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The PRSIST Intervention to Improve Self-Regulation in Preschoolers: An Adaptation to the Italian Context

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ABSTRACT

Self-regulation is the ability to control cognitive, behavioural and social–emotional processes in service of one's goals. In the preschool years, self-regulation develops rapidly, and during this period, it is influenced by the plasticity of the underlying neurofunctional circuits. Since good early self-regulation skills favour positive developmental trajectories, numerous interventions have been proposed to enhance early self-regulation skills. The present study aimed to investigate the efficacy of one of these, the Preschool Situational Self-Regulation Toolkit (PRSIST), adapted to the Italian context. Two hundred and twenty-seven preschoolers were randomly assigned at the classroom level to an experimental group (EG, $n = 117$) and a control group (CG, $n = 110$). The EG was involved in the intervention for 6 months, delivered by the classroom teachers through: daily playful activities with self-regulation challenge, participating in teacher training of beneficial adult practices and parent newsletters. The EG showed significant improvement compared to the CG in: cognitive self-regulation; inhibition; cognitive flexibility; and prosocial behaviours. Children with low initial performance improved even more from the training. These results support the acceptability and efficacy of this intervention, which can be implemented by teachers within Italian preschool contexts to promote the self-regulation skills of preschoolers.

1 | Introduction

1.1 | Self-Regulation

Self-regulation refers to the ability to remain goal-directed despite competing impulses or distractions (Vohs and Baumeister 2004). It thus entails the capacity to control attention and thinking, behaviour, emotional reactions and social interactions (Howard et al. 2018). Self-regulation represents a foundational skill in children's development as it enables behaviours that are conducive to school readiness and success (McWayne et al. 2004; McClelland et al. 2014; Skibbe et al. 2019), as well as the development of positive social relationships and adaptivity to life situations (Best et al. 2011; Moffitt et al. 2011). Early self-regulation also predicts adults' later quality of life (Causadias et al. 2012; Hentges et al. 2018; Moffitt et al. 2011). Considering compelling evidence of the importance of good early self-regulation skills, researchers are investigating more deeply this ability, its development, its underlying processes and ways to strengthen it.

Several studies show self-regulation develops most rapidly in early childhood (McClelland et al. 2014; Wanless et al. 2016; Grüneisen et al. 2023), after which the increase is more gradual and protracted (Montroy et al. 2016). The development of self-regulation is influenced by multiple stable and malleable

Summary

- A self-regulation intervention for preschool was adapted for the Italian context.
- The program improved self-regulation, executive functions and prosocial behaviour.
- Children with self-regulation difficulties benefited more from training.
- Findings suggest efficacy and acceptability of this program in the Italian context.

individual factors, such as temperament, as well as by environmental variables, such as socio-economic status and culture (Usai et al. 2012). By some prominent accounts, self-regulation involves the interaction between bottom-up reactivity to environmental stimuli and top-down control over resultant levels of arousal via executive functions (EF; Nigg 2017; Savina 2021). Underlying self-regulation, there are thus multiple processes, which are necessary to achieve one's goals and to cope with external events (Liebermann et al. 2007; Usai et al. 2012).

EF refers to a set of cognitive processes that are necessary (but not sufficient) for goal-directed behaviour, to organise actions in order to achieve specific goals or tasks (Diamond 2013). EF undergoes development from infancy through late adolescence (Conklin et al. 2007; Davidson et al. 2006; Diamond 2002; Rothbart and Posner 2005), with the preschool years identified as the most rapid and sensitive period for EF development (Carlson et al. 2005; Rueda et al. 2004). During infancy, the initial abilities related to EF emerge, typically around 12 months of age (Bernier et al. 2010; Diamond 2006). However, these abilities remain relatively limited until around the age of three, after which there is a period of rapid exponential growth (Roebers et al. 2011). Between the ages of 3 and 5 years, children experience significant development in inhibition and working memory (Diamond and Taylor 1996; Kochanska et al. 2000). Cognitive flexibility, which builds on these foundational EF (Diamond 2013), typically emerges later, with a critical developmental period between 6 and 9 years of age (Anderson 2002).

Taking advantage of the early malleability and plasticity of the neurofunctional circuits of the cognitive processes underlying self-regulation skills (Moriguchi and Hiraki 2013; Pan et al. 2018), a number of interventions have been proposed to promote the development of self-regulation, especially aimed at the preschool age (e.g., Greenberg and Kusché 2006; Raver et al. 2009, 2011; Bodrova and Leong 2007, 2018; Yamamoto and Imai-Matsumura 2023). The current study sought to evaluate one such programme, which aims to leverage early childhood settings and educators to promote children's self-regulation growth.

1.2 | Intervention on Self-Regulation in Preschool Age

Researchers have designed, implemented and evaluated diverse programmes aimed at promoting self-regulation and its underlying cognitive processes in preschoolers (e.g., Bodrova and Leong 2007; Di Lieto, Pecini et al. 2020; Klingberg et al. 2002; Greenberg and Kusché 2006; Raver et al. 2008; Traverso et al. 2015). These interventions can be broadly divided into two (not entirely mutually exclusive) types depending on whether they focus most highly on self-regulation or underlying EF components as their target (Muir et al. 2023).

For instance, some programmes aim to promote one or more EF components directly, often in structured environments with cognitively challenging activities (Scionti et al. 2020). These programmes provide graded practice with progressively more challenging demands (Diamond and Lee 2011). An example of this type of intervention is Cogmed Working Memory Training (Klingberg et al. 2002), a short-term, intensive computerised programme that delivers activities that increase in mental retention and manipulation demand to promote working memory (Klingberg et al. 2005; Thorell et al. 2009). Given its requisite individualised setup, Cogmed necessitates one computer per child. Accordingly, its predominant utilisation has been within laboratory and clinical contexts. Research indicates that while Cogmed generates effects on trained skills, transfer to untrained skills is less common (Aksayli et al. 2019).

Another example of EF interventions is educational robotics, wherein participants undertake programming tasks with robots and maps to promote basic EF skills (Di Lieto, Pecini et al. 2020; Di Lieto, Castro et al. 2020). This approach is more conducive to small group implementation. Frequency and intensity are variable between evaluations but tend to be short. This approach appears to be appropriate for both typically developing preschoolers (Di Lieto, Inguaggiato, et al. 2017) and school-aged children (Di Lieto, Pecini et al. 2020) within school settings, as well as with children with disabilities in clinical environments (Di Lieto, Castro et al. 2020). Effects have been found for inhibition and working memory skills (e.g., Di Lieto, Pecini et al. 2020; Di Lieto, Castro et al. 2020). Yet the use of educational robotics necessitates the purchase of technological apparatus and requisite technological skills to support child learning.

Accordingly, more 'ecological' and in vivo training of EF has been proposed for preschoolers, such as "Le avventure di Chicco e Nanà", which consists of teacher-led activities at school across 12 sessions over 1 month, using low-cost materials (Traverso et al. 2015). This intervention has been carried out by both psychologists (Traverso et al. 2015) and teachers (Traverso et al. 2019) in school settings. Following training, children demonstrated enhanced capacities for postponing immediate rewards, regulating ongoing responses, processing and refreshing information and handling situations of heightened cognitive conflict (Traverso et al. 2015), as well as interference suppression skills and far transfer effects to pre-academic literacy skills (Traverso et al. 2019). However, the programme activities did not inherently fit into daily school routines and thus placed an implementation burden on educators that could impact fidelity, scalability and sustainability.

Another example is shared book reading, using "Quincey Quokka's Quest" (Howard et al. 2017; Ruffini et al. 2021). During reading of the story, children perform cognitive tasks to help the story's protagonist overcome the cognitive challenges they encounter. Each cognitive activity serves to engage one or more executive components. The training is

intentionally brief, spanning approximately 2 months, with sessions occurring between one to three times per week. Results show increased EF scores after the programme, which were maintained up to a month after completion of the programme (Howard et al. 2017). This approach integrates well with the school environment, given the regularity of dialogic reading with children in preschool settings. However, this approach necessitates reading with single children or small groups to ensure opportunity for engagement with the activities, the opportunity for which is less frequent in preschools (compared to reading with the whole group or more spontaneously with one or a few children).

In general, EF interventions in preschoolers have been shown to be effective in improving directly trained skills (i.e., near transfer; Diamond and Ling 2016; Kassai et al. 2019; Scionti et al. 2020). However, there are mixed results regarding the transfer of effects to cognitive abilities not directly trained (far transfer; Melby-Lervåg and Hulme 2013; Kassai et al. 2019; Sala and Gobet 2017; Scionti et al. 2020). This has been a largely intractable challenge thus far for interventions that target only cognitive processes underlying self-regulation. Indeed, even for programmes that target EF, the aim of training is typically to generate improvements that generalise to children's real-world and everyday performance, abilities and outcomes.

A second type of intervention relates to programmes directly focused on self-regulation training. A common and crucial aspect of self-regulation interventions is to carry out activities in a responsive social environment, in which children feel secure and sources of stress (detrimental to self-regulation) are minimised. Then, the growth of self-regulation abilities is often pursued through the action of a caregiver, who provides appropriate challenge and support to extend children's development. Often, no specific materials are required to implement this type of intervention; activities can leverage existing resources, led by curricular teachers within the school setting (Takacs and Kassai 2019; Bodrova and Leong 2007, 2018; Greenberg and Kusché 2006; Raver et al. 2008).

One example is the preschool curriculum Tools of the Mind (Bodrova and Leong 2007, 2018), which supports educators to scaffold children's higher-order thinking in planning, social learning and play—particularly sustained make-believe play—with eventual, gradual withdrawal of their support. In pretend play, children must refrain from acting out of character, recall both their own and others' roles and demonstrate flexibility by adapting to their friends' improvisations. Self-regulation skills are thus routinely implicated in successful make-believe play. This intervention has shown positive effects on self-regulation, but somewhat inconsistently across studies (Diamond et al. 2007; Baron et al. 2017).

Another curriculum-based approach is the preschool adaptation of the Promoting Alternative Thinking Strategies (PATHS; Kusche and Greenberg 1994) programme. The PATHS curriculum (Greenberg and Kusché 2006) encourages the adoption of alternative thinking strategies and provides training for teachers to cultivate children's abilities in self-control, emotional recognition and interpersonal problem-solving. The training underscores the importance of articulating feelings and employing deliberate self-control tactics (e.g., pausing before acting and engaging in self-reflection). This programme has shown efficacy in promoting social and emotional skills (Domitrovich et al. 2007; Stanley 2019) and long-term benefits on educational achievement (Sasser et al. 2017). It focuses less explicitly, however, on cognitive components of self-regulation.

Similar to the PATHS curriculum, the Chicago School Readiness Project (CSRP; Raver et al. 2008) is designed to improve the school readiness of preschoolers from low-income backgrounds. The CSRP provides training for teachers on classroom management strategies and ways through which to offer emotional support to students. The strategies taught encompass implementing clearer rules and routines, reinforcing positive behaviour and redirecting negative behaviour. CSRP focuses primarily on fostering verbal articulation techniques to support regulation of emotions specifically. This intervention has yielded improvement in scores on EF tasks and pre-academic skills, as well as a decrease in behaviour problems (Raver et al. 2009, 2011). However, this requires psychologists to work closely over a sustained period with preschools.

Finally, a recent intervention developed by Grüneisen et al. (2023) provides instruction to educators and preschoolers on self-regulation strategies. The intervention involved nine sessions over 5 weeks, teaching preschoolers self-regulated learning strategies through a frame story. It was based on the consideration that both EF and language skills are needed to acquire self-regulatory abilities. Accordingly, sessions included story reading, practical exercises and reflection tasks, with children receiving stickers as rewards. This intervention emphasises the (meta-) cognitive abilities of children and has been shown to be efficacious in promoting self-regulation skills among preschoolers. However, the authors did not measure child EF; thus, the influence of these precursor abilities on the development of self-regulatory competencies remained unclear.

These curricula-like programmes typically place less emphasis on the cognitive components underlying self-regulation (Tools of the Mind being an exception), focusing instead on the child's self-regulation of emotions and social behaviours. There is evidence, however, that the integration of these elements might be more conducive to child-level effects (for a review; Muir et al. 2023).

1.3 | PRSIST Program

Muir et al. (2023) analysed these intervention approaches to identify their respective strengths and limitations. For example, they identified as constraints the amount of time required to implement activities, insufficient flexibility to adapt to different school settings and cohorts and cost constraints. Similarly, each approach emphasises narrow aspects and antecedents of self-regulation, rather than considering its full complexity. Based on these observations, they proposed a new approach following a low-cost and flexible design so that the timing, intensity, selection and sequence of children's activities could be varied and made compatible with preschool contexts and routines. They called this the Preschool Situational Self-Regulation Toolkit (PRSIST) programme, which aimed to incorporate the benefits

(and minimise the limitations) of current EF and self-regulation interventions. Accordingly, the PRSIST programme targets both self-regulation skills and its cognitive control processes, which play a significant role in successful self-regulation.

The PRSIST programme is a collection of professional learning, adult practices, play-based child activities and home-based resources to support the development of children's self-regulation across the child's contexts and carers. In their evaluation of the programme, Australian preschool educators implemented PRSIST over 6 months with a demographically diverse sample of 217 3- to-year-old children that completed the programme (that was compared to a waitlist control group of 209 children). After training, EF improved significantly more in the intervention group than in the control group, independent of age-related change. Self-regulation and school readiness also showed descriptively more growth in the intervention group compared to the control group, although these did not reach significance. Among the possible reasons that could explain the lack of effectiveness of the training for improving child self-regulation skills, Howard et al. (2020) emphasised the lack of coaching and mentoring by members of the research team, which could support teachers' self-efficacy, tailoring to their context and cohort and ultimately their fidelity in implementation (e.g., Lambert et al. 2015). As for the program's adaptability, acceptability, accessibility and flexibility, the different components of PRSIST were reported by educators to be highly compatible with the context and daily routine of Australian preschool centres (Howard et al. 2020; Vasseleu et al. 2024).

Considering the positive effects of this programme and the absence of a similar curriculum in the Italian context, this study aimed to adapt the PRSIST programme to the Italian context and replicate Howard et al. (2020) research. Although replication studies are rare in education (Gersten et al. 2015), replicating training is highly important for ensuring evidence-based policies and practices (Hattie and Timperley 2007; Makel and Plucker 2014). Moreover, despite the widespread need of early interventions on self-regulation, Italian preschools still lack feasible and effective supports, as few trainings (e.g., Traverso et al. 2015) have been developed so far. Thus, the PRSIST programme was adapted and implemented in the Italian context, given the expectation that the affordability and flexibility of the educational activities would allow its ready implementation in Italian preschools. The adaptation of the training programme to the Italian context entailed: modifying the play-based child activities; adding coaching and mentoring for the teachers; and more minor cultural and contextual refinements and language translations for the Italian context. Tailored children's storybooks were introduced to guide the participants throughout their journey with the child activities. The stories involved three fantastic characters and their forest-dwelling friends. A poster depicting the forest setting and an iconographic reference for each challenge faced during the child activities was introduced; using a token economy methodology (e.g., Sunyaev et al. 2021), at the end of each challenge passed, children could attach the image representing the location or aspect of the activity (e.g., bridge, pot) to the poster. In addition, teachers were given a chart with a suggested sequence of activities to follow over time. In line with this, teachers were also given an observation table of the progress of the activities to complete after each session. This supported the teachers in monitoring the progress of the activities and identifying when to increase their level of difficulty. A final noteworthy enhancement in the present study, following the results from the initial Australian study (Howard et al. 2020), was the provision of mentoring for the teachers involved in the programme. Teachers were supported by the research team throughout the entire training period. This aimed to strengthen educators' self-efficacy, supported the teachers to tailor the programme activities to their context and cohort and increase implementation fidelity and thereby children's self-regulation. All other programme materials underwent language translation and more minor refinement for alignment with Italian culture and context. Considering the structure of the programme, specifically the express self-regulatory learning and executive function challenge inherent in the design of the activities, it was hypothesised that at the end of the programme children in the Experimental Group (EG) would show greater improvements in self-regulation and executive function than children in the control group (CG).

2 | Material and Methods

2.1 | Participants

Two-hundred and twenty-seven preschoolers were recruited from 14 kindergarten classes from 10 different schools in the Tuscany region of Italy. Recruitment occurred through mail lists and with word-of-mouth support from the School Director in the area. In the Italian context, each School Director leads an Istituto Comprensivo, a school complex encompassing multiple grades and classes sharing common teaching methodologies. For each participating Istituto Comprensivo, we randomly assigned one class to the EG and the other to the CG. This random allocation aimed to match the groups in educational approaches, geography and socioeconomic background of the families. School Directors who consented to participate distributed information sheets to eligible families. Those children whose parents provided informed consent to participate in the intervention were included in this study. Children without consent also participated in the programme activities; however, no data were collected from or about these children.

The children were diverse in language (29.5% were exposed to at least one language other than Italian) and cultural background (48 mothers and 36 fathers were not Italian). Given the complexities in the capture of income and issues of individual indices of families' socioeconomic status, Socio Economic Status (SES) was assessed using a questionnaire that inquired about parental employment status (yes/no) and educational background (elementary school, middle school, diploma, or degree) for both parents (Baker 2014). The overall SES index ranges from 0 (both parents unemployed) to 10 (both parents employed and holding a master's degree). In this sample, SES was middle-high ($M = 7.93$, SD = 1.4, range = 3–10). Specifically, across the full sample, 4 mothers and 4 fathers had a primary school qualification, 28 mothers and 62 fathers had a secondary school qualification, 92 mothers and 105 fathers had a diploma and 93 mothers and 44 fathers had a degree. Additionally, 43 mothers and 3 fathers did not work.

Half (7) of the classes were randomly assigned to the PRSIST intervention (EG) and the other 7 classes were asked to continue their routine didactic activities (business as usual CG condition). In Italian preschools, typical curriculum activities often emphasise a blend of structured learning and creative expression. These activities typically include group activities, role-playing, collaborative projects, storytelling, games, manipulatives, simple experiments and observations, as well as artistic endeavours such as painting, drawing and music appreciation, aiming to nurture holistic development in young children.

The experimental group was composed of 117 preschoolers ($M = 54.38$ months, SD = 10.47, range: 33–70 months; 57.3% male) whose parents were mainly Italian citizens with the exception of 25 mothers and 21 fathers. Regarding the SES of the EG ($M = 8.04$, SD = 1.38), 25 mothers and 1 father were unemployed; 2 mothers and 1 father had a primary school qualification; 11 mothers and 29 fathers had a secondary school qualification; 51 mothers and 53 fathers had a diploma; and 48 mothers and 29 fathers had a degree.

The control group was composed of 110 preschoolers ($M = 56$ months, SD = 10.41 range: 34–71 months; 48.2% male) whose parents were mainly Italian citizens with the exception of 23 mothers and 15 fathers. Regarding the SES of the CG ($M = 7.80$, SD = 1.42), 18 mothers and 2 fathers were unemployed; 2 mothers and 3 fathers had a primary school qualification; 17 mothers and 33 fathers had a secondary school qualification; 41 mothers and 52 fathers had a diploma; and 45 mothers and 15 fathers had a degree.

No differences between experimental and control groups were identified for age ($t = 1.17$, $p = 0.245$), sex ($\chi^2(1) = 1.88$, $p = 0.171$), SES ($t = -1.30$, $p = 0.194$), mothers' nationality ($\chi^2(1) = 0.01$, $p = 0.941$), fathers' nationality ($\chi^2(1) = 0.68$, $p = 0.411$), mothers' employment status ($\chi^2(1) = 0.79$, $p = 0.374$), fathers' employment status ($\chi^2(1) = 0.44$, $p = 0.507$), mothers' level of education ($\chi^2(3) = 2.25$, $p = 0.523$) nor fathers' level of education ($\chi^2(3) = 5.36$, $p = 0.148$).

2.2 | Intervention

The PRSIST intervention lasted 6 months. PRSIST is a programme that was designed to easily integrate with the routine didactic and play activities of preschool contexts and thus would minimise the increase in burden on teachers' time. Furthermore, it is low-cost, because the programme is freely available online and required materials are cost-free or leverage existing materials (e.g., pens, cards, sheets). In line with the 'PRSIST Program Handbook' developed by Howard, Neilsen-Hewett, Vasseleu (2018), the intervention included four macro areas: activities for children, adult practices, training videos for teachers and newsletters for parents.

2.2.1 | Activities for Children

This component comprises 28 playful, inexpensive and fun activities that carry self-regulation demands that can be carried out in the classroom together with the children. Activities are integrated into the daily routine. They aim to engage and extend three areas to which self-regulation is applied: 10 activities support behavioural self-regulation; 9 activities support cognitive self-regulation; and 7 activities support socio-emotional self-regulation. The activities were translated into Italian, and only minor modifications were made; otherwise, these were then integrated into a manual and children's storybooks that were given to the class teachers. Each activity followed the same structure: a narrative introduction of protagonists' adventures; a description of how the activity was to be played; the rules to be followed; tools and materials needed; and means to make the activity more challenging.

In order to embed games within stories (similar to the original I Don't Miss the Shopping List; Polly & Her Lolly; The Pear that Wasn't There; Howard, Neilsen-Hewett, Vasseleu 2018, a narrative context suitable for Italian preschool children was developed. A story guided children through a journey of adventures and challenges, to help the main characters of the story. The story presented the adventures of two gnomes, Lilo and Bibi, and the witch Gigia. The first two are inseparable friends and companions in adventures, while the other is a character who loves mischief and mayhem. All three characters live in the 'Magic Wood' together with many other animals—friends of Lilo and Bibi. To maximise interest and engagement, children were given gnome and witch puppets and a poster depicting the 'Magical Forest' depicting the locations where challenges are set. Stickers depicting the challenges created a token economy, where children could affix a sticker on the poster at the end of a completed activity. This also served as a reminder of what was done and a fidelity check. At the beginning of each session, children called the gnomes and the witch by reciting a special opening rhyme and at the end of the daily activity, another closing rhyme was used to say goodbye to puppets.

A second Italian adaptation was teachers' use of an observation table, completed at the end of each activity. The table noted teachers' qualitative observations during the activities; the children's responses, behaviours, degree of understanding of the rules, the amount of adults' support and help needed, and the management of their emotional reactions. This made it possible to monitor children's progress over the course of 6 months and assess when to increase the activities' degree of difficulty for children. To further prompt this incrementing of challenge, for each session, teachers ranked the activity according to its degree of difficulty (low to high) to monitor children's progress over time. Three activities were administered each week, for 24 weeks, one from each area of self-regulation. Most activities were carried out in small groups of 4–5 children at a time. In line with previous studies (e.g., Dörr and Perels 2019; Grüneisen et al. 2023), each session lasted about 45 min. The 28 activities were repeated several times throughout the programme. Where individual children improved in their performance in an activity, the teacher was advised to either re-group children according to ability (retaining the difficulty level for children who had not yet mastered the challenge) or retain the current grouping but offer support/modifications to children in need.

Additionally, in the Italian adaptation, for each week there was a set sequence of activities to be followed, different from the

original intervention that let the educators choose which and in what order they did them (Howard et al. 2020). This change was linked to making the teachers follow a criterion of increasing difficulty of the activities and to ensure that every week each domain of self-regulation was engaged. In the early stages of the study, teachers kept to a weekly sequence of activities. Only in the later stages of the programme, after the activities had been repeated a few times, were the teachers enabled to choose the activities preferred by the children or that they considered most beneficial for the group. Even when teachers were free to choose the activities, they were asked to maintain the criterion of three activities per week, one per self-regulation domain.

2.2.2 | Exercises for Adults

The second component entailed 11 suggestions for adult practices to support self-regulation skills. The 11 key principles are described in the 'PRSIST Program Handbook' (Howard, Neilsen-Hewett, Vasseleu 2018). Each principle includes a description of a scenario that can occur within the school context, the theoretical description of the suggested principle and two exercises to practice what has been learned. For example, the third principle explains the importance of modelling to promote children's self-regulation skills and engage them in sensitive and responsive practices. The technique of modelling is exemplified by showing how adults can take the role of guide; in this way, the child, by observing, can begin to learn and internalise those behaviours.

2.2.3 | Training Videos for Teachers

The third component of the PRSIST programme comprises nine training videos prepared by Authors for preschool teachers, in which an extensive explanation is given of what self-regulation is, its basic components and the importance of its application in everyday life. In addition, tips are given on how to support these skills in preschool settings, how to observe and evaluate them and how to create rich and stimulating learning environments to enhance self-regulation skills.

2.2.4 | Monthly Newsletter for Parents

This component communicated current programme foci and example practices/activities to children's parents, to create continuity between the school context and the child's home environment. Six monthly newsletters, one at the end of each month of the programme, were translated and adapted from the original PRSIST manual (Howard, Neilsen-Hewett, Vasseleu 2018). In the first newsletter, for instance, there was an initial theoretical explanation of self-regulation (what self-regulation is, the important role it plays in a child's daily decisions and behaviours and how parents can support their children's development at home) and a description of a simple activity that can be conducted at home to promote self-regulation. In the following newsletters, parents were informed about the self-regulation activities carried out at school and about the general progress of the project, the degree of participation shown by the children and their achievements.

2.3 | Outcome Measures

Pre- and post-intervention direct and indirect measures were used to evaluate the efficacy of the intervention for generating child-level improvements in self-regulation and executive function.

2.4 | Executive Functions Assessments

Given theoretical interest in evaluating programme effects on individual EFs, precedent and prior findings of differential effects from EF and SR intervention and a CFA on the current data supporting a multidimensional factor solution as optimal, we assessed and analysed EFs individually. EF tasks were delivered via a tablet using the Gorilla.sc platform. Four tasks, with parallel forms for pre- and post-assessment, were built based on established paradigms for assessment of EF. Previous studies with similar samples have established the validity and reliability of the tasks we used (e.g., Ruffini et al. 2024; Traverso et al. 2015). From one version to another of the tasks we implemented, the stimuli changed (e.g., from fish to cats in the Go/No-Go task) while the underlying task structure remained the same. Each child performed each task individually, under the supervision of a trained fieldworker (a class teacher in training who ensured the physical safety and fulfilled maintenance requests of the child; e.g., need to go to the toilet). They also helped direct and sustain the child's attention towards the task through generic prompts and reminders that did not otherwise support task performance. Audio-visual task instructions and child's answers were automatically recorded by the system. A detailed description of EF tasks (Ruffini, Marzocchi, Pecini 2021) is provided in Appendix 1.

The Go-NoGo task was used to measure response inhibition. In this task, the child is required to touch the screen as fast as possible when a target stimulus (Go stimulus) is presented and not to touch the screen when a non-target stimulus (No-Go stimulus) is shown. The product of the proportion of correct Go and No-Go (0.00–1.00) was the outcome measure. Test–retest reliability of this task has been established by Ruffini et al. (under review) in a recent similar study using near-identical protocols (but with a shorter retest interval) (r: 0.70, $p < 0.001$, $n = 43$).

The Flanker task was implemented to measure interference control. Children saw five aligned stimuli on the screen, and they were asked to indicate the direction of the central arrow by tapping on a point corresponding to its direction. The number of correct responses for the incongruent items (CR, 0–26) and the median reaction time were recorded. As reported by Ruffini et al. (under review), test–retest reliability of this task was sufficient: for accuracy measure, $r = 0.55$, $p < 0.001$, $n = 40$; and for time measure, ($r = 0.47$, $p = 0.004$, $n = 37$).

The Mr. Ant task measures visuospatial working memory. In each trial, a number (2–6) of coloured spots appear on an animal's body for about 5 s, then the spots disappear, and children must point to the location of the spots depicted, in any order. The number of correct responses (CR, 0–15) was recorded.

As reported by Ruffini et al. (under review), test–retest reliability of this task was sufficient ($r = 0.55$, $p < 0.001$, $n = 47$).

Dimensional Change Card Sort task (DCCS) measures cognitive flexibility. Children have to categorise some cards depicting a figure with three levels of difficulty: firstly, they categorise according to the colour rule, then they follow the shape rule and lastly they shift between the previous rules according to a defined criterion. The total number of correct responses (CR, 0–24) and correct responses in Levels 2 (0–6) and 3 (0–12) were recorded. As reported by Ruffini et al. (under review), test–retest reliability of this task was sufficient (for total accuracy score, $r = 0.46$, $p = 0.001$, $n = 47$).

The Semantic Fluency task was used to measure fluency ability. The child is asked to name as many words belonging to a specific semantic category as possible in 1 min; two categories were used, colours and animals in both pre-and post-training assessment. The total number of correct words was recorded by a remote psychologist who administered the task via Google Meet. As reported by Ruffini et al. (under review), test–retest reliability of this task was acceptable ($r = 0.76$, $p < 0.001$, $n = 47$).

The Preschool Executive Functions Questionnaire (QUFE, Valagussa and Marzocchi 2015) is a questionnaire assessing EF skills in daily life. Children's parents answered 24 items investigating children's self-regulatory abilities in the three domains: behavioural, cognitive and socio-emotional, within daily situations and tasks. Responses were on a scale from 1 (not at all) to 5 (very much). The scale showed strong reliability ($\alpha = 0.918$; $\omega = 0.916$).

2.4.1 | Self-Regulation Assessment

The Preschool Situational Self-Regulation Toolkit (PRSIST) observational assessment (Howard et al. 2019, 2020) evaluated cognitive, behavioural and socio-emotional self-regulation using a 10-item Likert scale (1–7). Class teachers assessed each child after the Memory and Curiosity Boxes games. The Memory Game, played in small groups of four children, involved finding pairs of cards. The Curiosity Boxes game, individual and face-to-face, required children to guess unknown objects by touch. PRSIST yields three subscale scores: cognitive self-regulation, behavioural self-regulation and socio-emotional self-regulation. Subscales showed strong and acceptable reliability (Cognitive self-regulation: $\alpha = 0.956$; $\omega = 0.956$; Behavioural self-regulation, $\alpha = 0.920$; $\omega = 0.922$; Socio-emotional self-regulation: $\alpha = 0.836$; $\omega = 0.830$).

2.4.2 | Socio-Emotional Behaviour Assessment

Class teachers completed the Strength and Difficulties Questionnaire (Goodman 1997). This scale aims to capture strengths and weaknesses of children aged 4–16 years in terms of their: emotional symptoms ($\alpha = 0.841$; $\omega = 0.848$), behavioural problems ($\alpha = 0.827$; $\omega = 0.841$), hyperactivity/inattention ($\alpha = 0.879$; $\omega = 0.876$), peer relationships ($\alpha = 0.649$; $\omega = 0.663$) and prosocial behaviour (Cronbach's $\alpha = 0.836$; $\omega = 0.842$). The questionnaire comprises 25 items that are responded to on a 3-point scale: not true (0), partly true (1) and absolutely true (2).

2.5 | Plan for Statistical Analysis

Spearman's r was used to explore correlations between sex, age, SES and outcome measures at baseline. Next, Confirmatory factor analysis (CFA) was conducted to evaluate the appropriateness of considering discrete aspects of EF.

To evaluate the efficacy of the intervention, mixed models were run with class, children and time as cluster variables, time (pre and post intervention) and group (EG and CG) as factors, age, sex and SES as covariates, and outcome measures (NoGo CR, Flanker CR, Flanker RT, Mr. Ant CR, DCCS Shape Game CR, DCCS Border Game CR, DCCS Total CR, Semantic Fluency CR, QUFE, PRSIST Cognitive Self-regulation, PRSIST Behavioural Self-regulation, PRSIST Socio-Emotional Self-regulation, SDQ Emotional Symptoms, SDQ Behavioural Problems, SDQ Hyperactivity Inattention, SDQ Peer Relationships, SDQ Prosocial Behaviour) as dependent variables. Effect sizes were measured with Marginal R^2, considering only fixed effects, and measures the variance explained by these effects, and Conditional R^2, including both fixed and random effects, and measures the total variance explained by the model. Mixed models (Stroup 2012) were chosen because, in experimental studies involving assignment of clusters, they can appropriately handle the nested nature and inter-subject variability of the data, allowing for simultaneous estimation of within- and between-group effects. Additionally, they flexibly model fixed effects (overall effects) and random effects (individual/group differences). They address non-independence by explicitly modelling clustering within higher-level units, providing accurate standard error estimates. Mixed models handle missing data effectively by using all available data under missing at random assumptions.

To see if changes over time were related to individual differences, in the EG, correlations with Pearson's r on deltas (differences between post and pre training scores) of outcome measures were conducted. These statistical analyses were conducted by SPSS (2024), version 29.0.2.0 (20) and Jamovi (2022), version 2.3.

3 | Results

Table 1 reports correlations between sex, age, SES and outcome measures at baseline in the full sample. Among EF measures, significant correlations were found between most measures, ranging from $r = 0.04$ to 0.55 (mean $r = 0.28$), and CFA supported a multidimensional factor structure among EF measures (representing working memory, inhibition, cognitive flexibility). Thus, planned analysis of effects on separate EFs was run.

Full sample means and standard deviations for all variables are available at Table A1. Table 2 presents descriptive statistics of pre- and post-intervention scores on the outcome measures for EG and CG. The percentage of missing data in the outcome measurements at pre-test ranged from 0% to 9.40% for the

TABLE 1 | Correlations between sex, age, SES and outcome measures at baseline in the whole sample.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Sex	—																			
2. Months	−0.04	—																		
3. SES	−0.14*	−0.23**	—																	
4. Go-NoGo CR	0.14*	0.59**	−0.00	—																
5. Flanker CR	−0.07	0.17*	0.05	0.16*	—															
6. Flanker RT	0.07	0.11	0.06	0.19**	0.02	—														
7. Mr. Ant CR	0.09	0.48**	−0.11	0.42**	0.18**	0.05	—													
8. DCCS shape game CR	0.08	0.24**	−0.05	0.28**	0.03	0.11	0.21**	—												
9. DCCS border game CR	0.06	0.32**	−0.1	0.35**	0.04	0.1	0.33**	0.13*	—											
10. DCCS total CR	0.12	0.5**	−0.1	0.55**	0.03	0.16*	0.43**	0.69**	0.7**	—										
11. Semantic fluency CR	0.02	0.6**	−0.06	0.53**	0.04	0.03	0.46**	0.2**	0.29**	0.41**	—									
12. QUFE	0.13*	0.10	0.07	0.2**	−0.07	0.06	0.08	0.08	−0.0	0.08	0.1	—								
13. PRSIST cognitive self-regulation	0.21**	0.33**	−0.04	0.5**	0.02	−0.0	0.3**	0.29**	0.2**	0.42**	0.39**	0.25**	—							
14. PRSIST behavioural self-regulation	0.24**	0.42**	−0.06	0.54**	−0.02	0.06	0.31**	0.17*	0.23**	0.38**	0.42**	0.22**	0.83**	—						
15. PRSIST socio emotional self-regulation	0.21**	0.48**	−0.14*	0.53**	−0.12	0.04	0.31**	0.16*	0.24**	0.39**	0.46**	0.26**	0.72**	0.81**	—					
16. SDQ emotional symptoms	−0.06	−0.08	−0.06	−0.14*	−0.1	−0.06	0.01	−0.01	0.13	0.01	−0.08	−0.21**	−0.16*	−0.21**	−0.14*	—				
17. SDQ behavioural problems	−0.31**	−0.08	−0.03	−0.27**	−0.07	−0.04	−0.1	−0.07	−0.11	−0.13	−0.1	−0.24**	−0.31**	−0.34**	−0.25**	0.16*	—			
18. SDQ hyperactivity inattention	−0.37**	−0.24**	−0.08	−0.43**	0.01	−0.15*	−0.18**	−0.25**	−0.19**	−0.33**	−0.26**	−0.36**	−0.54**	−0.58**	−0.5**	0.33**	0.67**	—		

(Continues)

TABLE 1 | (Continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
19. SDQ peer relationships	−0.10	−0.22**	−0.11	−0.29**	−0.11	−0.03	−0.11	0.01	0.08	−0.02	−0.24**	−0.14*	−0.19**	−0.32**	−0.29**	0.43**	0.34**	0.37**	—	
20. SDQ prosocial behaviour	0.28**	0.22**	−0.02	0.4**	0.1	0.09	0.2**	0.19**	0.19**	0.31**	0.25**	0.16*	0.48**	0.49**	0.45**	−0.19**	−0.58**	−0.58**	−0.48**	—

Note: $^*p<0.05$; $^{**}p<0.001$.
Abbreviations: CR, correct responses; DCCS, dimensional change card sort; PRSIST, preschool situational self-regulation toolkit; RT, reaction time; SDQ, strength and difficulties questionnaire.

experimental group and from 0% to 7.27% for the control group and at post-test from 0% to 9.40% in the experimental group and from 0% to 10.91% for the control group. From pre- to post-test, the maximum missing percentage for the experimental group was 7.01% and for the control group 5.77%. The highest missing percentages are found in the Flanker RT in which if the child did not perform any correct answers and in the QUFE questionnaire completed by the parents. Considering all demographic and outcome variables (pre and post), the MCAR Little's test showed that missing data are not completely random: $\chi^2 = 823.860$, $df = 700$, $p = 0.001$.

The results of the mixed models showed a group*time interaction effect in GoNoGo CR, DCCS Border game correct responses, DCCS Total correct responses, cognitive self-regulation subscale of the PRSIST assessment and prosocial subscale of the SDQ questionnaire. In particular, the EG improved more from pre- to post-training in these indices than did the CG. Effect sizes of fixed effects (Marginal R^2) were high for GoNoGo CR, moderate for DCCS Total correct responses, cognitive self-regulation subscale of the PRSIST assessment and prosocial subscale of the SDQ questionnaire and low for DCCS Border game correct responses (Cohen 1992). For each dependent variable, the effects of the covariates within the model varied (the fixed effects for each dependent variable are shown in Table A2).

As shown in Table 3, analysis of relationships between performance at pre-assessment and significant deltas (significant differences between post and pre training scores) within the EG showed that pre-test performances were largely negatively correlated with gains in each task. More precisely, children with initially low scores on Go/No-Go and the QUFE pre-training questionnaire grew more in Go/No-Go scores. Children with low reaction times on the Flanker test and low scores on the Card Sort test grew more in Card Sort scores. Children with low PRSIST assessment scores and low scores in prosocial behaviours of the SDQ scale grew more in PRSIST cognitive self-regulation scores. Children with more difficulties as indicated by all SDQ scales grew more in prosocial behaviour. These results indicate that participants starting from a lower level of performance achieved larger gains at post-test.

4 | Discussion

This study sought to evaluate the efficacy of an existing intervention, the PRSIST programme developed by Howard et al. (2018b, 2020), adapted to the Italian context by the Authors. As with the original programme, the intervention aimed to promote children's self-regulation skills through four main areas of intervention: activities for children; practices and informational videos for adults; and newsletters for parents. However, the Italian adaptation was also unique in several ways. It introduced a unique story that structured the children's activity in each session: the adventures faced by the children were thus placed within a narrative context thus highly engaging children. Mentoring support was also provided to the teachers throughout the programme. Furthermore, in the adapted version, a training monitoring table was set up for teachers to complete after each session. This supported the teachers in monitoring the progress of the activities and identifying when

TABLE 2 | Pre- and post-intervention scores on EF tasks and questionnaires of experimental and control groups.

	Experimental group				Control group				Group × time effect	r^2 marginal	r^2 monditional
	N	Pre	*N*	Post	*N*	Pre	*N*	Post			
Go-NoGo CR	117	0.52 (0.28)	116	0.68 (0.23)	110	0.66 (0.28)	110	0.72 (0.25)	$F(1,212) = 8.45$, $p = 0.004$	0.32	0.77
Flanker CR	117	9.16 (6.24)	115	14.45 (8.01)	110	10.47 (6.94)	107	15.18 (8.51)	$F(1,213) = 0.56$, $p = 0.45$	0.13	0.65
Flanker RT	106	1506.26 (676)	113	1723.58 (584)	102	1460.88 (648.01)	106	1626.63 (599.37)	$F(1,207) = 0.03$, $p = 0.858$	0.03	0.62
Mr Ant CR	116	2.93 (2.83)	117	6.66 (4.29)	110	3.31 (3.16)	110	6.60 (3.92)	$F(1,213) = 0.66$, $p = 0.42$	0.33	0.75
DCCS shape game CR	116	3.57 (1.64)	117	4.59 (1.6)	110	3.71 (1.64)	110	4.46 (1.75)	$F(1,213) = 0.61$, $p = 0.434$	0.1	0.64
DCCS border game CR	116	7.28 (1.47)	117	7.91 (1.64)	110	7.62 (1.42)	110	7.59 (1.53)	$F(1,213) = 7.38$, $p = 0.007$	0.05	0.63
DCCS total CR	116	16.09 (3.07)	117	18.21 (2.94)	110	16.74 (3.06)	110	17.75 (3)	$F(1,213) = 8.94$, $p = 0.003$	0.2	0.68
Semantic fluency CR	114	11.61 (6.03)	115	14.92 (6.34)	107	13.21 (6.79)	110	15.30 (7.56)	$F(1,207) = 2.12$, $p = 0.147$	0.28	0.79
QUFE	114	92.68 (13.83)	106	95.54 (12.93)	104	93.8 (11.99)	98	96.55 (11.69)	$F(1,192) = 1.02$, $p = 0.314$	0.04	0.84
PRSIST cognitive self-regulation	117	14.43 (4.28)	116	16.87 (3.79)	106	17.52 (4.19)	108	17.88 (4.43)	$F(1,205.24) = 20.35$, $p < 0.001$	0.19	0.78
PRSIST behavioural self-regulation	117	15.61 (4.1)	116	17.27 (3.53)	106	17.29 (3.89)	108	17.92 (4.03)	$F(1,210) = 4.77$, $p = 0.03$	0.21	0.75
PRSIST socio emotional self-regulation	117	19.21 (4.49)	116	22 (4.71)	106	20.67 (4.62)	108	22.80 (4.58)	$F(1,210) = 0.6$, $p = 0.441$	0.25	0.76
SDQ emotional symptoms	117	1.32 (1.81)	117	1.54 (1.79)	110	1.47 (2.34)	110	1.23 (2)	$F(1,213) = 2.73$, $p = 0.1$	0.01	0.7
SDQ behavioural problems	117	2.03 (2.21)	117	1.44 (2.12)	110	1.35 (2.19)	110	1.44 (2.23)	$F(1,213) = 8.81$, $p = 0.003$	0.08	0.8

(Continues)

TABLE 2 | (Continued)

	Experimental group				Control group				Group × time effect	r^2 marginal	r^2 monditional
	N	Pre	N	Post	N	Pre	N	Post			
SDQ hyperactivity inattention	117	3.62 (2.97)	117	2.82 (2.94)	110	2.67 (2.56)	110	2.3 (2.58)	$F(1,213)=1.71$, $p=0.192$	0.16	0.77
SDQ peer relationships	117	1.57 (1.63)	117	1.17 (1.69)	110	1.28 (1.76)	110	0.95 (1.55)	$F(1,213)=0.19$, $p=0.66$	0.05	0.68
SDQ prosocial behaviour	117	6.22 (2.52)	117	7.6 (2.31)	110	7.31 (2.5)	110	7.25 (2.47)	$F(1,213)=24.87$, $p<0.001$	0.12	0.72

Abbreviations: CR, correct responses; DCCS, dimensional change card sort; PRSIST, preschool situational self-regulation toolkit; RT, reaction time; SDQ, strength and difficulties questionnaire.

to increase their difficulty. Like the original programme, the intervention was offered to preschool children for 6 consecutive months, with activities implemented three times per week, one activity per session (ensuring that, across the week, activities pertaining to cognitive, behavioural and social–emotional self-regulation were undertaken). The teachers were given ample freedom as to when they conducted the activities during the week and at what time of day. Thus, the teachers could flexibly integrate the intervention activities into their routines. However, in contrast to the original programme, in the early stages of the programme, the teachers followed a set order of child activities. Parents also received a monthly newsletter; in the current programme, this was customised for their child's class so that they were always kept up-to-date on the activities carried out by their children.

Effectiveness of the intervention was evaluated by child performance on tasks of executive functions (EF), teacher observation (i.e., PRSIST) and parent report measures (i.e., QUFE) of child self-regulation. A teacher report questionnaire to assess the children's socio-emotional behaviour within the school context was also used (i.e., SDQ). There was a significant overall effect of time; that is, all outcome measures showed growth over the 6 months. This was expected, given evidence of the rapid development of self-regulation and EF skills in preschool, confirmed across many studies and contexts (e.g., Grüneisen et al. 2023). The evaluation of the programme after a 6-month intervention period indicated significantly more improvement in the EG in Go/No-Go (inhibition), Dimensional Change Card Sort (cognitive flexibility), cognitive self-regulation in the PRSIST assessment and prosocial behaviour in the SDQ. This triangulation across multiple abilities and data sources (direct assessment, observation, teacher reports) provides converging support for the child-level effects of this Italian adaptation of PRSIST.

While these efficacy results are generally in line with the findings of the initial evaluation of the programme in an Australian context (Howard et al. 2020), the current results reflect stronger and broader growth. For instance, the improvement in inhibition and cognitive flexibility is in line with that initial evaluation showing a small but significant increase in EF in the EG compared to the CG. However, Howard et al. (2020) only evaluated this in terms of a global EF index. Considering evidence for the discrete yet interrelation between EF components (Diamond 2013; Miyake, Emerson, et al. 2000; Miyake, Friedman, et al. 2000) and that various EF develop at different stages (De Luca and Leventer 2008; Monette et al. 2015), it is important to understand impacts on distinct EF components. This is also important considering that cognitive self-regulation activities aimed to train EF components explicitly, either individually or several EF components at a time. The improvement in inhibition is notable, as it is a hallmark of self-regulated behaviours; that is, inhibition is often implicated in the ability to regulate, whether overcoming impulses or resisting task-irrelevant distractions. Promoting response inhibition, which emerges at the beginning of preschool age (Usai et al. 2014), is an important outcome of this programme, especially because inhibition has been found to be difficult to shift in preschoolers, requiring intensive and high-challenge activities (Ruffini et al. 2021, 2024; Thorell et al. 2009). It is important to note, however, that not

TABLE 3 | Correlations between pre-test performances and significant deltas of outcome measures in the experimental group.

	Go-NoGo	Flanker RC	Flanker RT	Mr Ant CR	DCCS shape game CR	DCCS border game CR	DCCS total CR	Semantic fluency CR	QUFE	PRSIST cognitive self-regulation	PRSIST behavioural self-regulation	PRSIST socio emotional self-regulation	SDQ emotional symptoms	SDQ behavioural problems	SDQ hyperactivity inattention	SDQ peer relationships	SDQ prosocial behaviour
Δ Go-NoGo	−0.61**	−0.17	−0.16	−0.06	−0.09	−0.10	−0.11	−0.04	−0.2*	−0.10	−0.02	−0.02	−0.03	0.12	0.11	−0.05	0.01
Δ DCCS border game CR	−0.04	−0.09	−0.22*	−0.03	−0.06	−0.56**	−0.33**	0.01	−0.02	0.08	0.04	0.06	−0.16	−0.10	0.02	−0.12	0.06
Δ DCCS total CR	−0.06	−0.05	−0.21*	−0.13	−0.48**	−0.38**	−0.56**	−0.06	0.04	−0.08	−0.01	0.03	−0.15	−0.08	−0.01	−0.12	−0.04
Δ PRSIST cognitive self-regulation	−0.11	−0.05	−0.05	−0.14	−0.07	−0.06	−0.08	−0.10	−0.09	−0.55**	−0.41**	−0.36**	0.05	−0.02	0.12	−0.11	−0.19*
Δ SDQ prosocial behaviour	0.17	0.01	−0.01	0.09	−0.03	0.05	0.08	0.10	−0.04	0.03	0.06	0.16	0.22*	0.26**	0.22*	0.20*	−0.54**

Abbreviations: Δ, significant differences between post and pre training scores; CR, correct responses; DCCS, dimensional change card sort; PRSIST, preschool situational self-regulation toolkit; RT, reaction time; SDQ, strength and difficulties questionnaire. *Note*: *p <.05, **p <.01.

all inhibitory skills improved with training; in fact, interference control, measured by the Flanker task, showed no significant effects of the training. This might be explained by the training activities focusing more highly on impulse control over resisting distraction.

The improvement in cognitive flexibility, which is a later EF component to emerge (Garon et al. 2008; Miller et al. 2012; Usai et al. 2014), is also a promising result. From this training, children showed enhanced ability to shift mental perspectives, adapting to a new rule and perspective. These abilities are fundamental skills required in all life contexts (Diamond 2013). This effect could be linked to the fact that the programme intentionally aims to stimulate growth in these abilities through activities that, for instance, promote the tendency to assume the perspective of another or see another point of view.

The absence of effects on working memory, while unexpected, could have benefited from more directed, intensive and frequent training (Diamond and Ling 2016). While programme activities do explicitly target this ability (e.g., recalling selections, rules), typical working memory training programmes that have shown good efficacy tend to concentrate particularly and extensively on this ability (Roche and Johnson 2014). Secondly, semantic fluency, which is considered an impure EF task as it also requires good language skills (Chami et al. 2022; Urgesi et al. 2011), did not improve with training. This could be primarily related to the activities prioritising children's motor and cognitive functions, without explicitly targeting and increasing in complexity activities related to children's verbal skills.

Consistent with the improvements obtained for two out of the three EF components evaluated, the programme was effective in increasing EG cognitive self-regulation scores above normal expected growth. This is directionally consistent with the findings of Howard et al. (2020)'s study–children in the intervention group compared to the control group showed descriptively higher self-regulation scores –although in that study this did not reach significance. This could be related to the self-regulation index used; like for EF, they evaluated an overall self-regulation index. This study, which considered different areas to which self-regulation is employed, showed training improvement in cognitive self-regulation specifically, but not socio-emotional or behavioural self-regulation. The absence of effects on behavioural and socio-emotional self-regulation was unexpected, given the training sought to explicitly target all self-regulation components equally, and weekly. This might be explained by teachers emphasising cognitive control processes even during the activities aimed at enhancing behavioural and socio-emotional self-regulation (e.g., asking children to reflect on what they were doing). Nevertheless, the significant improvement in at least cognitive self-regulation skills is in line with other curricular approaches which have successfully shown self-regulation improvements after similar or longer intervention periods (Pandey et al. 2018). However, it is worth noting that this intervention is less demanding in time and resources in comparison to many of those interventions.

Although there was no impact of the training on socio-emotional self-regulation, there was an effect on prosocial behaviour; that is, teacher ratings of children's ability to help other

people without seeking external rewards. While the respondents could not be blind to group assignment, this was not a uniform improvement across SDQ subscales, implying that teachers uniquely detected change in children's prosocial behaviours following the programme. In line with other studies (e.g., Traverso et al. 2015), the improvement of prosocial skills could be linked to the conduct of activities in small groups (a point of difference from the original evaluation, which tended to use more large/full group activity), which were rotated each time to ensure that each child could benefit from the skills of all pairs.

Despite a general trend towards programme-related reductions in emotional symptoms, behavioural problems, hyperactivity, inattention and relational problems, the difference in changes between the EG and the CG was non-significant. While this too was unexpected, any effect of training such as this on reducing these 'difficulties' would be considered a far transfer effect (Borella and Carretti 2020). Indeed, the training was not specifically aimed at these processes, although an improvement in self-regulation skills could have stimulated a cascade effect on reducing symptomatology. The absence of far transfer effects is broadly consistent with the literature, which demonstrates possible but difficult to stimulate far transfer effects from cognitive control training (for a meta-analysis see Bombonato et al. 2024; Scionti et al. 2020; Kassai et al. 2019). Still, it remains probable that any possible cascade effects at the symptomatological level may require a longer period of time from the end of the training (e.g., to fully manifest and/or for improvements to be noticed by teachers and their perceptions of the child updated). Thus, future studies would do well to plan for follow-up assessment; this remains an under-studied area in intervention research, related to self-regulation but also beyond.

Lastly, correlation analysis between pre-training performances and significant deltas (post-pre difference in performance) in the EG was conducted to see if changes over time were related to individual differences. Results suggest training was particularly effective in children with initially lower performance. Specifically, children with low scores on a dimension (i.e., inhibition, cognitive flexibility, self-regulation and strength and weakness-emotional symptoms, behavioural problems, hyperactivity/inattention, peer relationships, prosocial behaviour) routinely achieved more growth in that area after training, compared to children who scored higher on these abilities at baseline. This indicates that children with the lowest performances in pre-training assessment obtained the highest improvement in significant outcome measures. This can be explained by the compensation effect, common in the literature (e.g., Carretti et al. 2014, 2017; Cornoldi et al. 2015), according to which there is greatest potential for growth among this group—and this potential is realised through training.

4.1 | Limitations and Future Directions

It is worth noting some limitations of this study. Firstly, it was not investigated whether the effects obtained from the training were sustained over time after the end of the training (or if effects grew or newly emerged). Thus, as previously suggested, future studies should be designed to include follow-up assessment. A second limitation is the inability to determine which programme components exerted which effects. It is thus not possible in the present study to determine a minimum 'dose' sufficient to achieve improvements. A better understanding of mechanisms of change could yield improvements in terms of further reducing time and burdens of implementation. One additional limitation of the study is the convenience sample we implemented, since classes whose teachers were willing to participate were involved. However, despite the convenience sample, the sample was demographically diverse considering non-homogeneity of the sociocultural level. Nevertheless, the convenience sampling can introduce biases and limit the generalisability of findings to the broader population. Relatedly, randomisation into experimental and control groups was by class and not on the individual child level. However, the nature of the programme (i.e., group-based child activities and overarching adult practices) rendered it infeasible to allocate children within a classroom to training or control conditions. Indeed, this design is the strongest available for evaluating effects of programmes in settings in which children are already assigned within clusters. Additionally, another limitation of this study is the inability to blind teachers to group allocation, which has potential to introduce bias as the teacher who filled out the questionnaires also implemented the intervention. Results from these data should thus be interpreted with caution. However, we note the triangulation of efficacy evidence across more than just teacher-report measures, suggesting that effects are most plausibly genuine and sufficiently robust. Specifically, the alignment between direct objective assessments and teacher-reported improvements in cognitive self-regulation (PRSIST questionnaire), despite the broader nature of the QUFE scale used by parents, suggests the validity of the findings and mitigates concerns about desirability bias. A final limitation is the difficulty in determining the extent to which the effects achieved through the training translated into the children's everyday performance; although we aimed to address this, at least in part, through inclusion of questionnaires and observational measures of the children's everyday behaviours. Lastly, future research might be interested in investigating which area, among those included in the PRSIST programme (activities for children, adult practices, training videos for teachers, newsletter for parents), had the most impact in promoting the improvements achieved by the training.

5 | Conclusion

In conclusion, this study confirms the effectiveness of the PRSIST programme in enhancing self-regulation and executive function performance in preschoolers. Key factors believed to contribute to this efficacy include the programme's flexibility, continuity, duration, the narrative story accompanying sessions, teacher training and active involvement of both teachers and parents. Integration into school routines implies sustainability, wherein the activities were seamlessly incorporated in daily practices rather than abandoned or administered subthreshold due to its additional burden. Group activities were emphasised, further enabling children to benefit from peer presence (Traverso et al. 2015). As a practical implication, simultaneous direct training of children through daily playful activities and training of teachers together showed to be effective, aligning with previous findings (Grüneisen et al. 2023; Perels et al. 2020).

Author Contributions

Costanza Ruffini: conceptualization, data curation, formal analysis, investigation, methodology, project administration, writing – original draft, writing – review and editing. **Elena Magni:** conceptualization, data curation, investigation, writing – original draft. **Chiara Pecini:** conceptualization, methodology, project administration, supervision, writing – original draft, writing – review and editing. **Steven J. Howard:** conceptualization, methodology, supervision, writing – original draft, writing – review and editing.

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Ethics Statement

The research was approved by the Ethics Committee of the University of Florence reference number 0077761 date 04/06/2020. The research was carried out following Ethical guidelines of the Italian Association of Psychology and of the Declaration of Helsinki.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Peer Review

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Appendix 1

Detail Description of EF Measures

The Go-NoGo task was used to measure response inhibition (Ruffini, Marzocchi, Pecini 2021). In this task, the child is required to touch the screen as fast as possible when a target stimulus (Go stimulus) is presented and not to touch the screen when a non-target stimulus (No-Go stimulus) is shown. In the pre-training assessment, the target stimulus was a banana and the non-target stimulus was a watermelon; in the post-training version, all task characteristics remained the same, but the target stimulus was a car and the non-target stimulus was a bicycle. The task consisted of 3 blocks of 25 items each, to create a pre-potent response. The ratio of Go:NoGo stimuli was 76:24 in each block. Stimulus presentation lasted 1000 ms with an inter-stimulus interval of 500 ms. An inhibition index was calculated as the product of the proportion of correct Go and NoGo to obtain a proportional accuracy score ranging from 0.00 to 1.00.

The Flanker task was implemented to measure interference control (Ruffini, Marzocchi, Pecini 2021). Five horizontally aligned stimuli were shown, with the leftmost and rightmost two stimuli either pointing in the same direction as the centre stimulus (congruent condition) or opposite direction to the centre stimulus (incongruent condition). The child was asked to indicate the direction of the central arrow by tapping on a point corresponding to its direction. In the pre-training assessment, the stimuli were fish and the target points represented two fish houses. In the post-training assessment, the stimuli were cats and target points were two balls of wool. The task consists of 4 training items, then 2 test blocks of 24 items each. In each block, there were 12 congruent and 12 incongruent items. All items had a presentation time of 5000 ms and a random interstimulus interval between 400 ms and 1200 ms. The number of correct responses for the incongruent items (CR, 0 to 26) and the median reaction time were recorded.

The Mr. Ant task measures visuospatial working memory (Ruffini, Marzocchi, Pecini 2021). A picture of an animal is presented on the tablet screen. In each trial, a number (2 to 6) of coloured spots appear on the animal's body for about 5 s, then the spots disappear, and the child must point to the location of the spots depicted, in any order. Three trials were used at each level (corresponding to the number of spots), for a total of 15 trials. Each trial used a different spatial arrangement of the spots. In the pre-training assessment, the animal was a giraffe and in the post-training assessment, it was a bear. The number of correct responses (CR, 0 to 15) was recorded.

Dimensional Change Card Sort task (DCCS) measures cognitive flexibility (Ruffini, Marzocchi, Pecini 2021). The task consisted of 24 cards representing a red or blue rabbit or boat in the pre-training assessment and a red or blue airplane or horse in the post-training assessment. The task involves three successive levels of difficulty. First, in the Colour Game (6 cards), the child must indicate the box representing a red boat/airplane when the card is red and the box representing a blue rabbit/horse when the card is blue, regardless of the shape. Next, in the Shape Game (6 cards), the child must point to the letterbox representing a boat/airplane when the card is a boat/airplane and the letterbox representing a rabbit/horse when the card is a rabbit/horse, regardless of their colour. Finally, in the Border Game (12 cards), when the card has a black border, the child plays the Colour Game, and if the card does not have a black border, the child plays the Shape Game. The total number of correct responses (CR, 0 to 24) and correct responses in Levels 2 (0–6) and 3 (0–12) were recorded.

TABLE A1 | Full sample means and standard deviations for all variables.

	N	Min	Max	*M*	SD
Go-NoGo_pre	227	0	1	0.59	0.29
Go-NoGo_post	226	0	0.98	0.7	0.24
Flanker RC_pre	227	0	26	9.8	6.60
Flanker RC_post	222	0	26	14.8	8.24
Flanker RT_pre	208	449.85	3547	1484	661.54
Flanker RT_post	219	583.3	3281.65	1676.66	592.43
Mr Ant CR_pre	226	0	10	3.12	2.99
Mr Ant CR_post	227	0	15	6.63	4.11
DCCS Shape Game CR_pre	226	0	6	3.64	1.64
DCCS Shape Game CR_post	227	0	6	4.53	1.67
DCCS Border Game CR_pre	226	3	11	7.45	1.45
DCCS Border Game CR_post	227	3	12	7.76	1.59
DCCS Total CR_pre	226	8	23	16.4	3.07
DCCS Total CR_post	227	9	24	17.99	2.97
Semantic Fluency CR_pre	221	0	31	12.38	6.45
Semantic Fluency CR_post	225	0	32	15.11	6.95
QUFE_pre	218	52	120	93.22	12.96
QUFE_post	204	57	120	96.02	12.33
PRSIST Cognitive Self-regulation_pre	223	4	21	15.9	4.5
PRSIST Cognitive Self-regulation_post	224	3	21	17.36	4.13
PRSIST Behavioural Self-regulation_pre	223	6	21	16.41	4.09
PRSIST Behavioural Self-regulation_post	224	4	21	17.58	3.78
PRSIST Socio Emotional Self-regulation_pre	223	7	28	19.9	4.6
PRSIST Socio Emotional Self-regulation_post	224	4	28	22.38	4.65
SDQ Emotional Symptoms_pre	227	0	10	1.4	2.08
SDQ Emotional Symptoms_post	227	0	10	1.39	1.9
SDQ Behavioural Problems_pre	227	0	10	1.7	2.22
SDQ Behavioural Problems_post	227	0	9	1.44	2.17
SDQ Hyperactivity Disattention_pre	227	0	10	3.16	2.81
SDQ Hyperactivity Disattention_post	227	0	10	2.57	2.78
SDQ Peer Relationships_pre	227	0	7	1.43	1.7
SDQ Peer Relationships_post	227	0	7	1.06	1.63
SDQ Prosocial Behaviour_pre	227	0	10	6.75	2.56
SDQ Prosocial Behaviour_post	227	1	10	7.43	2.39

TABLE A2 | Fixed Effects for each outcome variable.

	Group effect	Time effect	Sex effect	Age effect	SES effect
Go-NoGo CR	$F(1,210) = 9.71$, $p = 0.002$	$F(1,2.19e\text{-}8) = 0.18$, $p = 1$	$F(1,213) = 9.22$, $p = 0.003$	$F(1,213) = 260.02$, $p < 0.001$	$F(1,213) = 7.91$, $p = 0.005$
Flanker CR	$F(1,210) = 0.36$, $p = 0.55$	$F(1,4.69e\text{-}8) = 0.22$, $p = 1$	$F(1,210) = 1.75$, $p = 0.19$	$F(1,211) = 69.11$, $p < 0.001$	$F(1,211) = 9.82$, $p = 0.002$
Flanker RT	$F(1,208) = 0.67$, $p = 0.41$	$F(1,2.93e\text{-}8) = 0.04$, $p = 1$	$F(1,208) = 6.33$, $p = 0.013$	$F(1,208) = 1.02$, $p = 0.314$	$F(1,213) = 6.38$, $p = 0.012$
Mr. Ant CR	$F(1,210) = 0.13$, $p = 0.72$	$F(1,2.65e\text{-}8) = 1.03$, $p = 1$	$F(1,210) = 5.4$, $p = 0.021$	$F(1,210) = 145.73$, $p < 0.001$	$F(1,210) = 2.55$, $p = 0.112$
DCCS Shape game CR	$F(1,210) = 0.22$, $p = 0.64$	$F(1,5.44e\text{-}9) = 0.18$, $p = 1$	$F(1,210) = 8.44$, $p = 0.004$	$F(1,210) = 37.73$, $p < 0.001$	$F(1,210) = 1.04$, $p = 0.31$
DCCS border game CR	$F(1,210) = 0.27$, $p = 0.61$	$F(1,1.55e\text{-}8) = 0.02$, $p = 1$	$F(1,210) = 3.08$, $p = 0.081$	$F(1,210) = 24.76$, $p < 0.001$	$F(1,210) = 0.24$, $p = 0.62$
DCCS total CR	$F(1,210) = 0.18$, $p = 0.674$	$F(1,7.14e\text{-}8) = 0.28$, $p = 1$	$F(1,210) = 12.03$, $p < 0.001$	$F(1,210) = 87.45$, $p < 0.001$	$F(1,210) = 1.81$, $p = 0.18$
Semantic fluency CR	$F(1,205) = 1.09$, $p = 0.297$	$F(1,1.49e\text{-}8) = 0.25$, $p = 1$	$F(1,205) = 0.35$, $p = 0.56$	$F(1,206) = 137.38$, $p < 0.001$	$F(1,205) = 7.61$, $p = 0.006$
QUFE	$F(1,206) = 0.26$, $p = 0.61$	$F(1,2.38e\text{-}4) = 0.04$, $p = 0.999$	$F(1,206) = 4.76$, $p = 0.03$	$F(1,207) = 4.43$, $p = 0.04$	$F(1,208) = 5.09$, $p = 0.025$
PRSIST Cognitive self-regulation	$F(1,206.08) = 16.14$, $p < 0.001$	$F(1,1.88) = 0.12$, $p = 0.766$	$F(1,206.42) = 13.6$, $p < 0.001$	$F(1,206.67) = 45.74$, $p < 0.001$	$F(1,210.05) = 1.62$, $p = 0.205$
PRSIST Behavioural self-regulation	$F(1,210) = 4.94$ $p = 0.027$	$F(1,1.67e\text{-}8) = 0.1$, $p = 1$	$F(1,210) = 26.08$, $p < 0.001$	$F(1,211) = 79.41$, $p < 0.001$	$F(1,214) = 3.35$, $p = 0.069$
PRSIST Socio emotional self-regulation	$F(1,210) = 2.74$, $p = 0.099$	$F(1,1.64e\text{-}8) = 0.33$, $p = 1$	$F(1,211) = 24.32$, $p < 0.001$	$F(1,211) = 93.47$, $p < 0.001$	$F(1,211) = 1.52$, $p = 0.219$
SDQ Emotional symptoms	$F(1,210) = 0.14$, $p = 0.71$	$F(1,2.64e\text{-}8) = 1.80e\text{-}5$, $p = 1$	$F(1,210) = 1.87$, $p = 0.173$	$F(1,210) = 1.29$, $p = 0.258$	$F(1,210) = 1.72$, $p = 0.191$
SDQ Behavioural problems	$F(1,210) = 0.64$, $p = 0.423$	$F(1,1.18e\text{-}8) = 0.02$, $p = 1$	$F(1,210) = 23.5$, $p < 0.001$	$F(1,210) = 2.34$, $p = 0.127$	$F(1,210) = 1.7$, $p = 0.193$
SDQ Hyperactivity inattention	$F(1,210) = 2.95$, $p = 0.087$	$F(1,2.71e\text{-}8) = 0.06$, $p = 1$	$F(1,210) = 47$, $p < 0.001$	$F(1,210) = 22.23$, $p < 0.001$	$F(1,210) = 5.69$, $p = 0.018$
SDQ Peer relationships	$F(1,210) = 0.61$, $p = 0.43$	$F(1,1.39e\text{-}8) = 0.04$, $p = 1$	$F(1,210) = 5.27$, $p = 0.023$	$F(1,210) = 15.47$, $p < 0.001$	$F(1,210) = 0.5$, $p = 0.478$
SDQ Prosocial behaviour	$F(1,210) = 0.42$, $p = 0.518$	$F(1,2.43e\text{-}8) = 0.06$, $p = 1$	$F(1,210) = 20.46$, $p < 0.001$	$F(1,210) = 29.58$, $p < 0.001$	$F(1,210) = 1.5$, $p = 0.221$