Construction Versus Closed Analogies: Effects of Mediation and Relation to Working Memory

Analogie costruite o chiuse: effetti della mediazione e relazione con la memoria di lavoro

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ABSTRACT

The goals of the current study are to examine (a) the effect of mediation of Construction Analogies versus mediation of Closed Analogies on cognitive modifiability in analogical thinking (b) the effect of mediation of analogies on working memory (WM), and (c) the correlation pattern between analogical thinking and WM in Construction and Closed analogies. A sample of Grade 1 children (49 boys and 47 girls) were randomly assigned to Construction analogies (E1, n = 48) and Closed Analogies (E2, n = 48) groups. Children in E1 group were administered the Construction version of the *Analogical Modifiability Puzzle Test* (AMPT) and children in E2 group were administered the Closed version. Both versions were administered in a dynamic assessment (DA) procedure which includes pre-teaching, teaching and post-teaching phases. Both groups were administered the *Children's Spatial Working Memory* (CSWM) test before and after the teaching phase. The findings reveal that both groups improved their analogical thinking from pre- to post-Teaching, with E1 group showing higher improvement than E2 group. Both groups showed significant pre- to post-teaching improvement in WM— a finding that indicates far-transfer effects. Analogical thinking was significantly correlated with WM in pre-Teaching phase of Construction Analogies whereas analogical thinking was significantly correlated with WM in post-teaching phase of Closed Analogies. The findings raise questions about the cognitive factors involved measuring analogical thinking using a closed analogies format. The findings are discussed in relation to the effects of task characteristics, mediation in DA and recent research on WM.

Gli obiettivi di questo paper sono di: a) esaminare gli effetti della mediazione delle Analogie Costruite vs. delle Chiuse sulla modificabilità cognitiva nel pensiero analgico; b) indagare gli effetti della mediazione delle analogie sulla memoria di lavoro; e c) analizzare il pattern di correlazione tra il pensiero analogico e la memoria di lavoro nelle Analogie Costruite e Chiuse. Un campione della classe prima della primaria (49 bambini e 47 bambine) sono stati

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assegnati casualmente ai gruppi Analogie Costruite (E1, n = 48) e Analogie Chiuse (E2, n = 48). I bambini nel gruppo E1 hanno effettuato la versione Costruita del Analogical Modifiability Puzzle Test (AMPT) mentre i bambini E2 hanno effettuato la versione Chiusa. Entrambe le versioni sono state utilizzate in una versione di valutazione dinamica con le fasi di pre-insegnamento, insegnamento, e post-insegnamento. A entrambi i gruppi è stato somministrato il test Children's Spatial Working Memory (CSWM) prima e dopo la fase di insegnamento. I risultati mostrano che entrambi i gruppi hanno migliorato il loro ragionamento analogico tra pre e post-insegnamento, con un miglioramento maggiore del gruppo E2. Entrambi i gruppi hanno mostrato un significativo miglioramento della memoria di lavoro tra pre e post-insegnamento, il che indica effetti di transfer a disantanza. Il pensiero analogico è significativamente correlato con la memoria di lavoro nella fase di pre-insegnamento delle Analogie Costruite, mentre il pensiero analogico è significativamente collegato con la memoria di lavoro nella fase di post-insegnamento delle Analogie Chiuse. I risultati sollevano interrogativi sui fattori cognitivi coinvolti nella misurazione del pensiero analogico utilizzando un formato di Analogie Chiuse. Il contributo, infine, discute i risultati in relazione agli effetti delle caratteristiche del compito, la mediazione nella valutazione dinamica e la recente ricerca sulla memoria di lavoro.

KEYWORDS
Dynamic assessment; analogical thinking; working memory; cognitive modifiability.
Valutazione dinamica; pensiero analogico; memoria di lavoro; modificabilità cognitiva.

1. Introduction

Closed and construction analogies are two distinct modes of analogies (Harpaz-Itay et al., 2006; Tzuriel 2021). In construction analogies individuals are given a set of stimuli or components and asked to create an analogy using the given components. In a typical problem, the stimuli include irrelevant components which should be sorted out. The task is to create a match between two components (A:B) using a specific relationship and then find an equivalent pair (C:D) with the same relationship (e.g., functional analogy – "the king lives in a castle and the man lives in the house"). In closed analogies format individuals are presented with three components (A:B :: C: __) and asked to complete the last one by choosing it from a list of 6-8 components, all but one are distractors. The nature of each format of presentation requires a different set of executive functions (EF) and especially working memory (WM). In closed analogy the individual should systematically analyze the problem dimensions, store them temporarily in the memory sketchpad (Baddeley 2012), sort out irrelevant stimuli, resist similar solutions, apply the stored solution, and choose the correct answer. In contrast solving a construction analogy does not require activation of WM because the task is to gradually construct the solution and sort out irrelevant distractors.

The objectives of the current study are to investigate (a) the cognitive modifiability in construction versus closed analogies, (b) the relation between WM and performance on construction versus closed analogies, and (c) the effects of teaching analogies within a dynamic assessment (DA) procedure on the expected correlation between WM and analogical thinking. The main expectations of the current study are that cognitive modifiability will be more evident in construction than in closed analogies and that processing of closed analogies requires much higher level of WM and attention control than solving construction analogies. Implicit in the expectation is the idea that solving construction analogies would reveal more accurately the analogical thinking skills than solving closed analogies which involves WM. In the following sections of the introduction, I will briefly discuss the DA of learning potential, the centrality of analogical thinking in cognitive development, analogical thinking at young age, and the relation between analogical thinking and executive functions (EF).

2. Dynamic assessment of learning potential

DA is assumed to capture an individual's potential for learning, by focusing on abilities that are not yet fully developed. DA includes provision of teaching within the testing procedure and examining cognitive improvement in a variety of skills (Feuerstein et al., 2002; Haywood & Lidz, 2007; Lidz & Elliott, 2000; Sternberg & Grigorenko, 2002; Tzuriel 2001; 2012; 2020; 2021). DA is perceived as an approach to measuring children's latent abilities and learning potential, believed to be more unbiased than conventional static tests. It is also considered to be more accurate because it enables compensating for weaknesses in EF (Resing et al., 2020). DA has been motivated by the inadequacy of static tests to provide accurate information about the individual's learning ability, specific deficient functions, change processes, and mediation strategies that are responsible for cognitive modifiability. Previous research has shown that standardized intelligence scores underestimate the cognitive potential of children coming from low SES backgrounds, ethnic minority, and children with special needs, and that DA was proved to be more accurate in revealing their learning potential than standardized tests do (e.g., Guthke & Wingenfeld 1992; Lidz & Elliott 2000; Resing et al. 2009; Sternberg & Grigorenko 2002; Tzuriel 2000; 2001, 2021; Wiedl 2003).

DA has been used frequently to assess the effectiveness of cognitive intervention programs (Tzuriel & Caspi, 2017; Tzuriel & Shamir 2010; Tzuriel et al., 1999) and was found as more accurate in revealing the effectiveness of intervention programs than conventional tests (Tzuriel 2011). The rationale of using DA to examine the effects of cognitive education programs is matching the declared objective of the cognitive program (e.g., «learning how to learn») with criterion measures of change.

In a study by Tzuriel and Flor (2010) an attempt was made to predict early literacy by construction analogies using the *Children's Conceptual and Perceptual Analogical Modifiability* test (CCPAM, Tzuriel 2002; Tzuriel & Galinka, 2000). One of the main findings was that post-teaching construction analogies, significantly added (9%) to the prediction of early literacy above and beyond the pre- and post-teaching phases within a DA procedure. The authors attributed this finding to the unique active pattern of thinking that is used to solve construction analogies. The active pattern of construction analogies corresponds to the active nature of encoding phonemes to graphemes in early literacy.

3. Centrality of analogical thinking in cognitive development

Analogical thinking is a process of representing information and objects in the world as systems of relationships. These systems of relationships can be compared, contrasted, and combined in novel ways depending on contextual goals (Gentner 1996; Holyoak 2004). Analogical thinking has been considered as central factor in cognitive development (e.g., Piaget & Inhelder 1969; Goswami 2012) and as crucial cognitive operation behind many of the 21st century competencies (e.g., Gray & Holyoak, 2020; Halford 1993; Holyoak 2004; Richland & Simms, 2015; Tzuriel 2020; 2021). Furthermore, analogical thinking was found as a central factor predicting a variety of instructional contexts (e.g., Alfieri, et al., 2014; Matlen & Klahr, 2012; Star & Rittle-Johnson, 2009). The ability to solve analogical problems was found even at the age of 3 and 4 years, if children receive requisite knowledge (Brown, 1989) or adequate mediation and training (Resing 2000; Tzuriel 2021; Tzuriel & Klein, 1985; White & Alexander, 1986).

3.1 Analogical thinking at young age

Until recently, developmental psychologists viewed changes in children's thinking as essentially a maturational process that develops in orderly natural stages. Analogical reasoning of young children was conceptualized as starting with the ability to understand low-order relations between two objects in a group (i.e. A:B analogy terms). Only later were children thought to be able to apply this relationship to another set of objects (i.e. C:D terms). According to Piaget, et al., (1977), only towards adolescence could children cope with high-order relational inference. Piaget's approach was supported by several neo-Piagetian researchers who showed that children before the formal operations stage have difficulty in grasping analogies (e.g., Gallagher & Wright, 1979). Young children have been viewed as being "perceptually bound" and therefore as unable to engage in inferential process or to transfer their knowledge. Further, the claim has been that transfer of learning depends largely on the degree of perceptual similarity that exists among objects, ideas, or events.

In the last three decades, however, Piaget's ideas have come under criticism by developmental and cognitive psychologists who showed that cognitive shifts are not due to maturation so much as to a changing knowledge base, including theoretical knowledge (e.g., Goswami 2012; Guberman & Greenfield, 1991; Tzuriel 2001; 2021). Goswami (2012) suggested the notion that young children's difficulties in understanding high-order analogies reflect unfamiliarity with the relationship rather than difficulty with the inferential process of analogy. Goswami's argument was that use of analogies based on familiar relations would help young children show high-level performance of analogical thinking. This idea was supported by several studies (e.g., Richardson & Webster, 1996). In one of the earlier studies, Goswami and Brown (1989) presented pictorial analogies containing familiar objects to children at the ages of 3, 4, and 6. The analogies were based on the transformation of the objects using cause and effect inferential processes (e.g., dough: cut dough = apple: cut apple). Development of this type of inference was found to begin at about age 3 to 4 (Das Gupta & Bryant, 1989). Children in Goswami and Brown's study were given the task to complete an analogy by choosing the correct picture from among five alternatives and then justify their answer. The four incorrect alternatives represented, each, a different type of mistake (i.e., a different inferential process). One represented a perceptual alternative ("mere appearance match" such as apple: ball) (like the C component), another represented an associative alternative (apple : banana), and two other incorrect alternatives indicated understanding of high order relations of cause and effect but difficulty with simultaneous consideration of two relevant components. Goswami and Brown reported that in all age groups the children performed beyond guessing level. The findings showed that 52%, 90%, and 100%, of the 3-, 4-, and 6-year-old children, respectively, solved at least five of the eight analogies presented. These researchers attributed the drastic improvement in ability to solve analogies from the ages of 3 to 6 to the development of understanding of the relations upon which analogical reasoning is based.

Previous findings with a DA approach showed that young children can solve complex analogies at a much higher level after a teaching phase than what might have been expected of children their age (Resing 2000; Tzuriel 2000; 2001; Tzuriel & Klein, 1985). Tzuriel and Klein (1985) used the *Children's Analogical Thinking Modifiability* (CATM) test with three groups of kindergarten children: advantaged, disadvantaged, and children with special education needs. A fourth group of children with intellectual disability whose mental ages were equivalent to kindergarten age was also included in the study. Administration of the CATM test was according to a measurement/research version in which pre- and post-teaching phases are given statically, and the child's responses are scored. A short-term teaching, which is given between the pre- and post-teaching phases, is usually intensive but is not "tailored" to the child's specific needs. The findings showed that the advantaged and disadvantaged groups achieved a high level of performance and high pre- to post-teaching gain as compared with the other two special needs groups. The subgroups of advantaged and disadvantaged children scored 69% and 64%, respectively, on the CATM post-teaching test, as compared to, respectively, 39% and 44% on the Raven's total score (Raven 1956), and 11% and 9% on the Raven's B8-B12 items which are focused on analogies.

3.2 Analogical thinking of children with learning difficulties

Analogical reasoning using a DA approach was found to be efficient in diagnosing groups of handicapped kindergarten children (Missiuna & Samuels, 1989), Grade 1 Ethiopian immigrants to Israel (Tzuriel & Kaufman, 1999), deaf kindergarten children (Tzuriel & Caspi, 1992), children in the autistic spectrum (Tzuriel & Groman, 2017), and learning disabled and slow learning children (Resing 2000; Tzuriel & Shomron, 2018). The DA approach revealed, as expected, more qualitative information about the child's cognitive functioning (e.g., type of hints needed, type of strategies used) than did standardized test performance, showed better performance than expected for children with learning difficulties, and had significant additional predictive value for school performance. DA was found to be of most importance when there were doubts about a child's real intelligence level because of cultural background or disadvantaged educational history (Tzuriel 2020, 2021).

3.3 The relation between analogical thinking and Executive Functions (EF)

The relation between analogical thinking and EF has been reported extensively in the literature (e.g., Richland & Burchinald, 2013; Weatherholt et al., 2006). Inhibitory behavior and WM as major EFs were reported as intimately related to analogical reasoning capacity (Krawczyk et al., 2008; Thibaut, et al., 2010). The development of analogical thinking was found to depend on the interplay among relational knowledge, the capacity to integrate multiple relations, and the inhibitory control over featural distraction (e.g. Holyoak 2012).

4. Hypotheses

Three hypotheses were formulated:

1. Children solving construction analogies will show higher Pre- to Post-Teaching improvement on AMPT Accuracy scores than children solving closed analogies. The rationale of this hypothesis is that construction analogies allow better planning of the solution. Construction analogies by nature direct children to build the solution progressively and avoid distraction of interfering information.
2. Children in the whole sample will show a significant Pre- to Post-Teaching improvement on spatial WM. In other words, the teaching on analogies will be transferred to improvement of spatial WM. The rationale of this hypothesis is that teaching of AMPT analogies enhances efficient and systematic storing of information, inhibition of impulsivity, and systematic consideration of dimensions. These cognitive skills overlap with training of WM, hence the transfer to WM task.
3. Higher correlations will be found between CSWM and AMPT Accuracy scores on closed than on construction analogies. The rationale of this hypothesis is that closed analogies depend more on WM than construction analogies, as children must preserve the solution in the "visual sketchpad" (Baddeley 2012) while searching the correct answer in the list of answer options.

5. Participants

The sample was composed of 96 Grade 1 children (49 boys and 47 girls) who were randomly drawn from 15 classes in the central region of Israel. Children were assigned randomly to two experimental groups: construction analogies (E1) and closed Analogies (E2). Children in E1 group (n = 48) were administered the construction version of the *Analogical Modifiability Puzzle Test* (AMPT, Tzuriel 2019) and children in E2 group (n = 48) were administered the closed version of the AMPT. Both versions were administered in a DA procedure which includes Pre-Teaching, Teaching and Post-Teaching phases (see Measures). The mean age (in months) of the E1 and E2 groups was 75.96 (SD = 7.28) and 78.20 (SD = 6.15), respectively; no significant differences were found for age, $t(94) = -1.62$, $p > .05$. The parental years of education showed no significant group differences for fathers, $t(94) = 1.33$, $p > .05$ or mothers, $t(94) = 1.73$, $p > .05$. Most parents came from middle class families. They had between 12 to 15 years of education and worked in professional and semi-professional occupations.

6. Measures

6.1 Analogical Modifiability Puzzle Test (AMPT)

The AMPT (Tzuriel, 2019, 2021) is a DA measure aimed at assessing cognitive modifiability in analogical thinking, considered to be central operation in cognitive development of children and lie within the fluid intelligence domain (Halford 1993; Holyoak 2004; Richland & Simms, 2015; Tzuriel 2021). The goals of the AMPT are: (a) To evaluate the child's initial mastery of the analogy operation, (b) to observe the level of cognitive modifiability following mediation, (c) to assess deficient cognitive functions, (d) to assess the type and amount of mediation required to modify the child's cognitive functioning, and (e) to recommend specific teaching strategies for better performance and "bridging" of these strategies to academic and daily life areas. In the current study the AMPT was administered in a measurement/research version (Tzuriel 2001; 2021) which is composed of Pre-Teaching, Teaching, and Post-Teaching phases, each containing 10 parallel items. Two example problems are presented at the start of the AMPT to familiarize the child with test dimensions and rules of problem solving. The items are arranged progressively from easy to difficult problems. The AMPT can be administered in one of two versions: Closed Analogies and Construction Analogies.

Closed Analogies. In this version, the child is presented with three components of a classical analogy format (A:B :: C: ?) and the child must choose the fourth component (D), from 6 possible answers, of which 5 are distractors. An easy and a difficult item are presented in Figures 1 and 2, respectively.

Each task is composed of 6 components: two background panels, two hearts and two triangles (placed in the middle of the background panels). When all components are combined, they create a puzzle. To solve the problems, the child must consider changes in the color and position of the panels and geometrical figures from left to right and from top to bottom.

In Figure 1 the color of the background changes from left to right (red to blue) but the color of the inside shapes, changes from top to bottom (white to blue). The correct solution is number 4 (blue background panels, blue hearts, and blue triangles). In Figure 2, the color of the background changes from left to right (blue to white); the color of the two hearts changes from left to right (white to blue); the color of the two triangles changes from top to bottom (white to blue) and the position of the design is rotated 90^0 - anti-clockwise. To solve this problem, the child must gather all the information accurately, work systematically on each dimension, understand the transformation rules, encode the information in his/her WM, and finally integrate all components to reach the correct solution. The most difficult aspect in this problem is to recognize that the position of the design rotates 90^0 - anti-clockwise, not only at the top (A:B), but also rotates 90^0 anti-clockwise from top to bottom (A:C). The correct solution is number 5; background is white, hearts and triangles are blue, and the position of hearts changes so that and edges are pointed up (correct answer is 5).

Construction Analogies. The Construction Analogies are identical to the Closed analogies, but the child must construct the solution using tactile colored parts and a plate with four "windows" in which the puzzle-like design is created. As can be seen in Figures 1 and 2, the child is presented with the three designs of the problem, constructed by the examiner, and the child must construct the last design following the analogy rules (The five distractor solutions are used only for the Closed Analogies version).

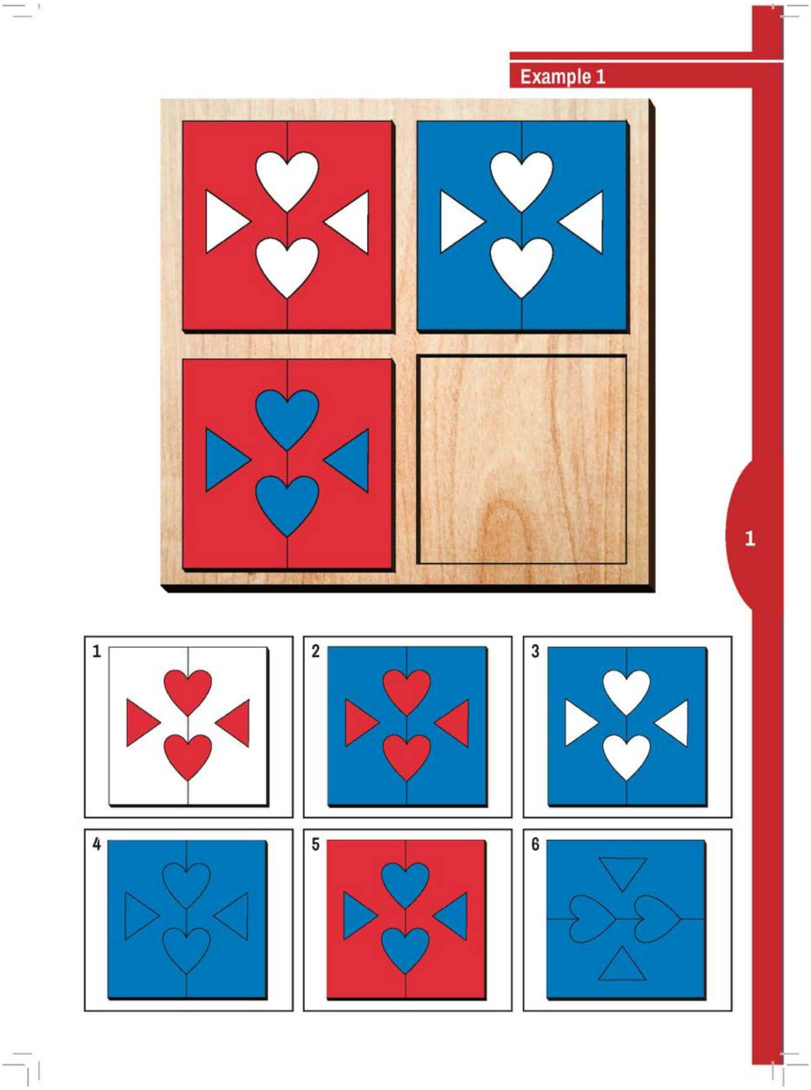

Figure 1. Example of an Easy Item from the AMPT

The AMPT analogies require a relatively high level of abstraction and complexity, use of various cognitive functions (e.g., systematic exploratory behavior, need for accuracy, spatial orientation, inhibition of impulsivity, WM, receptive verbal tools, and simultaneous consideration of several sources of information). Cronbach-alpha reliability coefficients for the Pre- and Post-Teaching phases of the AMPT based on the whole sample (n = 96) were .94 and .95, respectively.

6.2 The Children's Spatial Working Memory (CSWM) Test

The CSWM is a newly developed test of visuo-spatial WM span for young children based on materials used in the *Cognitive Modifiability Battery* (CMB, Tzuriel 2000;

2021). The CSWM test (Tzuriel & Weiss, 2019) is comprised of a squared wooden plate with two rows of three carved out «windows» (3 x 2) into which small red wooden squares are placed (Figure 3)

Visuo-spatial WM is assessed by asking the child to point to a predetermined sequence of windows (spatial locations). The test includes 7 levels of 4 trials each. In each level, the examiner points to several windows (increasing in number from 1-7) of different spatial arrays, thus increasing the difficulty of the spatial memory task with successive trials. The test is terminated when the child fails three successive trials.

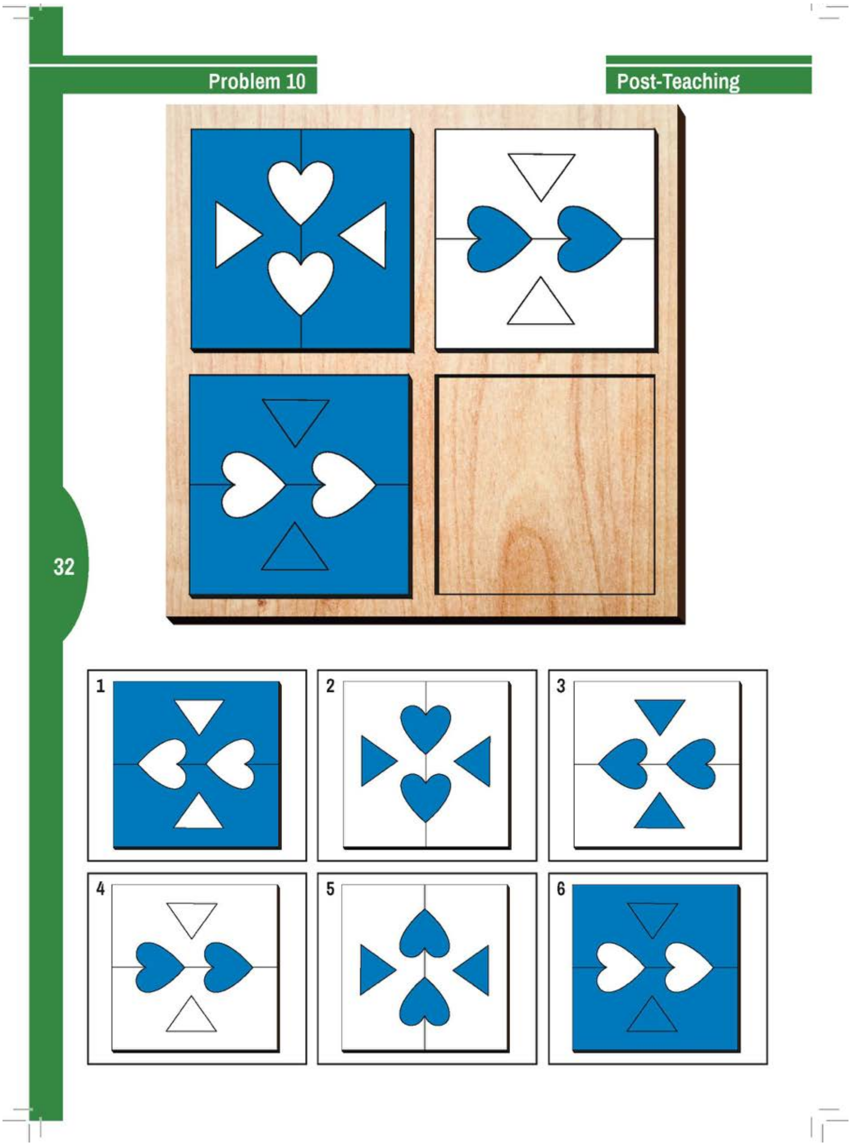

Figure 2: Example of a Difficult Item from the AMPT.

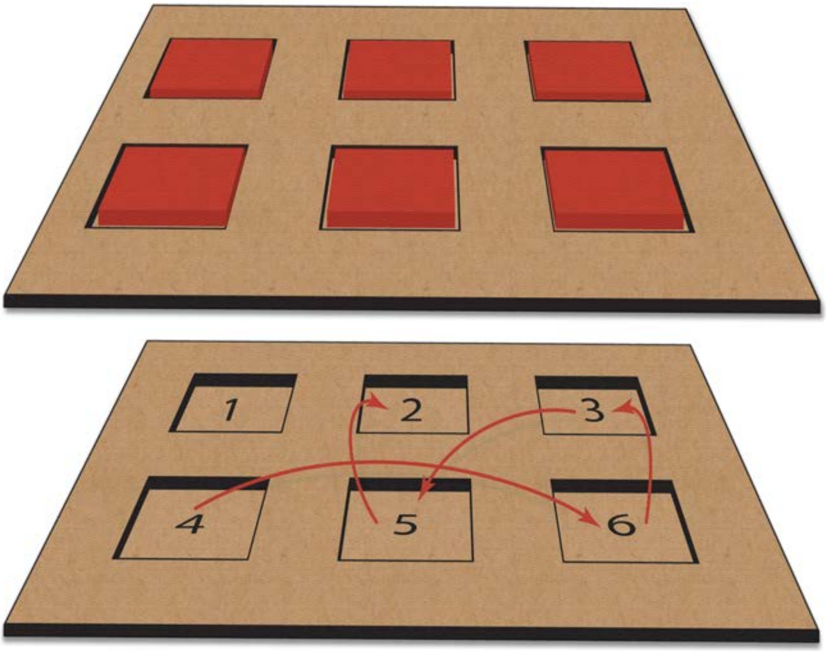

Figure 3: Example of the CSWM Test (By permission of the author).

The child receives one point for each correctly recalled trial and the points are tallied to produce a total score for each task. The Cronbach-alpha reliability of the CSWM has been found to be 0.71 (Tzuriel & Weiss, 2019).

The CSWM was administered in a pre- and post-intervention phase of a WM training program, the *Cognitive Modifiability Working Memory Program* (CM-WMP, Tzuriel & Weiss, 2022). The Cronbach-alpha reliability coefficients for the pre- and post- intervention tests were .73 and .87, respectively. The CSWM has been found also to be significantly correlated ($r = .48$, $p < .01$) with the *Knox Cube Test* (Stone, 2002) and with the *Mental Rotation Subtest* ($r = .55$, $p < .001$) of the *Cognitive Modifiability Battery* (CMB, Tzuriel, 2000c). Tzuriel and Weiss (2022) reported a significant correlation of the CSWM with the *Children's Verbal Working Memory* test (CVWM, Tzuriel, 2018) ($r = .34$, $p < .01$), the *Backward Digit Recal*l test (BDR, subtest of the WMBT-C, Pickering & Gathercole, 2001) ($r = .46$, $p < .01$), the *Understanding of Directions* (UND) test from the Woodcock-Johnson IV Tests of Achievement (UND, WJ 1V, 2014) ($r = .49$, $p < .01$), the *Head-Toes-Knees-Shoulders* test (HTKS, Ponitz, et al., 2008) ($r = .44$, $p < .01$), and the *Children's Analogical Thinking Modifiability* test (CATM, Tzuriel & Klein, 1985) ($r = .27$, $p < .01$).

6.3 Process

Children in both groups were administered the CSWM and the AMPT in that order. The construction analogies group used the tangible version of the AMPT whereas the closed analogies group used a booklet of problems.

7. Results

The means and standard deviations of the AMPT Pre- and Post-Teaching scores for E1 and E2 groups are presented in Table 1. The effect of teaching the AMPT Construction versus Closed analogies was analysed by a repeated measures ANOVA of Treatment X Time (2 x 2) for the AMPT and CSWM variables (see Table 2).

7.1 AMPT scores

The findings for Accuracy show that while both groups improved their performance from Pre- to Post-Teaching, the E1 group improved their performance accuracy more than the E2 group, thus supporting Hypothesis 1. The interaction of Treatment x Time is portrayed in Figure 4. Post hoc analyses revealed no significant group difference in Pre-Teaching phase, $t(96) = .44$, $p > .05$ but a significant difference in the post-Teaching phase, $t(96) = 2.46$, $p < .01$. Within group analyses showed significant improvement for both groups — E1, $t(48) = 5.91$, $p < .001$; E2, $t(48) = 3.60$, $p < .01$.

		AMPT Accuracy		CSWM	
Group		Pre	Post	Pre	Post
E1	M	2.46	6.83	15.33	18.27
	SD	1.60	5.80	3.12	3.80
E2	M	2.29	4.60	16.52	19.83
	SD	2.17	2.42	3.44	4.39

Table 1. Means and Standard Deviations of AMPT Accuracy and Spatial WM Scores in Pre- and Post-Teaching Phases for Construction Analogies (E1) and Closed Analogies (E2) Conditions.

		AMPT Accuracy			CSWM		
Source of Variation	Df	MS	F	η_p^2	MS	F	η_p^2
Treatment (A)	1	68.88	4.93*	.03	90.75	3.72	.04
Error	94	13.98			24.39		
Time (B)	1	536.67	61.69***	.40	468.75	147.58***	.61
A x B	1	51.05	5.87*	.06	1.69	.53	.01
Error	94	8.70			3.18		

***$p < .05$, ***$p < .001$**

Table 2. Analysis of Variance of AMPT Accuracy and Time of Performance by Treatment (Closed/Construction Analogies) by Time (Pre/Post-Teaching).

7.2 CSWM scores

The findings on the CSWM revealed significant main effect of treatment. These finding indicates that both groups improved their spatial WM from Pre- to Post-Teaching of the AMPT analogies, thus supporting Hypothesis 2.

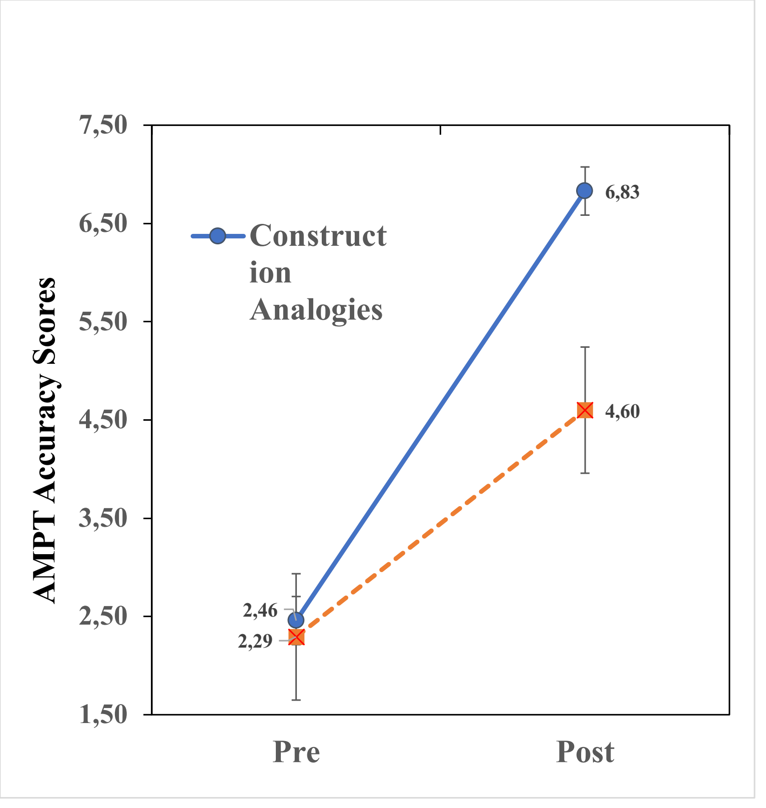

Figure 4. The AMPT Pre- and Post-Teaching Accuracy Scores in the Construction Analogies (E1) and Closed Analogies (E2) Groups.

7.3 Pearson correlations of AMPT and CSWM scores in pre-teaching and post-teaching phases

According to hypothesis 3 higher correlations will be found between CSWM and AMPT Accuracy scores on closed than on construction analogies. Pearson correlations revealed (see Table 3) higher correlations for closed than for construction analogies only in Post-Teaching phase whereas in Pre-Teaching phase higher correlations were found for construction than for closed analogies, thus hypothesis 3 was partially supported.

	Construction	Closed	Fisher Z
Pre-Teaching	.46***	.23	.10
Post-Teaching	.05	.32*	-1.34
Fisher Z	2.12*	.32	

***$p < .05$, **$p < .01$, ***$p < .001$**

Table 3: Pearson Correlations and Fisher Z analyses between AMPT Accuracy Scores and CSWM Score

8. Discussion of the results

The findings on the AMPT show that children in the construction analogies group demonstrated higher Pre- to Post-Teaching improvement than children in the closed analogies group, thus supporting hypothesis 1. It should be noted that both groups showed similar Accuracy scores in the Pre-Teaching scores so that the improvement is attributed to both the different mediation strategies used in each group and the unique task characteristics. In construction analogies children are taught to create the solution in a progressive way; first to analyze the colors of the background components, then the colors of shapes (hearts and triangles), and finally the position. The construction modality leads the child to inhibit impulsivity, to work systematically on each of the task's component and reduce the cognitive load (e.g., Paas et al., 2010) and WM requirements. In contrast, the closed analogies require maintaining the solution in the "memory sketchpad" while searching for the correct solution and actively comparing the answer with distractors. Support for this explanation may be found in the significant correlations between the AMPT scores and CSWM scores in both the Pre-Teaching (r = .47) and post-Teaching (r = .47) phases of the closed analogies version as opposed to low and insignificant correlations with the construction analogies (Table 4). These findings raise the question whether analogy scores measured in conventional tests, assess analogical thinking or other constructs such as WM and impulsivity orientation. Previous research have shown that WM is intimately related with analogical reasoning (e.g., Richland et al., 2006). The AMPT construction analogies suggest a way to measure analogical thinking without the WM component involved. Furthermore, comparing Accuracy scores in construction versus closed analogies may provide indications about interference of WM in analogical thinking.

The findings on the CSWM scores are intriguing as they show that intervention for analogical thinking improved spatial WM. The improvement in WM was even more powerful ($\eta_p^2 = 61$) than the effect on analogical thinking ($_p^2 = .40$) which was the targeted mediation activity. This finding supports hypothesis 2. It should be noted that the WM task has no similarity to the intervention contents, so that the improvement may be considered as an indication for a far transfer effect. The question is of course what the durability of the improvement in WM is, especially since the intervention was short within a DA procedure. One may infer that a longer intervention of analogical thinking would produce a more durable effect than the short-term DA teaching. This finding is of importance in view of research showing that WM training is limited and has not produced the expected changes (e.g., Melby-Lervåg & et al., 2016). Sala and Gobet (2020) in their study on WM training reported a small to medium effects size in memory tasks, the higher the similarity between the training task and the outcome measure, the higher was the effect size. In contrast the findings of the current study show that training of analogical thinking which saturated with WM components is efficient to transfer to WM capacity. This finding paves the way for more sophisticated studies considering mediation strategies, deficient cognitive functions, metacognitive factors, and specific task characteristics (Tzuriel & Weiss, 2022).

The correlation pattern of the correlations between AMPT and CSWM scores (Table 3) shows a complicated correlational pattern and partially supports hypothesis 3. The correlation in the Pre-Teaching phase is significant only for construction analogies whereas in post-Teaching phase it is significant only in closed analogies. Construction analogies in general do not require WM to solve the analogy problem. However, with young children the task is relatively demanding and require young children a certain level of WM, hence the significant correlation between construction analogies and the CSWM (r = .46). Closed analogies by nature require high level of WM to maintain the components of the solution, to sort out the irrelevant distractors and focus on the components of the correct option. In the Pre-Teaching phase, there was a small and insignificant correlation between WM and accuracy (r = .23), probably because children were not aware of the task difficulty, the need to pay attention to details, and contain the answer in their "sketch pad" (Baddeley 2012) until finding the right answer. However, after the mediation phase they realize how important it is to pay attention to the details, inhibit impulsivity, use verbal anticipation of the answer, and mentally contain the information. Thus, children with higher WM knew how to benefit from mediation, apply their WM and eventually be more accurate. This finding requires further research using different criteria of WM and mediation techniques.

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