et al., 2021).

ADHD has a complex aetiology and demonstrates clinical heterogeneity, suggesting that multiple pathophysiological pathways contribute to its development. Neuroimaging studies have provided insights into the underlying mechanisms of ADHD, implicating several cortical and subcortical regions of the brain responsible for many executive functions (EF) in the disorder (e.g., the dorsolateral prefrontal cortex, inferior frontal cortex, and ventral and dorsal anterior cingulate cortices). Networks that mediate EF have been identified as being implicated in ADHD. These networks are underactivated and exhibit reduced functional inter-regional connectivity in individuals with ADHD compared with those without ADHD (Faraone et al., 2024).

According to Dovis et al. (2015), deficits in executive functioning are believed to be a significant contributing factor to the challenges faced by children with ADHD on a daily basis. Executive functions (EF) are defined as the cognitive processes that enable individuals to regulate their behavior, thoughts, and emotions, thereby facilitating self-control (p.1). EF is a top-down control model responsible for the regulation of cognition, action, and emotion. It encompasses neurocognitive processes such as working memory, inhibition, and cognitive flexibility (Arán-Filippetti & Richaud de Minzi, 2011; Huizinga et al., 2006; Miyake et al., 2000; Vugs et al., 2017; Zelazo et al., 2003). The concept of EF is often perceived as a complex one, comprising a number of separate sub-functions (Miyake et al., 2000). As proposed by Stuss and Alexander (2000), these processes are interrelated and function as a unified supervisory control system.

The term "working memory" (WM) is used to describe the systems and procedures used to temporarily store and process information (Baddeley, 2003). Furthermore, it encompasses the capacity to maintain information in an online state while awaiting a response, utilizing an internal representation (Baddeley, 1992, 2000). Inhibition is defined as the ability to suppress prepotent responses (Miyake et al., 2000). Barkley (1997) defined inhibition as the repression of an overlearned, competing, or disrupting response. Research indicates that challenges in inhibitory control are a primary mechanism associated with

the clinical and cognitive difficulties observed in children with ADHD (Barkley, 1997; Romero-Ayuso et al., 2006; Rubia et al., 2009). Cognitive flexibility, also known as shifting, is defined as the capacity to shift attention between tasks (Miyake et al., 2000). According to another approach, it is the capacity to alter one's thoughts or behavior in response to changing circumstances (Monsell, 2003).

However, it is necessary to identify which EFs are typically affected in children with ADHD. The literature on this topic examines EF impairments from a variety of perspectives. For instance, van der Oord et al. (2014) asserted that children with ADHD encounter difficulties in the domains of WM, behavioral inhibition, and cognitive flexibility (Cepeda et al., 2000; Willcutt et al., 2005; Wu et al., 2006). Another perspective suggests that challenges in the prepotent inhibition or the inhibition of an ongoing response are common features of ADHD (Sergeant et al., 2002). The EF with the greatest deficiency in ADHD literature are attention and vigilance, inhibition, planning, organization, and verbal and spatial working memory (Landínez-Martínez et al., 2022; Nigg et al., 2008; Pineda et al., 2007; Sergeant, 2005). Cognitive deficits include emotional dysregulation (Shaw et al., 2014), temporal processing (Rubia et al., 2009; Sonuga-Barke et al., 2010), a preference for small immediate rewards (Marx et al., 2021), and poor decision-making in general (Sonuga-Barke et al., 2016). It is also important to consider the potential impact of other factors, such as processing speed (Cook et al., 2018) and delay aversion (Sonuga-Barke, 2003).

Furthermore, children with ADHD demonstrate inferior performance in visuospatial tasks that require the integration of multiple cognitive operations and exhibit poor executive memory due to a lack of behavioral inhibition (McInnes et al., 2003; Oosterlaan et al., 1998). A substantial body of research indicates that children with ADHD exhibit difficulties in executive functioning, which manifests as difficulty in inhibiting impulsive responses, resisting interference, and maintaining cognitive efforts focused on a single task (Barkley & Murphy, 2010; Brown, 2009; Pennington & Ozonoff, 1996; Roberts et al., 2017).

These findings have enhanced our understanding of ADHD and the efficacy of interventions and rehabilitation methods by elucidating the implications of EF and its effect on core symptoms. Studies have demonstrated that certain cognitive processes may benefit from pharmacological treatments, including response inhibition (Coghill et al., 2014a; Griffiths et al., 2018; Lee et al., 2022), working memory (Coghill et al., 2014a), non-executive aspects of short-term memory (Coghill et al., 2014a, 2014b), attention (Epstein et al., 2011), response reaction time (Coghill et al., 2014b), and reaction time variability (Coghill et al., 2014b). The pharmacological treatment of ADHD typically involves the use of psychostimulant drugs, which act on the neurotransmitter systems implicated in the psychopathology of the disorder. A number of empirical and meta-analytical investigations have demonstrated that central nervous system stimulants are effective in reducing symptoms of inattention, hyperactivity,

impulsivity, and other disruptive behaviors (Connor, 2015). In the study by Landínez-Martínez et al. (2022), the standard approach to treating ADHD was found to involve the use of medications to enhance focus, reduce impulsivity, and treat other overactive behaviors by controlling the signal components transmitted between synapses (Ng, 2017).

However, it is not always the case that children benefit from psychostimulants. In some instances, the side effects may be counterproductive. Rosa et al. (2017) emphasized the efficacy of medication, particularly stimulants, as a treatment for ADHD. However, despite this, there is still concern about this, given that 30% of patients do not respond to or tolerate the side effects of stimulant medication. Furthermore, the long-term effects of medication have not yet been established, and the cognitive symptoms of ADHD typically do not completely improve.

As outlined by Briars and Todd (2016), the administration of pharmaceuticals has been associated with an increased risk of anorexia, weight loss, and insomnia. A number of potential limitations may affect some patients, including partial or non-response to treatment (Cortese et al., 2018), adverse side effects (Cortese et al., 2013), poor adherence (Adler & Nierenberg, 2010), concerns about long-term costs and benefits (Molina et al., 2009), and negative medication-related attitudes from patients, parents, or healthcare professionals (Cortese et al., 2015; Veloso et al., 2020). In light of these constraints, parents and medical professionals are investigating alternative therapeutic avenues (Rabipour & Raz, 2012).

van der Donk et al. (2015) highlighted that these limitations have increased interest in non-pharmacological alternatives for treating children with ADHD. They further noted that treatments that focus on the underlying cognitive deficits appear to be critical in the mechanism that mediates the ADHD causal pathway. Furthermore, in order to treat ADHD, the outcomes of interventions should focus on enhancing cognitive abilities, daily performance, and quality of life, rather than on symptomatic improvement (Adamo et al., 2015; Mulraney & Coghill, 2018; NICE, 2019).

Veloso et al. (2020) explained that the development of non-pharmacological treatments for ADHD has been a subject of investigation. Furthermore, cognitive training has been identified as a promising treatment for ADHD (Cortese et al., 2015). Cognitive training interventions are defined as all actions and practices whose purpose is to restore impaired cognitive functions (Portellano & García, 2014). As proposed by Vinogradov et al. (2012), cognitive training can enhance and expand brain networks by training the brain in specific learning tasks, thereby fostering more adaptable behaviors under varying conditions or circumstances. Digital tools have been employed in non-pharmacological interventions based on cognitive training with the objective of enhancing cognitive function and alleviating ADHD symptoms.

Although the evidence base for these types of interventions is expanding, the quality of many studies is low, and they have demonstrated inconsistent benefits on ADHD outcomes (Faraone et al., 2024; Hollis et al., 2017; Robledo-Castro et al., 2023). The most recent meta-analysis of computer-based cognitive training has confirmed the findings of previous meta-analyses (e.g., Rapport et al., 2013), which demonstrated that there is no significant impact on ADHD symptoms when blinded raters are considered (Westwood et al., 2023). Nevertheless, a large randomised controlled trial (RCT) of a video game-like intervention targeting divided attention and cognitive control demonstrated a small but significant improvement in neuropsychological measures of attention, but a non-significant improvement in ADHD symptoms (Kollins et al., 2020). Furthermore, a gamified treatment targeting EF has demonstrated efficacy in a randomised controlled trial for reducing the symptoms of ADHD and improving academic achievement (Singh et al., 2022). The evidence thus far has been inconclusive regarding the general benefits of computerized training on the executive functions of children with ADHD.

Cognitive training methods have been employed to address impairments in a range of EF processes, including attentional control, WM, and inhibition. However, WM is frequently the focus of cognitive training, as explained by Tajik-Parvinchi et al. (2014), because it can influence other cognitive processes. WM training has received the greatest attention in the field of cognitive therapy as a potential treatment for ADHD in children, given that it is an essential process for a variety of other challenging tasks, including comprehension, reasoning, and learning (Baddeley, 2007). Studies have indicated that difficulties with WM may be associated with the emergence of ADHD symptoms (Barkley, 1997; Willcutt et al., 2005). Furthermore, studies that have focused on WM training as a potential ADHD treatment have demonstrated significant improvements (Beck et al., 2010; Gathercole et al., 2019; Gray et al., 2012; Green et al., 2012; Holmes et al., 2010; Klingberg et al., 2002, 2005; Landínez-Martínez et al., 2022; Melby-Lervåg & Hulme, 2013; Rapport et al., 2013; Shipstead et al., 2012; van der Donk et al., 2015; Vugs et al., 2017; Wiest et al., 2020).

A paucity of studies has examined the efficacy of training cognitive flexibility and inhibition, two EF processes that are compromised in ADHD. For instance, White and Shah (2006) found that attention-switching impairments in adults with ADHD may be ameliorated with short-term, targeted training, with the effects from such training transferred to new tasks of attention switching. Kray et al. (2012) demonstrated that task-switching training is an efficacious cognitive intervention that enhances executive control functioning in children with ADHD. Johnstone et al. (2010) investigated the behavioral and physiological effects of computer-based WM and inhibition training for children with ADHD using a randomised double-blind design. Their findings indicated that there was no statistically significant improvement in the treatment group in the inhibition and WM tasks. Nevertheless, they posited that children in the

high-intensity training condition exhibited a diminished frequency of inattention and hyperactivity symptoms.

Braingame Brian is a computer program designed for the training of EF that has yielded some scientific discoveries in the past ten years. This computerized programme of Dutch origin trains WM, inhibition, and cognitive flexibility. The preliminary outcomes of Braingame Brian usage with children diagnosed with ADHD appear promising. The children not only demonstrate notable improvements in the targeted activities, but also exhibit enhanced cognitive abilities. Additionally, parents report a reduction in their children's behavioral symptoms associated with ADHD (Prins et al., 2013; van der Oord et al., 2014).

This study aimed to explore the potential of Braingame Brian for executive function improvement in Spanish-speaking children with ADHD aged 8–12 years. A comparison was made between the performance of the children assigned to either an EF training group or a waitlist control group, before and after training, on cognitive EF tasks and the ratings of EF behaviors by parents and teachers. The research questions were as follows: (1) Does the EF training programme Braingame Brian result in significant improvements in WM, inhibition, and cognitive flexibility in children with ADHD? (2) Does it result in significant improvements in the ratings of EF behaviors by parents and/or teachers in children with ADHD?

Given the limited and inconsistent evidence currently available, we adopted an exploratory approach to the study. The hypotheses are that (1) EF training will significantly improve WM, inhibition, and cognitive flexibility in children with ADHD compared with the waitlist control group, and (2) it will also improve parents' and teachers' perceptions of EF behaviors in children with ADHD compared with the waitlist control group.

Method

Design

A quasi-experimental study was conducted with a non-equivalent control group to identify potential changes in EF following the Braingame Brian Intervention Program. This was a prospective, non-randomised, non-blinded, controlled study in which a treatment group and a control group were compared using pre-test and post-test measures. A matching strategy was employed to mitigate the influence of confounding variables resulting from non-random participant assignment. In order to ensure that the two groups were as similar as possible, a set of observable baseline characteristics (e.g., age, sex, educational level, and baseline scores of EF cognitive tasks) was selected to be matched between the two groups. A comparison of baseline scores between the matched groups was conducted using the standardized mean difference method (Ho et al., 2007). This type of design allows for the control of threats to internal validity resulting

from history, maturation, evaluation, instrumentation, and statistical regression (Shaughnessy et al., 2007). The purpose of this study was to conduct an initial trial in preparation for future randomised controlled trials.

Participants

A total of 41 children aged between 8 and 12 years were recruited from outpatient mental health clinics and schools in Cartagena, Colombia. The total sample consisted of seven females ($M_{age} = 8.9$ years, SD = 1.2 years) and 34 males ($M_{age} = 9.7$ years, SD = 1.4 years). All children currently or previously diagnosed with ADHD were contacted and invited to participate. The participants were recruited between 1 May 2019 and 20 February 2020. The inclusion criteria for participation were as follows:(1) a DSM-5 (APA, 2013) diagnosis of ADHD combined presentation established by a child neurologist or psychiatrist and confirmed by their medical history, and (2) an estimated full-scale IQ of 80 or above, as established by a short version of the Wechsler Intelligence Scale for Children–Revised (WISC-R; Wechsler, 1993) (Sattler & Hoge, 2006). The clinical assessment was supplemented by a validated questionnaire completed by teachers: the EDAH Attention Deficit with Hyperactivity Assessment Scale (Farré & Narbona, 1998). The questionnaire was applied to confirm the main symptoms of inattention and/or hyperactivity-impulsivity, as documented in the medical records. The following exclusion criteria were applied: a documented history of traumatic brain injury (TBI), sensory or motor deficits, autism spectrum disorder, intellectual disability, learning disability (e.g., dyslexia), or any other psychiatric condition (e.g., oppositional defiant disorder). The participants were divided into two groups: the intervention group, which included 20 children with ADHD ($M_{age} = 9.5$ years, SD = 1.4 years), and the waiting list control group, which comprised 21 children ($M_{age} = 9.6$ years, SD = 1.4 years). Of the original sample, 34 participants remained until the end of the study. Seven children in the intervention group and two in the waitlist control group were receiving pharmacological treatment with methylphenidate at the time of the study. Six children in the intervention group and one in the waitlist control group received pharmacological treatment for ADHD (methylphenidate or atomoxetine) but were not medicated at the time of the intervention.

Measures

Working memory

The Working Memory Index (WMI) of the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler, 2005) was estimated. This is a measure of short-term memory and reflects the ability to temporarily retain information in memory, operate with it, and generate results. The index was

calculated using two tasks: Digit Span and Letter-Number Sequencing. During the Digit Span task, participants were required to listen to sequences of numbers and then repeat them. The sequences were to be recited in the order in which they were heard for the forward span, and in reverse order for the backward span. Conversely, the Letter-Number Sequencing task challenges the child to mentally organize a jumbled series of letters and numbers. They must sort out numbers in ascending order and letters alphabetically before verbally presenting an organized sequence. The Mexican adaptation of the scale was employed due to the linguistic and cultural similarities between Mexico and Colombia.

Inhibition

The Stroop Colour and Word Test (Golden, 2010) was used for this purpose. This consisted of three tasks: word reading, colour naming, and a final word-colour or interference task. In this task, participants were presented with words denoting colours, but these words were printed in the ink of a colour that did not match the word itself. The individual's challenge was to name the ink colour rather than the word itself. The degree of control exerted by the individual over the interference was quantified by calculating the interference score. This instrument has normative data for the Colombian population aged 6–17 years, and its reliability is good, as indicated by a Cronbach's alpha value exceeding 0.70 for the three test sheets (Arango et al., 2017).

Cognitive flexibility

The Modified Wisconsin Card Sorting Test (M-WCST; Schretlen, 2010) was used. The abbreviated version of the test consisted of 48 response cards and four stimulus cards. Participants were presented with a set of cards that varied in multiple dimensions, such as colour, shape, and number of symbols. Participants are required to sort the cards according to a rule that is not explicitly stated but must be derived from the feedback provided by the examiner following each sorting attempt. As the task progresses, the sorting rule changes without prior warning, requiring for participants to adapt their strategy in response to the new feedback. This effectively measures their ability to shift cognitive strategies and adapt to changing conditions. The test is scored based on three main performance parameters: total errors, perseverative errors, and categories completed. This instrument has normative data for the Colombian population aged 6–17 years and its reliability is good, as indicated by Cronbach's alpha ($\alpha = 0.83$) (Arango et al., 2017).

EF behaviors

The Behavior Rating Inventory of Executive Function (BRIEF-2) (Gioia et al., 2015; Maldonado et al., 2017) is a standardized rating scale for parents and teachers of

children aged 5–18 years. In this study, a Spanish version of the questionnaire was employed. Each item involved specific daily behaviors related to EF. The items were grouped into nine clinical scales, each measuring a different aspect of EF. These scales form three broader indices: the Behavior Regulation Index (BRI), the Emotion Regulation Index (ERI), and the Cognitive Regulation Index (CRI). The overall global executive function (GIEF) score was calculated based on the composite scores. In this study, we employed the clinical scales of inhibition, shift, and working memory, as well as the general indices (BRI, ERI, CRI, and GIEF) as dependent variables. The standard mean is 50 (SD = 10), with higher scores indicating more problems.

Intervention

The EF training programme, Braingame Brian, incorporates the training of three EF (cognitive flexibility, inhibition, and WM) in a game-like setting (Prins et al., 2013). The primary character of this video game universe is Brian, a creative child who enjoys inventing things. The training programme comprises 25 sessions, each lasting approximately 45 min, which the child plays over the course of nine weeks. The sessions were individual and took place two or three times per week in a quiet room. Three training tasks (WM, inhibition, and cognitive flexibility training) are performed in a fixed sequence over two blocks of time during each session. The degree of difficulty is automatically adjusted to the following block of tasks.

The game comprises seven worlds, each populated by characters facing a variety of challenges. By completing the training tasks, Brian assists these characters in resolving their issues, creating a variety of useful machines in the process. The child receives reinforcement for starting and finishing the training assignments.

The WM training involves a grid of rectangles, each lit up in a random order. At the first level, the child copies each sequence using a computer mouse to click on the rectangles in the proper sequence. In subsequent levels, the challenges become more complex (Dovis et al., 2008; Prins et al., 2013; Vugs et al., 2017). The game is graphically constructed to resemble a factory setting. In the inhibition training, children must react as quickly and accurately as possible to an arrow on a machine. A stimulus is illuminated on the left or right side of the device during the initial practice block of trials. In the "go trials," the youngster is required to click the left button in response to a stimulus that lights up on the left and the right button in response to a stimulus that lights up on the right. The amount of time that the youngster must answer is indicated by a stimulus at the top of the screen. In the following block, "stop trials" are presented. Once the stimulus has been presented, the child must cease responding when the stop signal is given (a tone and the machine's stimulus turning red) (Prins et al., 2013; Vugs et al., 2017).

Finally, in cognitive flexibility training, the child sorts out objects according to the instructions provided in a task graphically structured as a factory. The child was asked to sort out the objects in the two practice blocks, first by colour and then by shape. In subsequent blocks, the child is required to switch the rule of sorting out the components from colour to form or shape to colour. The response window is gradually shortened according to the child's proficiency in the task. The objective of the training is to decrease switching costs (Dovis et al., 2008; Prins et al., 2013; Vugs et al., 2017). For a more comprehensive description of the intervention programme, please refer to Prins et al. (2013).

Procedure

The study was carried out in four phases: (1) selection of participants, (2) pre-test assessment to establish a baseline, (3) intervention, and (4) post-test assessment. In the initial phase of the study, the children were initially assessed using the abbreviated version of the WISC-R (Wechsler, 1993), and the teachers completed the EDAH scale. Children who met the inclusion criteria were enrolled in this study. In the second phase of the study, the baseline of the research was established (pre-test). The children were assessed using cognitive tests of EF (WM, inhibition, and cognitive flexibility), and parents and teachers completed questionnaires regarding their behavior. Following the pre-test, the participants were divided into two groups: an intervention group and a control group in the waitlist condition. It was not possible to randomise the participants to groups.

In the third phase of the study, the intervention group received the EF training programme Braingame Brian. The intervention was conducted in an office environment that was conducive to the study's objectives, with minimal distractions. A computer was available for the exclusive use of the training program. During the intervention period, the waitlist group engaged in traditional pencil-and-paper cognitive stimulation exercises, while their parents received general information about the disorder and some tips for managing their children's behavior at home.

Finally, in the fourth phase, a post-test evaluation was conducted at the conclusion of the training period for both the intervention and waitlist groups using the same instruments administered for the baseline. On average, the post-test assessment was performed six weeks after the end of the intervention. Following this assessment, the children in the waitlist group also received intervention with the EF training programme Braingame Brian.

A total of 93 children were recruited for the study, of whom 41 met the inclusion criteria (see Figure 1). Twenty children were assigned to the treatment group, and 21 to the waitlist control group. Overall, one child in the treatment condition failed the criterion for at least 20 of the 25 training sessions (Klingberg et al., 2005; van der Oord et al., 2014). Furthermore, six children in the waitlist

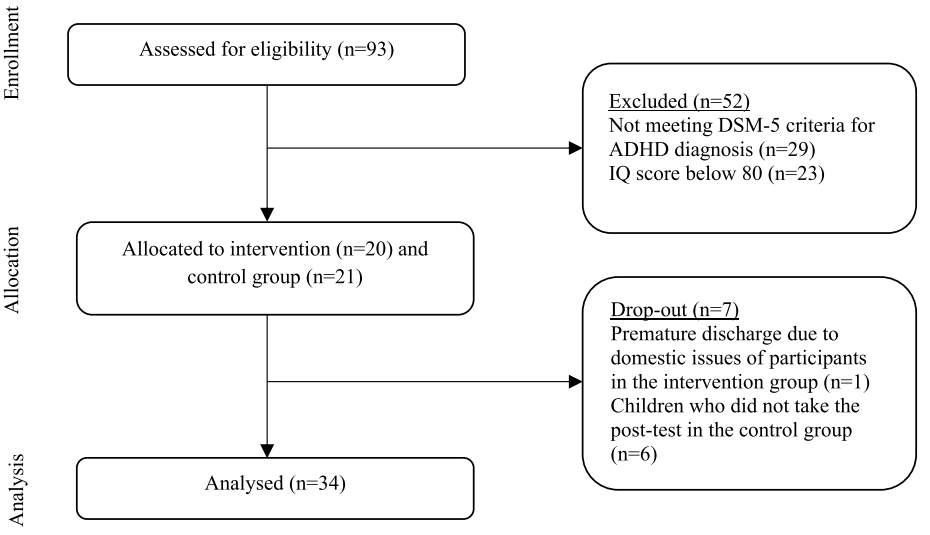

Figure 1. CONSORT flow diagram.

control group did not agree to undergo the post-test or did not complete the entire process, resulting in the exclusion of their scores from the analyses. Consequently, the total sample size for the analyses was 19 for the intervention group and 15 for the waitlist control condition.

All phases of the study were conducted by an expert neuropsychologist with over 12 years of experience. During both the treatment and waitlist periods, the dose of pharmacological treatment was maintained stable for children who were receiving medication.

The authors assert that all procedures adhere to the ethical standards established by the pertinent national and institutional committees overseeing human experimentation, in accordance with the principles outlined in the Helsinki Declaration. This study was approved by the Ethics Committee of Universidad del Norte (Act No. 197).

Statistical analyses

The data were systematised and processed using SPSS version 27. Descriptive statistics were calculated for all variables. To determine whether the EF training programme Braingame Brian improved WM, inhibition, and cognitive flexibility in children with ADHD, a 2×2 repeated-measures analysis of variance (ANOVA) was performed. This involved two groups (intervention and control groups) and two evaluation times (pre-test and post-test). The dependent variables were the cognitive tasks of EF and behavioral ratings, as previously described. The group $\times$ time interaction effects and main effects were estimated separately for the dependent variables of the study, and pairwise comparisons were performed for the main and interaction effects by post-hoc

analyses using the Bonferroni adjustment. The effect sizes for all estimates were assessed.

Results

Table 1 provides the main descriptive data for participants' EF baseline in both the intervention and control groups, and the post-test results of both groups.

Trained EF outcomes

The results of the repeated-measures ANOVA for the evaluation of WM, inhibition, and cognitive flexibility showed group-by-time interactions in four of the measures, validating that the increase in scores over time occurred only in the intervention group (see Table 2 and Figure 2).

Inhibition

There was a significant group × time interaction in the interference score for the Stroop task [$F\ (1,\ 32) = 5.008$, $p < .05$, $\eta_p^2 = 0.58$], with a large effect size. This

Table 1. Descriptive data of scores at pre-test and post-test for children in the EF-Training Condition (intervention group) and the Waitlist Condition (control group).

	Pre-test				Post-test			
	CG		IG		CG		IG	
	M	SD	M	SD	M	SD	M	SD
Stroop_INT	48.7	22.2	42.1	18.1	52.0	27.6	67.6	26
M-WCST categories	45.3	29.0	39.9	35.3	37.3	30.9	67.7	20.4
M-WCST Errors	37.0	22.5	37.4	29.6	35.0	27.7	54.7	21.2
M-WCST Perseverative errors	42.0	15.7	54.2	21.2	62.0	21.4	57.3	17.9
WMI	85.1	10.3	86.9	19.6	82.1	9.1	105.6	11.1
Brief-2								
BRI _F	69.1	9.4	68.2	10.1	65.7	13.7	59.6	10.4
ERI_F	66.1	11.7	63.7	13.0	65.1	14.8	54.4	10.7
CRI_F	62.0	10.1	67.4	9.4	60.9	12.7	58.8	7.4
GIEF_F	66.6	9.4	69.2	8.9	64.8	12.8	59.0	8.4
Inhibit_F	68.7	10.9	67.8	10.4	63.9	14.3	59.7	10.3
Shift_F	60.3	12.9	60.6	13.5	58.8	17.5	54.5	6.9
Working Memory_F	62.7	11.5	68.3	10.8	62.0	13.4	61.8	10.7
BRI _T	63.8	11.1	72.6	15.9	63.0	12.5	57.6	9.3
ERI_T	61.3	12.4	70.2	14.1	60.3	11.2	52.9	9.0
CRI_T	64.7	12.7	64.8	13.7	63.1	13.2	53.7	7.4
GIEF_T	65.4	11.3	70.2	14.7	64.1	10.2	54.7	7.6
Inhibit_T	63.5	13.7	71.8	15.7	61.5	13.9	57.6	11.1
Shift_T	60.3	11.8	67.1	13.1	61.3	11.8	53.0	12.0
Working Memory_T	67.6	11.9	65.3	13.1	67.6	12.8	54.6	7.9

IG: Intervention group; CG: Control group in the waitlist condition; WMI: Working Memory Index; Stroop INT: PC score in the interference measure of the Stroop task; BRI_F: Brief-2 family Behavioral Regulation Index; ERI _F: Brief-2 family Emotional Regulation Index; CRI _F: Brief-2 family Cognitive Regulation Index; GIEF _F: Brief-2 family Global Index of Executive Function; BRI_T: Brief-2 teacher Behavioral Regulation Index; ERI _T: Brief-2 teacher Emotional Regulation Index; CRI _T: Brief-2 teacher Cognitive Regulation Index; GIEF _T: Brief-2 teacher Global Index of Executive Function.

Table 2. Results of ANOVAs of repeated measures for EF cognitive tasks.

Factor	Variable	*F*	Sig.	Partial eta squared
Time	Stroop INT	8.469	**.007****	.806
	M-WCST Categories	3.359	.076	.428
	M-WCST Errors	2.939	.096	.383
	M-WCST Perseverative errors	5.991	**.020***	.660
	WMI	9.884	**.004****	.862
Group	Stroop INT	.491	.488	.104
	M-WCST Categories	2.131	.154	.294
	M-WCST Errors	1.751	.195	.250
	M-WCST Perseverative errors	.658	.423	.123
	WMI	10.098	**.003****	.869
Time × Group	Stroop INT	5.008	**.032***	.583
	M-WCST Categories	10.874	**.002****	.892
	M-WCST Errors	4.668	**.038***	.554
	M-WCST Perseverative errors	3.169	.085	.408
	WMI	19.172	**.000****	.989

WMI: Working Memory Index; Stroop INT: PC score in the interference measure of the Stroop task.
*$p < .05$, **$p < .01$.

interaction indicates a larger increase in inhibition scores over time in the intervention group than in the control group.

Cognitive flexibility

No interaction effect of group × time was found on the number of perseverative errors in the M-WCST, a measure of cognitive flexibility. However, there was a significant group × time interaction in M-WCST scores in terms of the number of categories achieved [F (1, 32) = 10.874, $p < .05$, $\eta_p^2 = 0.89$] and the number of errors [F (1, 32) = 4.668, $p < .05$, $\eta_p^2 = 0.55$]. The effect sizes of these interactions were large. These interactions indicate larger increases in cognitive scores over time in the intervention group than in the control group.

Working memory

There was a significant group × time interaction in the working memory index score (WMI) [F (1, 32) = 19.172, $p < .05$, $\eta_p^2 = 0.98$], with a large effect size. This interaction indicates a larger increase in WMI score over time in the intervention group than in the control group.

Behavioral ratings outcomes

Brief-2 family

Significant interaction effects were only found in three of the indices of the Brief-2 Family test (see Table 3 and Figure 3). The results of the interaction effects are as follows:

Emotion regulation index (ERI). There was a significant group × time interaction in the ERI score of the Brief-2 family [F(1, 32) = 6.729, $p < .05$, $\eta_p^2 = 0.71$], with a

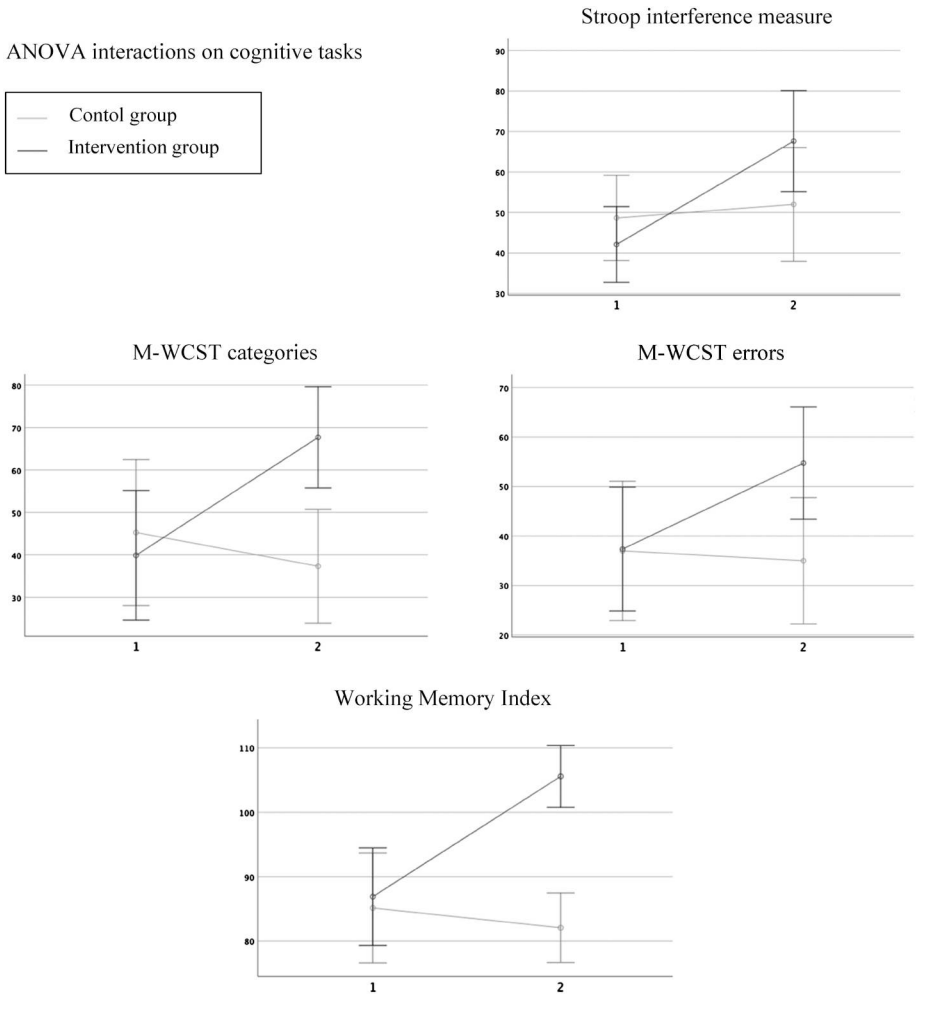

Figure 2. ANOVA interactions on cognitive tasks.

large effect size. This interaction indicates a larger decrease in the ERI score over time in the intervention group than in the control group.

Cognitive Regulation Index (CRI). There was a significant group × time interaction in the CRI score of the Brief-2 family [$F(1, 32) = 6.820$, $p < .05$, $\eta_p^2 = 0.71$], with a large effect size. This result indicates a larger decrease in the CRI score over time in the intervention group than in the control group.

Global Index of Executive Functioning (GIEF). There was a significant group × time interaction in the GIEF score of the Brief-2 family [$F(1, 32) = 8.55$, $p < .05$, $\eta_p^2 = 0.81$], with a large effect size. This interaction indicates a larger decrease in the GIEF score over time in the intervention group than in the control group.

Table 3. Results of ANOVAs of repeated measures for Brief-2 Family.

Factor	Variable	*F*	Sig.	Partial eta squared
Time	Indices			
	BRI	13.095	**.001****	.939
	ERI	10.059	**.003****	.868
	CRI	11.605	**.002****	.910
	GIEF	17.506	**.000****	.982
	Clinical Scales			
	Inhibit	11.302	**.002****	.903
	Shift	4.493	**.042***	.538
	Working memory	5.047	**.032***	.587
Group	Indices			
	BRI	1.046	.314	.168
	ERI	2.626	.115	.349
	CRI	.298	.589	.083
	GIEF	.275	.604	.080
	Clinical Sales			
	Inhibit	.554	.462	.112
	Shift	.330	.570	.086
	Working memory	.552	.463	.111
Time × Group	Indices			
	BRI	2.387	.132	.323
	ERI	6.729	**.014***	.711
	CRI	6.820	**.014***	.717
	GIEF	8.552	**.006****	.809
	Clinical Scales			
	Inhibit	.759	.390	.135
	Shift	1.030	.318	.166
	Working memory	3.327	.078	.424

BRI: Behavioral Regulation Index; ERI: Emotional Regulation Index; CRI: Cognitive Regulation Index; GIEF: Global Index of Executive Function.
*$p < .05$; **$p < .01$.

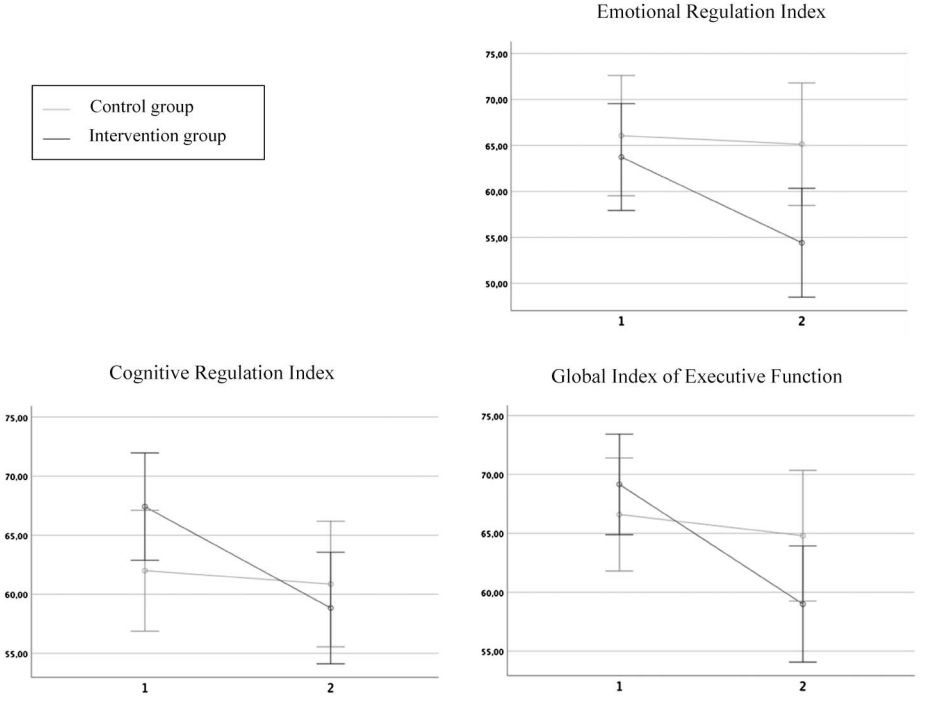

Figure 3. ANOVA interactions on Brief-2 Family.

Brief-2 teachers

Significant interaction effects were found for all the major indices and clinical scales (see Table 4 and Figure 4). The results of the interaction effects are as follows:

Behavioral Regulation Index (BRI). There was a significant group × time interaction in the BRI score of the Brief-2 teachers [$F(1, 32) = 9.054$, $p < .05$, $\eta_p^2 = 0.215$], with a large effect size. This interaction indicates a larger decrease in the BRI score over time in the intervention group than in the control group.

Emotional Regulation Index (ERI). There was a significant group × time interaction in the ERI score of Brief-2 teachers [$F(1, 32) = 10.905$, $p < .05$, $\eta_p^2 = 0.248$] with a large effect size. This interaction indicates a larger decrease in the ERI score over time in the intervention group than in the control group.

Cognitive Regulation Index (CRI). There was a significant group × time interaction in the CRI score of Brief-2 teachers [$F(1, 32) = 7.257$, $p < .05$, $\eta_p^2 = 0.180$] with a large effect size. This interaction indicates a larger decrease in the CRI score over time in the intervention group than in the control group.

Table 4. Results of ANOVAs of repeated measures for Brief-2 Teachers.

Factor	Variable	*F*	Sig.	Partial eta squared
Time	Indices			
	BRI	11.239	**.002****	0.25
	ERI	13.563	**.001****	0.29
	CRI	12.754	**.001****	0.27
	GIEF	15.267	**.000****	0.31
	Clinical Scales			
	Inhibit	10.656	**.003****	0.24
	Shift	7.609	**.009****	0.18
	Working memory	9.005	**.005****	0.21
Group	Indices			
	BRI	0.232	.634	.007
	ERI	0.059	.809	.002
	CRI	1.636	.210	.047
	GIEF	0.522	.475	.016
	Clinical Scales			
	Inhibit	0.310	.581	.009
	Shift	0.050	.825	.002
	Working memory	4.756	**.036**	.126
Time × Group	Indices			
	BRI	9.054	**.005****	.215
	ERI	10.905	**.002****	.248
	CRI	7.257	**.011***	.180
	GIEF	10.865	**.002****	.248
	Clinical Scales			
	Inhibit	6.130	**.019***	.157
	Shift	10.108	**.003****	.234
	Working memory	9.218	**.005****	.218

BRI: Behavioral Regulation Index; ERI: Emotional regulation Index; CRI: Cognitive regulation Index; GIEF: Global index of executive function.
*$p < .05$; **$p < .01$.

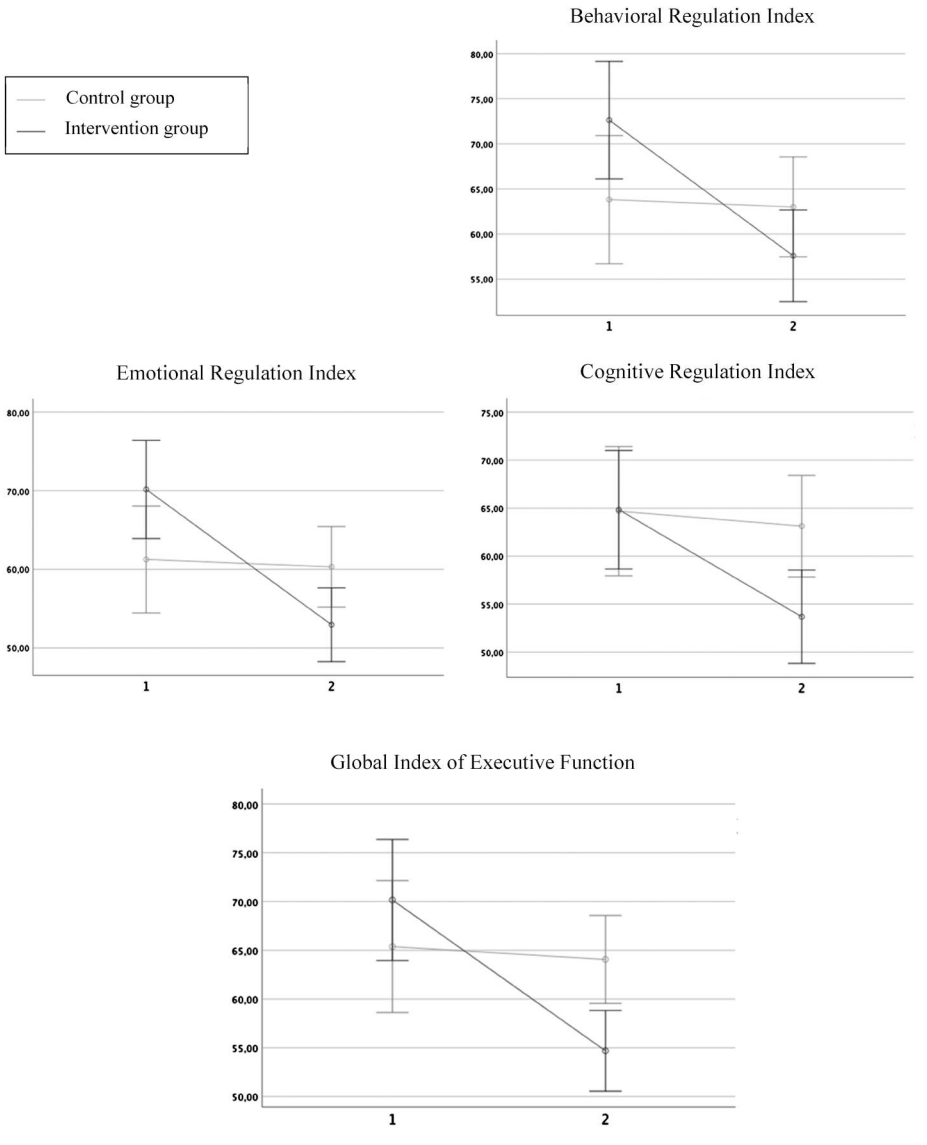

Figure 4. ANOVA interactions on Brief-2 Teachers.

Global Index of Executive Functioning (GIEF). There was a significant group × time interaction in the GIEF score of Brief-2 teachers [$F(1, 32) = 10.865$, $p < .05$, $\eta_p^2 = 0.248$] with a large effect size. This interaction indicates a larger decrease in the GIEF score over time in the intervention group than in the control group.

Clinical scales of the Brief-2 Teachers. There was a significant group × time interaction in the scores of the clinical scales of inhibition, flexibility, and WM (see Table 4) with large effect sizes. These interactions indicate a larger decrease in these clinical scale scores over time in the intervention group than in the control group, which

showed better ability to control impulses, regulate behavior, stop behavior, be cognitively flexible, and temporarily keep information in mind to complete a task.

Discussion

In individuals with ADHD, impairments in WM, cognitive flexibility, and inhibition are common, and these can contribute to challenges in academic and daily functioning (Dahlin, 2013; Holmes & Gathercole, 2014; Nigg et al., 2008; Söderqvist & Bergman Nutley, 2015). Braingame Brian is a training program for EF that has garnered recognition as a tool to enhance cognitive abilities in individuals with ADHD and other disorders (Bul et al., 2016; Dovis et al., 2015; Kramer et al., 2020; Prins et al., 2011; van der Oord et al., 2014; Vugs et al., 2017) and has also been used for this purpose in neurotypical individuals (Kramer, 2018). However, the scientific evidence supporting the efficacy of the Braingame Brian program specifically for ADHD is limited.

This pilot study is the first to explore the potential of Braingame Brian for EF improvement in a clinical sample of Spanish-speaking children diagnosed with ADHD and adds to the available evidence of its feasibility for enhancing EF. Children who followed the intervention program showed improvement in cognitive measures of WM and inhibition and in behavioral measures of EF compared to children in the waitlist condition, with moderate to large post-test effect sizes. Thus, our results are comparable to the findings of Dovis et al. (2015), Klingberg et al. (2005), Dunning and Holmes (2014), and Hovik et al. (2013) in studies conducted in other latitudes. Although, in our research, the cognitive measure of WM used was verbal, the training proved to improve this process, similar to that reported by Dovis et al. (2015). In this regard, Klingberg et al. (2005) found that computerized training of visual WM also has a generalizing influence on untrained EFs such as verbal WM and advanced reasoning.

Although in our study we did not perform medium-term follow-up measurements, some studies have found that WM training programs have improved performance on a variety of WM and cognitive measures after 20 training sessions (Wiest et al., 2020), with sustained improvements observed over a six-month period (Gathercole et al., 2019). Therefore, the beneficial effects of the post-test found in this study are expected to persist and may even stabilize after training (Holmes et al., 2009; Holmes et al., 2010; Klingberg et al., 2005; Vugs et al., 2017). Further studies are required to confirm this assumption.

The observed enhancement of WM following training in the sample studied is particularly relevant, considering that, in previous studies, improvements in WM in individuals with ADHD have been associated with improvements in most EF assessed by neuropsychological tests (Capodieci et al., 2018), which have positive effects on people's daily lives (Beck et al., 2010; Bigorra et al., 2016a, 2016b; Dahlin, 2013; Holmes & Gathercole, 2014; Muris et al., 2018; Söderqvist & Bergman Nutley, 2015; van Dongen-Boomsma et al., 2014). Lee

et al. (2022) have shown that after completing a WM training program, inattention in daily life improves considerably, which is consistent with the association previously described by Kofler et al. (2010) between WM impairments and inattention in children diagnosed with ADHD.

Unexpectedly, we found no significant changes on perseverative errors in the M-WCST, a measure of cognitive flexibility, although other studies have found an effect of treatment on cognitive flexibility after six weeks of training (Vugs et al., 2017). However, the effect size observed in this task is clinically important as it is a moderate effect, although not statistically significant, considering that the sample size in this study was small.

A significant improvement was observed in the scores of the main indices of the Brief-2 parents and teachers, as well as in the clinical subscales of Inhibition, Shift, and WM in the teacher report. We found no significant changes in the WM, Inhibition, and Shift subscale scores of the Brief-2 Family following the training period. This highlights the importance of considering multiple informants in assessing the efficacy of interventions as it provides a broader, more balanced view of a child's progress and the generalizability of treatment effects across different settings.

The results of this study suggest that specific EF like WM, cognitive flexibility, and inhibition may be enhanced in Spanish-speaking children with ADHD through computerized interventions such as Braingame Brian (Prins et al., 2011, 2013), but it's essential to consider the broader context of these findings. The field has expressed concerns regarding the generalizability and efficacy of such computerized cognitive training programs. Critics argue that while these interventions may show efficacy in controlled experimental settings, their benefits might not extend as effectively to real-world scenarios. Additionally, the motivation and engagement elicited by gamified elements in cognitive training could contribute positively, yet the long-term retention of skills and their practical application outside of the training context remain uncertain (Westwood et al., 2023). Therefore, while initial results are promising, further research is necessary to confirm these findings and to explore how they translate into everyday functional improvements for children with ADHD.

Regarding the limitations of the study, it was not possible to randomly assign participants to the intervention and waitlist conditions because the research was conducted during the COVID-19 pandemic, which posed significant challenges. Therefore, the assignment of children to the intervention group depended on parental decisions to participate in the program under the given circumstances and adherence to biosafety protocols. Alternatively, they could choose to be placed in the waitlist group and receive the intervention at a later stage. It is important to note that this study had a relatively small sample size and lacked a structured blind design (teachers/parents were not blind to the intervention) and follow-up measures.

The limited sample size of this study prevented us from generalizing the favourable results of the Braingame Brian EF training program. It is essential for subsequent research to replicate positive findings using larger samples and employ more robust methodologies, such as a randomized double-blind design, with extended follow-up periods. Future studies should investigate the specific effects of each component of EF training on daily life activities such as academic performance. Given the diversity of neurocognitive profiles in ADHD, it is crucial to understand which EF training component is the most effective for children with a particular executive functioning profile.

Another limitation of our study is the absence of a placebo control group due to the limitations imposed by the COVID-19 pandemic. Placebo control is a standard practice in cognitive training because of the prevalent placebo effects driven by expectations and motivation, which can confound the interpretation of an intervention's efficacy (Wager & Jung, 2022). While our pilot study was designed to explore the potential use of the Braingame Brian program among Spanish-speaking children with ADHD to improve EFs, this limitation restricts our ability to ascertain the program's efficacy definitively. Nonetheless, these findings provide valuable preliminary insights into its potential applicability and suggest directions for future research. To enhance the rigour of these findings, future studies should include a placebo control group to better evaluate the specific effects of the intervention.

In conclusion, the results of this pilot study suggest that the Braingame Brian EF intervention for Spanish-speaking children with ADHD provides a promising way to offer non-pharmacological adjunctive treatment, aiming to improve central deficits in EFs, thereby enhancing daily functioning. This training program should be viewed as part of a professionally guided care process, preceded by an EF assessment, followed by a contextualized, multi-component approach (Chronis et al., 2006). It is not a substitute for evidence-based forms of intervention in ADHD (e.g., pharmacological treatment and behavioral therapy) but could be integrated with these and other intervention methods (e.g., psychoeducation and parent or teacher training).

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Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Data deposition

The data was not stored in a public data repository and is only accessible upon request from the corresponding author.

Author contribution

NR planned and conducted experiments. KG performed statistical analyses. NR, KG, TI, and SL wrote and revised the manuscript before submission.

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References

Adamo, N., Seth, S., & Coghill, D. (2015). Pharmacological treatment of attention-deficit/hyperactivity disorder: Assessing outcomes. *Expert Review of Clinical Pharmacology*, *8*(4), 383–397. https://doi.org/10.1586/17512433.2015.1050379

Adler, L. D., & Nierenberg, A. A. (2010). Review of medication adherence in children and adults with ADHD. *Postgraduate Medicine*, *122*(1), 184–191. https://doi.org/10.3810/pgm.2010.01.2112

American Psychiatric Association (APA). (2013). *Diagnostic and statistical manual of mental disorders (5th ed.): DSM-5*. American Psychiatric Association.

Arán-Filippetti, V., & Richaud de Minzi, M. C. (2011). Efectos de un programa de intervención para aumentar la reflexividad y la planificación en un ámbito escolar de alto riesgo por pobreza. *Universitas Psychologica*, *10*(2), 341–354. https://doi.org/10.11144/Javeriana.upsy10-2.epia

Arango, J. C., Rivera, D., & Olabarrieta, L. (2017). *Neuropsicología infantil*. Manual Moderno.

Baddeley, A. (1992). Working memory. *Science*, *255*(5044), 556–559. https://doi.org/10.1126/science.1736359

Baddeley, A. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, *4*(11), 417–423. https://doi.org/10.1016/S1364-6613(00)01538-2

Baddeley, A. (2003). Working memory and language: An overview. *Journal of Communication Disorders*, *36*(3), 189–208. https://doi.org/10.1016/S0021-9924(03)00019-4

Baddeley, A. (2007). *Working memory, thought, and action* (1st ed.). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198528012.001.0001

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65–94. https://doi.org/10.1037/0033-2909.121.1.65

Barkley, R., & Murphy, K. (2010). Impairment in occupational functioning and adult ADHD: The predictive utility of executive function (EF) ratings versus EF tests. *Archives of Clinical Neuropsychology*, *25*(3), 157–173. https://doi.org/10.1093/arclin/acq014

Beck, S. J., Hanson, C. A., Puffenberger, S. S., Benninger, K. L., & Benninger, W. B. (2010). A CGled trial of working memory training for children and adolescents with ADHD. *Journal of Clinical Child & Adolescent Psychology*, *39*(6), 825–836. https://doi.org/10.1080/15374416.2010.517162

Bigorra, A., Garolera, M., Guijarro, S., & Hervas, A. (2016a). Impact of working memory training on hot executive functions (decision-making and theory of mind) in children with ADHD: A randomized CGled trial. *Neuropsychiatry*, *6*(5), 251–263. https://doi.org/10.4172/Neuropsychiatry.1000147

Bigorra, A., Garolera, M., Guijarro, S., & Hervás, A. (2016b). Long-term far-transfer effects of working memory training in children with ADHD: A randomized CGled trial. *European Child & Adolescent Psychiatry*, *25*(8), 853–867. https://doi.org/10.1007/s00787-015-0804-3

Briars, L., & Todd, T. (2016). A review of pharmacological management of attention-deficit/hyperactivity disorder. *The Journal of Pediatric Pharmacology and Therapeutics*, *21*(3), 192–206. https://doi.org/10.5863/1551-6776-21.3.192

Brown, T. E. (2009). ADD/ADHD and impaired executive function in clinical practice. *Current Attention Disorders Reports*, *1*(1), 37–41. https://doi.org/10.1007/s12618-009-0006-3

Bul, K. C., Kato, P. M., Van der Oord, S., Danckaerts, M., Vreeke, L. J., Willems, A., van Oers, H. J., Van Den Heuvel, R., Birnie, D., Van Amelsvoort, T. A., Franken, I. H., & Maras, A. (2016). Behavioral outcome effects of serious gaming as an adjunct to treatment for children with attention-deficit/hyperactivity disorder: A randomized controlled trial. *Journal of Medical Internet Research*, *18*(2), e26. https://doi.org/10.2196/jmir.5173

Capodieci, A., Gola, M. L., Cornoldi, C., & Re, A. M. (2018). Effects of a working memory training program in preschoolers with symptoms of attention-deficit/hyperactivity disorder. *Journal of Clinical and Experimental Neuropsychology*, *40*(1), 17–29. https://doi.org/10.1080/13803395.2017.1307946

Cepeda, N. J., Cepeda, M. L., & Kramer, A. F. (2000). Task switching and attention deficit hyperactivity disorder. *Journal of Abnormal Child Psychology*, *28*(3), 213–226. https://doi.org/10.1023/A:1005143419092

Chronis, A. M., Jones, H. A., & Raggi, V. L. (2006). Evidence-based psychosocial treatments for children and adolescents with attention-deficit/hyperactivity disorder. *Clinical Psychology Review*, *26*(4), 486–502. https://doi.org/10.1016/j.cpr.2006.01.002

Coghill, D. R., Seth, S., & Matthews, K. (2014a). A comprehensive assessment of memory, delay aversion, timing, inhibition, decision making and variability in attention deficit hyperactivity disorder: Advancing beyond the three-pathway models. *Psychological Medicine*, *44*(9), 1989–2001. https://doi.org/10.1017/S0033291713002547

Coghill, D. R., Seth, S., Pedroso, S., Usala, T., Currie, J., & Gagliano, A. (2014b). Effects of methylphenidate on cognitive functions in children and adolescents with attention-deficit/hyperactivity disorder: Evidence from a systematic review and a meta-analysis. *Biological Psychiatry*, *76*(8), 603–615. https://doi.org/10.1016/j.biopsych.2013.10.005

Connor, D. (2015). Stimulant and nonstimulant medications for childhood ADHD. In R. A. Barkley (Ed.), *Attention-Deficit/Hyperactivity disorder: A handbook for diagnosis and treatment* (pp. 666–685). Guilford Press.

Cook, N. E., Braaten, E. B., & Surman, C. B. (2018). Clinical and functional correlates of processing speed in pediatric attention-deficit/hyperactivity disorder: A systematic review and meta-analysis. *Child Neuropsychology*, *24*(5), 598–616. https://doi.org/10.1080/09297049.2017.1307952

Cortese, S., Adamo, N., del Giovane, C., Mohr-Jensen, C., Hayes, A. J., Carucci, S., Atkinson, L. Z., Tessari, L., Banaschewski, T., Coghill, D., Hollis, C., Simonoff, E., Zuddas, A., Barbui, C., Purgato, M., Steinhausen, H. C., Shokraneh, F., Xia, J., & Cipriani, A. (2018). Comparative efficacy and tolerability of medications for attention-deficit hyperactivity disorder in children, adolescents, and adults: A systematic review and network meta-analysis. *The Lancet Psychiatry*, *5*(9), 727–738. https://doi.org/10.1016/S2215-0366(18)30269-4

Cortese, S., Ferrin, M., Brandeis, D., Buitelaar, J., Daley, D., Dittmann, R. W., & European ADHD Guidelines Group (EAGG) (2015). Cognitive training for attention-deficit/hyperactivity disorder: Meta-analysis of clinical and neuropsychological outcomes from randomized CGled trials. *Journal of the American Academy of Child and Adolescent Psychiatry*, *54*(3), 164–174. https://doi.org/10.1016/j.jaac.2014.12.010

Cortese, S., Holtmann, M., Banaschewski, T., Buitelaar, J., Coghill, D., Danckaerts, M., Graham, J., Taylor, E., & Sergeant, J. (2013). Practitioner review: Current best practice in the management of adverse events during treatment with ADHD medications in children and adolescents. *Journal of Child Psychology and Psychiatry*, *54*(3), 227–246. https://doi.org/10.1111/jcpp.12036

Dahlin, K. I. E. (2013). Working memory training and the effect on mathematical achievement in children with attention deficits and special needs. *Journal of Education and Learning*, *2*(1), 118–133. https://doi.org/10.5539/jel.v2n1p118

Dovis, S., Geurts, H., Ponsioen, A., Ten Brink, E., Van der Oord, S., & Prins, P. J. M. (2008). *Executive function training tasks: Inhibition and cognitive flexibility. Theoretical background and parameters*. Task force ADHD & computer.

Dovis, S., Van del Oord, S., Wiers, R., & Prins, P. (2015). Improving executive functioning in children with ADHD: Training multiple executive functions within the context of a computer game. A randomized double-blind placebo-controlled trial. *PLoS One*, *10*(4), e0121651. https://doi.org/10.1371/journal.pone.0121651

Dunning, D. L., & Holmes, J. (2014). Does working memory training promote the use of strategies on untrained working memory tasks? *Memory & Cognition*, *42*(6), 854–862. https://doi.org/10.3758/s13421-014-0410-5

Epstein, J. N., Brinkman, W. B., Froehlich, T., Langberg, J. M., Narad, M. E., Antonini, T. N., Shiels, K., Simon, J. O., & Altaye, M. (2011). Effects of stimulant medication, incentives, and event rate on reaction time variability in children with ADHD. *Neuropsychopharmacology*, *36*(5), 1060–1072. https://doi.org/10.1038/npp.2010.243

Faraone, S. V., Banaschewski, T., Coghill, D., Zheng, Y., Biederman, J., Bellgrove, M. A., Newcorn, J. H., Gignac, M., Al Saud, N. M., Manor, I., Rohde, L. A., Yang, L., Cortese, S., Almagor, D., Stein, M. A., Albatti, T. H., Aljoudi, H. F., Alqahtani, M. M. J., Asherson, P., … Wang, Y. (2021). The world federation of ADHD international consensus statement: 208 evidence-based conclusions about the disorder. *Neuroscience and Biobehavioral Reviews*, *128*, 789–818. https://doi.org/10.1016/j.neubiorev.2021.01.022

Faraone, S. V., Bellgrove, M. A., Brikell, I., Cortese, S., Hartman, C., Hollis, C., Newcorn, J. H., Philipsen, A., Polanczyk, G. V., Rubia, K., Sibley, M. H., & Buitelaar, J. (2024). Attention-deficit/hyperactivity disorder. *Nature Reviews Disease Primers*, *10*(11). https://doi.org/10.1038/s41572-024-00495-0

Farré, A., & Narbona, J. (1998). *EDAH: Escalas para la evaluación del trastorno por déficit de atención con hiperactividad*. TEA Editions.

Gathercole, S. E., Dunning, D. L., Holmes, J., & Norris, D. (2019). Working memory training involves learning new skills. *Journal of Memory and Language*, *105*, 19–42. https://doi.org/10.1016/j.jml.2018.10.003

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2015). *BRIEF-2: Behavior rating inventory of executive function*. Psychological Assessment Resources.

Golden, C. (2010). *Stroop test de colores y palabras. Manual (5° Ed.)*. TEA Ediciones.

Gray, S. A., Chaban, P., Martinussen, R., Goldberg, R., Gotlieb, H., Kronitz, R., Hockenberry M., & Tannock, R. (2012). Effects of a computerized working memory training program on working memory, attention, and academics in adolescents with severe LD and comorbid ADHD: A randomized CGled trial. *Journal of Child Psychology and Psychiatry*, *53*(12), 1277–1284. https://doi.org/10.1111/j.1469-7610.2012.02592.x

Green, C. T., Long, D. L., Green, D., Iosif, A. M., Dixon, J. F., Miller, M. R., Fassbender, C., & Schweitzer, J. B. (2012). Will working memory training generalize to improve off-task behavior in children with attention-deficit/hyperactivity disorder? *Neurotherapeutics*, *9* (3), 639–648. https://doi.org/10.1007/s13311-012-0124-y

Griffiths, K. R., Leikauf, J. E., Tsang, T. W., Clarke, S., Hermens, D. F., Efron, D., Williams, L. M., & Kohn, M. R. (2018). Response inhibition and emotional cognition improved by atomoxetine in children and adolescents with ADHD: The ACTION randomized CGled trial. *Journal of Psychiatric Research*, *102*, 57–64. https://doi.org/10.1016/j.jpsychires.2018.03.009

Ho, D. E., Imai, K., King, G., & Stuart, E. A. (2007). Matching as nonparametric preprocessing forreducing model dependence in parametric causal inference. *Political Analysis*, *15*, 199–236. https://doi.org/10.1093/pan/mpl013

Hollis, C., Falconer, C. J., Martin, J. L., Whittington, C., Stockton, S., Glazebrook, C., & Davies, E. B. (2017). Annual research review: Digital health interventions for children and young people with mental health problems–a systematic and meta-review. *Journal of Child Psychology and Psychiatry*, *58*(4), 474–503. https://doi.org/10.1111/jcpp.12663

Holmes, J., & Gathercole, S. E. (2014). Taking working memory training from the laboratory into schools. *Educational Psychology*, *34*(4), 440–450. https://doi.org/10.1080/01443410.2013.797338

Holmes, J., Gathercole, S. E., & Dunning, D. L. (2009). Adaptive training leads to sustained enhancement of poor working memory in children. *Developmental Science*, *12*(4), F9–F15. https://doi.org/10.1111/j.1467-7687.2009.00848.x

Holmes, J., Gathercole, S. E., Place, M., Dunning, D. L., Hilton, K. A., & Elliott, J. G. (2010). Working memory deficits can be overcome: Impacts of training and medication on working memory in children with ADHD. *Applied Cognitive Psychology*, *24*(6), 827–836. https://doi.org/10.1002/acp.1589

Hovik, K. T., Saunes, B. K., Aarlien, A. K., & Egeland, J. (2013). RCT of working memory training in ADHD: Long-term near-transfer effects. *PLoS One*, *8*(12), e80561. https://doi.org/10.1371/journal.pone.0080561

Huizinga, M., Dolan, C. V., & Van der Molen, M. W. (2006). Age-related change in executive function: Developmental trends and a latent variable analysis. *Neuropsychologica*, *44*(11), 2017–2036. https://doi.org/10.1016/j.neuropsychologia.2006.01.010

Johnstone, S. J., Roodenrys, S., Phillips, E., Watt, A. J., & Mantz, S. (2010). A pilot study of combined working memory and inhibition training for children with AD/HD. *ADHD Attention Deficit and Hyperactivity Disorders*, *2*(1), 31–42. https://doi.org/10.1007/s12402-009-0017-z

Klingberg, T., Fernell, E., Olesen, P. J., Johnson, M., Gustafsson, P., Dahlström, K., Gillberg, C. G., Forssberg, H., & Westerberg, H. (2005). Computerized training of working memory in children with ADHD - A randomized, controlled trial. *Journal of the American Academy of Child & Adolescent Psychiatry*, *44*(2), 177–186. https://doi.org/10.1097/00004583-200502000-00010

Klingberg, T., Forssberg, H., & Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Experimental Neuropsychology*, *24*(6), 781–791. https://doi.org/10.1076/jcen.24.6.781.8395

Kofler, M. J., Rapport, M. D., Bolden, J., Sarver, D. E., & Raiker, J. S. (2010). ADHD and working memory: The impact of central executive deficits and exceeding storage/rehearsal capacity

on observed inattentive behavior. *Journal of Abnormal Child Psychology*, *38*(2), 149–161. https://doi.org/10.1007/s10802-009-9357-6

Kollins, S. H., DeLoss, D. J., Cañadas, E., Lutz, J., Findling, R. L., Keefe, R. S., Epstein, J. N., & Faraone, S. V. (2020). A novel digital intervention for actively reducing severity of paediatric ADHD (STARS-ADHD): a randomised controlled trial. *The Lancet Digital Health*, *2*(4), e168–e178. https://doi.org/10.1016/S2589-7500(20)30017-0

Kramer, J. (2018). *The effects of "Braingame Brian" on executive functions in typically developing children* [Master's thesis]. Radboud University. Radboud Educational Repository.

Kramer, J., Roelofs, R., Wingbermühle, P. A. M., Pieters, S., & Egger, J. I. M. (2020). Executive function training Braingame Brian in children with Noonan syndrome: A pilot study. *Journal of the International Neuropsychological Society*, *26*(2).

Kray, J., Karbach, J., Haenig, S., & Freitag, C. (2012). Can task-switching training enhance executive control functioning in children with attention deficit/-hyperactivity disorder? *Frontiers in Human Neuroscience*, *5*, 180. https://doi.org/10.3389/fnhum.2011.00180

Landínez-Martínez, D., Quintero-López, C., & Gil-Vera, V. (2022). Working memory training in children with attention deficit hyperactivity disorder: A systematic review. *Revista de Psicología Clínica con Niños y Adolescentes*, *9*(2), 73–83. https://doi.org/10.21134/rpcna.2022.09.3.7

Lee, S., Hill, T. R., Johnson, B., Testa, R., Priya, V., Spencer-Smith, M., & Coghill, D. (2022). Can neurocognitive outcomes assist measurement-based care for children with attention-deficit/hyperactivity disorder? A systematic review and meta-analyses of the relationships Among the changes in neurocognitive functions and clinical outcomes of attention-deficit/hyperactivity disorder in pharmacological and cognitive training interventions. *Journal of Child and Adolescent Psychopharmacology*, *32*(5), 250–277. https://doi.org/10.1089/cap.2022.0028

Levitt, K., & Felt, B. (2022). Child with attention deficit disorder/child with attention deficit hyperactivity disorder (ADHD). In D. M. Kamat & L. Sivaswamy (Eds.), *Symptom-based approach to pediatric neurology* (pp. 67–80). Springer. https://doi.org/10.1007/978-3-031-10494-7_5

London, A. S., & Landes, S. D. (2021). Cohort change in the prevalence of ADHD among U.S. adults: Evidence of a gender-specific historical period effect. *Journal of Attention Disorders*, *25*(6), 771–782. https://doi.org/10.1177/1087054719855689

Lopera, J. (2008). Funciones ejecutivas: Aspectos clínicos. *Revista Neuropsicología, Neuropsiquiatría y Neurociencias*, *8*(1), 59–76.

Maldonado, M. J., Fournier, C., Martínez, R., González, J., Espejo-Saavedra, J. M., & Santamaría, P. (2017). *BRIEF-2. Evaluación conductual de La función ejecutiva* [BRIEF-2. Behavioral assessment of the executive functioning]. TEA Editions.

Marx, I., Hacker, T., Yu, X., Cortese, S., & Sonuga-Barke, E. (2021). ADHD and the choice of small immediate over larger delayed rewards: A comparative meta-analysis of performance on simple choice-delay and temporal discounting paradigms. *Journal of Attention Disorders*, *25*(2), 171–187. https://doi.org/10.1177/1087054718772138

McInnes, A., Humphries, T., Hogg-Johnson, S., & Tannock, R. (2003). Listening comprehension and working memory are impaired in attention-deficit hyperactivity disorder irrespective of language impairment. *Journal of Abnormal Child Psychology*, *31*(4), 427–443. https://doi.org/10.1023/A:1023895602957

Melby-Lervåg, M., & Hulme, C. (2013). Is working memory training effective? A meta-analytic review. *Developmental Psychology*, *49*(2), 270–291. https://doi.org/10.1037/a0028228

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contribution to complex "frontal lobe"

tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Molina, B. S. G., Hinshaw, S. P., Swanson, J. M., Arnold, L. E., Vitiello, B., Jensen, P. S., Epstein, J. N., Hoza, B., Hechtman, L., Abikoff, H. B., Elliott, G. R., Greenhill, L. L., Newcorn, J. H., Wells, K. C., Wigal, T., Gibbons, R. D., Hur, K., & Houck, P. R. (2009). The MTA at 8 years: Prospective follow-up of children treated for combined-type ADHD in a multisite study. *Journal of the American Academy of Child & Adolescent Psychiatry*, *48*(5), 484–500. https://doi.org/10.1097/CHI.0b013e31819c23d0

Monsell, S. (2003). Task switching. *Trends in Cognitive Sciences*, *7*(3), 134–140. https://doi.org/10.1016/S1364-6613(03)00028-7

Mulraney, M., & Coghill, D. (2018). Quality of life and impairment in ADHD. In T. Banaschewski, D. Coghill, & A. Zuddas (Eds.), *Oxford textbook of attention deficit hyperactivity disorder* (pp. 161–169). Oxford University Press.

Muris, P., Roodenrijs, D., Kelgtermans, L., Sliwinski, S., Berlage, U., Baillieux, H., Deckers, A., Gunther, M., Paanakker, B., & Holterman, I. (2018). No medication for My child! A naturalistic study on the treatment preferences for and effects of cogmed working memory training versus psychostimulant medication in clinically referred youth with ADHD. *Child Psychiatry & Human Development*, *49*(6), 974–992. https://doi.org/10.1007/s10578-018-0812-x

National Institute for Health and Care excellence (NICE). (2019). *Attention deficit hyperactivity disorder: Diagnosis and management*.

Ng, Q. X. (2017). A systematic review of the Use of bupropion for attention-deficit/hyperactivity disorder in children and adolescents. *Journal of Child and Adolescent Psychopharmacology*, *27*(2), 112–116. https://doi.org/10.1089/cap.2016.0124

Nigg, J. T., Knottnerus, G. M., Martel, M. M., Nikolas, M., Cavanagh, K., Karmaus, W., & Rappley, M. D. (2008). Low blood lead levels associated with clinically diagnosed attention-deficit/hyperactivity disorder and mediated by weak cognitive control. *Biological Psychiatry*, *63*(3), 325–331. https://doi.org/10.1016/j.biopsych.2007.07.013

Oosterlaan, J., Logan, G. D., & Sergeant, J. A. (1998). Response inhibition in AD/HD, CD, comorbid AD/HD + CD, anxious, and CG children: A meta-analysis of studies with the stop task. *Journal of Child Psychology and Psychiatry*, *39*(3), 411–425. https://doi.org/10.1111/1469-7610.00336

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry*, *37*(1), 51–87. https://doi.org/10.1111/j.1469-7610.1996.tb01380.x

Pineda, D. A., Puerta, I. C., Aguirre, D. C., García-Barrera, M. A., & Kamphaus, R. W. (2007). The role of neuropsychologic tests in the diagnosis of attention deficit hyperactivity disorder. *Pediatric Neurology*, *36*(6), 373–381. https://doi.org/10.1016/j.pediatrneurol.2007.02.002

Portellano, J. A., & García, J. (2014). Principios de rehabilitación neuropsicológica. In J. A. En Portellano & J. García (Eds.), *Neuropsicologia de la atención, las funciones ejecutivas y la memoria* (pp. 43–72). Síntesis.

Prins, P. J., Dovis, S., Ponsioen, A., ten Brink, E., & van der Oord, S. (2011). Does computerized working memory training with game elements enhance motivation and training efficacy in children with ADHD? *Cyberpsychology, Behavior, and Social Networking*, *14*(3), 115–122. https://doi.org/10.1089/cyber.2009.0206

Prins, P. J., Ten Brink, E., Dovis, S., Ponsioen, A., Geurts, H. M., De Vries, M., & Van Der Oord, S. (2013). "Braingame Brian": toward an executive function training program with game elements for children with ADHD and cognitive control problems. *Games for Health Journal*, *2*(1), 44–49. https://doi.org/10.1089/g4h.2013.0004

Rabipour, S., & Raz, A. (2012). Training the brain: Fact and fad in cognitive and behavioral remediation. *Brain and Cognition*, *79*(2), 159–179. https://doi.org/10.1016/j.bandc.2012.02.006

Rapport, M. D., Orban, S. A., Kofler, M. J., & Friedman, L. M. (2013). Do programs designed to train working memory, other executive functions, and attention benefit children with ADHD? A meta-analytic review of cognitive, academic, and behavioral outcomes. *Clinical Psychology Review*, *33*(8), 1237–1252. https://doi.org/10.1016/j.cpr.2013.08.005

Roberts, B. A., Martel, M. M., & Nigg, J. T. (2017). Are there executive dysfunction subtypes within ADHD? *Journal of Attention Disorders*, *21*(4), 284–293. https://doi.org/10.1177/1087054713510349

Robledo-Castro, C., Lerma-Castaño, P. R., & Bonilla-Santos, G. (2023). Effect of cognitive training programs based on computer systems on executive functions in children with ADHD: A systematic review. *Journal of Attention Disorders*, *27*(13), 1467–1487. https://doi.org/10.1177/10870547231187164

Romero-Ayuso, D. M., Maestú, F., González-Marqués, J., Romo-Barrientos, C., & Andrade, J. M. (2006). Disfunción ejecutiva en el trastorno por déficit de atención con hiperactividad en la infancia. *Revista de Neurología*, *42*(5), 265–271. https://doi.org/10.33588/rn.4205.2004566

Rosa, V. O., Schmitz, M., Moreira-Maia, C. R., Wagner, F., Londero, I., Bassotto, C. F., Moritz, G., de Souza, C. D. S., & Rohde, L. A. P. (2017). Computerized cognitive training in children and adolescents with attention deficit/hyperactivity disorder as add-on treatment to stimulants: Feasibility study and protocol description. *Trends in Psychiatry and Psychotherapy*, *39*(2), 65–76. https://doi.org/10.1590/2237-6089-2016-0039

Rubia, K., Halari, R., Christakou, A., & Taylor, E. (2009). Impulsiveness as a timing disturbance: Neurocognitive abnormalities in attention-deficit hyperactivity disorder during temporal processes and normalization with methylphenidate. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1525), 1919–1931. https://doi.org/10.1098/rstb.2009.0014

Sattler, J. M., & Hoge, R. D. (2006). *Assessment of children: Behavioral, social, and clinical foundations*. Publisher Inc.

Schretlen, D. (2010). *Modified Wisconsin card sorting test: M-WCST. Professional manual*. PAR.

Sergeant, J. A. (2005). Modeling attention-deficit/hyperactivity disorder: A critical appraisal of the cognitive-energetic model. *Biological Psychiatry*, *57*(11), 1248–1255. https://doi.org/10.1016/j.biopsych.2004.09.010

Sergeant, J. A., Geurts, H. M., & Oosterlaan, J. (2002). How specific is a deficit of executive functioning for attention-deficit/hyperactivity disorder? *Behavioural Brain Research*, *130*(1-2), 3–28. https://doi.org/10.1016/S0166-4328(01)00430-2

Shaughnessy, J., Zechmeister, E., & Shaughnessy, J. (2007). *Métodos de investigación en psicología* (7a. Ed.). McGraw-Hill.

Shaw, P., Stringaris, A., Nigg, J., & Leibenluft, E. (2014). Emotion dysregulation in attention deficit hyperactivity disorder. *American Journal of Psychiatry*, *171*(3), 276–293. https://doi.org/10.1176/appi.ajp.2013.13070966

Shipstead, Z., Redick, T. S., & Engle, R. W. (2012). Is working memory training effective? *Psychological Bulletin*, *138*(4), 628. https://doi.org/10.1037/a0027473

Singh, L. J., Gaye, F., Cole, A. M., Chan, E. S., & Kofler, M. J. (2022). Central executive training for ADHD: Effects on academic achievement, productivity, and success in the classroom. *Neuropsychology*, *36*(4), 330. https://doi.org/10.1037/neu0000798

Söderqvist, S., & Bergman Nutley, S. (2015). Working memory training is associated with long term attainments in math and Reading. *Frontiers in Psychology*, *6*, 1711. https://doi.org/10.3389/fpsyg.2015.01711

Sonuga-Barke, E. J. (2003). The dual pathway model of AD/HD: An elaboration of neuro-developmental characteristics. *Neuroscience & Biobehavioral Reviews*, *27*(7), 593–604. https://doi.org/10.1016/j.neubiorev.2003.08.005

Sonuga-Barke, E., Bitsakou, P., & Thompson, M. (2010). Beyond the dual pathway model: Evidence for the dissociation of timing, inhibitory, and delay-related impairments in attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, *49*(4), 345–355. https://doi.org/10.1016/j.jaac.2009.12.018

Sonuga-Barke, E. J. S., Cortese, S., Fairchild, G., & Stringaris, A. (2016). Annual research review: Transdiagnostic neuroscience of child and adolescent mental disorders - differentiating decision making in attention-deficit/ hyperactivity disorder, conduct disorder, depression, and anxiety. *Journal of Child Psychology and Psychiatry*, *57*(3), 321–349. https://doi.org/10.1111/jcpp.12496

Stuss, D. T., & Alexander, M. P. (2000). Executive functions and the frontal lobes: A conceptual view. *Psychological Research*, *63*(3-4), 289–298. https://doi.org/10.1007/s004269900007

Tajik-Parvinchi, D., Wright, L., & Schachar, R. (2014). Cognitive rehabilitation for attention deficit/hyperactivity disorder (ADHD): promises and problems. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, *23*(3), 207.

van der Donk, M., Hiemstra-Beernink, A. C., Tjeenk-Kalff, A., van der Leij, A., & Lindauer, R. (2015). Cognitive training for children with ADHD: A randomized CGled trial of cogmed working memory training and 'paying attention in class'. *Frontiers in Psychology*, *6*, 1081. https://doi.org/10.3389/fpsyg.2015.01081

van der Oord, S., Ponsioen, A. J., Geurts, H. M., Ten Brink, E. L., & Prins, P. J. (2014). A pilot study of the efficacy of a computerized executive functioning remediation training with game elements for children with ADHD in an outpatient setting: Outcome on parent- and teacher-rated executive functioning and ADHD behavior. *Journal of Attention Disorders*, *18*(8), 699–712. https://doi.org/10.1177/1087054712453167

van Dongen-Boomsma, M., Vollebregt, M. A., Buitelaar, J. K., & Slaats-Wil - lemse, D. (2014). Working memory training in young children with ADHD: A randomized placebo-CGled trial. *Journal of Child Psychology and Psychiatry*, *55*(8), 886–896. https://doi.org/10.1111/jcpp.12218

Veloso, A., Vicente, S. G., & Filipe, M. G. (2020). Effectiveness of cognitive training for school-aged children and adolescents with attention deficit/hyperactivity disorder: A systematic review. *Frontiers in Psychology*, *10*, 2983. https://doi.org/10.3389/fpsyg.2019.02983

Vinogradov, S., Fisher, M., & de Villers-Sidani, E. (2012). Cognitive training for impaired neural systems in neuropsychiatric illness. *Neuropsychopharmacology*, *37*(1), 43–76. https://doi.org/10.1038/npp.2011.251

Vugs, B., Knoors, H., Cuperus, J., Hendriks, M., & Verhoeven, L. (2017). Executive function training in children with SLI: A pilot study. *Child Language Teaching and Therapy*, *33*(1), 47–66. https://doi.org/10.1177/0265659016667772

Wager, T. D., & Jung, H. (2022). Unpacking placebo and working memory training effects on cognitive performance. *Proceedings of the National Academy of Sciences*, *119*(42), e2214268119. https://doi.org/10.1073/pnas.2214268119

Wechsler, D. (1993). *Escala de inteligencia para niños revisada*. TEA Ediciones.

Wechsler, D. (2005). *Escala wechsler de inteligencia para niños-IV*. Manual Moderno.

Westwood, S. J., Parlatini, V., Rubia, K., Cortese, S., Sonuga-Barke, E. J. S., Banaschewski, T., Baeyens, D., Bölte, S., Brandeis, D., Buitelaar, J., Carucci, S., Coghill, D., Daley, D., Döpfner, M., Ferrin, M., Galera, C., Hollis, C., Holtmann, M., Purper-Ouakil, D., … Zuddas, A. (2023). Computerized cognitive training in attention-deficit/hyperactivity disorder (ADHD): A meta-analysis of randomized controlled trials with blinded and objective outcomes. *Molecular Psychiatry*, *28*(4), 1402–1414. https://doi.org/10.1038/s41380-023-02000-7

White, H. A., & Shah, P. (2006). Training attention-switching ability in adults with ADHD. *Journal of Attention Disorders*, *10*(1), 44–53. https://doi.org/10.1177/1087054705286063

Wiest, D. J., Wong, E. H., Bacon, J. M., Rosales, K. P., & Wiest, G. M. (2020). The effectiveness of computerized cognitive training on working memory in a school setting. *Applied Cognitive Psychology*, *34*(2), 465–471. https://doi.org/10.1002/acp.3634

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/hyperactivity disorder: A meta-analytic review. *Biological Psychiatry*, *57*(11), 1336–1346. https://doi.org/10.1016/j.biopsych.2005.02.006

Wu, K. K., Anderson, V., & Castiello, U. (2006). Attention-deficit/hyperactivity disorder and working memory: A task switching paradigm. *Journal of Clinical and Experimental Neuropsychology*, *28*(8), 1288–1306. https://doi.org/10.1080/13803390500477267

Zelazo, P. D., Müller, U., Frye, D., Marcovitch, S., Argitis, G., Boseovski, J., Chiang, J. K., Hongwanishkul, D., Schuster, B. V., & Carlson, S. M. (2003). The development of executive function in early childhood. *Monographs of the Society for Research in Child Development*, *68*(3), i–151. https://doi.org/10.1111/j.0037-976x.2003.00260.x