A Digital-Analogical Intervention Program Following a Play-Based Approach for Preschoolers: The Effects on Executive Functions and ADHD Symptoms in a Pilot Study

Sabrina Panesi* and Lucia Ferlino

***Abstract*—Today, the effective use of technological tools is a fundamental aspect of learning. Nevertheless, in Italy's education system the integration of digital technologies in a pedagogically meaningful way is still not very widespread, especially in non-compulsory levels, such as preschool. Integration of digital technologies as early as preschool could be useful to support child development, especially for fostering executive functions (EFs). These play an important role in the daily life of all children, whether or not they have special education needs (SEN), such as coping with attention deficit hyperactivity disorder (ADHD) symptoms. This paper reports a pilot study in which a play-based intervention is adopted that combines interaction with both educational apps and analogical materials. The main aim of the study is to investigate whether application of this intervention promotes the development of EFs and a decrease in ADHD symptoms (inattention and impulsivity/hyperactivity), as perceived by teachers and parents. The results show significant improvements in various EFs components and, in the experimental group, ADHD symptoms seem to decrease, especially in those children considered at risk by their teachers and parents. This suggests that the digital-analogical intervention can be implemented in preschool as an innovative way to improve cognitive abilities and as an early strategy for children with ADHD symptoms.**

***Index Terms*—ADHD symptoms, educational apps, executive functions, preschool**

I. Introduction

In today's digital era, many children continuously interact with digital tools from a very young age, integrating virtual and physical experiences. At school, digital technologies have the potential for enhancing teaching and learning, granting access to a wealth of information and resources, providing new means for enabling pedagogical innovation [1], and promoting well-being and inclusion at different school levels [2]. In Italy's education system, the introduction of digital technologies and their integration in a pedagogically meaningful way remains a challenge. Moreover, the mere presence of digital technologies in classrooms does not automatically translate into better learning outcomes [3], especially at non-compulsory levels, such as kindergarten. Digital integration at preschool level has been the subject of relatively few recent studies [4], even though this period is very critical for fundamental aspects of children's development, such as social [5] and cognitive [6, 7] dimensions. Specifically, there is agreement in the literature that the preschool age is crucial for the development of executive functions (EFs) [6–8]. These comprise a family of adaptive, goal-directed, top-down mental processes that are supported by the prefrontal cortex. They are activated in cases where an automatic cognitive response would be inappropriate, for example when it is necessary to focus and pay attention so as to apply inhibition, attention shifting and updating of working memory [9]. Because these skills play such a large role in our daily activities, it is important to find ways to foster them. Furthermore, from the first years of life, EFs seem to be associated with—and predictive of—other abilities and for this reason intervention programs to enhance EFs in young children are becoming a hot topic (for a systematic review [10]). These not only address children with typical development but also those with special education needs (SEN), especially preschoolers with attention deficit hyperactivity disorder (ADHD) symptoms (inattention and hyperactivity/impulsivity), who often seem to benefit from educational interventions developed to improve EFs [11]. However, most of these programmes propose activities that employ analogue materials [12–14], few studies conducted in preschools have analysed the effect of interaction with digital technologies, such as educational robotics [15, 16], educational apps [17], software [18], or exergames [19]. Although integration of digital technologies in traditional school activities appears to be on the increase generally, to the best of our knowledge efforts to foster EFs in preschoolers by using a combination of digital and analogical materials is scarce [20]. To fill this gap, we have conducted a study to test the effectiveness of a digital-analogical educational intervention aimed at fostering preschoolers' EFs and addressing ADHD symptoms (inattention and hyperactivity/impulsivity). The intervention adopts a play-based approach that involves using educational apps jointly with analogical playful activities. The paper describes the intervention's design and presents the results of a pilot implementation in Italy with a sample cohort of preschoolers that includes children with ADHD symptoms.

II. Literature Review

A. The Importance of Executive Functions Development in Preschoolers

Executive functions (EFs) develop from the very first year of life until late adolescence, but in literature there is general agreement that the preschool age is the period of most intensive change in EFs [6–8]. Several studies involving preschoolers found that individual variations in the

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The authors are with the National Research Council of Italy, Institute for Educational Technology, Genoa, Italy.

*Correspondence: panesi@itd.cnr.it (S.P.)

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development of EFs were associated with other components, such as representational systems [21, 22], self-regulation [23], and the theory of mind [24]. Furthermore, EFs seem to be predictive of future academic outcomes [25], such as math or literacy achievement [26].

Concerning atypical development, EFs deficits are present in young children with psychopathological conditions of different kinds, such as pervasive developmental disorders [27], intellectual disabilities [28], and ADHD symptoms [29] from the first years of life.

These findings highlight the importance of fostering EFs from the preschool period onwards. In the educational context, teachers could play a crucial role in this direction by creating stimulating environments and learning paths that help foster EFs through playful activities. Adopting play-based approaches is fundamental in this regard; research not only shows that they are highly motivating for children, but also that play facilitates maturation of the frontal lobes, a process that supports EFs both in children with typical development and those with SEN caused by ADHD symptoms [30].

B. Enhancing Executive Functions in Young Preschoolers: Digital or Analogical Tools?

In recent years, many studies have investigated the effects of educational interventions designed to improve EFs in preschoolers [10]. A number of these have considered the effects on children with typical development and also those with SEN, in particular with ADHD symptoms (inattention and hyperactivity / impulsivity). The latter seem to benefit from early interventions to improve EFs [11, 12], providing an opportunity to prevent severe problems developing in the future.

For example, Traverso and colleagues [13] engaged a group of preschoolers with typical development in an intervention program to enhance EFs via playful activities run using low-cost analogical materials. The authors found that (i) the experimental group outperformed the control group on an interference suppression composite score, and (ii) significant far transfer effects to pre-academic skills in the literacy domain. Re and colleagues [12] proposed a group-based intervention featuring analogical games focusing on the attention, inhibition and working memory of 5-year-old schoolchildren, some with ADHD symptoms and others with typical development. They found that (a) the children with ADHD symptoms improved especially in the tasks measuring their control of attention, impulsive behaviour, and working memory, and that (b) the competences of the children with typical development improved as well. This means that early EFs intervention in the educational context can be considered a resource not only for children with ADHD symptoms but for the whole class group.

It should be noted that the two examples cited above [12, 13] involved use of exclusively analogical materials.

As digital technologies become an increasingly pervasive part of our everyday lives, they are also playing an ever-more important role in school activities. The use of digital technologies in intervention programmes to foster EFs is most common in the clinical context [18]. Only recently have digital technologies they been adopted for this purpose in the educational context, largely for addressing school-age children with inattention and hyperactivity. For example, Di Lieto and colleagues [16] devise and employed an intervention entailing educational robotics for children with special needs at primary school level. They found that in motor responses tasks, children with attentional impairment benefited in terms of inhibition.

While on the one hand there is increasing interest in investigating the effect of training to foster EFs in preschoolers, on the other the use of technologies in these training programs is a matter for ongoing debate [31]. Indeed, several researches claim that intervention with technologies yields benefits because digital natives find technologies familiar and motivating to use, so they can represent a "powerful" tool for engaging young children [32]. Furthermore, they argue, with technologies task difficulty can be modified automatically, so the focus is more firmly on specific EFs components, thus making the intervention program more personalized [18, 19].

By contrast, others are in favour of interventions with playful materials of analogue type, highlighting the importance of using low-cost materials in school, proposing generalizable to daily life activities, and thus making the training program more ecological [11–13].

The literature contains few studies attempting the integration of digital and analogical tools in EF interventions performed in the educational context [31]. For example, Röthlisberger and colleagues [20] propose mixed individual and group training that uses different types of activities and games. Their experience represents a good trade-off between individualized computer-based interventions and large-group curriculum interventions. In line with these authors, the intervention we report in this paper sought to foster preschoolers' EFs by proposing a mix of digital and non-digital games. In our opinion, the integration of digital and analogical tools could represent added value because makes it possible to exploit the different affordances of both forms.

For the digital activities, we chose educational apps for three reasons: their low cost; ease of use for preschoolers [32]; and potential to foster active, engaged, meaningful, and socially interactive learning within the context of a supported learning goal [33]. Furthermore, if selected appropriately, apps can respond to some key criteria for training EFs [34]. First, according to standard EFs intervention approaches [10, 35], the activities apps propose must be graduated in difficulty from the simplest to the most complex. They can also offer added value by proposing activities that are automatically calibrated dynamically in response to the performance of the young user, that is, children can start from an easy level and progress to increasingly complex levels based on their individual performance. This helps to optimize the level of challenge, which is key to both motivation and successful performance in cognitive tasks. Another key to motivation in young children is the level of fun the app induces. Furthermore, apps need to provide timely feedback so that the young user gains a sense of their performance and progress [34].

Based on previous investigations, the present study seeks to extend previous research on preschoolers' EFs training by proposing an intervention that combines playful individual activities using low-cost digital technologies, that is. apps, with low-cost, collective, analogical playful activities.

C. The Present Study

EFs intervention programs for preschool children that involve use of technologies can be challenging and expensive when applied in standard educational contexts. On the other hand, these they can be based on low-cost paper-and-pencil activities, which can be cost-effective but clash with the drive for digitally-based school innovation. A further consideration is that while digital-based EFs intervention programs tend to favour individual activities, those based on paper-and-pencil activities tend to favour small group activities.

So both approaches have particular strengths that make it worthwhile opting for a strategy that combines the two.

Accordingly, we have devised and implemented an intervention program to foster preschoolers' EFs that involves use of both digital and analogical materials, respectively during individual/personalized and collective playful activities.

In light of these considerations, the main aim of the study is to verify the efficacy of digital-analogical training intervention to enhance EFs in preschoolers, as perceived by teachers and parents. In addition, we aimed to explore the effect of the training on ADHD symptoms (inattention and impulsivity/hyperactivity) in the experimental group, especially in children considered 'at risk'. Therefore, the two main research questions were the following:

RQ1: Does the digital-analogical intervention program foster EFs in children in the delicate period of their preschool years, as perceived by their teachers and parents?

RQ2: Does the digital-analogical intervention program help reduce ADHD symptoms (inattention and impulsivity/hyperactivity) in the experimental group, especially in children considered 'at risk'?

The hypothesis underlying RQ1 is that preschool children in the experimental group would show a greater increase in EFs compared to those in the control group following the standard educational program.

Regarding RQ2, a positive influence on ADHD symptoms was expected among children in the experimental group, especially among children considered 'at risk'.

III. METHODOLOGY

A. Study Design

A quantitative, quasi-experimental pre-test–post-test control group design was used for the study. The design is *quasi-experimental* in that it does not adopt random sampling for the formation of the experimental group [36]. In paired control-group models, random sampling is not used to equalize the experimental group, but nevertheless it is important to ensure that the participants have similar characteristics. When forming the experimental and control groups based on children's pre-test scores, care was taken to achieve a balance in gender, age, and in the ADHD symptoms perceived by teachers and parents.

B. Participants

A total of 32 children from 50 to 71 months old were recruited in a little Italian preschool were involved. Parents provided informed consent for their children's participation. The sample was divided into experimental (N=16) and control (N=16) groups. Table I reports the demographic profile of the two groups (gender, age and ADHD symptoms). As this shows, the experimental group was made up—of nine girls and seven boys. Out of these, 31% were four years old and 69% were five years old. The control group comprised 11 girls and five boys. The distribution of age groups shows that 25% were four years old and 75% were five years old.

TABLE I: DEMOGRAPHICS FOR THE EXPERIMENTAL AND CONTROL GROUPS

		Gender			Age			ADHD symptoms (teachers)			ADHD symptoms (parents)		
		Girls	Boys	Total	4 years	5 years	Total	At Risk	No Risk	Total	At Risk	No Risk	Total
Experimental group	n	9	7	16	5	11	16	2	14	16	5	11	16
	%	56%	44%	100%	31%	69%	100%	12.5%	87.5%	100%	31%	69%	100%
Control Group	n	11	5	16	4	12	16	2	11	13*	3	11	14**
	%	69%	31%	100%	25%	75%	100%	15.4%	84.6%	100%	21%	79%	100%

Note: *3 missing **2 missing

Concerning the definition of ADHD symptoms in children with the condition, we followed the approach proposed by Capodieci and colleagues [11], whereby information is collected from teachers and parents using validated rating scales, respectively the IPDDAI for teachers and the IPDDAG for parents [37, 38] in the pre-test phase. The presence of each type of behaviour was reported by parents using a 4-point Likert scale ranging from 0 to 3 (0 = never, 1 = sometimes; 2 = often; 3 = always). Ratings for the single items were summed in order to obtain, respectively, overall Inattention and Hyperactivity scores. We considered children "at risk" to be those who scored more than nine (similar to the cut-off suggested by Caponi and colleagues [35], approximately corresponding to the 15th percentile) either on the Inattention or the Hyperactivity subscale or on both, based on teachers' (IPDDAI) and parents' (IPDDAG) ratings. In the experimental group, two children (12.5%) were considered at risk by teachers and five (31%) were considered at risk by parents. In the control group, 2 children (15.4%) were considered at risk by teachers and three (21%) were considered at risk by parents. In line with Re and Cornoldi [38], parents attributed more symptomatic behaviours in their children than did the teachers.

Finally, Table II reports the mean pre-test scores in order to see whether the control and experimental groups were equivalent concerning EFs. The data in show that there was no statistically significant difference in mean pre-test scores between the experimental and control groups for both teachers and parents (all $p > 0.05$). These results confirmed that there was no statistically significant difference between the pre-test scores of the children in the experimental and control groups, showing that the groups were statistically equivalent regarding their EFs.

TABLE II: PRE-TEST SCORES ACCORDING TO THE BRIEF-P SCALES (FOR TEACHERS AND PARENTS) FOR THE CONTROL AND EXPERIMENTAL GROUPS: DESCRIPTIVE STATISTICS (MIN, MAX, MEAN, S.D.) AND MANN-WHITNEY TEST

		N	Min.	Max.	Mean	S.D.	*U*	*p*	
Teachers									
Inhibit	*Control*	12	16	28	18.17	3.59	112.5	0.450	No dif
	Experimental	16	16	40	19.62	5.98			
Shift	*Control*	12	10	19	11	2.56	102.5	0.767	No dif
	Experimental	16	10	22	11.37	3.12			
Emotional Control	*Control*	12	10	15	11.25	1.96	125	0.205	No dif
	Experimental	16	10	25	12.81	3.97			
Working Memory	*Control*	12	17	34	19	4.79	115	0.397	No dif
	Experimental	16	17	34	19.93	4.43			
Plan/	*Control*	12	10	18	11	2.30	103.5	0.732	No dif
Organize	*Experimental*	16	10	16	11.31	2.06			
Parents									
Inhibit	*Control*	15	0	33	23.20	7.96	156	0.163	No dif
	Experimental	16	16	38	27.31	4.70			
Shift	*Control*	15	0	19	12.73	4.54	136.5	0.520	No dif
	Experimental	16	11	21	13.94	2.93			
Emotional Control	*Control*	15	0	21	14.13	5.28	143	0.379	No dif
	Experimental	16	12	21	16	2.61			
Working Memory	*Control*	15	0	37	22.13	8.69	146	0.318	No dif
	Experimental	16	17	34	24.44	4.86			
Plan/	*Control*	15	0	22	13.20	4.93	160.5	0.110	No dif
Organize	*Experimental*	16	10	21	15.81	3.27			

C. Procedure

The study was conducted in three main phases: (1) pre-intervention; (2) training intervention; (3) post-intervention (Fig. 1).

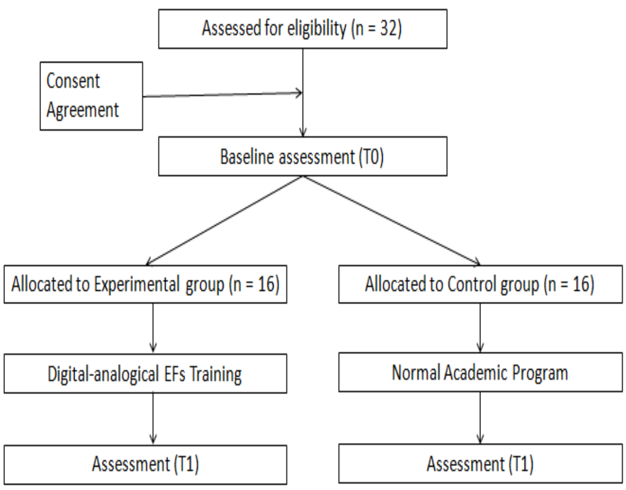

Fig. 1. The study flow diagram.

Pre- and post-intervention assessments were conducted for both the control and experimental groups. During the three phases, teachers and parents filled in two questionnaires: (i) IPDDAI/G to investigate ADHD symptoms [38], and (ii) BRIEF-P [39] to investigate EFs. We decided to use BRIEF-P because in the literature it is the questionnaire considered to be most closely related to tests on EFs [40].

The training intervention phase involving the experimental group lasted 6 weeks. It was conducted by a university graduate who had been thoroughly trained to ensure they understood the aims of the intervention, how to perform the activities foreseen, and to manage the situation in general. To scaffold this effort, the CNR-ITD research team provided the graduate with a training book produced specifically for this research undertaking. During the intervention, the children carried out cognitive enhancement activities in a reserved space (the gym). During these activities, the children were videotaped and the trained graduate filled in specially devised observation sheets—one for each child—under the supervision of CNR-ITD researchers. During the 6 weeks phase of the intervention, the control group were involved in the normal academic program.

D. Instruments

BRIEF-P [39] is a 63-item questionnaire for measuring preschoolers' executive functions as revealed in everyday behaviour. Parents or teachers can fill in this questionnaire. Specifically, it measures various aspects of EF and consists of the following scales: Inhibit, Emotional Control, Plan/Organize, Shift, and Working Memory. All scales reportedly show good internal consistency, reliability and validity [41].

IPDDAI [42] is an 18-item questionnaire designed to help teachers in the early identification of ADHD symptoms. Seven items concern inattention, seven regard hyperactivity/impulsivity; the other items are considered additional and concern risk factors. Teachers indicated the presence of each behaviour using a 4-point Likert scale, ranging from 0 to 3 (0 = behaviour never present/not at all, 1 = behaviour sometimes present, 2 = behaviour often present, 3 = behaviour always/very much present). In this study, we also considered two subscales: inattention and hyperactivity/impulsivity. Re and Cornoldi [38] reported Cronbach's alphas 0.82 ad 0.84 for inattention and hyperactivity/impulsivity, respectively, and test-retest reliability as 0.74 and 0.83, respectively.

IPDDAG [37] is a 19-item questionnaire designed to help parents in the early identification of ADHD symptoms. Seven items concern inattention and seven items regard hyperactivity/impulsivity; the other items are considered additional, concerning risk factors and language problems. In the same manner as the teachers did with the IPDDAI questionnaire, the parents indicated the presence of each behaviour using a 4-point Likert scale. Once again, we also considered the two subscales inattention and hyperactivity/impulsivity. Re and Cornoldi [38] reported that the overall scale has a high Cronbach's alpha (0.88) and the follow-up test-retest reliabilities showed the following results: r = 0.59 for the total score, r = 0.48 for inattention, and r = 0.65 for hyperactivity.

E. Intervention

The intervention program we developed aimed to foster EFs through individual interaction with a series of game-based apps, and game activities played in small groups. In both cases, the set of activities proposed required progressively higher levels of working memory capacity, inhibition, shifting and updating. For the intervention activities, the cohort of 16 children was split into two groups of eight. Meanwhile the control group performed normal kindergarten activities. The intervention sessions lasted approximately 45 minutes and were performed twice a week. In total, 12 sessions were held over approximately 6–7 weeks. These took place during normal kindergarten hours and were held in the school gym, which was specially set up each time. For the intervention, we adopted a play-based approach in which the children enacted the same story and characters throughout. This was considered a suitable strategy to get the children involved and maintain their motivation to collaborate. The activities proposed to the children can be grouped in six main blocks: (1) Familiarization (session 1); (2) Fostering Working Memory (sessions 2–5); (3) Fostering inhibition (sessions 6–7); (4) Fostering shifting (sessions 8-9); (5) Fostering updating (sessions 10–11); (6) Closure (session 12). For details, see Table III.

TABLE III: DIGITAL-ANALOGICAL INTERVENTION PROGRAM

Block	Sessions	Aim	Activities
1	1	Familiarization	Introduction to session activities, presentation of Rita the Sheep, doggerel, contract with the main rules to follow during the training.
2	2–5	Fostering short term memory and working memory	Individual playful activities with the apps and specially created collective playful activities to foster short term memory and working memory in verbal and visuo-spatial domains.
3	6–7	Fostering inhibition	Individual playful activities with the apps and specially created collective playful activities to foster inhibitory control (verbal and motor activities).
4	8–9	Fostering shifting	Individual playful activities with the apps and specially created collective playful activities to foster shifting ability
5	10–11	Fostering updating in working memory	Specially created collective playful activities to foster the ability to monitor and update information held in working memory.
6	12	Closure	Final collective metacognitive reflection about the strategies adopted in the previous activities. Building jigsaw puzzle together.

Specifically, in the first session, the children are invited to listen to and repeat the doggerel of Rita the Sheep, who unfortunately is lost and must undergo different adventures to return to her sheep friends. To perform these adventures, Rita needs the help of the children, who sign a 'contract' designed to commit them to helping her. To aid Rita, the children are instructed to "listen...memorize...observe carefully...wait your turn...reflect together".

This doggerel is reproposed in each session so as to create a common thread. Furthermore, to make the experience more concrete, a board was created to illustrate the adventures that Rita undergoes.

Sessions 2 to 11 each followed the same general structure:

1) Introduction to activities: the activity leader captured the children's attention and commented on the goal of the session activities that day, thus providing a metacognitive introduction;
2) Preparing and developing EF training activities (individual activities with the apps and collective games): the activity leader (a) presented cognitive requests, (b) provided instructions and preliminary practice with the tasks of the day, (c) organized the activities, and (d) invited the children to complete the tasks.
3) Metacognitive reflection and conclusion: the activity leader asked the children to comment and reflect together on the activities, and (with assistance) report strategies

that they had used or thought they could use. Furthermore, the leader asked the children how well they thought they had done the task, and invited them to individually complete a metacognitive schedule. Finally, as a reward the children received a packet containing a piece of jigsaw puzzle representing Rita the Sheep.

Sessions 2, 4, 5, 6, 7, 8, 9 included two training phases, individual training with game-based apps and a specially created collective roleplay activity with the aim of fostering EFs.

All the apps adopted for this EF training had been identified, selected and analysed by CNR-ITD researchers as being suitable for fostering EFs, together with the collective roleplay activities. All the selected apps are free, feature a simple and attractive graphic interface, well-defined and focused content, and provide timely feedback. The apps used in sessions 2, 4, 5 vary in difficulty in line with the child's performance. Instead, the apps in sessions 6, 8, 9 were used to train the children in the prerequisites necessary to engage in the collective activities (see Table IV).

TABLE IV: INTERVENTION APPS

Session	App' s name	Link	Cognitive abilities involved/ or prerequisites
2	A memory app for kids—game: auditory memory	https://play.google.com/store/apps/details?id=air.com.shubi.memoryEnglish&hl=it	Short term memory, ability to discriminate sounds, attention
4	A memory app for kids—game: spatial memory	https://play.google.com/store/apps/details?id=air.com.shubi.memoryEnglish&hl=it	Short term memory, Working memory, attention, visual discrimination
5	Memory Challenge (Simon)	https://play.google.com/store/apps/details?id=com.lasthero.simon	Short term memory, working memory in the visuo-spatial domain, attention, the ability to control impulsive responses to respect turn taking
6	Colours for children or Busy shapes and colours	https://play.google.com/store/apps/details?id=com.gokids.colors0	Prerequisites: colour recognition
7	Draw for children or Play, colour, children 2 years	https://play.google.com/store/apps/details?id=com.bbbbb.fingerdraw&hl=it&rdid=com.bbbbb.fingerdraw	Motor inhibition, attention
8	Play for kids from 2 to 5 years (Bimi Boo Kids)—game Classify by size	https://play.google.com/store/apps/dev?id=5399967083006869522&hl=it	Prerequisites: classify by size
9	Play for kids from 2 to 5 years (Bimi Boo Kids)—game Classify by shape and colour	https://play.google.com/store/apps/dev?id=5399967083006869522&hl=it	Prerequisites: classify by shape and colour

For the activities with the apps, the activity leader presented the game/s for that session, then handed out Android 5.0 tablets to the children, who played for 5 minutes.

In the last session (12), the children engaged in a group discussion (with the activity leader's help) about the activities they had performed in the previous sessions. Finally, they completed the jigsaw of Rita the Sheep together, and then had a party.

F. Statistical Analyses

The data were analysed with the SPSS 20.0 software program [43]. Descriptive analyses were performed to calculate the arithmetic means and the standard deviations in the experimental and control groups.

The Mann—Whitney Test was used to determine whether the scores of the two independent samples (experimental and control groups) differed significantly from each other in both pre- and post-phases.

The Wilcoxon Test was used to determine the possible presence and magnitude of differences between pre- and post-test scores in the groups.

The same test was applied to investigate whether children in the experimental group with high-level ADHD symptoms (children considered 'at risk') showed major reductions in inattention and hyperactivity/impulsivity.

IV. RESULTS

Experimental and control groups post-test EFs scores provided by teachers and parents were analysed with the Mann—Whitney U test, the results are presented in Table V.

As can be seen in Table III, statistically significant differences were found in inhibition by both teachers ($U = 171.00$, $p = 0.013$) and parents ($U = 191.50$, $p = 0.004$), and by teachers only for shifting ($U = 161.50$, $p = 0.038$), working memory ($U = 166.00$, $p = 0.025$), and plan/organize ($U = 165.50$, $p = 0.025$).

The control and experimental groups' pre- and post-test EF scores provided by teachers and parents were analysed with the Wilcoxon Test; the results are presented in Table VI. This shows that for the control group, teachers and parents observed no differences between pre- and post-test scores, except for the inhibit score reported by parents ($Z = -3.072$, $p = 0.002$).

TABLE V: CONTROL AND EXPERIMENTAL GROUPS' POST-TEST SCORES ACCORDING TO THE BRIEF-P SCALES (ATTRIBUTED BY TEACHERS AND PARENTS): MANN-WHITNEY TEST

		N	Min.	Max.	Mean	S.D.	*U*	*p*	
Teachers									
Inhibit	*Control*	14	0	23	14.57	6.55	171.00	0.013	**Dif**
	Experimental	16	16	41	20.56	6.85			
Shift	*Control*	14	0	19	9.43	4.65	161.50	0.038	**Dif**
	Experimental	16	10	21	12.75	3.68			
Emotional Control	*Control*	14	0	19	10.21	5.10	152.50	0.093	No dif
	Experimental	16	10	26	14.19	4.73			
Working Memory	*Control*	14	0	34	15.93	8.10	166.00	0.025	**Dif**
	Experimental	16	17	31	21.06	5.33			
Plan/Organize	*Control*	14	0	20	9.36	4.76	165.50	0.025	**Dif**
	Experimental	16	10	20	12.56	3.26			
Parents									
Inhibit	*Control*	15	0	29	19.40	6.85	191.50	0.004	**Dif**
	Experimental	16	19	33	25.31	3.88			
Shift	*Control*	15	0	17	11.73	4.16	166.00	0.072	No dif
	Experimental	16	10	19	14.06	2.79			
Emotional Control	*Control*	15	0	22	13.13	5.22	147.00	0.299	No dif
	Experimental	16	11	20	14.56	2.85			
Working Memory	*Control*	15	0	31	21.27	7.97	124.50	0.861	No dif
	Experimental	16	17	31	22.31	4.36			
Plan/Organize	*Control*	15	0	20	12.73	4.83	144.00	0.358	No dif
	Experimental	16	10	20	14.19	3.19			

TABLE VI: CONTROL AND EXPERIMENTAL GROUPS' PRE-TEST AND POST-TEST SCORES ACCORDING TO THE BRIEF-P SCALES (ATTRIBUTED BY TEACHERS AND PARENTS): WILCOXON TEST

	Teachers			Parents		
	Z	*p*		*Z*	*p*	
Control group						
Inhibit	−1.156	0.248	No dif	−3.072	0.002	**Dif**
Shift	0.000	1	No dif	−1.482	0.138	No dif
Emotional Control	0.857	0.391	No dif	−1.546	0.122	No dif
Working Memory	−1.518	0.129	No dif	−0.983	0.325	No dif
Plan/Organize	−0.272	0.785	No dif	−0.562	0.574	No dif
Experimental group						
Inhibit	1.123	0.262	No dif	−1.711	0.087	No dif
Shift	2.395	0.017	**Dif**	0.387	0.699	No dif
Emotional Control	1.685	0.092	No dif	−1.864	0.062	No dif
Working Memory	1.133	0.257	No dif	−2.583	0.010	**Dif**
Plan/Organize	2.393	0.017	**Dif**	-2.494	0.013	**Dif**

Concerning the experimental group, several statistically significant differences were found: (i) shift score for teachers (Z = 2.395, $p = 0.017$); (ii) working memory score for parents (Z = −2.583, $p = 0.010$); and (iii) plan/organize score for both teachers (Z = 2.393, $p = 0.017$) and parents (Z = −2.494, $p = 0.013$).

Concerning ADHD symptoms, the Wilcoxon Test was used to investigate whether the children in the experimental group demonstrated reduced inattention and Impulsivity/ Hyperactivity symptoms, especially those considered 'at risk'. Table VII shows that the teachers did not report such a reduction. By contrast, the parents reported a reduction in inattention symptoms (Z = −3.108, *p* = 0.002), and in the children considered 'at risk' they reported a reduction in both inattention (Z = −2.041, *p* = 0.041) and Impulsivity/ Hyperactivity (Z = −2.041, *p* = 0.041) symptoms.

TABLE VII: TEACHERS' AND PARENTS' PRE-TEST AND POST-TEST SCORES FOR ADHD SYMPTOMS DEMONSTRATED BY EXPERIMENTAL GROUP CHILDREN (INCLUDING CHILDREN AT RISK) : WILCOXON TEST

	Teachers											
	All children in the experimental group (N = 16)						**Children "At Risk" in the experimental group (N = 2)**					
	Pre		Post		Wilcoxon test		Pre		Post		Wilcoxon test	
	M	SD	M	SD	Z	*P*	M	SD	M	SD	Z	*p*
Inattention	4.69	3.50	2.87	3.34	2.594	**0.009**	9.00	2.83	8.00	5.66	−0.447	0.655
Impulsivity/ Hyperactivity	3.37	2.94	1.87	2.65	1.831	0.067	6.00	4.24	5.00	0.00	−0.447	0.655
	Parents											
	All children in the experimental group (N = 16)						**Children "At Risk" in the experimental group (N = 5)**					
	Pre		Post		Wilcoxon test		Pre		Post		Wilcoxon test	
	M	SD	M	SD	Z	*p*	M	SD	M	SD	Z	*p*
Inattention	4.00	3.34	2.56	2.10	−3.108	**0.002**	6.40	2.07	3.80	1.64	−2.041	**0.041**
Impulsivity/ Hyperactivity	7.31	3.11	6.56	3.36	−1.313	0.189	10.60	2.61	8.60	3.13	−2.041	**0.041**

V. DISCUSSION

Several studies have highlighted the importance of developing executive functions (EFs) during preschool years [6–9]. A potentially useful way to enhance early achievement and reduce the risk of children with Special Education Needs (SEN), such as children with ADHD symptoms [11–13], falling behind is to develop and deploy early EFs interventions. Ideally, given the target age, these should be based on games and play activities. These can provide children with enjoyment and a positive emotional experience, increasing their intrinsic motivation to exercise EFs [19]. What's more, such activities are easily implemented in the educational services, with the opportunity to adopt low-cost digital technologies jointly with more traditional analogical means. This approach is in line with the European Digital Education Action Plan [44] and the Italy's national plan for digital school (PNSD) [45], two key policy initiatives that have the common the aim to promote pedagogical innovation via effective and appropriate employment of digital technologies [1].

The present study was conducted in this direction, and more specifically to examine the efficacy of a short EFs intervention program designed to be suitable for educational services to implement. Accordingly, it combines individual and collective playful activities, respectively via use of educational apps and analogical materials.

The main aim of this work was to promote the EFs of children with typical development and with ADHD symptoms in the delicate period of their preschool years. Specifically, this study examined the effect of the digital-analogical EFs intervention program on preschool children's EFs and on ADHD symptoms (inattention and impulsivity/hyperactivity), as perceived by teachers and parents.

The results regarding impact on EFs provide good support for the first hypothesis in this study in that they demonstrate the effectiveness of implementing the digital-analogical EFs intervention program for preschoolers. Specifically, comparison between the experimental and control groups in the post-test phase showed that the experimental group's inhibition ability was perceived by both teachers and parents to have improved. Furthermore, teachers perceived a significant post-test improvement in the experimental groups' shifting, working memory, and planning. Additionally, between pre-intervention and post-intervention phases, teachers also perceived significant improvements in the experimental groups' shifting and planning, while parents perceived gains in working memory and planning. The same comparison for the control group revealed only a significant change perceived by parents concerning inhibitory control. These findings are in line with the literature, which has identified the preschool age as a critical period of rapid EF development and brain development [6–8]. Authors also highlight that the implementation of an intervention program that combines individual and collective playful activities, performed respectively with digital and analogical instruments, can generate useful results in the short term (6–7 weeks) to foster EFs in this delicate age.

Concerning the perception of teachers and parents about the effect of a digital-analogical EFs training program on ADHD symptoms, the findings of this study indicate that (i) teachers perceived a significant reduction in the experimental groups' inattention; (ii) parents also perceived a significant reduction in the experimental group's inattention, and specifically perceived a significant reduction in both inattention and impulsivity/hyperactivity in children considered 'at risk'. These findings confirm our second hypothesis (positive influence of the intervention on ADHD symptoms) and are in line with previous research that has highlighted the importance of EF training programs in the first years of life to reduce the ADHD symptoms [11, 12]. Therefore, as well as being aligned with previous research, the present study adds empirical evidence for this area of research.

VI. Conclusion

Rapid digitalization over the past decade has transformed many aspect of daily life, including the education system. For this reason, starting from preschool, it's fundamental to integrate educational use of digital tools along with more traditional analogical instruments in a pedagogically meaningful way. To do this, in the present paper we have proposed an innovative low-cost EF digital-analogical intervention program that combines playful activities with educational apps and analogical tools. This has allowed us to activate cooperation between peers during the collective playful activities with analogue materials and leverage affordances that educational apps offer for personalizing activities according to the needs of children. The study confirmed that the implementation of this training had a positive impact on EFs and ADHD symptoms in preschoolers, including those considered 'at risk'. Therefore, implementation of this training in educational services could be also considered useful in the field of prevention research.

VII. Limitation and Further Research

Three major limitations of this study should be noted. The first concerns the sample. The study involved a relatively small sample size and this may have affected the generalizability of results. Hence, these should be interpreted with caution and future research is needed with a larger sample so as to confirm and validate the current findings. The second limitation concerns the tools used in the pre- and post-intervention phases. Specifically, we relied on questionnaires that captured the perception of teachers and parents. Future research might also test the effects of the training by administering direct tests before and after the intervention (comparing control and experimental groups). Finally, the intervention was administered by a trained university graduate. In the future, training courses for teachers on this intervention program could be implemented; overall raise awareness among teachers on the importance to integrate the use of educational apps in educational services to enhance EFs jointly with traditional activities conducted with analogical materials could be useful to promote the digital competence of teachers [46], in line with the strategic priorities of the Digital Education Action Plan [34].

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization SP; Data curation SP; Formal analysis SP; Funding acquisition LF; Investigation SP; Methodology SP; Project administration LF; Supervision LF; Writing—original draft SP; Writing—review & editing SP, LF; all authors approved the final version.

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References

[1] S. Bocconi, S. Panesi, and P. Kampylis, "Fostering the digital competence of schools: Piloting SELFIE in the Italian education Context," *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, vol. 15, no. 4, pp. 417–425, October 2020.

[2] S. Panesi, S. Bocconi, and L. Ferlino, "Promoting students' well-being and inclusion in schools through digital technologies: Perceptions of students, teachers and school leaders in Italy expressed through SELFIE piloting activities," *Frontiers in Psychology*, 11, 1563, July 2020.

[3] OECD, *Students, Computers and Learning—Making the Connection*, Paris: OECD, 2015.

[4] M. Benvenuti, A. Chioccariello, and S. Panesi, "Using online learning environments with kindergarten children during the COVID-19 emergency: A case study in Italy" in *Handbook of Research on Lessons Learned From Transitioning to Virtual Classrooms During a Pandemic,* A.W. Thornburg, R. J. Ceglie and D. F. Abernathy, IGI GLOBAL, 2021, ch. 7, pp. 125–143.

[5] K. A. Blair, S. A. Denham, A. Kochanoff, and B. Whipple, "Playing it cool: Temperament, emotion regulation, and social behavior in preschoolers," *Journal of School Psychology*, vol.42, no. 6, pp. 419–443, November-December 2004.

[6] N. Garon, S. E. Bryson, and I. M. Smith, "Executive function in preschoolers: A review using an integrative framework," *Psychological Bulletin*, vol. 134, no. 1, pp. 31–60, 2008.

[7] S. Panesi and S. Morra "Executive functions and mental attentional capacity in preschoolers," *Journal of Cognition and Development*, vol. 21, no. 1, pp. 72–91, November 2020

[8] A. Diamond, "The early development of executive functions," in *Lifespan Cognition: Mechanisms of Change,* E. Bialystok and F. I. M. Craik, Eds., Oxford University Press, pp. 70–95, 2006.

[9] A. Miyake, N. P. Friedman, M. J. Emerson, A. H. Witzki, A. Howerter, and T. D. Wager, "The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis," *Cognitive Psychology*, vol. 41, no. 1, pp. 49–100, August 2000

[10] N. Scionti, M. Cavallero, C. Zogmaister, and G. M. Marzocchi, "Is cognitive training effective for improving executive functions in preschoolers? A systematic review and meta-analysis," *Frontiers in psychology*, 10, 2812, 2020.

[11] A. Capodieci, M.L. Gola, C. Cornoldi, and A.M. Re, "Effects of a working memory training program in preschoolers with symptoms of attention-deficit/hyperactivity disorder," *Journal of clinical and Experimental Neuropsychology*, vol. 40, no. 1, pp. 17–29, 2018.

[12] A. M. Re, A. Capodieci, and C. Cornoldi, "Effect of training focused on executive functions (attention, inhibition, and working memory) in preschoolers exhibiting ADHD symptoms," *Frontiers in Psychology*, 6, 1161, August 2015.

[13] L. Traverso, P. Viterbori, and M. C.Usai. "Effectiveness of an executive function training in Italian preschool educational services and far transfer effects to pre-academic skills," *Frontiers in Psychology*, 10, 2053, September 2019

[14] J. Bai, H. Huang, H. Ouyang, "Effects of Group-Play Moderate to Vigorous Intensity Physical Activity Intervention on Executive Function and Motor Skills in 4-to 5-Year-Old Preschoolers: A Pilot Cluster Randomized Controlled Trial," *Frontiers in Psychology*, 2585, June 2022

[15] M. C. Lieto, E. Inguaggiato, E. Castro, F. Cecchi, G. Cioni, M. Dell'Omo, C. Laschi, C. Pecini, G. Santerini, G. Sgandurra, and P. Dario, "Educational Robotics intervention on Executive Functions in preschool children: A pilot study," *Computers in Human Behavior*, vol. 71, pp. 16–23, June 2017.

[16] M. C. Lieto, C. Pecini *et al*., "Empowering executive functions in 5- and 6-year-old typically developing children through educational robotics: An RCT study," *Frontiers in Psychology*, 10, 3084, February 2020.

[17] Q. Liu, X. Zhu, A. Ziegler, and J. Shi, "The effects of inhibitory control training for preschoolers on reasoning ability and neural activity," *Scientific Reports*, vol. 5, 14200, September 2015.

[18] L. B. Thorell, S. Lindqvist, S. Bergman Nutley, G Bohlin, and T. Klinberg, "Training and transfer effects of executive functions in

preschool children," *Developmental Science*, vol. 12, no. 1, pp. 106–113, January 2009.

[19] Z. M. Liu, C. Q. Chen, X. L. Fan, C. C. Lin, and X. D. Ye, "Usability and effects of a combined physical and cognitive intervention based on active video games for preschool children," *International Journal of Environmental Research and Public Health*, vol. 19, no. 12, 7420, June 2022

[20] M. Röthlisberger, R. Neuenschwander, P. Cimeli, E. Michel, and C. M. Roebers, "Improving executive functions in 5-and 6-year-olds: Evaluation of a small group intervention in prekindergarten and kindergarten children," *Infant and Child Development*, vol.21, no. 4, pp. 411–429, July-August 2012

[21] S. Panesi and S. Morra, "Relationships between the early development of drawing and language: The role of executive functions and working memory," *The Open Psychology Journal*, vol. 11, pp. 15–24, March 2018

[22] S. Panesi and S. Morra, "The relation between drawing and language in preschoolers: The role of working Memory and executive functions," *Cognitive Development*, vol. 61, 101142, January-March 2022.

[23] B. W. Sokol and U. Muller, "The development of self-regulation: Toward the integration of cognition and emotion," *Cognitive Development*, vol. 22, no. 4, pp. 401–405, 2007

[24] C. Hughes and R. Ensor, "Executive function and theory of mind: Predictive relations from ages 2 to 4," *Developmental Psychology*, vol. 43, no. 6, 1447, 2007

[25] N. P. Allan and C. J. Lonigan, "Examining the dimensionality of effortful control in preschool children and its relation to academic and socioemotional indicators," *Developmental Psychology*, vol. 47, no. 4, pp. 905–915, July 2011.

[26] C. Blair and R. P. Razza "Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten," *Child Development*, vol. 78, no. 2, pp. 647–663, March-April 2007

[27] E. Pellicano, "The development of executive function in autism," *Autism Research and Treatment*, pp. 1–8, July 2012.

[28] S. Lanfranchi, O. Jerman, and R. Vianello, "Working memory and cognitive skills in individuals with Down syndrome," *Child Neuropsychology*, vol. 15, no. 4, pp. 397–416, June 2009

[29] K. Lawson and H. Ruff, "Early attention and negative emotionality predict later cognitive and behavioural function," *International Journal of Behavioral Development*, vol. 28, no. 2, pp. 157–165, 2004.

[30] J. Panksepp, "Play, ADHD, and the construction of the social brain: Should the first class each day be recess?" *American Journal of Play*, vol. 1, no. 1, pp. 55–79, 2008

[31] S. Panesi and L. Ferlino, "Enhancing executive functions in preschoolers: Technologies yes or not?" *International Proceedings of 18th International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2021)*, eds. Demetrios G. Sampson, Dirk Ifenthaler and Pedro Isaías, pp. 367–369, October 2021

[32] S. Dini and L. Ferlino, "La conoscenza tra le dita dei bambini. Imparare e giocare a tempo di app," *Italian Journal of Educational Technology*, vol. 24, no. 3, pp. 147–147, 2016

[33] K. Hirsh-Pasek, J. M. Zosh, R. M. Golinkoff, J. H. Gray, M. B. Robb, and J. Kaufman, "Putting education in "educational" apps: Lessons from the science of learning," *Psychological Science in the Public Interest*, vol. 16, no. 1, pp. 3–34, 2015

[34] S. Panesi and L. Ferlino, "Using apps in formal education to improve executive functions in preschoolers" *International Proceedings of the International Conference on Innovation, Documentation and Education INNODOCT 2019*, pp. 189-19, November 2019

[35] B. Caponi, L. Clama, A. M. Re, and C. Cornoldi, *Sviluppare la concentrazione e l'autoregolazione: Giochi e attività sul controllo della Memoria di Lavoro*, vol. 3, Trento: Erickson, 2009

[36] J. R. Fraenkel and N. E. Wallen, *How to Design and Evaluate Research in Education*, Mc Grawall Hill, 2006.

[37] M. Riello, A. M. Re, and C. Cornoldi, "Costruzione di uno strumento rivolto alla famiglia per l'identificazione precoce del DDAI," *Disturbi di attenzione e iperattività*, vol. 1, no. 1, pp. 9–26, 2005

[38] A. M. Re and C. Cornoldi, "Two new rating scales for assessment of ADHD symptoms in Italian preschool children: A comparison between parent and teacher ratings," *Journal of Attention Disorders*, vol. 12, no. 6, pp. 532–539, 2009.

[39] G. A. Gioia, K. Andrwes, and P. K. Isquith, *Behavior Rating Inventory of Executive Function-Preschool Version (BRIEF-P)*, Odessa, FL: Psychological Assessment Resources, 1996.

[40] N. Garon, C. Piccinin, and I. Smith, "Does the BRIEF-P predict specific executive function components in preschoolers?" *Applied Neuropsychology: Child*, vol. 5, no. 2, pp. 110–118, 2015.

[41] E. M. Mahone and J. Hoffman, "Behavior ratings of executive function among preschoolers with ADHD," *The Clinical Neuropsychologist*, vol. 21, no. 4, pp. 569–586, 2007

[42] E. Marcotto, B. Paltenghi, and C. Cornoldi, "La scala IPDDAI: Contributo per la costruzione di uno strumento per l'identificazione precoce del disturbo da deficit di attenzione e/o iperattività," *Difficoltà di apprendimento*, vol. 8, no. 2, pp. 153–172, 2002.

[43] J. L. Arbuckle, *IBM SPSS Amos 20 User's Guide*, Amos Development Corporation, SPSS Inc, 2011.

[44] *Digital Education Action Plan*. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0624&from=EN

[45] *Piano Nazionale Scuola Digitale*. [Online]. Available: https://www.miur.gov.it/documents/20182/50615/Piano+nazionale+scuola+digitale.pdf/5b1a7e34-b678-40c5-8d26-e7b646708d70?version=1.1&t=1496170125686

[46] JRC European Commission, *European Framework for the Digital Competence of Educators: DigCompEdu*, European Union, 2017.