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Article

Cognitive Training in the Domain of Mathematics for Potentially Gifted Children in Primary School

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Abstract: This study examined auditive and visual working memory and metacognitive knowledge in 92 gifted children (aged between eight and twelve), utilising a pre-test-training-post-test design, known as the cognitive training design. This approach was used to examine the working memory and metacognitive knowledge of gifted children concerning the progression after a cognitive training programme in arithmetical problem solving, taking into account the role of intelligence. Children were allocated to one of two experimental conditions: children received training after the pre-test (cognitive training condition) or were provided with training after the post-test (control condition). The results show that all children made significant improvements in working memory and metacognition. Intelligence significantly predicted verbal and visual working memory. However, we did not find a meaningful relationship between intelligence and metacognitive knowledge. The cognitive training in arithmetical problem solving seems to bring additional measurable changes in metacognitive knowledge, but not in working memory.

Keywords: gifted children; working memory; metacognition; cognitive training; mathematics; executive functions

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1. Introduction

In the Dutch educational system, gifted children may undergo part of their education in enrichment classes. In the Netherlands, enrolment in these classes is often based on their school performance; those who score at least at the 80th percentile in comprehensive reading and mathematics are admitted to enrichment classes. Formal intelligence testing is often not conducted in primary education in the Netherlands [1]. What it means to be gifted has changed tremendously over the past decades. In general, the definition changed from a unidimensional conceptualisation, incorporating only intelligence, to a multidimensional conceptualisation taking into account other characteristic abilities, such as excelling in arts, sport, leadership or specific academic skills [2]. Gifted children are, however, not a homogeneous group; they differ in terms of intellectual capacity, school grades, executive functioning, motivation and metacognitive skills [1,2]. Consequently, gifted children also have different educational and instructional needs in the classroom. Often, interventions are administered focusing on enrichment and deepening of the curriculum, acceleration, social–emotional skills and metacognitive skills, such as planning and organising [2].

In practice, giftedness is associated with the ability to excel academically in one or more subjects [3]. As a result, it is often assumed that these children are autonomous learners and do not need instruction, guidance or training [1]. It is often assumed that their cognitive and intellectual capacities should enable them to reach excellence independently [4]. However, recent studies have shown that these children's learning takes place within a zone of proximal development, and, just like the learning processes of typically developing children, they need help to unfold their potential [5]. Indeed, studies show that gifted children can also struggle with academic domains, specifically arithmetic and maths [2,6,7].

In education, cognitive training is sometimes used to help children develop expertise and unfold their potential. Cognitive training can be defined as providing organised practice of tasks relevant to complex cognitive activity, such as language, executive functioning, attention and memory [8]. It is as yet, however, not known whether cognitive training programmes can be implemented to help potentially gifted children unfold their potential. Therefore, the current study aimed to investigate the potential usefulness of a cognitive training programme in the field of arithmetical problem solving, designed specifically for gifted children.

1.1. Cognitive Training

Cognitive training interventions have received much attention in the literature [8]. Often, they employ a pre-test-training-post-test design. The training generally consists of several sessions designed to strengthen different cognitive and intellectual abilities. Cognitive training can be offered in various forms, varying in selected tasks and task modalities, settings, duration of the training sessions and the amount of guided practice provided [8,9]. In general, research shows that training cognitive functions related explicitly to complex academic competencies can help improve academic abilities, such as reading and arithmetic, in primary school children [10,11]. For example, researchers found that reading comprehension and performance can be improved by cognitive training [11–13]. In relation to arithmetic, it was found that a kindergarten programme incorporating embedded and explicit training on metacognition can have positive effects on arithmetic performance in young children [14]. More specifically, in two studies by Cornoldi et al. [15,16] investigating a cognitive training programme focusing on metacognitive awareness and control processes among typically developing children, it was found that increases in metacognition could be related to problem-solving and logical reasoning skills. This study highlights the importance of activating and strengthening metacognitive beliefs in mathematical problem solving [14].

Individual child factors known to influence the effectiveness of cognitive training programmes include intellectual ability, metacognitive skilfulness and executive functioning [17–19]. In general, those who have lower initial levels of cognitive ability improve more with training than those with higher initial levels of cognitive ability [20]. As for executive functioning, individual differences in baseline performance were found to compensate training effects [21].

Often, cognitive training programmes target several cognitive skills and processes, combining general and specific underlying abilities, such as executive functioning and problem solving [12,17,22–26].

1.2. Executive Functioning

Executive functions can be described as essential skills for academic achievement, goal achievement and everyday life [27]. There are three core executive functions: inhibition, working memory and cognitive flexibility, which combine into higher-order executive functions, such as updating information, metacognition and problem solving [27]. Effective use of executive functions, serving and controlling critical complex cognition processes, develops during preschool years. Good executive functioning in early childhood predicts lifelong achievement in various aspects of life [27]. A recent meta-analysis indicated that focusing on executive functioning in cognitive training can lead to improvements in executive functioning of pre-schoolers, especially for atypically developing children, or those who come from families with lower socio-economic status (SES) [27]. However, in a second meta-analysis, it was found that improvements in executive functioning were found in pre-schoolers, but cognitive training did not transfer to learning behaviour [28]. These authors suggest that in pre-schoolers, training might be more effective for developmentally at-risk children.

Research suggests that focusing on executive functioning in cognitive training in school children has led to transfer to and progression in complex cognitive tasks, such as reading comprehension [12,27] and mathematical performance [29,30].

Cognitive training programmes often target working memory. Working memory can be defined as the capacity to store information in the mind while processing data that is no longer perceptually present [17,27,31]. As such, it is essential in supporting learning [32,33] and is linked to various activities, ranging from reasoning tasks to verbal comprehension [34]. In addition, it is crucial to high-level cognition tasks, such as mathematics [17,32]. Theories regarding working memory indicate that there are different modalities, including visual-spatial and auditory modalities [27]. Working memory can be trained, with improvements found within and across modalities. In a recent study by Nelwan, it was found that training auditory working memory led to gains in visual working memory [35].

A second executive function often targeted in cognitive training is metacognition. Metacognition consists of skills and knowledge. Metacognitive knowledge can be defined as one's knowledge about cognitive processes and tasks and knowledge about oneself as a learner. They depend on knowledge about cognitive procedures and the control and regulation over one's learning [15,36]. Metacognitive skills concern self-regulatory strategies (self-instructing, self-questioning and self-monitoring) [29], which help structure the process of problem solving [30]. Research has shown that metacognition is teachable; children need to explicitly learn about metacognitive skills because they do not develop spontaneously from implicit exposure [15]. Assessment and training of metacognition within the framework of improving mathematical performance appear to be promising; both metacognitive knowledge and skills are seen as separated, but interactive, predictors of mathematics achievement [30].

1.3. Cognitive Training in Arithmetical Problem Solving

In addition to focusing on executive functions, cognitive training programmes aim to improve problem solving [11,19]. Problem solving refers to behaviour in which potential strategies for the solution of a problem are determined, and the most appropriate strategy is chosen and evaluated in relation to its usefulness in solving the problem [37]. Solving problems is complex, consisting of several underlying problem-solving strategies [37]. These processes can be divided into two cooperating subprocesses: "understanding" and "searching" [29]. "Understanding" refers to understanding a problem at hand or making an internal visualisation of a problem. "Searching" refers to searching for a solution to a problem. Problem-solving processes often alternate or occur together [29]. Understanding the process's meaning and function is essential to successfully solve real-life problems [37].

The ability to solve problems is essential in daily life [37]. It is also related to performance in various academic domains. More specifically, it is a crucial component of mathematics [11,31,32], for example concerning solving mathematical word problems [32,38]. Therefore, several studies have focused on the effect of cognitive training interventions in the domain of mathematical word problems [11,18]. Such studies revealed that arithmetical problem solving consists of the following five subprocesses: text comprehension, problem representation, problem categorisation, planning the solution and procedural self-evaluation [29,32].

In a recent study, Cornoldi et al. studied whether promoting working memory and metacognition in a cognitive group training programme could positively affect mathematical problem solving [11]. The authors found that their training led to growth in metacognitive and working memory tasks, as well as gains in arithmetical problem solving. Furthermore, concerning the effectiveness of training, it was found that those with initial lower performance levels and poor problem-solving skills benefitted most from the training. These findings indicate that in addition to repeated mathematical practice, mathematical training programmes should rely on training cognitive abilities. In other recent studies, it was found that beneficial effects of cognitive training programmes for mathematics performance were found using brain games [39], as well as in programmes focusing on real-life mathematics [40].

1.4. The Current Study

The majority of studies into cognitive training in the domain of mathematics focused on typically developing children or children at risk of learning problems or disorders. No study as yet has been conducted focusing on cognitive training for gifted children, which seems surprising as, just like other children, gifted children can also struggle with arithmetic and mathematics [2,6,7], and they can benefit from training programmes in the domain of mathematics [41]. Moreover, although in practice, it is sometimes assumed that gifted children excel in executive functioning [6], research indicates that this is not necessarily the case. Just like typically developing children, gifted children show individual differences in their mastery of executive functions [5–7,42–44]. Recent studies, more importantly, suggest that training the executive functions of gifted learners not only leads to improvements in their executive functions themselves, but also benefits their academic performance [45].

Therefore, the current study aimed to investigate whether a cognitive training programme in the domain of arithmetical problem solving incorporating executive functions could be used effectively to improve the executive functions of potentially gifted children. To measure the effectiveness of the cognitive training, children were divided into a cognitive training and a control group. The cognitive programme utilised was based on the programme developed by Cornoldi et al. [11] and adapted to fit potentially gifted children's needs.

The first research question addressed children's potential improvement in working memory and metacognition from pre-test to post-test. Based on previous research [11,18,30,33], we hypothesised that children who received training would improve more in auditory working memory and arithmetical metacognition from pre-test to post-test than those in the control condition. Considering that the cognitive training programme incorporated auditory, but not visual, working memory, it was explored whether training in auditory working memory would be transferred to the domain of visual working memory. As such, it was expected that trained children would show more improvement from pre-test to post-test on visual working memory than children in the control condition, demonstrating a transfer from trained auditory working memory to non-trained visual working memory [35]. As for metacognition, we investigated whether promoting metacognition would positively affect arithmetical metacognition [11]. More specifically, it was expected that trained children would improve more in arithmetical metacognition from pre-test to post-test than their peers in the control condition [18].

The second research question concerned the potential relationship between children's intelligence, on the one hand, and working memory and metacognition performance at pre-test and post-test on the other hand. Based on previous research [21,22], we hypothesised that initial cognitive–intellectual abilities would predict pre-test working memory and metacognition performance. Furthermore, it was hypothesised that at the post-test, intelligence could predict results on working memory and metacognition tasks for untrained children but not for trained children, indicating a learning effect during training.

2. Materials and Methods

2.1. Participants

In the current study, 133 gifted children between eight and twelve participated. They were selected based on their enrolment in enrichment classes. Unfortunately, 41 children were excluded from the data analysis due to missing data due to the COVID-19 school closure. Of the three excluded participants, we did not collect any data. The other excluded participants (N = 38) did not differ from the remaining participants in either age (p = 0.724) or IQ scores (p = 0.493).

The final sample consisted of 92 participants, of whom 56 were boys and 36 girls (M_{age} = 10.67, SD_{age} = 0.63. Per class, the participants were randomly allocated to either the cognitive training or the control condition. The children in the two conditions did not differ in age (p = 0.639), IQ scores (p = 0.691), initial digit span performance (p = 0.357), initial picture span performance (p = 0.124) or initial metacognition performance (p = 0.384).

2.2. Design and Procedure

The study had a test-training-test design, also known as a cognitive training design, with two conditions: an experimental condition and a waitlist condition. Children in the experimental condition received the training after the pre-test, and children in the waitlist condition received the training after the post-test. Schools were randomly divided over the two conditions.

In the first session, the pre-test was administered, consisting of the Intelligence and Development Screener [46], Digit Span, Picture Span from the Wechsler Intelligence Scale-V-NL [47] and a metacognitive questionnaire [16]. Then, those in the training condition received the group training at their school consisting of eight sessions administered twice a week. After the cognitive training programme was finished, all children were administered the post-test, consisting of the same digit and picture span tests and the metacognitive questionnaire used in the pre-test. Finally, the children in the waitlist condition were administered the cognitive training programme.

2.3. Instruments

2.3.1. Intelligence and Development 2 (IDS-2) IQ Screener

The IDS-2 intelligence screener was used to measure intelligence [46]. The Intelligence and Development screener provides an indication of intellectual ability and consists of two subtests: Matrix Reasoning and Category Naming. Matrix Reasoning is a non-verbal test of fluid intelligence. It consists of 35 multiple-choice items referring to children's inductive reasoning and problem-solving skills. Children were asked to choose one out of five possible solutions that fit best in an analogy of type A:B:C:?. Matrix Reasoning has a test–retest reliability of r = 0.86. [46]. Category naming is a verbal test of crystallised intelligence. It consists of 34 multiple-choice items (first pictures, later words) referring to children's verbal reasoning and prior knowledge of categories. The tester shows the pictures (and later says the name) of three different entities that can be categorised together. The child should name the category in which the three entities fit. Category naming has a test–retest reliability of r = 0.93 [46].

2.3.2. Digit Span Wechsler Intelligence Scale for Children-V-NL

Digit Span was used to measure working memory. It provides an indication of auditory working memory and consists of three subtests; Digit Span Forward, Digit Span Backward and Digit Span Sequencing. Each subtest consists of nine items with an increasing difficulty level. The tester tells the children a sequence of numbers. The child is asked to repeat this verbally given sequence, forward, backwards, or they are asked to repeat in an increasing sequence. The Digit Span task has a test–retest reliability of r = 0.79 [47]. In the current sample, a test–retest reliability of r = 0.63 ($p < 0.001$) was found for the children in the cognitive training condition and of r = 0.77 ($p < 0.001$) for those in the control condition.

2.3.3. Picture Span Wechsler Intelligence Scale for Children-V-NL

The Picture Span was used to measure working memory. It provides an indication of visual working memory. It consists of one subtest containing 26 items with an increasing difficulty level. The tester shows a page with pictures of objects in a particular order. After five seconds, a new page is presented with the same and some new pictures. The child should point out the pictures presented earlier in the same order. The Picture Span task has a test–retest reliability of r = 0.60 [47]. In the current sample, a test–retest reliability of r = 0.56 ($p < 0.001$) was found for the children in the cognitive training condition and of r = 0.53 ($p < 0.001$) for those in the control condition.

2.3.4. Metacognition Questionnaire

Arithmetical metacognition was measured using a Dutch version of the metacognition questionnaire designed by Cornoldi et al. [16]. The questionnaire consists of 17 items; 13 items asses arithmetical metacognition and 4 are filler items. All items are statements that can be answered with true or false. An example of a statement is "someone good in arithmetic is very smart". An incorrect answer was scored with a one, and a correct answer was scored with a two. Since the filler items were not scored, it was possible to obtain a score between 13 and 26. The questionnaire has a test–retest reliability of $r = 0.69$ [16]. In the current sample, a test–retest reliability of $r = 0.009$ ($p = 0.95$) was found for the children in the cognitive training condition and of $r = 0.46$ ($p = 0.003$) for those in the control condition.

2.3.5. Cognitive Training Programme

The training programme consisted of eight sessions, administered twice a week, conducted by master students and under the supervision of the second author. Every session followed a strict schedule containing five elements: introduction (5 min), arithmetic-related metacognitive activities (20 min), working memory activities (various versions of the listening span task, 10 min) [11], problem solving in arithmetic tasks with the use of a problem-solving heuristic (20 min) and a brief summary of the session (5 min). Each session covered a different topic of arithmetical metacognition and a new step in the problem-solving heuristic strategy. The arithmetical metacognition topics and the steps in the problem-solving heuristic strategy were based on the model used by Cornoldi et al. [11].

In addition, over the sessions, the number of sentences to be remembered on the listening span task increased to fit the difficulty level to the target groups' expected larger baseline capacity and learning potential. At the beginning of the training, all children received a workbook with the problem-solving heuristic strategy and assignments covering the main elements of each session. The arithmetic tasks consisted of five open-ended arithmetic word problems per week. Although the sessions were held in groups, the children had to work independently. When solving the arithmetic problems, children had to apply the steps of the problem-solving heuristic strategy that were covered so far in the sessions. The listening task consisted of three-word sentences that could be true or false. During the first session only the last word of the sentence should be remembered and written down by the child. In the other sessions, the child needed to write down the last word and determine whether the sentence was true or false. See Table 1 for an overview of the cognitive training programme and Table A1 in the Appendix A for an example of a specific training session. We adapted the programme of Cornoldi et al. [11] to be more suitable for potentially gifted children by making the tasks more challenging, based on input from teachers and educational advisers involved in teaching gifted children in the Netherlands. In a pilot study, prior to the current study taking place, these materials were tested and evaluated for their suitability.

Table 1. Overview of the cognitive training programme, based on Cornoldi et al. [11].

	Metacognitive Beliefs	**Working Memory**	**Problem-Solving Components**
Session 1	Discussion of the importance of attention for problem solving	Listening span task without a secondary task	Understanding the wording of the problem: focus on relevant information
Session 2	Discussion of the role of self-efficacy in problem solving	Listening span task with a secondary task (2–6 sentences)	Understanding the wording of the problem: focus on irrelevant information
Session 3	Discussion of the importance of working memory in problem solving	See session 2	A mental representation of the problem: building up a visual representation of the problem to insert and connect new information

Table 1. *Cont.*

	Metacognitive Beliefs	Working Memory	Problem-Solving Components
Session 4	Distinguishing between different maths problems; identifying the characteristics of a maths problem	Listening span task with a secondary task (3–7 sentences)	Classify different maths problems by their structure
Session 5	Discussion of how that problem can be solved using different procedures	See session 4	Identifying the phases that lead to the solution
Session 6	Using mistakes to improve problem-solving performance	Listening span task with a secondary task (3–8 sentences)	Producing plans for solving a given problem
Session 7	The importance of intrinsic motivation	See session 6	Solving problems: the importance of choosing the proper operations and performing them in the right order
Session 8	The importance of factors that negatively affect school attainment, particularly in mathematics (e.g., anxiety)	See session 6	The importance of monitoring problem-solving activities

3. Results

3.1. Training Effectiveness: Progression from Pre-Test to Post-Test

To examine the effectiveness of the cognitive training, we conducted a Repeated Measures MANOVA on the raw scores for digit span, picture span and metacognition, with Condition (cognitive training/control) as the between-subjects factor and Test session (pre-test/post-test) as the within-subjects factor. The multivariate and univariate effects of the Repeated Measures ANOVA are reported in Table 2.

Table 2. Multivariate and univariate effects of the RM MANOVA for Digit Span, Picture Span and Metacognition scores.

	Wilk's λ	F	p	η_p^2
Multivariate effects				
Measurement	0.57	21.73	<0.001	0.43
Measurement × Condition	0.93	2.23	0.090	0.07
Univariate effects				
Digit Span				
Measurement		31.26	<0.001	0.26
Measurement × Condition		1.34	0.251	0.02
Picture Span				
Measurement		28.50	<0.001	0.25
Measurement × Condition		0.38	0.539	0.004
Metacognition				
Measurement		7.51	0.007	0.08
Measurement × Condition		5.59	0.020	0.06

The univariate results indicated that, with regard to working memory, scores were found to improve significantly from pre-test to post-test for both digit span ($F(1,88) = 31.26$, $p < 0.001$) and picture span ($F(1,88) = 28.50$, $p < 0.001$). The cognitive training did not affect this progression for either digit span ($F(1,88) = 1.34$, $p = 0.251$) or picture span ($F(1,88) = 0.38$, $p = 0.539$).

The multivariate effects indicated a significant effect of time for the variables investigated (Wilk's $\lambda = 0.57$, $F(1,88) = 21.73$, $p < 0.001$, $\eta_p^2 = 0.43$). The interaction effect between time and condition was bordering on significance (Wilk's $\lambda = 0.93$, $F(1,88) = 2.23$, $p < 0.090$, $\eta_p^2 = 0.07$).

For metacognition, scores were found to improve significantly from pre-test to post-test ($F(1,88) = 7.51$, $p = 0.007$). Additionally, for the children administered the cognitive training, progression from pre-test to post-test was significantly larger than those in the control group ($F(1,88) = 5.59$, $p = 0.020$). Descriptive statistics of these measures per condition are displayed in Table 3 and Figure 1, respectively.

Table 3. Descriptive statistics for the scores of Digit Span, Picture Span and Metacognition, per condition and measurement.

		Cognitive Training		Control Group	
		Pre-Test	**Post-Test**	**Pre-Test**	**Post-Test**
Digit Span	M (SD)	28.00 (0.53)	30.32 (0.55)	27.05 (0.60)	28.58 (0.61)
Picture Span	M (SD)	34.18 (0.74)	36.40 (0.58)	33.28 (0.82)	36.08 (0.65)
Metacognition	M (SD)	22.64 (0.16)	23.32 (0.14)	22.73 (0.18)	22.78 (0.15)

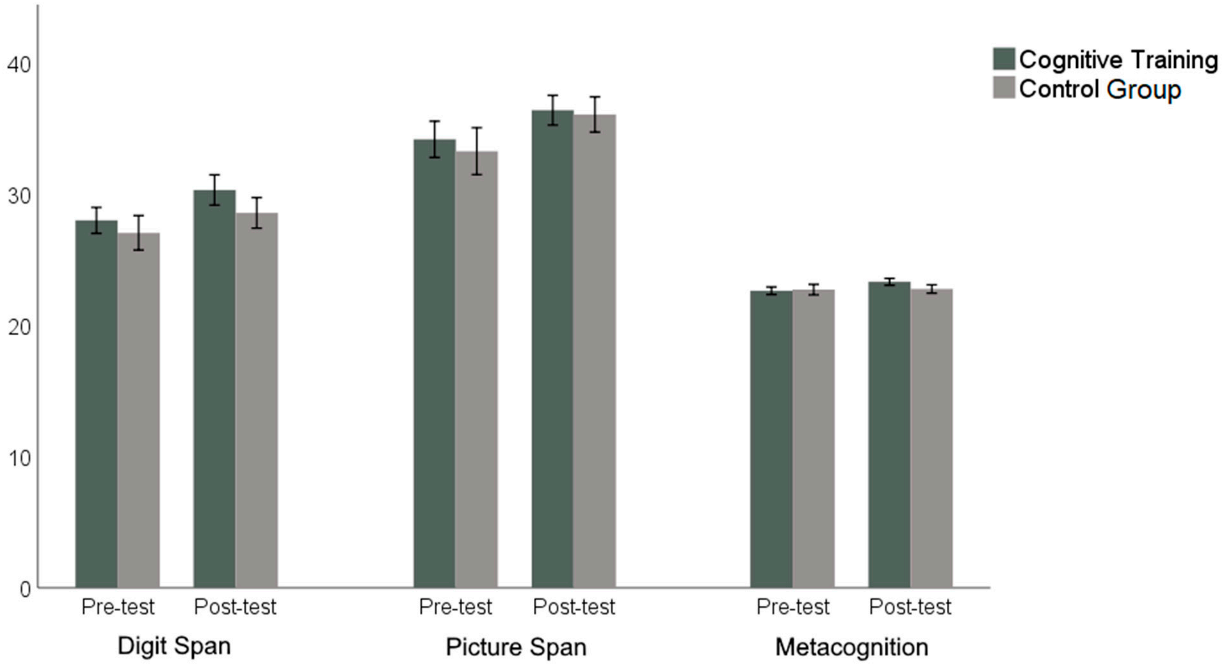

Figure 1. Progression in scores on pre-test and post-test per condition.

3.2. Role of IQ Score in Working Memory and Metacognition Performance

The role of IQ in predicting working memory and metacognition performance was analysed through three separate linear regression analyses for the pre-test, and three linear regression analyses for the post-test, including condition, cognitive training or control group as a predictor for the post-test scores.

The regression model with IQ score as a predictor for digit span pre-test scores was found to be significant ($F(1,90) = 4.37$, $p = 0.039$, $R^2 = 0.046$). IQ significantly predicted digit span pre-test scores ($b = 0.07$, $p = 0.039$). The regression model for the post-test scores, which also included condition as a predictor, was found to be significant ($F(2,89) = 4.59$, $p = 0.013$, $R^2 = 0.093$). IQ was found to be a significant positive predictor for digit span post-test scores ($b = 0.07$, $p = 0.029$), but condition was not.

The regression model with IQ score as a predictor for picture span pre-test scores was also found to be significant ($F(1,90) = 11.07$, $p = 0.001$, $R^2 = 0.109$). IQ was found to be a significant positive predictor for picture span pre-test scores ($b = 0.13$, $p = 0.001$).

The regression model for the post-test scores, which also included condition as a predictor, was found to be significant ($F(2,89) = 8.34$, $p < 0.001$, $R^2 = 0.158$). IQ was found to be a significant positive predictor for picture span post-test scores ($b = 0.14$, $p < 0.001$), but condition was not. The regression model with IQ score as a predictor for metacognition pre-test scores was not found to be significant ($F(1,88) = 3.69$, $p = 0.058$, $R^2 = 0.040$). IQ did not significantly predict metacognition pre-test scores. The regression model for the post-test scores, which also included condition as a predictor, was found to be significant ($F(2,89) = 3.39$, $p = 0.038$, $R^2 = 0.071$). IQ was not found to be significant predictor for metacognition post-test scores, but condition was ($b = 0.54$, $p = 0.011$). See Table 4 for an overview of the regression models analysed.

Table 4. Regression models analyses.

	Pre-test						Post-test					
	Digit Span		Picture Span		Metacognition		Digit Span		Picture Span		Metacognition	
Variable	B (SE)	β	B (SE)	β	B (SE)	β	B (SE)	β	B (SE)	β	B (SE)	β
Constant	20.47 (3.34)		19.55 (4.28)		24.60 (1.01)		21.40 (3.28)		21.80 (3.56)		23.22 (0.86)	
IDS score	0.07 (0.03)	0.22 *	0.13 (0.04)	0.33 **	−0.02	−0.20	0.07 (0.03)	0.23 *	0.14 (0.03)	0.40 ***	−0.004 (0.01)	−0.05
Condition							1.49 (0.80)	0.19	−0.31 (0.86)	−0.04	0.54 (0.21)	−0.27 *
R^2	0.046		.109		0.040		0.093		0.158		0.071	
F	4.37 *		11.07 **		3.69		4.59 *		8.34 ***		3.39 *	

Note: $p < 0.050$ *, $p < 0.010$ **, $p < 0.001$ ***.

4. Discussion

The current study sought to investigate the usefulness of a cognitive training programme, focusing on executive functions in the domain of arithmetical problem solving. Building on Cornoldi et al. [11], we took a different approach by adapting the training to fit potentially gifted children's needs. The study's main aim was to examine whether executive functions could be trained in a cognitive training programme designed for potentially gifted children.

Firstly, the results revealed that all groups of children showed significant improvements in auditory and visual working memory and metacognition from pre-test to post-test. However, concerning metacognition specifically, it was found that those in the cognitive training condition demonstrated more improvement than their peers in the control group. Discussion and guided instruction on various aspects of metacognitive knowledge seem effective in children with high abilities. They strengthen the belief that metacognition in gifted children does not develop automatically [48], and training in metacognition can significantly contribute to this development.

In contrast to our expectations and the findings of Cornoldi et al. [11], it appears that training did not bring about any significant measurable changes in working memory [49]. A possible explanation for this finding is that the working memory tasks utilised in training differed too much from the pre-and post-test working memory measures.

Perhaps the working memory tasks utilised in training were too easy for the high-performing participants [49]. Therefore, further research should look into the difficulty and duration of the working memory tasks in cognitive training.

Secondly, this study investigated the relationship between intelligence and executive functioning. The results showed that intelligence significantly predicts verbal and non-verbal working memory, with higher intelligence levels predicting stronger working memory. This finding seems in line with previous meta-analytic research, which demonstrated that talented and gifted children excel in both visual and verbal working memory [50,51].

However, we did not find a significant relationship between intelligence and metacognitive knowledge. The findings suggest that higher intelligence, thus, does not necessarily indicate better metacognitive knowledge. This outcome is supported by previous research, in which it was posited that a difference in metacognitive skills between average-ability and gifted children is less evident [39]. Individual differences in metacognition have been found in average-ability and gifted children [50,52]. The current study suggests that intelligence and metacognitive knowledge could be seen as independent concepts. The finding that intelligence predicts working memory skills but does not predict metacognition underlines that metacognition and intelligence are not necessarily linearly related, as is sometimes assumed by teachers, and it makes us mindful of the fact that all children, regardless of their cognitive abilities, can have deficits in their metacognition. Of course, it should be kept in mind that the children who participated in the current study were all potentially gifted and had relatively high IQ scores.

The following limitations of the study should be kept in mind when interpreting the results. Due to COVID-19, our sample size became smaller. Future research should aim to use a larger sample, as this will potentially improve statistical power. Furthermore, the results of the training should be compared to actual curricular mathematic achievements to measure the scale of the transfer.

5. Conclusions

In conclusion, it was found in the current study that potentially gifted children can benefit from cognitive training programmes, specifically with regard to their metacognition. Although in practice, some teachers and other educational professionals assume that these children might excel in executive functions and, therefore, may not need additional help [2], the findings of the current study underline that gifted children can also benefit from particular interventions and explicit instruction. Moreover, teachers and practitioners in education should be aware that not every gifted child demonstrating above-average academic performance is already able to use metacognitive knowledge in the right way independently.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy regulations.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Example of a specific training session (session 4).

Arithmetical metacognition	Distinguishing between different arithmetic problems; identifying the characteristics of an arithmetic problem	The trainer starts with a general explanation of categories and how problems can be categorised. Then, children discuss how arithmetic problems can be categorised. Children fill in a diagram with possible arithmetic categories and their characteristics. At last, children are guided on reflecting on how this diagram can help them with arithmetical problem solving

Table A1. *Cont.*

Working memory	Listening span task with a secondary task (3–7 sentences)	Children listen to a series of short sentences. For each sentence, they have to recall the last word, write it down in the same order and write down whether the sentences are true or false. The difficulty of the task increases from 3 to 7 words to recall.
Arithmetical problem-solving component	Categorising different arithmetic problems by their structure	The trainer starts by explaining the fourth step in the problem-solving heuristic. Then, children are presented with five arithmetic problems that they need to solve individually according to the first four steps of the problem-solving heuristic.

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