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A metacognitive visuospatial working memory training for children

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Abstract

The paper studies whether visuospatial working memory (VSWM) and, specifically, recall of sequential-spatial information, can be improved by metacognitive training. Twenty-two fourth-grade children were involved in seven sessions of sequential-spatial memory training, while twenty-four children attended lessons given by their teacher. The post-training evaluation demonstrated a specific improvement of performances in the Corsi blocks task, considered a sequential-spatial working memory task. However, no benefits of training were observed in either a verbal working memory task or a simultaneous-spatial working memory task. The results have important theoretical implications, in the study of VSWM components, and educational implications, in catering for children with specific VSWM impairments.

Keywords: visuospatial working memory, metacognitive treatment, sequential-spatial

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Metacognition

Metacognition refers to higher order thinking that involves active control over the thinking processes involved in learning. The term metacognition is attributed to Flavell (1971) who defined metacognition as thinking about one's own thinking. He described metacognition from a developmental perspective, with reference to learn how monitoring our cognitive processes, setting goals for understanding and activating strategies. Thus, metacognitive *knowledge* involved knowledge people have about their cognitive abilities (i.e., I have a bad memory), about cognitive strategies (i.e., to remember a number I should rehearse it) and about tasks (i.e., categorized items are easier to recall) (Flavell, 1979). Metacognitive *regulation* refers to processes that coordinate cognition. These include both bottom-up processes called cognitive *monitoring* (e.g., error detection, source monitoring in memory retrieval) and top-down processes called cognitive *control* (e.g., conflict resolution, error correction, inhibitory control, planning, resource allocation) (Nelson & Narens, 1990; Reder & Schunn, 1996).

Metacognitive knowledge and skills are essential components of successful learning since they can guide choice of strategies and, where necessary, provide for their adjustment (Sternberg, 1997).

Many researchers have dealt with metacognition as Brown (1975; 1987), Flavell and Wellman (1977), Borkowski, Milstead and Hale (1988), Vadhan and Stander (1994). In particular, Flavell and Wellman (1977; see also Cornoldi, 1998) proposed a distinction between *metacognitive attitude* and *specific metacognitive knowledge*. On the one hand, the metacognitive attitude regards general inclination to reflect about the nature of own cognitive activity and to recognize the possibility to use and extend them (Borkowski et al., 1988). On the other hand, the specific metacognitive knowledge regards the set of knowledge about the mental functioning and includes also the metacognitive control processes. Several studies have shown as metacognitive knowledge is involved in cognitive processes and influences, with other variables, not only memory but also learning performance of children (Cornoldi, 1990). Ericsson and Kintsch (1995) suggested that strategy use is the result of practice and experience, and a better use of strategies should make the task less attention-demanding, thus increasing the performance, e.g., in a working memory task. Finally, another important factor of strategy use is whether the individual is aware of the benefits of using a certain strategy at a young age.

Kluwe (1987) refined the concept of metacognition by noting two characteristics: the thinker knows something about his or her own and others' thought processes, and the thinker can pay attention to and change his or her thinking. This latter type of metacognition was called by Kluwe as *executive process*. Many other researchers also make the point that metacognition is best defined by acknowledging that it is both knowledge about, and control over thinking processes (Allen & Armour-Thomas 1993). Hacker (1998) divided metacognition into three types of thinking focused on the participants' cognitive activities:

- Metacognitive knowledge: What one knows about knowledge;
- Metacognitive skill: What one is currently doing;
- Metacognitive experience: One's current cognitive or affective state.

Visuospatial Working memory and Metacognitive Trainings

Working memory (Baddeley, 1986) is a theoretical construct referred to the mechanism underlying the maintenance and processing of information during performance on cognitive tasks. The Baddeley's multi-component original model contains a central executive system, responsible for controlling the overall model, and two slave systems, the phonological loop dealing with verbal information and the visuospatial sketchpad dealing with visual and spatial information. The visuospatial sketchpad, also known as the visuospatial working memory (VSWM), has been explored in recent years, but to date there is no consensus on its architecture. For example, according to Logie (1995), the VSWM consists of a visual store, known as the *visual cache*, and a rehearsal mechanism, known as the *inner scribe*. The visual cache provides a temporary store for visual information (colour and shape), while the inner scribe handles information about movement sequences and provides a mechanism through which visual information can be rehearsed in the working memory system. In contrast, Pickering, Gathercole, Hall and Lloyd (2001) believe it is possible to distinguish between a static format, in which series of locations are presented simultaneously, and a dynamic format, in which the reproduction of moving paths is required. They found a developmental fractionation for static and dynamic conditions, suggesting that a critical distinction may concern not the visual and spatial properties of the tests, but the static and dynamic nature of the tasks, which tap different subcomponents of VSWM.

Regarding memory for object location, a further distinction was made by Postma and De Haan (1996). The authors subdivided object location memory into three separate processes. The first process requires encoding metric information and the coordinates of a particular object located in the environment. The second process, the *object-location binding,* requires the object's identity to be linked to its position. The final process integrates the first two mechanisms and combines metric information with object identity and location (Kessels, De Haan, Kappelle, & Postma, 2002a; Kessels, Kappelle, De Haan & Postma, 2002b). Recently, Lecerf and de Ribaupierre (2005) distinguished between an extra-figural encoding responsible for anchoring objects with respect to an external frame of reference, and an intra-figural encoding based on the relations that each item presents within a pattern. Within the intra-figural encoding, the authors further distinguished between pattern encoding, leading to a global visual image, and path encoding, leading to sequential-spatial positions. Mammarella, Pazzaglia and Cornoldi (2008; see also Pazzaglia & Cornoldi, 1999) in a recent study tested various VSWM models in primary-school children, using confirmatory factor analyses. The best model fitting the data differentiated among visual working memory tasks, which require memorisation of shapes and colours, and two kinds of spatial tasks sharing the requirement to memorise patterns of spatial locations, but differing in presentation format and therefore in type of spatial processes involved: simultaneous in one case, sequential in the other. Evidence collected with different groups of children also gives support to differentiation between visual and spatial processes (Mammarella, Cornoldi, & Donadello, 2003) and between simultaneous-spatial and sequential-spatial processes (Mammarella, Cornoldi, Pazzaglia, Toso, Grimoldi, & Vio, 2006).

Research on working memory training can address a series of important issues. In particular, whether working memory capacity – despite being connected with neurological basic structures and generally held to be a fixed property of an individual – can be improved, and whether improvement reflects the well-established differentiations within the system.

Very little research has investigated whether working memory can be improved by practice and/or training. One example is Klingberg and colleagues (Klingberg, Forssberg, & Westerberg, 2002; Klingberg et al., 2005), who used an adaptive working memory training with ADHD children. The training consisted of performing visuospatial and verbal working memory tasks implemented through a computer program. Their results showed that not only did ADHD children improved performance on verbal and VSWM tasks, but also the training benefits could be generalised to others domains such as response inhibition, complex reasoning (Klingberg et al., 2002), and fluid intelligence (Klingberg et al., 2005). Moreover, Olesen, Westerberg, and Klingberg (2004) demonstrated that the benefit of working memory training could also be seen in changes in cortical activity. Specifically, after five-weeks' training, an increase in prefrontal and parietal cortical activity was found. It is worth noting that changes occurred in the multimodal association cortices that are active in a wide range of cognitive functions involving working memory. The same research group also tested if working memory training could help stroke sufferers (Westerberg et al., 2007). In this case, the results demonstrated an improvement in both working memory and attention. The common aspect of these studies is that they aim to clarify whether working memory training could be generalised to other cognitive functions. Other research, instead, is focused on understanding whether use of strategies or metacognitive knowledge could improve working memory performance.

In the research of McNamara and Scott (2001), participants had to learn word lists and were trained in use of a strategy, based on creation of a story, using the given words. Two experiments demonstrated that the strategic training improved working memory. In another study, Cavallini, Pagnin, and Vecchi (2003) trained young, young-old and old-old individuals in two memory strategies, i.e. loci mnemonic (imagine a well-known route and then associate the objects to be remembered) and strategic training (use of different imagery strategies depending on the task requirement). However, the benefits of the training were relevant for tasks involving activities specifically trained, while working memory performances showed only modest training effects. Finally, Carretti, Borella, and De Beni (2007) examined the effect of strategic training, based on the creation of integrated images, with young and old adults. The authors found that the improvement of younger and older adults was comparable in both recall of word lists and a working memory task.

Recently, few case studies have been worked out about the effectiveness of metacognitive working memory trainings, in particular Mammarella, Coltri, Lucangeli & Cornoldi (in press) test the efficacy of a visuospatial memory treatment for a child with nonverbal learning disabilities (NLD) and results demonstrated that the metacognitive training was successful and improvements were maintained after six months.

In general, then, these studies showed that working memory performance can be improved by training, but did not take into consideration evidence concerning working memory subcomponents, nor examine the specific effects of training on different working memory subcomponents.

Goals of the present study

The present study is in line with research designed to understand whether working memory performance can be improved, but is focused on specific changes within VSWM. Specifically, we investigated whether sequential-spatial working memory could be improved by training of fourth-grade children using metacognitive strategies. To our knowledge, in the literature there is either general working memory training involving both verbal and visuospatial tasks (Klingberg et al., 2002; Klingberg et al., 2005; Cavallini et al., 2003), or else training involving only verbal materials (McNamara & Scott, 2001; Carretti et al., 2007). Specific VSWM trainings have recently been studied only in a single case with specific impairment of visuospatial working memory (Mammarella et al., in press). Our training involved not only VSWM tasks, but also a hypothesised subcomponent of VSWM (i.e. sequential-spatial working memory) that will be improved specifically using metacognitive strategies.

In sequential-spatial tasks, participants are usually presented with locations of items shown one at a time, and have to either recognise or remember them; the presentation order (or reverse order) is therefore paramount. The most typical test tapping sequential-spatial processes is the Corsi blocks task (Corsi, 1972), which consists of nine blocks irregularly arranged on a board. The blocks are tapped by an examiner following random sequences of increasing length, which participants must reproduce immediately following the presentation order (forward recall) or the reverse presentation order (backward recall).

According to Cornoldi and Vecchi (2003; see also Mammarella et al., 2006), sequential-spatial and simultaneous-spatial tasks differ in the presentation format of the stimuli, which are presented sequentially in one case and all together (simultaneously) in the other. A widely used VSWM task that does not involve sequential items presentation, and which has been interpreted as visual (Della Sala, Gray, Baddeley, & Wilson, 1997; Logie & Pearson, 1997) and as simultaneous-spatial (Mammarella et al., 2006), is the visual pattern test (VPT: Della Sala, Gray, Baddeley, & Wilson, 1997). The VPT involves irregular matrices of increasing complexity in which half of the cells are filled in, and participants have to recall the locations of the filled-in cells. Both the Corsi blocks task and the VPT were used in the present study as pre- and post-training evaluation, together with the digit span task, a measure of verbal working memory, as control. We expected to find a specific increase in sequential-spatial memory due to a specific sequential training, and thus specifically in the Corsi blocks task, but no improvement in the VPT and digit span task.

As regards the training, the difficulty was adjusted considering the type of processing involved. Three sessions required recognition of locations and identity of the stimuli sequentially presented, three sessions required them to be remembered, while a last session was introduced to generalise the sequential-spatial memory in everyday life. This training started with simple tasks in order to allow children to experience success, and thus gain motivation. The training was given to a whole classroom by an expert trainer assisted by a teacher. The trainer suggested one or more possible strategies for recalling visuospatial information depending on the type of task and/or materials involved and, at the end of each session, strategy efficacy was discussed. The children were regular fourth-graders, with no learning disabilities or other cognitive impairments.

Method

Participants

A total sample of 46 fourth-grade children was divided according to their classroom into two groups: 22 (12M, 10F) children were assigned to the experimental training group, while the remaining 24 (14M, 10F) children were assigned to the control group. The classrooms were located in two different parts of the town and both teachers and children were unaware of the objectives of the research. Before the pre-training evaluation, teachers were presented with the SVS Questionnaire (Cornoldi, Venneri, Marconato, Molin, & Montinari, 2003) and were asked to rate a series of children's characteristics on a four-point scale. Ten items on the questionnaire (used to obtain a visuospatial score) refer to some of the deficits that, according to the literature, represent critical features of non-verbal learning disability children (Rourke, 1995). Two items gather information about a child's verbal abilities (verbal score), and one item estimates socio-cultural level. The questionnaire was administered in order to ensure that no child had symptoms of non-verbal learning disabilities, and to match the groups on the basis of these scores. The two groups did not differ in visuospatial score $t(44) = -1.46$ $p = .15$ (experimental training group: $M = 36.40$; $SD = 6.13$; control group: $M = 33.67$; $SD = 6.59$), verbal score $t(44) = -.55$ $p = .58$ (experimental training group: $M = 6.90$; $SD = 1.59$; control group: $M = 6.09$; $SD = 1.52$), or socio-cultural level U Mann-Whitney = 246, $p = .59$.

Materials and Procedure

Pre- and post-training evaluation. In pre- and post-training evaluation, the children of both groups were presented with one verbal (forward and backward digit span, see Wechsler's procedure, 1974) and two visuospatial working memory tasks: *the Corsi blocks test* (adapted from Corsi, 1972), tapping sequential-spatial working memory and *the visual pattern test (VPT),* (Della Sala et al., 1997) tapping a simultaneous-spatial component of VSWM. The tests were administered in a quiet room of the child's school during a single individual session. In order to avoid specific performance on a test being biased by effects of either practice or fatigue, test presentation order was balanced. Tests were administered four days before the first session of the training, and before the administration of each task two practice trials with feedback were given to the participants.

The Corsi blocks test consists of a series of nine blocks irregularly arranged on a board. On the tester's side of the board, the blocks are numbered to facilitate administration; the blocks are tapped by the examiner in random order, and the participant has to reproduce the same sequence of increasing length following either forward or backward recall direction according to the tester's instructions. In our study, items were presented at a rate of one cube per second, and sequence length varied from 3 to 8 in the forward direction and 2 to 7 in the backward direction. Children were presented with three trials at each difficulty level: when they correctly performed two trials, the third was not administered. Also, the procedure stopped when the participant was unable to solve two items of the same level of difficulty. The spatial span was taken to be the longest sequence in which at least two of the three trials presented were correctly reproduced.

In the VPT, children were presented with random square matrices created by filling in half the number of squares in the grid, for 3 seconds. The grids increased in size from smallest (4 squares at the first level, with two filled-in cells) to largest (22 squares at the last level, with 11 filled-in cells). After the presentation phase, in which participants memorised the filled-in squares, the initial stimulus was removed and children were presented with a blank test matrix in which they had to indicate the filled-in squares previously occupied by the targets. The level of complexity was defined as the number of filled-in cells in the matrix (from 1 to 10). The span was taken to be the longest sequence in which at least two of the three trials presented were correctly reproduced.

Training phase. The entire experimental training group attended seven training sessions, which were completed within one month with a fixed interval between sessions. Specifically, the trainer, assisted by the class teacher, gave the training on Monday and Thursday each week. Each session took about 40 minutes, plus ten final minutes for discussing strategies used and giving a metacognitive debriefing to the children. The training was presented as a game in which the protagonist, Alex, had to undertake various activities. The same sequence of events characterised each session: explanation of objectives, stimuli presentation, demonstration of the task, questions, feedbacks, and finally, discussion about the strategies employed to perform the tasks. For each task, the trainer suggested a number of strategies, depending on the task requirements, and at the end of the activity, the children and trainer discussed the usefulness of them in a particular task. Some suggested strategies used to carrying out the tasks were: coding the stimuli in different ways, and then analyze information (for example, looking well at the figures, naming, rehearsing the labels following a path); creating chunks of visuospatial stimuli; using mental images to execute a task; verbalizing mental images. Finally, discussions were improved on the importance of recognizing the best strategy and on the children awareness.

The main goal was to train children in tasks involving sequential-spatial memory processes. The difficulty was increased both within each session (changing the number of stimuli to be remembered) and over the whole training (distinguishing among the cognitive task requests). For this latter, the training was divided into three sub-objectives: *memory recognition*, *memory recall* and *everyday memory*. In the *memory recognition* sessions, the children had to recognise pathways or positions and order of items; in the *memory recall* sessions, their task was to reproduce pathways or positions and order of items and, finally, in the everyday memory sessions, the children were presented with maps and had to reproduce some pathways. The specific organisation of the individual sessions is presented in the Appendix.

The control group was involved at the corresponding times in general cognitive activities administered by their teachers, without any focus on working memory.

Results

Pre-training evaluation

The two groups did not differ in the pre-training evaluation. Specifically, they performed similarly in the forward digit span task $F(1, 44) = .05$ $MSE = .80$ $p = .82$ $\eta_p^2 = .001$, the backward digit span task $F(1, 44) = .05$ $MSE = .81$ $p = .82$ $\eta_p^2 = .001$, the forward Corsi blocks task $F(1, 44) = 1.09$ $MSE = .47$ $p = .30$ $\eta_p^2 = .02$, the backward Corsi blocks task $F(1, 44) = .49$ $MSE =$

.99 $p = .48$ $\eta_p^2 = .01$, and, finally, the VPT $F(1, 44) = .08$ $MSE = 2.10$ $p = .77$ $\eta_p^2 = .002$. The mean values of both pre- and post-training evaluations are given in Table 1.

Table 1. Mean values (standard deviations in brackets) obtained from control and experimental training groups, in both pre- and post-training evaluation.

	Pre-training				Post-training			
	Control	95%CI	Treatment	95%CI	Control	95%CI	Treatment	95%CI
Forward digit span	5.17 (.92)	4.78-5.55	5.23 (.87)	4.84-5.61	5.54 (1.10)	5.01-6.01	5.50 (1.01)	5.05-5.95
Backward digit span	3.33 (.82)	2.99-3.68	3.27 (.99)	2.84-3.71	3.42 (.78)	3.09-3.74	3.55 (.80)	3.19-3.90
Forward Corsi	4.33 (.70)	4.04-4.63	4.55 (.67)	4.25-4.84	4.17 (.64)	3.90-4.44	4.68 (.84)	4.31-5.05
Backward Corsi	3.79 (1.02)	3.36-4.22	4.00 (.97)	3.57-4.43	3.71 (.99)	3.29-4.13	4.27 (.88)	3.88-4.66
VPT	3.12 (1.45)	2.51-3.74	3.00 (1.45)	2.36-3.64	3.17 (1.40)	2.57-3.76	3.22 (1.51)	2.56-3.90

Post-training evaluation

Pre- vs post-training changes in experimental and control groups were compared using mixed ANOVAs. For verbal working memory, a 2x2x2 mixed ANOVA was run, with group (experimental vs control) as between-subject factor and recall direction (forward vs backward) and treatment (present vs absent) as within-subject factors. The main effect of recall direction was significant $F(1,44) = 207.33$ $MSE = .857$ $p = .001$ $\eta_p^2 = .83$, indicating that children had better recall of digits following a forward direction rather than working backwards. Also, the main effect of treatment was significant $F(1,44) = 26.21$ $MSE = .11$ $p = .001$ $\eta_p^2 = .37$, showing that both groups improved performance over one month. A similar 2x2x2 mixed ANOVA was run for the Corsi blocks task. A main effect of group was observed $F(1,44) = 4.52$ $MSE = 1.43$ $p = .04$ $\eta_p^2 = .09$. Also the main effect of recall direction was significant $F(1,44) = 10.21$ $MSE = 1.07$ $p = .003$ $\eta_p^2 = .19$, showing that forward recall was higher than backward recall. Moreover, the interaction treatment by group was significant $F(1,44) = 6.89$ $MSE = .18$ $p = .01$ $\eta_p^2 = .14$. Post-hoc comparisons with Tukey's test showed that the experimental group improved performance after training ($p < .05$). Finally, a 2 (group) x 2 (treatment) mixed ANOVA on the VPT span did not show either significant variations due to the training or main effect of group.

Benefit due to training

To gain a better understanding of the training effect, we calculated a score expressing the benefit resulting from the treatment. The formula used was: [(post-training scores–pre-training scores)/ pre-training scores] (see Carretti, et al., 2007).

Separate one-way ANOVAs were run using benefit indices for all working memory measures. No benefit was found in either forward digit span test *F(1,44)* = .013 *MSE* = 1.43 *p* = .62 η_p^2 = .006, or backward digit span *F(1,44)* = 2.81 *MSE* = .03 *p* = .10 η_p^2 = .06. For the Corsi blocks task, the variation in forward recall was in the positive direction, in contrast with the observation for the control group (see Figure 1), but not significant, *F(1,44)* = 2.33 *MSE* = .019 *p* = .13 η_p^2 = .05. However, a clear benefit was observed in backward recall *F(1,44)* = 5.08 *MSE* = .029 *p* = .03 η_p^2 = .10 (see Figure 1). Finally, no benefit due to the training was observed in the VPT *F(1,44)* = 1.17 *MSE* = .063 *p* = .27 η_p^2 = .03.

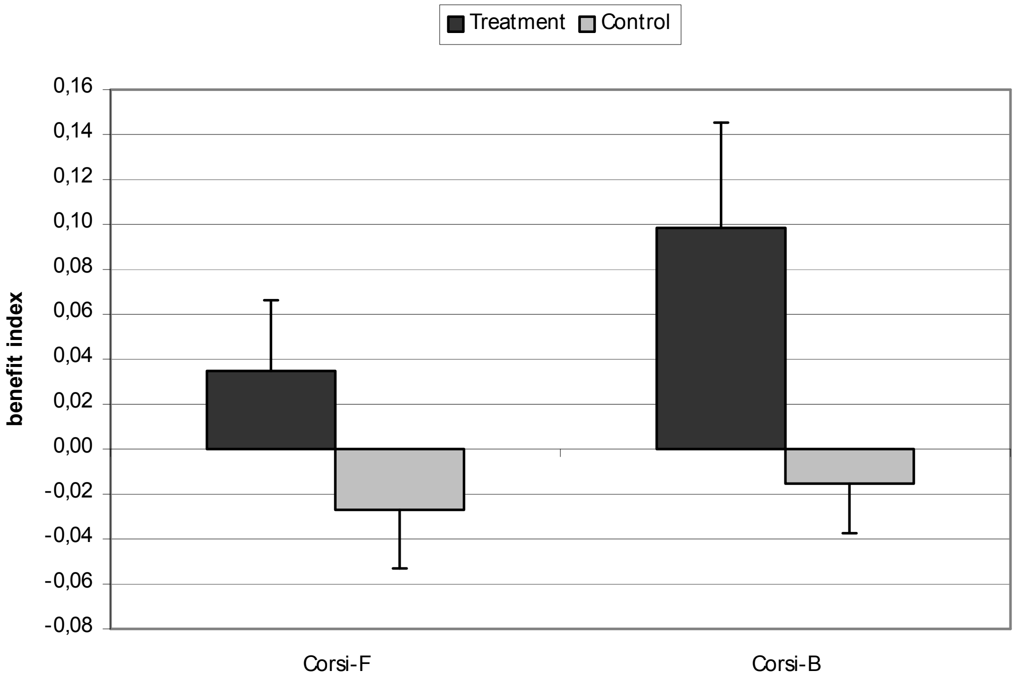

Figure 1. Variation of performance in the treatment and control groups in the forward Corsi (Corsi-F) and backward Corsi (Corsi-B) blocks task. Errors bars represent standard errors.

Moreover, in order to demonstrate the magnitude of the training-related gains in the Corsi blocks task, participant were classified into two groups: 1) a gain of one or more span-scores, 2) an absence of gain or a loss of one or more span-scores (for a similar procedure see Singer, Lidenberger, & Baltes, 2003). The numbers of cases were thus compared with a chi-squared. For the forward recall of the Corsi blocks task, we found only a tendency, the percentage of children who improved performance after training being 18% of the experimental training group and 4% of the control group, χ^2(1,N = 46) = 2.33 *p* = .13. In the backward recall, on the other hand, the percentage was significantly different χ^2(1, N = 46) = 7.56 *p* = .006:

specifically 36% of the experimental training group and 4% of the control group improved performance.

Discussion

The present study shows that sequential-spatial working memory training can increase the amount of sequentially presented information that children can keep in VSWM. The improvement due to training was present, in general, for the Corsi blocks task and, specifically, gains were evident for the backward Corsi. Performances also improved in verbal working memory (i.e. the digit span task), but the spans increased to the same extent in both the experimental and the control groups, demonstrating that there was an effect due to external factors (probably a combination of maturation, practice and cognitive verbal stimulation) but not a specific training effect. In contrast, in the simultaneous-spatial task (i.e. the VPT) no improvement was observed. It should be noted that training was not presented to children with memory or learning impairments, and the specific increase of sequential-spatial spans proved that an initial deficit in VSWM or in spatial abilities is not necessary for improvement to occur. The presence of specific rather than generalised improvement is in agreement with our distinction within VSWM of visual, simultaneous-spatial and sequential-spatial processes. The result we obtained - i.e. the specific effect of a sequential-spatial training on the Corsi blocks task - could be interpreted as further support for the distinction between different VSWM processes (Pazzaglia & Cornoldi, 1999; Mammarella et al., in press). Moreover, our results confirm the positive effect of metacognitive training, in particular teaching new strategies, on sequential-spatial tasks performance. A meta-analysis of memory training in aging (Verhaeghen, Marcoen, & Grossen, 1992) demonstrated that the benefits of training are closely linked to metacognitive aspects – such as thinking about one's own memory – and to opportunities to share experiences. Children could also benefit from these aspects. Moely, Hart, Leal, Santulli, Rao, Johnson & Hamilton (1992) found that children who were trained and encouraged to use strategies were more likely to use the strategies in the specified learning situation, and were more likely to generalise the strategies they learnt to other pertinent situations. This result demonstrated that whether an individual employs strategies depends to some extent on whether they where trained to use strategies as children.

However, some limitations of this study should be borne in mind. First, the improvements in the control group were not particularly dramatic partly because the span measures employed could have underestimated improvement and consequently the benefits of the training. In fact, the scores have a limited range - from 3 to 5 or 6 - since the children attended primary school. Second, although in the training we avoided presenting situations similar to those found in the criterion tests, children could have benefited from general similarities between the training situations and the Corsi task. Further evidence is therefore needed in order to know the generality of the effects of training of sequential-spatial working memory.

Finally, the results of the present study have important educational implications: recognizing the crucial role of metacognition, meaning that education could affect directly cognitive skills, but also, indirectly, on the possibility of using similar or different strategies during cognitive tasks. Moreover, training benefits may be transferred to other areas; thus, metacognitive treatment may be involved in other cognitive domains and may offer interesting implications in the fields of both education and rehabilitation.

In conclusion, our data suggest that not only children without VSWM impairments could benefit from training, but, in addition, children with specific sequential-spatial working memory impairments might gain from domain-specific intervention.

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Appendix

The training was divided into three sub-goals: *memory recognition*, *memory recall* and *everyday memory*. The training was presented as a game in which the protagonist, Alex, had to undertake different activities. Each child had a booklet in which s/he could follow the activities and give her/his response.

1) *Memory recognition*
   - Session 1: The aim of the session was to recognise a series of maze pathways (of increasing complexity) selecting among three of four alternatives. The trainer showed the pathway sequentially in front of the children, who had to choose in their booklet the pathway shown by the trainer. For each maze a short story about Alex was presented in order to gain the children's interest.
   - Session 2: In this session, the concept of presentation order was introduced, and the children had to recognise the location and order of some patterns (e.g. the places where Alex's friends sit in the classroom following the order given by the trainer) or answer simple questions about the relationship between order and locations (e.g. Is Mary sitting near Robert? Who sat down before Robert? Where is Robert's desk?). The level of complexity increased in each trial, with increasing number of items to be recognised.
   - Session 3: In this session the children were introduced to the concept of reverse order. Simple stories about Alex involving locations and order were then presented and the children had to recognise or answer questions in the booklet, as in Session 2.
2) *Memory recall*
   - Session 4: This session had the same aim as Session 1, the only difference being that the children had to reproduce in their booklet the maze pathways shown by the trainer and then recall them.
   - Session 5: The objective of Session 5 was to guide the children in recalling items and locations following the presentation order given by the trainer. The children gave their responses in their booklet.
   - Session 6: As in Session 3, the children were presented with the concept of reverse order recall; however; after the presentation of stimuli and their locations, the children had to recall them in a backward direction.
3) *Everyday memory*
   - Session 7: The main aim of the last session was to generalise sequential-spatial memory processes in everyday life. For this reason, in this session, maps with landmarks (i.e. train station, church, school and so on) were presented and the children had to reproduce the pathways given by the trainer. In the final trials, maps with just street names but no landmarks were presented to familiarise the children with real town maps.