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Running title: Board Game's Efficacy in Children with ADHD

Title: A pilot study of the Efficacy of a Cognitive Training based on Board Games in Children with ADHD: A Randomized Controlled Trial

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Abstract

Objective. The main aim of this study was to prove the efficacy of an intervention based on board games on executive functioning and clinical symptoms in children with ADHD. **Materials and Methods.** A non-blinded randomized controlled trial was conducted with a sample of children with a diagnosis of ADHD (diagnosed by psychiatrists and clinical psychologists in a mental health Center). Children were randomly allocated by matching age and sex, into two groups: experimental executive function training group (n=13; M_{age}=9.46, Sd=1.20; Boys=53.8%) or a wait-list control group (n=14; M_{age}=9.50, Sd=1.09; Boys=71.4%). Measures assessed individually at pre, post and follow-up intervention included executive functions and clinical symptoms. **Results**. ANCOVA repeated measures analysis showed that linguistic short-term memory, F (1,28) = 7.45, p =0.02, and conduct problems, F (1,28) = 12.51, p =0.00, significantly improved with larger effects in the board games training group after intervention when compared to the wait-list group. Although non-significant effects were reported at the follow-up, large effects sizes were actually found. **Conclusion.** Although future studies are needed, the results of the present study highlight the importance of board games and its efficacy as a possible therapeutic and/or preventive intervention on ADHD.

Keywords

ADHD, Board games, working memory, executive functions, conduct problems

Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) constitutes the most prevalent neurodevelopmental disorder among children and adolescents, rising to a prevalence of 5.29% in individuals under the age of 18(1). Alterations in the frontal lobe have constituted one of the most important explicative hypothesis for ADHD, putting particular emphasis on the impairment of executive functions (EF) (see (2,3)). There is a broad consensus to accept that there are three relatively basic EFs (*shifting*, *updating (Working Memory (WM)* and *inhibition*) which can account for the other more complex ones(4). The impairment in these EFs in children with ADHD has consequences at different levels such as lowering academic achievement(5), increasing difficulties in socialization(6) or hindering of peer functioning (7,8). Dovis et al.(9) also found that, besides the WM functioning, ADHD children also showed impairments in the capacity of storage short-term information, also known as Short-Term Memory (STM).

Nowadays, psychopharmacological treatments are the primary interventions to treat ADHD, though there is not an agreement about its efficacy in improving EFs(10). Additionally, some children do not respond to this kind of treatment(11), and many others show secondary effects due to medication, such as insomnia or decreased appetite, which hampers treatment's acceptability by parents and children(12).

An alternative to pharmacological interventions, or even a complementary treatment to them, is the use of cognitive training procedures. Although the benefits of this kind of therapy have not been yet clarified concerning EFs(10), most studies have found significant effects of the trainability of WM and some of its components(13,14). Also, previous evidence shows that cognitive training of specific cognitive processes could improve the execution in other tasks for which the subject has not received specialized treatment (15). This is known as the *transfer effect*, which could be divided into *near-transfer* (improvement when doing similar

tasks or processes) and *far-transfer* (a broader improvement, such as the symptoms of ADHD attributed to the enhancement of the functioning of specific brain areas)(14). In relation with these effects, there are studies in favour(16) or opposing(14,17,18).

Recently, some authors suggested that computerized cognitive training procedures may improve the cognitive functioning(19), enhancing the dopaminergic tone(20) in neural structures related to the ADHD (21). Benefits of these cognitive training procedures could be higher with the inclusion of game elements because more cerebral areas could be activated(22). In different studies(23,24), it has been found that those children with ADHD who were trained with computerized training with game elements obtained better scores in WM and motivation than those who had not. In an analog way, Mohammad & El-Shamieh (25) found that playing chess improved concentration capacity in children with ADHD. Nowadays, sales(26) and research(27,28) of board games are arising. Modern board games are considered cognitive games that are mainly played on a board with pieces (and or cards) on it, with predefined rules that fix the number of pieces/cards on the board, the number of positions of the elements on the board, and the number of their possible moves (29). Some of these board games depend low on fate and are manufactured more attractive to children than chess and are easy to get. Board games are sometimes oriented and published by the editors to improve specific EFs(30). As far as we know, there is still no scientific study that assesses the efficacy of this kind of board games to improve the cognitive functioning and the recovery of symptoms in children with ADHD specifically.

To sum up, in the present study we aimed at studying the efficacy of board games as a cognitive training for EF (near-transfer effect) and for reducing general symptomatology (far-transfer effect) in children aged 8 to 12 years old with a diagnose of ADHD using a randomized control trial methodology. For this reason, we hypothesized that the participants of the experimental group would get better scores on the EF's measures and that they would

show more far-transfer effects after the intervention in comparison to the control group. A follow up of a month was also conducted in the study.

Materials and Methods

Participants

The sample was initially composed of 29 children, aged 8 to 12 years old and recruited from one public mental health Center for children and adolescents in Lleida, Spain. All children were receiving treatment for ADHD at the moment of the study (see Table 1 for demographic characteristics). About ethnicity, the 97% of the sample was of Spanish origin.

------Insert Table 1-------

Inclusion criteria for participation were i) being 8 to 12 years old, ii) studying in a primary school grade, and iii) having a diagnostic of ADHD disorder –including Inattentive or Combination subtype because no significant differences have been previously found in EF between children with hyperactivity alone or combined with inattention diagnose(31). ADHD's diagnosis was established after a clinical evaluation made by clinical psychologists –including second and third authors- and/or psychiatrists of the ADHD unit in the mental health center following the suggestions of the clinical practice guidelines for ADHD(32). Exclusion criteria included i) having other mental disorders, ii) having an estimated full-scale IQ measured by WISC-IV of less than 80 (clinigal psychologists from the center gave this data), and iii) being in a sheltered center. The assessment necessary to apply the inclusion and exclusion criteria was performed by the team of psychiatrists and clinical psychologists of the mental health center which offered the data to the research team for this research.

Measures

At the present study, as it can be seen in Table 2, the primary outcome measures consisted in the assessment of linguistic and visuospatial STM, the functioning of the updating process

of the linguistic and visuospatial WM, and inhibition and shifting EF skills. We also analyzed the effects of the intervention in secondary outcomes: ADHD behaviors and general psychopathological symptoms. Finally, four confounding variables were assessed based in past research (3,10,33): dose per day of medication (in mg); socioeconomic index (formula's index was: [education scale score]x3 + [occupation scale score]x5) (34); fluid reasoning (RAVEN test(35)); and sustained attention skills (CARAS test(36)). As it can be seen in Table 3, reliability was high in most of the analyzed subscales. However, those SDQ subscales with reliability scores smaller than .50 were not considered in the analysis: hyperactivity/inattention, peer relationship problems, and prosocial behavior.

------Insert Table 2-------

Treatment

The intervention consisted of a cognitive training based on board games. A total of 5 board games were used: Alles Tomate!(37) and Alles Kanone!(38) which are supposed to work the linguistic updating process of the WM; Spooky Stairs(39) which requires visuospatial information updating of WM; Out of Mine!(40) which is focused on visuospatial rotation; and Chicken Cha Cha Cha(41) which is specifically centered in visuospatial STM and WM (see Supplementary Material 1 for a detailed description adapting Baranowski's suggestions(42)).

Sessions were organized in closed groups (6-8 participants/group). The games consisted of 5 training sessions of about 60 minutes each one during 5 weeks. People who conducted the sessions were one researcher (the first author of the present paper) and two assistant researchers. The intervention team remained stable across the sessions. Each session was planned previously and described in a handbook for the research, and was always executed in the same way: i) during the first 15 minutes, different social activities were executed in order

to facilitate the interactions between the participants (most of them did not know each other previously); ii) the first board game was administered during 30 minutes; iii) the second board game was administered during 30 minutes; iv) during the last 15 minutes, researchers thanked the participation and attended parents' questions about individual situations of their children. In the different sessions, the board games used were: session 1; Alles tomate! and Spooky Stairs; session 2; Out of mine! and Chicken Cha Cha Cha; session 3; Spooky Stairs and Alles tomate!; session 4; Chicken Cha Cha Cha and Out of mine!; session 5; Alles Kanone! and the game they liked most (this was decided democratically by all the participants in each wave). Every 4 participants formed a playing group. We had 2 playing groups in each wave. In each intervention session, 1 playing group played first with a board game and the other playing group to the another during the first 30 minutes. During the last 30 minutes, the games were interchanged between the playing groups. Researchers and assistant researchers only controlled that the rules of each game were properly followed but letting the participants managing different situations that naturally occurred during playing (i.e. chatting). At the end of the last session, a certificate of attendance was given to each participant. No adverse effects were found during the intervention.

Procedure

First, the Clinical Research Ethical Committee of the university accepted the study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Sample size calculation was determined following the results obtained by Klingberg et al.(43), considering 2 points of variance. On the calculation, the fields introduced were: a bilateral 95% IC with a 90% statistical power and a 50% of possible drop-outs. Finally, 11 subjects of each group were determined, and 21 subjects in total were considered with possible drop-

outs. For the recruitment, all children with an ADHD diagnose being treated at the Center were put on a list. After applying inclusion and exclusion criteria, 53 families were randomly contacted by telephone and informed by phone or in person about the research project by the first author of the article. Informed written consent was obtained from all individual participants included in the study. Those parents, who accepted the participation of their children in the investigation, answered the informant questionnaires. Also, at baseline, all the participant children were assessed in selection and outcome measures by researchers from the investigation group and research assistants trained before in a laboratory at the University. Then, participants were stratified by age and sex, randomly assigned by a code to a wait-list condition (n=14) or to the intervention group (n=13), with a 1:1 allocation ratio by the first author. During the present study, children continued with their regular treatment in their mental health center. Attendance at the sessions in the same laboratory at the University was collected to assess treatment adherence, due to all children, except one, assisted at least four sessions. After the intervention, a post-test and a follow-up (1 month) evaluation of the outcome measures were carried out by the same assessment team that performed the pre-intervention assessments. Between post-test and follow-up, no intervention was implemented. The first author was the person who generated the random allocation sequence, who enrolled participants and who assigned participants to interventions, and also made assessments and conducted the intervention. The other researchers weren't blinded, and even participants knew the group assigned. The order of the neuropsychological tests on individual sessions was counterbalanced across participants to control assessment bias. Due to technical circumstances, the assessments and the interventions were performed into two waves (see the timeline in Supplementary Material 2). Figure 1 shows the diagram flow of participants through each stage of the study.

------insert Fig 1-------

Statistical Analysis

First of all, sociodemographic (age, gender, birth's country, and socioeconomic index) and clinical (diagnose subtype, type, and dose of pharmacology, fluid reasoning level or family history of ADHD) differences between the experimental groups were analyzed using Chi-square tests for categorical variables and independent t-test for continuous variables. Baseline differences in the outcome measures were also reported. Effects sizes were calculated following Cohen(44) and Cárdenas(45). Regarding the SDQ and CPRS-48, a variable was created with the average of mother and father scores for each subscale. Then, differences between experimental and control conditions were tested with Analysis of Covariance (ANCOVA)s for repeated measures with the time of assessment as within factor (pre and post or pre and follow-up) and treatment condition as between factor (training or wait-list) to assess short and long-term effects. The effect of pharmacological-dose/day, attentional level, socio-economical level, and fluid reasoning was controlled in all the ANCOVAs. Multiples testing were corrected by Bonferroni correction. Following van der Oord et al.(46) methodology, missed items were replaced by the mean of the other items of the scale. If more than one item was missing, the subscale was not used in the analysis.

Results

Pre-test comparisons

No significant differences were found in any sociodemographic or clinical characteristics comparing the experimental and control groups (see Table 1).

Table 3 shows the mean, standard deviations and the comparison between the intervention and control groups in the outcome variables of the study (in addition to the reliability of the psychometric scales). We only found a trend towards significance for the Digits STM task, t (24) = -1.69, p= 0.10, and for Psychosomatic, t (21) = -2.03, p= 0.06, with medium effect sizes. The rest of the analyses were not significant.

------Insert Table 3-------

Short-term effects of the intervention

EF. As can be seen in Table 4, we found one significant time effect at post-test assessment. Children of both conditions showed higher scores in linguistic WM, F (1,21) = 4.82, p = 0.04, at post-test than at pre-test, showing a large effect size (η_p^2= 0.19). This result was not significant after the Bonferroni correction.

We also found one significant difference between both groups comparing pre- and post-test assessments. Children in the EF Game-Training Condition showed significant increases at the linguistic STM scores, F (1,20) = 7.45, p =0.02, with larger effects (η_p^2= 0.27) than Wait-List Condition (see Figure 2a). Children in the EF Game-Training Condition improved their linguistic STM in 15.24%. This result remained significant after the Bonferroni correction.

ADHD behaviors and general psychopathology. We found one significant effect at the Conduct Problems SDQ scale, F (1,18) = 12.51, p <0.001, with large effects (η_p^2 = 0.41) (See Table 4). Children in the EF Game-Training Condition showed lower conduct problems than children in the Wait-List Condition (see Figure 2b). Children in the EF Game-Training Condition reduced their conduct problems in 33.67%. This result remained significant after the Bonferroni correction.

------Insert Table 4-------

------Insert Fig 2-------

Long-term effects of the intervention

When analyzing the effects of the intervention in the experimental group 1 month after the intervention (see Supplementary material 3 which shows all the long-term effects), only

Linguistic Keep Track task showed a significant difference when carrying out an intra-group comparison, F (1,18) = 5.86, p =0.03, with a large effect size (η_p^2=0.25). Although the short-term interaction previously found at the Conduct Problems SDQ scale was not significantly replicated, $F_{SDQ's\ conduct\ problems}$ (1,13) = 2.25, p = 0.16), the effect size of the intervention could be considered as large (η_p^2=0.15).

Discussion

Previous research showed that computerized training could be efficacious in ADHD to improve WM(14) and EF's (46). However, except for chess(25), no other board game has been studied in depth as a training tool for individuals with ADHD.

In general, we found few significant results. One possible explanation is about the limitations of the study (i.e., the number of subjects). Another argument is that it is difficult to find far transfer effects in cognitive training procedures(47). Furthermore, the board games used in the present research were focused in WM & STM processes and, in a weaker way, in the other EF's. It is possible that if we want to improve different cognitive processes, we must train them specifically. However, we found some significant results which are explained below.

Near-transfer effects

Results of the study showed that solely STM significantly improved after the intervention. It was estimated that those children who played board games could retain more linguistic information (up to 15.24% more information) than the control group. This fact is consistent with those studies which show that improvement can only be observed in the input capability (17,18). It is also in line with the studies which claim that, in many cases, this specific improvement is more noticeable in the linguistic STM(14).

Regarding linguistic WM, statistically significant improvements in time were found irrespective of whether the participants played the board games or not. This fact can be explained by the maturation effect produced in children of this age since it occurred in both groups (experimental and control). Orevious literature has pointed at the relationship that may exist between this kind of WM and age or speed(48,49). This effect was replicated in the follow-up.

Far-transfer effects

The main short-term far-transfer effect found in this study is an important improvement regarding conduct problems. Since board games required the monitoring of standards and rules, as well as appropriate social interaction with other participants, an additive effect among the rules of the board games may have appeared. Taking into account the social impairment that many children with ADHD present(6) and that conduct problems and hyperactivity symptoms are highly associated(50), the reduction of conduct problems has clinical relevance. Specifically, before the intervention, both groups –experimental and control- were on a normal range on Conduct Problems. Following raw scores from the SDQ(51), children from the experimental group continued on the normal range, though with lower levels of conduct problems than before the intervention. On the contrary, the control group changed from normal range to subclinical range after the intervention. Hence, it seems that the board games intervention could prevent behavior deterioration. Moreover, group dynamics were taken into account in each one of the experimental sessions, which could have also helped in the control and maintenance of adequate behavior. Hence, future research is needed to clarify whether the improvement in conduct problems was due to playing to table-top games or to improving the STM capacity. The other results found, which were non-significant, were in line with past studies(17,18).

Assessments at the follow-up to explore the stability of the effects of the training (long-term far-transfer effect) did not show significant results. However, we did find a large effect size in conduct problems. Although the effect was not statistically significant, the large effect size found implies that the improvement in conduct problems could remain stable for one month after the cognitive intervention.

Limitations and future studies

The very first pitfall of the present study was the sample size. More participants are recommended in future studies. One explanation for this sample size was the strict inclusion and exclusion criteria, which included comorbidity.

The number of training sessions that participants took in the present investigation should also be considered. Klingberg(20) suggests that to ensure the efficacy of memory training, there should be 8 hours of session for each subject. Future investigations should take into account the training with more sessions and with board games which train another EFs. Also, future interventions should take into account a follow-up of a more extended period. Besides, another improvement to future studies is to assess the clinical outcomes with multiple reporters (i.e., teachers).

Concerning the design of the study, another limitation is that the trial wasn't blinded. As others authors consider(52), it is important to use this kind of methodology in future studies to guarantee the generalization and validity of the study. Also, it is essential to ensure an adequate control group, performing an in-group activity. In fact, probably, the best control group for the present intervention should be playing board games which would not train any EF. Another consideration is the percentage of children who did not accept to participate in the study (26.42 %), being interesting to assess ecological validity by playing at home or in school. Also, it would be interesting to perform an attrition analysis(53) to test if there would have differences between children who did accept to participate in the study and those who

did not accept. As we could not assess any data from the non-participating children, we could not perform any attrition analysis in the present research.

Finally, future investigations should also measure other variables related to cognitive training (for example, previous experience with board games or motivation). Besides, the industry of board games have been adapted some of them to a video game environment. Future studies are intended to compare the efficacy of analog board games versus board video games. Finally, other diagnoses in childhood characterized by EF's impairments, such as autism spectrum disorder (ASD)(54), could profit from this intervention, suggesting future studies on this line.

Conclusions

To summarize, our study shows evidence regarding the improvement of linguistic STM trained with board games in children with ADHD. Additionally, children had the chance of interacting with other participants which in turn, improved their conduct problems. No other executive functions or behavioral outcomes were modified. Hence, although the benefits of this game based intervention are limited, it could be advisable to use it to help pharmacological interventions to improve the STM capacity and to reduce conduct problems in ADHD children.

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Author Disclosure Statement

No competing financial interest exists.

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Table 1.

Differences in Demographic Characteristics Between Children in the EF Game-Training (Experimental) and the Wait-List Condition (Control).

	Experimental (n=13)	**Control (n=14)**	t/χ^2	*d*/W
Age *M (SD*)	9.46 (1.20)	9.50 (1.09)	*t*=-0.09	.03
Gender			χ^2= 0.89	.37
Boys, *n (%)*	7 (53.8 %)	10 (71.4 %)		
Girls, *n (%)*	6 (46.2 %)	4 (28.6 %)		
Fluid reasoning, *M (SD)*	36.92 (20.34)	47.14 (26.18)	*t* = -1.13	.44
Socio-Economical Index, *M(SD)*	28.92 (9.58)	30.43 (12.73)	*t* = -0.35	.13
Diagnosis, *n (%)*			χ^2= 0.52	.25
ADHD-I	3 (23.1 %)	5 (35.7 %)		
ADHD-H/I	10 (76.9 %)	9 (64.3 %)		
Familiar history of ADHD, *n (%)*			χ^2= 0.30	.41
Yes	7 (53.8%)	9 (64.3%)		
No	6 (46.2%)	5 (35.7%)		
Pharmacology Type			χ^2= 1.72	.42
Stimulant	8 (61.5%)	10 (71.4%)		
Non-Stimulant	2 (15.4%)	1 (7.1%)		
Both	0 (0.0%)	1 (7.1%)		
No	3 (23.1%)	2 (14.3%)		
Pharmacological –dose/day *(M/SD)*	26.81 (23.14)	43.39 (32.79)	*t*= -1.51	.59

Note. Effect sizes were interpreted according to Cohen (1992) and Cárdenas (2014): *d*< .20= trivial; .20<*d*<.50= small; 50<*d*<.80= medium; *d*>.80= large; w< .10= trivial; .10<w<.30= small; .30<w<.50= medium; w>.50= large.

Table 2.

Description of instruments to assess outcome measures.

Primary outcome measures	
Working memory/updating	
Visuospatial STM	It was assessed by the Corsi block span task (Logie, 1995[55], adapted from Andersson & Lyxell, 2007) [56]. The measure included in the study was the total sum of the trials repeated correctly.
Linguistic STM	The direct digits from WISC-IV (Wechsler) [57] was used. For every trial remembered, one point was given. The final score was the sum of the previously obtained points.
Updating visuospatial WM	The Keep Track Task was adapted for school-aged children from Tamnes et al.[49] A table 3 · 3 was shown on the computer screen on each trial. The targets consisted of six different faces in different colors (black, blue, green, red, white, and yellow). Faces were presented on the computer screen, in a variable number of presentations (between one and five). The task was to recall the last position presented in each different color face. Trials with different memory load (three, four, and five different color faces) and presentation's time off, and between every item were the same as Tamnes et al.[49] The total of faces' positions to recall was 33. The total of faces' positions recalled was the measure of interest. The task ended when all the trials were administered.
Updating linguistic WM	The Keep Track Task was adapted administered according to the guidelines presented by Tamnes et al.[49] to assess linguistic WM in school-aged children and adolescents by a computerized task. The task consists of 18 words, 3 words from six possible categories (animals, clothing, colors, countries, fruit, and relatives). Words were presented on the computer screen, in a variable number of presentations (between one and five). The

	categories remained on the screen during the trial. The task was to recall the last word presented in each of these categories (four trials with three categories, four trials with four categories and one trial with five categories). The total words recalled was the measure considered in the study, scoring 1 point to every hit, with a maximum of 33 words to be remembered. The task ended when all the trials were administered.
Inhibition	A Go/NoGo task was used as outcome measure. It was a response inhibition task where a motor response has to be executed or inhibited (adapted from Bezdjian, Baker, Lozano& Raine) [58]. Four values were calculated for each condition: 1) correct responses to the target Go (hits), 2) misses of the target Go (omission errors), 3) incorrect responses to the NoGo letter (commission errors), and, 4) correct rejections to the NoGo letter. The average Reaction times (RT) were calculated by the mean of time used to press the letter in the condition to the target Go (hits).
Shifting	Trail Making Tests (TMT) A and B were administered according to the guidelines presented by Andersson & Lyxell [56]. In the present study, time to complete each part was recorded as dependent variable.
	Secondary outcome measures
ADHD behaviors	CPRS-48 (Conners)[59] was administered due to it is sensible to changes by treatment. For this study, the short parental version (48 items) was used. Subscales were: conduct problems, learning difficulties, psychosomatic, impulsive-hyperactive, anxiety, and a hyperactivity index.
General psychopathology	For the assessment of symptoms of psychopathology, the SDQ (Goodman)[60] was used. This instrument consists of a brief behavioral screening questionnaire with 25 items which are divided into 5 scales: emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems, and prosocial behavior. In the present investigation, the scale was reported by parents in a Likert scale 0 (not true) to 2 (completely true).

Table 3.

Baseline Differences Between Children in the EF Game-Training (Experimental) and the Wait-List Condition (Control).

		EF Game-Training (n=13)		Wait-List Condition (n=14)			
		α	***M (SD)***	**α**	***M (SD)***	**t**	***d***
Performance tasks	CARAS	-	34.00 (7.54)	-	31.50 (12.45)	0.63	0.24
	TMT-A	-	65.00 (46.05)	-	48.64 (12.86)	1.28	0.48
	TMT-B	-	211.00 (108.39)	-	163.57 (98.51)	1.19	0.46
	Difference TMTB-TMTA	-	146.00 (87.90)	-	114.93 (93.09)	0.89	0.34
	Direct digits	-	6.15 (1.41)	-	7.31 (2.02)	-1.69	0.67
	Corsi-block tapping test	-	6.85 (1.46)	-	6.27 (1.83)	0.66	0.36
	Linguistic keep track task	-	17.69 (7.69)	-	21.64 (4.77)	-1.62	0.62
	Visuospatial keep track	-	21.38 (6.12)	-	20.71 (7.35)	0.26	0.11
	Go-nogo *hits*	-	237.00 (33.89)	-	229.08 (54.82)	0.44	0.17
	Go-nogo *omissions*	-	19.00 (33.89)	-	26.92 (54.82)	-0.44	0.17
	Go-nogo *commissions*	-	16.69 (13.85)	-	17.46 (13.62)	-0.14	0.06
	Go-nogo *correct foil*	-	47.31 (13.85)	-	46.54 (13.62)	0.14	0.06
	Go-nogo RT	-	515.38 (201.70)	-	482.39 (181.11)	0.44	0.17
Questionnaires	*CPRS-48 (M/SD)*						
	Conduct Problems	0.89	6.50 (5.11)	0.87	9.64 (5.04)	-1.51	0.62
	Learning difficulties	0.68	7.96 (2.25)	0.79	7.73 (2.46)	0.24	0.10
	Psychosomatic	0.80	1.62 (1.53)	0.58	3.14 (2.25)	-1.96	0.79
	Impulsive-Hyperactive	0.86	5.69 (2.41)	0.80	5.86 (3.13)	-0.15	0.06
	Anxiety	0.67	4.23 (2.29)	0.67	5.50 (1.90)	-1.46	0.60
	Hyperactivity Index	0.87	14.62 (5.90)	0.91	15.73 (6.13)	-0.45	0.18
	SDQ (M/SD)						
	Total	0.89	17.50 (7.24)	0.83	18.45 (6.56)	-0.33	0.14
	Emotional symptoms	0.81	4.04 (2.40)	0.83	4.36 (2.74)	-0.31	0.12
	Conduct problems	0.61	3.04 (2.05)	0.70	3.50 (1.78)	-0.59	0.24

Note. SDQ=Strengths and Difficulties Questionnaire; CPRS=Conners Parent Rating Scale; TMT= Trail Making Test.

A Due to practical reasons, the SDQ and CPRS were only fully answered by a subset of parents at pretest and posttest (N=24/27).

B. Due to practical reasons, Digits and Go-Nogo task was only administered a subset of children at pretest (N=26/27).

All the analyses were non-significant. Effect sizes were interpreted according to Cohen (1992): d< 20= trivial effect size; 20<d<50= small effect size; 50<d<80= medium effect size; d>80= large effect size.

Table 4.

Scores at Pretest, Postest for Children in the EF Game-Training (Experimental) and the Wait-List Condition (Control).

	Pretest		Postest					
	Experimental M (SD)	**Control** M (SD)	**Experimental** M (SD)	**Control** M (SD)	**Time**	η_p^2	**Time by group**	η_p^2
Executive functions								
TMT-A	63.88 (10.34)	49.70 (9.90)	65.18 (15.59)	40.69 (14.92)	F(1,21)= 1.72	0.08	F(1,21)= 1.01	0.05
TMT-B	215.42 (33.21)	159.47 (31.88)	213.72 (27.17)	140.34 (25.99)	F(1,21)= 0.01	0.00	F(1,21)= 0.19	0.01
Difference TMTB - TMTA	151.56 (29.76)	109.77 (28.47)	148.54 (19.48)	99.64 (18.64)	F(1,21)= 0.05	0.00	F(1,21)= 0.04	0.00
Direct digits	5.84 (0.44)	7.63 (0.44)	6.89 (0.53)	7.41 (0.53)	F(1,20)= 0.03	0.00	**F(1,20)= 7.45****	**0.27**
Corsi-block tapping test	6.88 (0.53)	6.40 (0.50)	6.48 (0.46)	7.12 (0.44)	F(1,21)= 0.12	0.01	F(1,21)= 2.28	0.10
Linguistic keep track task	17.61 (1.84)	21.72 (1.76)	19.65 (1.16)	23.75 (1.11)	**F(1,21)= 4.82***	0.19	F(1,21)= 0.00	0.00
Visuospatial keep track	22.10 (1.86)	20.052 (1.78)	21.93 (1.73)	22.57 (1.65)	F(1,21)= 2.31	0.10	F(1,21)= 1.02	0.05
Go-nogo *hits*	244.15 (13.01)	230.32 (12.41)	229.19 (11.06)	236.37(10.55)	F(1,19)= 0.04	0.00	F(1,19)= 0.73	0.04
Go-nogo *commissions*	15.69 (4.70)	17.52 (4.48)	15.19 (4.41)	24.67 (4.20)	F(1,19)=1.85	0.09	F(1,19)= 1.36	0.07
Go-nogo *omissions*	10.42 (11.96)	26.99 (11.46)	25.28 (10.19)	21.05 (9.76)	F(1,20)= 0.04	0.00	F(1,20)= 0.93	0.05
Go-nogo *correct foil*	48.31 (4.70)	46.48 (4.48)	48.81 (4.41)	39.32 (4.20)	F(1,19)= 1.85	0.09	F(1,19)= 1.36	0.07
Go-nogo *TR*	466.92 (50.34)	491.95 (48.03)	544.92 (54.92)	536.66 (52.47)	F(1,19)= 1.26	0.06	F(1,19)= 0.17	0.01
CPRS-48 (M/SD)								
Conduct Problems	6.61 (1.45)	9.51 (1.61)	6.42 (1.07)	7.50 (1.19)	F(1, 18)= 0.05	0.00	F(1, 18)= 0.69	0.04
Learning difficulties	7.97 (0.732)	7.72 (0.82)	6.57 (0.70)	7.51 (0.77)	F(1, 18)= 0.50	0.03	F(1, 18)= 1.95	0.10
Psychosomatic	1.63 (0.45)	3.12 (0.50)	1.62 (0.45)	2.55 (0.52)	F(1, 18)= 0.01	0.00	F(1, 18)= 0.33	0.02
Impulsive-Hyperactive	5.98 (0.92)	5.52 (1.02)	5.26 (0.78)	4.83 (0.87)	F(1, 18)= 0.39	0.02	F(1, 18)= 0.00	0.00
Anxiety	4.78 (0.60)	4.85 (0.66)	4.54 (0.65)	4.82 (0.72)	F(1, 18)= 0.02	0.00	F(1, 18)= 0.05	0.00
Hyperactivity Index	15.13 (1.70)	15.12 (1.86)	12.63 (1.59)	14.16(1.77)	F(1, 18)= 0.00	0.00	F(1, 18)= 0.41	0.02
SDQ (M/SD)								
Total	17.60 (2.18)	18.29 (2.42)	15.58 (1.53)	17.87 (1.70)	F(1, 18)=0.11	0.01	F(1, 18)=0.39	0.02
Emotional symptoms	4.04 (0.73)	4.40 (0.83)	3.50 (0.61)	3.65 (0.69)	F(1, 18)=0.01	0.00	F(1, 18)=1.26	0.09
Conduct problems	3.00 (0.59)	3.54 (0.66)	1.99 (0.55)	4.51 (0.61)	F(1, 18)=0.98	0.05	**F(1, 18)=12.51*****	0.41

Note. SDQ=Strengths and Difficulties Questionnaire; CPRS=Conners Parent Rating Scale; TMT= Trail Making Test.

A Due to technical reasons, SDQ and CPRS-48 (N=24/27) was only administered a subset of parents at pretest and postest

B. Due to technical reasons, Digits and Go-Nogo task was only administered a subset of children at pretest (N=26/27).

C. Due to technical reasons, Go-Nogo task was only administered a subset of children at postest (N=25/27).

p<0.05=*; p<0.01=**; p<0.001=***; η_p^2<.06= small effect size; 0.06<η_p^2<0.14= medium effect size; η_p^2 >0.14= large effect size (Cohen, 1988)

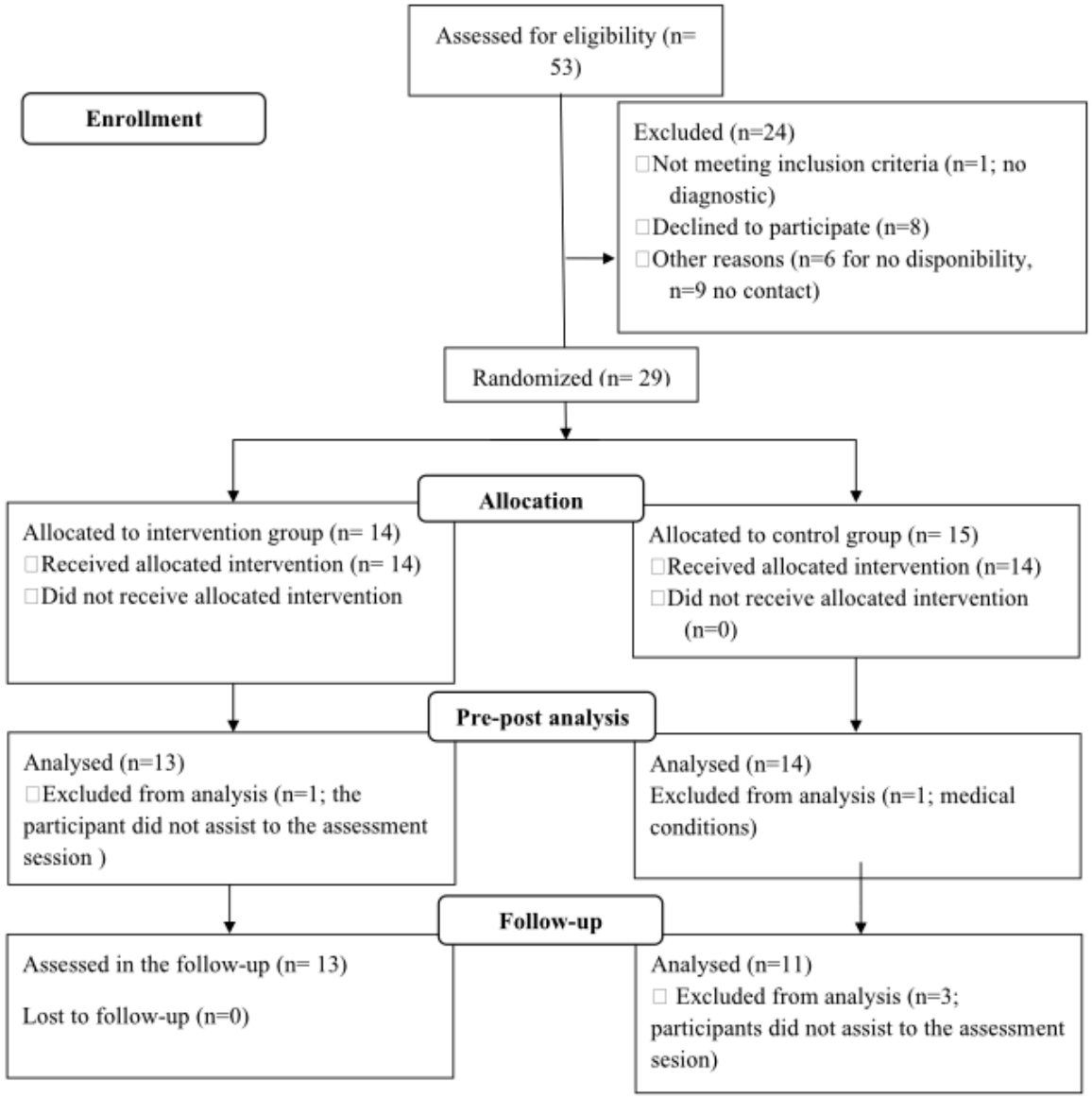

Figure 1. *Diagram flow.*

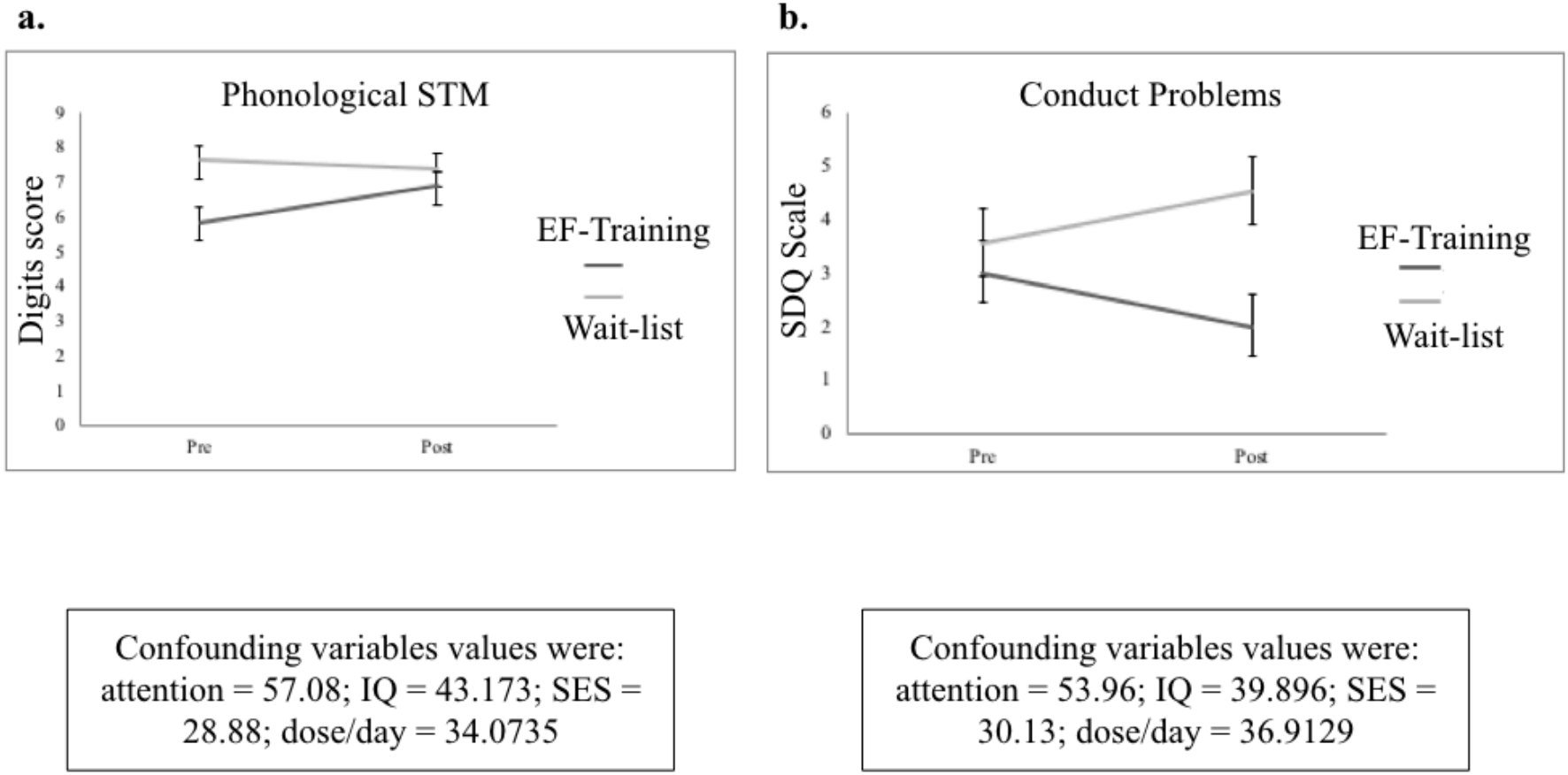

Figure 2. a. *Average and 95% confidence intervals for the interaction within and between factor for Phonological Short-Term Memory assessed by Digits task.* **b.** *Average and 95% confidence intervals for the interaction within and between factor for Conduct Problems subscale assessed by SDQ questionnaire.*

***Supplementary material 1*. Description of characteristics and instructions of board games**

Table 1.

Characteristics of a board game for health: Alles Kanone! (code BoardGameGeek (BGG): 149516)

General characteristics	
Health topic (s):	Phonological STM and WM, attention.
Short description of game idea:	It is supposed to specifically work the linguistic updating process of the WM when players have to keep in mind what is currently lying at the seven different objects of the cards, but this items are changing constantly.
Targeted age group:	6+
Target player (s) (check one):	Individual Dyad **Small group (2 to 8)** MMOG Other.
Other targeted group characteristics:	None.
Sensors used:	None.
Estimated play time:	15-20 minutes.
Type of game:	Active Action Adventure Role-playing Simulation Strategy Sports Casual Educational **Other: modern board games (cognitive skill training).**
Game platform(s) needed to play the game (check all that apply):	Smartphone Tablet Kinect Xbox Wii PlayStation Computer Handheld device **Other: table (Board games).**
Health outcome	
Guiding knowledge or behaviour change theory(ies), models or conceptual framework(s):	There are different cognitive-focused interventions that directly or indirectly target cognitive functioning[1]. One type of these interventions is cognitive training, which "*entails repeated exercise of a specific cognitive process over a period of time to improve performance on the trained task as well as on tasks that were not specifically trained (transfer effect)*"[2]. Some authors have considered that gaming could increase the improvement from computerised cognitive training in cognitive processes [3,4,5]. For all of the above mentioned, board games could be considered a tool included in cognitive training interventions with memory and other cognitive processes as the health's outcome.
Intended health behaviour changes:	To increase phonological STM and WM capacities and attention skills.
Knowledge element(s) to be learned:	None.
Behavior change procedure(s) (taken	There is a game without chance. For this reason, in order to win the game, players have to put into

from Michie inventory) or therapeutic procedure(s) employed:	operation cognitive processes.
Clinical or parental support needed? (please specify):	Clinicians help children to know the rules of the games and they ensured that game worked correctly.
Data shared with parent or clinician?:	Yes No **Others:** only clinicians, children play with clinicians in this randomised controlled trial, so clinicians have access to data, but no parents.
Story (if any)	
Synopsis (including story arc):	*"Johnny Jokey is a successful pirate. On his forays, he has amassed so many treasures that he sometimes gets quite confused. Is the parrot actually sitting on his shoulder or is it just depicted on his arm as a tattoo? Is the crown still hidden on the island or has he already looted it? Should he better go to the tavern now before driving himself crazy-or doesn't any of it matter anyway?! Helps him clear the decks!"*
How the story relates to targeted behaviour change:	There isn't a relation between targeted behaviour and the story, but children could be identified with the pirate due to they could have memory difficulties.
Game components	
Player's game goal/objective(s):	To achieve the bigger number of cards.
Rules:	1. Each player may always shout out only one term. 2. If several players simultaneously shout out the correct term and the other players cannot agree who was first, one of the fastest players receives the corresponding object card from the middle and the other players involved each receive one card from the card pile. One of the quickest players reveals the next object card. 3. If no player says the correct term, the respective object card is put back into the card pile. The card drawn from the pile is placed at the location now vacant.
Game mechanic(s);	This game uses two types of cards: the "themed or topic cards" and the "pirate's object cards". The themed cards are 7 cards which show the image of a pirate with a different background and color each. Each themed card is associated with different pirate's concepts. The other 49 cards of the deck are object cards, which show specific objects related semantically to each themed card. Visually, object and themed cards of the same semantic category are related because they have the same background color. Hence, there are 7 object cards per each themed card. The game initiates

	distributing the themed cards over a table. Next, one object card is positioned face-up down the themed card with the same background color. The rest object cards are positioned at the deck, face-down. All the players tell aloud which object is depicting each object card. Hence, all object cards are face-down. At this point, the game begins. One person takes the first object card from the deck and reveals the card's object. The first player to recall which element was on the face-down object card positioned down the themed card with the same color background wins the card. End of the game arrives as soon as all cards in the card pile have been used up.
Procedure to generalize or transfer what's learned in the game to outside the game:	Considering the kind of board games in order to improve cognitive skills, if phonological STM and WM and attention skills could be ameliorated, this could beneficiate all the daily activities which require them. Also playing board games implies abiding rules and playing in a social environment. For this reason, there could be an improvement in conduct problems involved in social relationships with peers and adults.
Setting or environment	Relaxed room, with adequate furniture elements (chairs, table) and favourable environmental conditions (adequate light, temperature, without noise).
Avatar	
Characteristics:	None.
Abilities:	None.

Note. Chosen option is in bold.

Table 2.

Characteristics of a board game for health: Alles Tomate! (code BGG: 32405)

General characteristics	
Health topic (s):	Phonological STM and WM, attention.
Short description of game idea:	It is supposed to specifically work the linguistic updating process of the WM when players have to update linguistic information from the objects of the cards.
Targeted age group:	6+
Target player (s) (check one):	Individual Dyad **Small group (2 to 8)** MMOG Other.
Other targeted group characteristics:	None.
Sensors used:	None.
Estimated play time:	15-20 minutes.
Type of game:	Active Action Adventure Role-playing Simulation Strategy Sports Casual Educational **Other: modern board games (cognitive skill training)**
Game platform(s) needed to play the game (check all that apply):	Smartphone Tablet Kinect Xbox Wii PlayStation Computer Handheld device **Other: table (Board games).**
Health outcome	
Guiding knowledge or behaviour change theory(ies), models or conceptual framework(s):	There are different cognitive-focused interventions that directly or indirectly target cognitive functioning[1]. One type of these interventions is cognitive training, which "*entails repeated exercise of a specific cognitive process over a period of time to improve performance on the trained task as well as on tasks that were not specifically trained (transfer effect)*"[2]. Some authors have considered that gaming could increase the improvement from computerised cognitive training in cognitive processes [3,4,5]. For all of the above mentioned, board games could be considered a tool included in cognitive training interventions with memory and other cognitive processes as the health's outcome.
Intended health behaviour changes:	To increase phonological STM and WM capacities and attention skills.
Knowledge element(s) to be learned:	None.
Behavior change procedure(s) (taken from Michie inventory) or therapeutic procedure(s) employed:	There is a game without chance. For this reason, in order to win the game, players have to put into operation cognitive processes.

Clinical or parental support needed? (please specify):	Clinicians help children to know the rules of the games and they ensured that game worked correctly.
Data shared with parent or clinician?:	Yes No **Others:** only clinicians, children play with clinicians in this randomised controlled trial, so clinicians have access to data, but no parents.
Story (if any)	
Synopsis (including story arc):	*Max and Emma, a farmer couple, have a huge barnyard. Therefore, they sometimes lose track of everything. Do the cherries belong in the henhouse, can the horse sleep in the bed, does the pitchfork stick in the butter or doesn't any of it matter anyway? Can you show Max and Emma where everything belongs?*
How the story relates to targeted behaviour change:	There isn't a relation between targeted behaviour and the story, but children could be identified with Max and Emma due to they could have memory difficulties.
Game components	
Player's game goal/objective(s):	To achieve the bigger number of cards
Rules:	1. Each player may always shout out only one term. 2. If several players simultaneously shout out the correct term and the other players cannot agree who was first, one of the fastest players receives the corresponding object card from the middle and the other players involved each receive one card from the card pile. One of the quickest players reveals the next object card. 3. If no player says the correct term, the respective object card is put back into the card pile. The card drawn from the pile is placed at the location now vacant.
Game mechanic(s);	This game uses two types of cards: the "themed cards" and the "object cards". The themed cards are 7 cards which show the image of a cow with a different background and color each. Each themed card is associated with different farming concepts (i.e., farming animals, farming tools). The other 49 cards of the deck are object cards, which show specific objects related semantically to each themed card. Visually, object and themed cards of the same semantic category are related because they have the same background color. Hence, there are 7 object cards per each themed card. The game initiates distributing the themed cards over a table. Next, one object card is positioned face-up down the themed card with the same background color. The rest object cards are positioned at the deck, face-down. All the players tell aloud which object is depicting each object card. Hence, all object cards are face-down. At this point, the game begins. One person takes the first object card from the deck and

	reveals the card's object. The first player to recall which element was on the face-down object card positioned down the themed card with the same color background wins the card. End of the game arrivea as soon as all cards in the card pile have been used up.
Procedure to generalize or transfer what's learned in the game to outside the game:	Considering the kind of board games in order to improve cognitive skills, if phonological STM and WM and attention skills could be ameliorated, this could beneficiate all the daily activities which require them. Also playing board games imply abiding rules and playing in a social environment. For this reason, there could be an improvement in conduct problems involved in social relationships with peers and adults.
Setting or environment	Relaxed room, with adequate furniture elements (chairs, table) and favourable environmental conditions (adequate light, temperature, without noise).
Avatar	
Characteristics:	None.
Abilities:	None.

Note. Chosen option is in bold.

Table 3.

Characteristics of a board game for health: Out of mine! (code BGG: 153509)

General characteristics	
Health topic (s):	It is also a memory game, focused on visuospatial rotation, which is related to visuospatial information short term memory (STM)[6].
Short description of game idea:	It is supposed to specifically work the visuospatial STM of the WM when players have to update linguistic information from the objects of the cards.
Targeted age group:	10+
Target player (s) (check one):	Individual Dyad **Small group (2 to 4)** MMOG Other.
Other targeted group characteristics:	None.
Sensors used:	None.
Estimated play time:	20 minutes.
Type of game:	Active Action Adventure Role-playing Simulation Strategy Sports Casual Educational **Other: modern board games (cognitive skill training)**
Game platform(s) needed to play the game (check all that apply):	Smartphone Tablet Kinect Xbox Wii PlayStation Computer Handheld device **Other: table (Board games)**
Health outcome	
Guiding knowledge or behaviour change theory(ies), models or conceptual framework(s):	There are different cognitive-focused interventions that directly or indirectly target cognitive functioning[1]. One type of these interventions is cognitive training, which "*entails repeated exercise of a specific cognitive process over a period of time to improve performance on the trained task as well as on tasks that were not specifically trained (transfer effect)*"[2]. Some authors have considered that gaming could increase the improvement from computerised cognitive training in cognitive processes [3,4,5]. For all of the above mentioned, board games could be considered a tool included in cognitive training interventions with memory and other cognitive processes as the health's outcome.
Intended health behaviour changes:	To increase visual rotation, which is related to STM capacities.
Knowledge element(s) to be learned:	None.
Behavior change procedure(s) (taken from Michie inventory) or therapeutic	It is a game without chance. For this reason, in order to win the game, players have to put into operation cognitive processes.

procedure(s) employed:	
Clinical or parental support needed? (please specify):	Clinicians help children to know the rules of the games and they ensured that game worked correctly.
Data shared with parent or clinician?:	Yes No **Others:** only clinicians, children play with clinicians in this randomised controlled trial, so clinicians have access to data, but no parents.
Story (if any)	
Synopsis (including story arc):	*"The mountain is calling! Equipped with pick axes and the secret knowledge of the mine elves, the dwarf's rush below ground in order to dig u precious crystals. Everybody gets his own mine gallery in which he tries to dig out the crystals that are said to lie there, according to the elves. If a dwarf manages to find the predicted crystals in all the sections of his gallery, he shouts aloud "Out of mine!". This is the signal for all dwarfs to drop their pick axes and return to daylight. Now a scoring takes place. But only at the end of the week, after the seventh round of digging, will it turn out which dwarf was the most successful one"*
How the story relates to targeted behaviour change:	None.
Game components	
Player's game goal/objective(s):	Players have to find the best combination of different crystals to complete his/her tunnel, in order to get better scores. The player who gathered the most points after one work week (7 game rounds) wins the game.
Rules:	1. If one player shouts aloud "Out of mine!", the rest of the players have to stop playing. 2. When points are counting up, a crystal is incorrectly placed if it protrudes over the edge of the gallery or has a color that is not listed on the treasure card, or if the number of the crystal you used dos not match the number on the treasure card. 3. Each player receives 10 plus points and for each empty space on his galley board, have to deduct one point. 4. The player who shout aloud Out of Mine!, additionally earns 2 points, if he has covered his gallery bard correctly. However, if he has not done everything right, he gets 2 minus points. 5. If a player has more than 10 empty gallery spaces, he gets zero points. 6. Players cannot repeat a gallery board. In this case, the player has to turn it to the other side.
Game mechanic(s);	Every player has a double-sided gallery or tunnel board randomly, which have to be completed with

	different precious crystals. Every player can decide on which side he wants to play. In order to complete the mind, every player also has a treasure card with some rules to do it. If one player finds the crystals to complete his/her tunnel, he/she has to say out loud "Out of Mine!". Each crystal has a geometric form. After noting down points, new treasure card and gallery are randomly assigned to every player, unless the winner of the round before, who only changes his/her treasure card.
Procedure to generalize or transfer what's learned in the game to outside the game:	Considering the kind of board games in order to improve cognitive skills, if visuospatial rotation related with STM could be ameliorated, this could beneficiate all the daily activities which require them. Also playing board games imply abiding rules and playing in a social environment. For this reason, there could be an improvement in conduct problems involved in social relationships with peers and adults.
Setting or environment	Relaxed room, with adequate furniture elements (chairs, table) and favourable environmental conditions (adequate light, temperature, without noise).
Avatar	
Characteristics:	Every player is a dwarf who works on a gallery.
Abilities:	None.

Note. Chosen option is in bold.

Table 4.

Characteristics of a board game for health: Spooky stairs (code BGG: 12346)

General characteristics	
Health topic (s):	Visuospatial information updating of WM, visuospatial STM, attention
Short description of game idea:	It is supposed to specifically work the linguistic updating process of the WM when players have to update linguistic information from the objects of the cards.
Targeted age group:	4+
Target player (s) (check one):	Individual Dyad **Small group (2 to 4)** MMOG Other.
Other targeted group characteristics:	None.
Sensors used:	None.
Estimated play time:	10-15 minutes.
Type of game:	Active Action Adventure Role-playing Simulation Strategy Sports Casual Educational **Other: modern board games (cognitive skill training).**
Game platform(s) needed to play the game (check all that apply):	Smartphone Tablet Kinect Xbox Wii PlayStation Computer Handheld device **Other: table (Board games).**
Health outcome	
Guiding knowledge or behaviour change theory(ies), models or conceptual framework(s):	There are different cognitive-focused interventions that directly or indirectly target cognitive functioning[1]. One type of these interventions is cognitive training, which "*entails repeated exercise of a specific cognitive process over a period of time to improve performance on the trained task as well as on tasks that were not specifically trained (transfer effect)*"[2]. Some authors have considered that gaming could increase the improvement from computerised cognitive training in cognitive processes [3,4,5]. For all of the above mentioned, board games could be considered a tool included in cognitive training interventions with memory and other cognitive processes as the health's outcome.
Intended health behaviour changes:	To increase visuospatial STM and updating-WM capacities and attention skills.
Knowledge element(s) to be learned:	None.
Behavior change procedure(s) (taken from Michie inventory) or therapeutic procedure(s) employed:	There is a game without chance. For this reason, in order to win the game, players have to put into operation cognitive processes.

Clinical or parental support needed? (please specify):	Clinicians help children to know the rules of the games and they ensured that game worked correctly.
Data shared with parent or clinician?:	Yes No **Others:** only clinicians, children play with clinicians in this randomised controlled trial, so clinicians have access to data, but no parents.
Story (if any)	
Synopsis (including story arc):	*"In an old castle ruin there is a spooky stair –Spirit Stairs-, where a ghost lives at the top of the stairs. Being completely quiet, a few brave children dart up the stairs- everyone wants to be first to scare the ghost with a "BOOOO! But the ghost knows this age-old game and tries to transform the players into ghosts - one after the other one! Which children will be the most courageous and will scare the old ghost?"*
How the story relates to targeted behaviour change:	None.
Game components	
Player's game goal/objective(s):	The objective is to arrive your pawn at first place to the top of the stairs. At that moment, the pawn that was inside the ghost piece is revealed. The player's pawn that arrives first, wins.
Rules:	1. The younger player starts the game. 2. If a dice shows a number, the player has to climb the number of stairs indicated by the dice. 3. There can be two or more pawns on a step. 4. If a dice shows a ghost, the player has to roll a "ghost"-his or to roll another player- and he/she should place a ghost piece over a player's pawn, which is connected by a magnetic field. 5. If all players become in ghosts and the dice shows a ghost, the player who throws the dice must change the position of two ghost pieces. 6. Players are not allowed to see the color of the pawn when is covered by the ghost piece.
Game mechanic(s);	This game consists of a race in an old castle ruin, where there is a ghost. Every player has to climb the stairs as fast as possible, as the number depicted in the dice indicates, moving a color pawn. If the dice shows a ghost (there is a ghost representation in two out of the 6 faces of the dice), the player has to roll a "ghost", and he/she should place a ghost piece over his or another player's pawn, which is connected by a magnetic field. The ghost piece positioned on player's pawn makes it impossible to see the pawn's color. Hence, at this point, players have to remember under which ghost their own and the other figures were, and many mistakes could be produced.

Procedure to generalize or transfer what's learned in the game to outside the game:	Considering the kind of board games in order to improve cognitive skills, if visuospatial updating from WM and STM capacities and attention skills could be ameliorated, this could beneficiate all the daily activities which require them. Also playing board games imply abiding rules and playing in a social environment. For this reason, there could be an improvement in conduct problems involved in social relationships with peers and adults.
Setting or environment	Relaxed room, with adequate furniture elements (chairs, table) and favourable environmental conditions (adequate light, temperature, without noise).
Avatar	
Characteristics:	Players are the children who want to scare the old ghost of the story's game. Children can become on ghosts, represented by a piece colored in white with face elements (two eyes and a mouth) which is positioned over the colored pawn.
Abilities:	None.

Note. Chosen option is in bold.

Table 5.

Characteristics of a board game for health: Chicken Cha Cha Cha (code BGG: 3570)

General characteristics	
Health topic (s):	Visuospatial STM, attention.
Short description of game idea:	It is supposed to specifically work the visuospatial updating process of the WM when players have to update linguistic information from the objects of the cards.
Targeted age group:	4+
Target player (s) (check one):	Individual Dyad **Small group (2 to 4)** MMOG Other.
Other targeted group characteristics:	None.
Sensors used:	None.
Estimated play time:	15-20 minutes.
Type of game:	Active Action Adventure Role-playing Simulation Strategy Sports Casual Educational **Other: modern board games (cognitive skill training).**
Game platform(s) needed to play the game (check all that apply):	Smartphone Tablet Kinect Xbox Wii PlayStation Computer Handheld device **Other: table (Board games).**
Health outcome	
Guiding knowledge or behaviour change theory(ies), models or conceptual framework(s):	There are different cognitive-focused interventions that directly or indirectly target cognitive functioning[1]. One type of these interventions is cognitive training, which "*entails repeated exercise of a specific cognitive process over a period of time to improve performance on the trained task as well as on tasks that were not specifically trained (transfer effect)*"[2]. Some authors have considered that gaming could increase the improvement from computerised cognitive training in cognitive processes [3,4,5]. For all of the above mentioned, board games could be considered a tool included in cognitive training interventions with memory and other cognitive processes as the health's outcome.
Intended health behaviour changes:	To increase visuospatial STM capacities and attention skills.
Knowledge element(s) to be learned:	None.
Behavior change procedure(s) (taken from Michie inventory) or therapeutic procedure(s) employed:	There is a game without chance. For this reason, in order to win the game, players have to put into operation cognitive processes.

Clinical or parental support needed? (please specify):	Clinicians help children to know the rules of the games and they ensured that game worked correctly.
Data shared with parent or clinician?:	Yes No **Others:** only clinicians, children play with clinicians in this randomised controlled trial, so clinicians have access to data, but no parents.
Story (if any)	
Synopsis (including story arc):	"*The hen house is scrambled! We are assisting to the Hen's Olympic Games. Today is the race where hens could be plucked. Each hen will try to overtake the others. When a hen overtakes the one in front of her, it will take the tail of the hen which has been passed. However, the hens are allowed to advance if they know the hen house very well. They must remember all the floor tiles accurately. The first hen which overtakes all the other hens will be the winner"*
How the story relates to targeted behaviour change:	There isn't a relation between targeted behavior and the story, but children could be identified with the hen due to they could have memory difficulties.
Game components	
Player's game goal/objective(s):	The game ends when one player has the four feathers. This one is the winner.
Rules:	1. At the beginning of the game, every player has a hen in one tile. 2. The younger player starts the game. 3. Hens can move on –in clockwise- if the player finds the same image of the next egg-shaped tile on the octagons positioned on the center of the table. 4. If one hen is just before other, in order to snatch the tile, the hen has to jump it. This can be done by finding the same octagon of the egg-shaped tile just before the other hen.
Game mechanic(s);	Twelve octagons are positioned face-down at the center of the table. Round the octagons, different egg-shaped tiles are positioned, where one hen figure by each participant is placed at an equidistant space among them. Each octagon has the same image of two of the egg-shaped tiles. There are five spaces at the back of each hen figure, where a feather could be placed. Each hen begins with one feather. To progress, each player, in his/her turn, has to successfully memorize the image on each of the twelve octagon tiles that the game has. Each player moves the number of times equivalent to the number of correct pairs he/she remembers. The circuit is a circle. Then, the hens are always moving, being like an endless race. When a hen overtakes another one, the first hen takes the nail of the second.

Procedure to generalize or transfer what's learned in the game to outside the game:	Considering the kind of board games in order to improve cognitive skills, if visuospatial STM capacities and attention skills could be ameliorated, this could beneficiate all the daily activities which require them. Also playing board games imply abiding rules and playing in a social environment. For this reason, there could be an improvement in conduct problems involved in social relationships with peers and adults.
Setting or environment	Relaxed room, with adequate furniture elements (chairs, table) and favourable environmental conditions (adequate light, temperature, without noise).
Avatar	
Characteristics:	Four hens, all of them colored differently (green, blue, yellow and beige) but have in common black eyes and red nose and tuft.
Abilities:	The hens can walk and jump over other hens, overtaking them. When a hen overtakes another one, the first hen takes the nail of the second.

Note. Chosen option is in bold.

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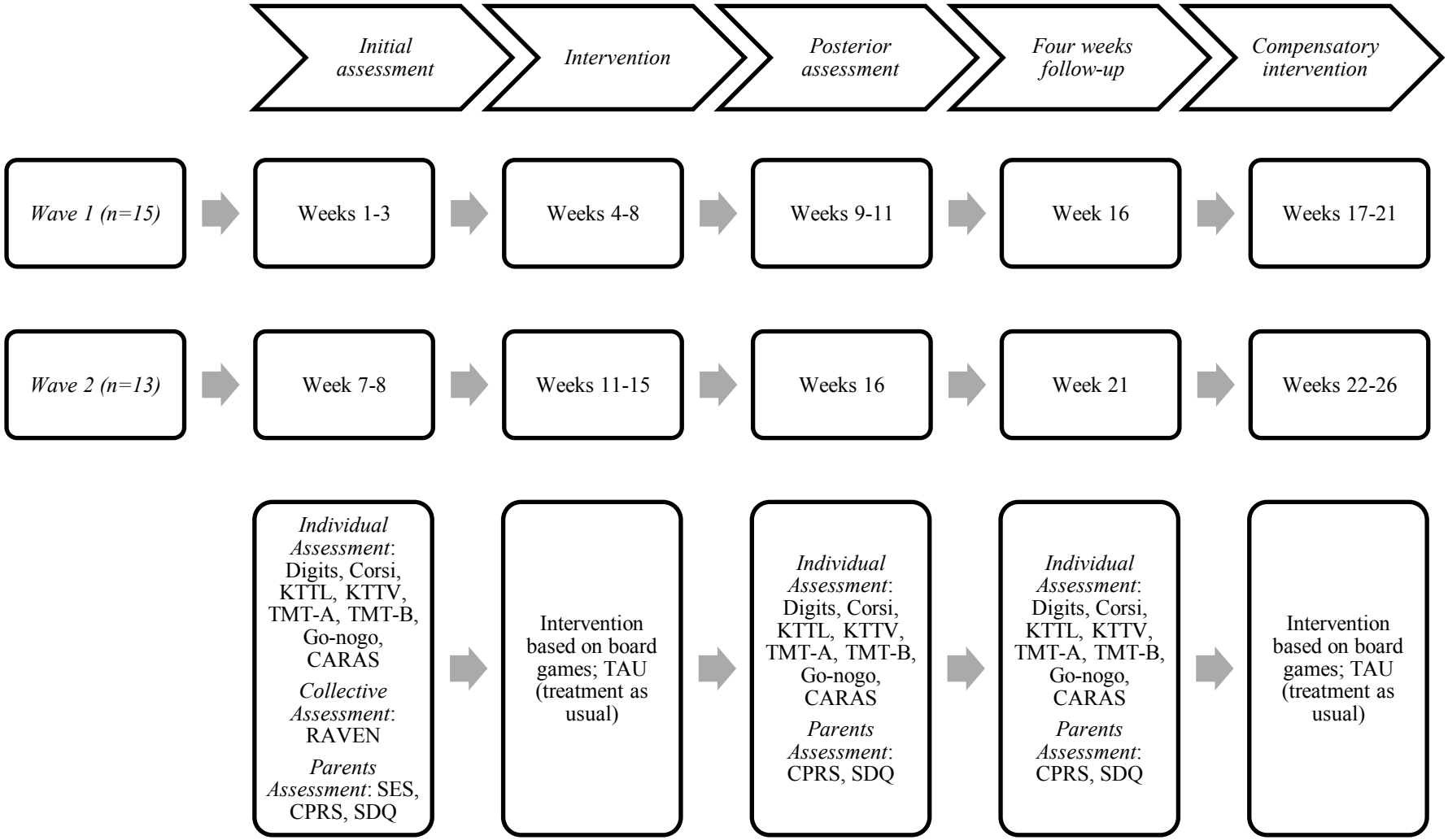

Supplementary Material 2. Time-line.

Supplementary material 3.

Scores at Pretest, Follow-up for Children in the EF Game-Training (Experimental) and the Wait-List Condition (Control)

	Pretest		**Follow-up**					
	Experimental *M (SD)*	**Control** *M (SD)*	**Experimental** *M (SD)*	**Control** *M (SD)*	**Time**	η_p^2	**Time x group**	η_p^2
TMT-A	63.82 (10.51)	50.76 (11.56)	51.36 (7.93)	38.94 (8.72)	F(1,18)= 4.01 ^{t}	0.18	F(1,18)= 0.00	0.00
TMT-B	213.68 (32.98)	166.65 (36.28)	170.36 (16.30)	122.39 (17.93)	F(1,18)= 0.15	0.01	F1,18)= 0.00	0.00
Difference TMTB - TMTA	149.86 (29.58)	115.89 (35.54)	119.00 (13.24)	83.45 (14.57)	F(1,18)= 0.00	0.00	F(1,18)= 0.00	0.00
Direct digits	6.00 (0.44)	7.70 (0.51)	7.13 (0.62)	8.23 (0.72)	F(1,17)= 1,25	0.07	F(1,17)= 0.64	0.04
Corsi-block tapping test	6.74 (0.47)	6.04 (0.52)	6.67 (0.55)	6.66 (0.61)	F(1,18)= 2.33	0.11	F(1,18)= 1.03	0.05
Linguistic keep track task	17.75 (1.68)	21.29 (1.85)	20.61 (1.10)	21.65 (1.21)	**F(1,18)= 5.86***	**0.25**	F(1,18)= 0.83	0.04
Visuospatial keep track	21.94 (1.62)	19.08 (1.78)	24.10 (1.43)	22.24 (1.57)	F(1,18)= 2.81	0.14	F(1,18)= 0.20	0.01
Go-nogo *hits*	239.22 (8.13)	239.21 (9.41)	229.84 (13.51)	227.50 (15.64)	F(1,17)= 0.07	0.00	F(1,17)= 0.01	0.00
Go-nogo *commissions*	17.08 (4.39)	18.29 (5.08)	20.44 (4.23)	26.22 (4.90)	F(1,17)= 3.29 ^{t}	0.16	F(1,17)= 0.91	0.05
Go-nogo *omissions*	17.56 (7.71)	15.77 (8.86)	24.53 (12.87)	30.72 (14.78)	F(1,18)= 0.00	0.00	F(1,18)= 0.13	0.01
Go-nogo *correct foil*	46.92 (4.39)	45.71 (5.08)	43.58 (4.23)	37.78 (4.90)	F(1,17)= 3.29 ^{t}	0.16	F(1,17)= 0.92	0.05
Go-nogo *TR*	500.75 (54.57)	488.94 (63.18)	564.64 (47.38)	627.75 (54.85)	F(1,17)= 0.25	0.02	F(1,17)= 0.88	0.05
CPRS-48 (M/SD)								
Conduct Problems	6.87 (1.72)	10.19 (2.09)	6.80 (1.23)	8.65 (1.50)	F(1,13)= 2.37	0.15	F(1,13)= 0.94	0.07
Learning difficulties	7.78 (0.82)	8.25 (1.00)	7.31 (0.69)	7.52 (0.83)	F(1,13)= 0.48	0.04	F(1,13)= 0.06	0.00
Psychosomatic	1.75 (0.51)	3.72 (0.62)	1.44 (0.57)	3.01 (0.69)	F(1,13)= 0.04	0.00	F(1,13)= 0.14	0.01
Impulsive-Hyperactive	6.50 (0.98)	5.12 (1.19)	6.50 (0.98)	4.44 (1.20)	F(1,13)= 0.00	0.00	F(1,13)= 0.38	0.03
Anxiety	4.99 (0.67)	5.08 (0.82)	3.89 (0.57)	4.72 (0.67)	F(1,13)= 0.62	0.05	F(1,13)= 0.32	0.02
Hyperactivity Index	16.16 (1.94)	14.64 (2.36)	14.22 (1.65)	13.25(2.00)	F(1,13)= 0.02	0.00	F(1,13)= 0.06	0.00
SDQ (M/SD)								
Total	17.67 (2.47)	18.46 (3.01)	15.52 (1.62)	16.91 (1.97)	F(1,13)=0.02	0.00	F(1,13)=0.06	0.01
Emotional symptoms	4.52 (0.92)	4.16 (1.12)	3.27 (0.51)	3.45 (0.62)	F(1,13)=0.03	0.00	F(1,13)=0.24	0.02
Conduct problems	3.14 (0.71)	3.69 (0.87)	2.38 (0.65)	3.98 (0.80)	F(1,13)=0.06	0.01	F(1,13)=2.25	0.15

Note. SDQ=Strengths and Difficulties Questionnaire; CPRS=Conners Parent Rating Scale; TMT= Trail Making Test.

A Due to practical reasons, CPRS-48 (N=19/27) and SDQ (N= 19/27) was only administered a subset of parents at pretest and follow-up

B. Due to practical reasons, Digits task (N=23/27), TMT, Corsi-blocks tapping task, Lingüistic and Visuospatial keep track task (N=24/27) test was only administered a subset of children at pretest and follow-up.

C. Due to practical reasons, Go-Nogo task was only administered a subset of children at pretest and follow-up (N=23/27).

$p<0.10=$ ^{t} ,$p<0.05$=*; $p<0.01$=**; η_p^2<.06= small effect size; $0.06<\eta_p^2<0.14$= medium effect size; η_p^2 >0.14= large effect size