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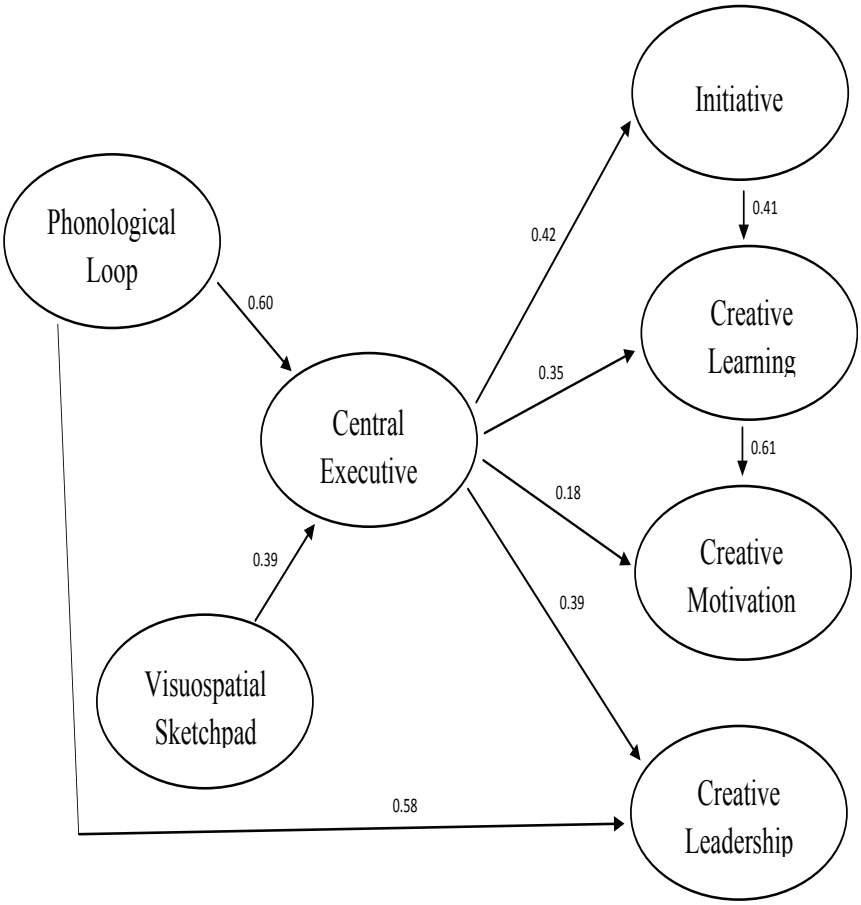
The second aim was to investigate the impact of working memory components on creative thinking indicators through path analysis; we found that central executive mediated the model between the other two components (phonological loop and visuospatial sketchpad) and creative thinking indicators (initiative, creative learning, creative motivation, and creative leadership).



Model analysis of the causal path between working memory components and indicators of creative thinking among pre-school children

Discussion

The first aim of this study was to investigate the relationships between working memory components and creative thinking indicators; it was found that all working memory components correlate with all creative thinking indicators.

Model fitness indexes

Table 1: Correlation matrix and descriptive statistics for observed variables.

	1	2	3	4	5	6	7	8	9
1 Phonological Loop	1								
2 Visuospatial Sketchpad	.553**	1							
3 Central Executive	.549**	.708**	1						
4 Working Memory	.895**	.823**	.825**	1					
5 Initiative	.482**	.505**	.515**	.580**	1				
6 Creative Learning	.386**	.500**	.498**	.519**	.963**	1			
7 Creative Motivation	.422**	.523**	.483**	.541**	.938**	.953**	1		
8 Creative Leadership	.419**	.519**	.500**	.544**	.957**	.969**	.959**	1	
9 Indicators of Creative Thinking	.434**	.521**	.507**	.555**	.980**	.987**	.979**	.979**	1
Maximum	113.00	69.00	68.00	246.00	91.00	97	94	96	365.00
Minimum	23	23	19	82	20	23	21	21	86
M	72.5185	45.4630	43.8189	161.8004	59.2593	63.1852	62.7222	60.9444	246.1111
SD	22.46905	11.57863	12.50509	39.87819	18.06193	18.81797	18.55885	18.58932	72.80827
Reliability (Cronbach's alpha)	0.829	0.632	0.624	0.752	0.949	0.958	0.963	0.955	0.989
Skweness	-.346-	-.135-	-.124-	-.316-	-.473-	-.318-	-.510-	-.347-	-.434-
Kutosis	-.564-	-.872-	-.828-	-.797-	-.361-	-.335-	.041	-.405-	-.238-

** p < .01.

p < .01, and r=.523, p < .01, and r =.519, p < .01) respectively. The relationships between the central executive and creative thinking indicators (initiative, creative learning, creative motivation, and creative leadership) are (r=.515. p < .01, r=.498, p < .01, and r=.483, p < .01, and r =.500, p < .01) respectively. The relationships between the working memory and creative thinking indicators (initiative, creative learning, creative motivation, and creative leadership) are (r=.580. p < .01, r=.519, p < .01, and r=.541, p < .01, and r =.544, p < .01) respectively.

The relationships between working memory components and creative thinking indicators

Using the path analysis of liseral 8.8 to make a model of working memory components and creative thinking indicators. It was found that phonological loop positively affected central executive and creative leadership; their respective paths were significant (β = .6 and β = .58, respectively, all ρs > .01). Visuospatial sketchpad positively affected central executive; its respective path was significant (β = .39, ρs > .01). Central executive positively affected initiative, creative learning, creative motivation, and creative leadership; their respective paths were significant (β = .42, β = .35, β = .18, and β = .39, respectively, all ρs > .01). Initiative positively affected creative learning; its respective path was significant (β = .41, ρs > .01). Creative learning positively affected creative motivation; its respective path was significant (β = .61, ρs > .01).

Index of model fit	Data fit for
x^2	17.27
Df	11
P	.01
CFI	.99
RMSEA	.099

(4) Perception-of-Relationships Test: which is composed of 4 levels; level 1 is composed of 4 pictures, 2 pictures in the right side and 2 pictures in the left side. Pictures increase by one picture in the right and one picture in the left in each level. Each picture in the right side has a relationship with one of the picture in the left. The child views the pictures and has to match between 2 pictures that have a relationship.

The Indicators of Creative Thinking Inventory

Behavioral Indicators Inventory of Creative Thinking for Preschool Children:

It is composed of 80 items to measure 4 dimensions**:**
Initiative: composed of 20 items.
Creative Learning: composed of 20 items.
Creative Motivation: composed of 20 items.
Creative Leadership: composed of 20 item.

Results

Descriptive statistics are listed in the lower section of Table 1. Reliability scores of the working memory components and dimensions of creative thinking indicators ranged between 0.624 and 0.963, indicating sufficient to good internal consistency.

Correlational analyses

The interrelationships between working memory components and creative thinking indicators are all significant at level 0.01. As can be seen in table 1 the relationships between the phonological loop and creative thinking indicators (initiative, creative learning, creative motivation, and creative leadership) are (r=.482. $p < .01$, r=.386, $p < .01$, and r=.422, $p < .01$, and r =.419, $p < .01$) respectively. The relationships between the visuospatial sketchpad and creative thinking indicators (initiative, creative learning, creative motivation, and creative leadership) are (r=.505. $p < .01$, r=..500,

trial, the child has to recall the location of each red dot on the triangle in sequence by pointing to the picture on the screen.

(4) **Visual spatial sequence:** which is composed of 4 levels; level 1 composed of a picture of 2 circles; one of the two circles contains number 1, the other circle contains number 2. Circles increase by one circle in each level. The child views the picture, and has to match numbers from smaller to larger. The numbers disappear and the child has to match between the cicles without numbers.

Central Executive

Four tests were used to measure central executive

(1) **Backward digit recall test:** which is composed of 4 levels, each of which is composed of 3 trials. Test trials begin with two number in level 1, and increase by one number in each level. The child listens to each trail and has to recall that trial but in reverse order.

(2) **Count recall test:** which is composed of 4 levels, each of which is composed of 3 trials, and trials increase by one trial in each level. Each trial is composed of a picture of a visual array, which is composed of red circles and blue triangles. The child views the picture, and has to calculate the number of red circles in each array, the circles and triangles disappear and the child has to recall the number of red circles in correct order.

(3) **Listening test:** which is composed of 4 levels; level 1 is composed of 1 trial, and trials increase by one trial in each level. Each trial is composed of one sentence. The child listens to the sentence, then verify it by stating ‘‘true’’ or ‘‘false,’’ and recalls the final word for each sentence in sequence.

Visuospatial Sketchpad

Four tests were used to measure visuospatial sketchpad

(1) **Odd one out recall test:** which is composed of 4 levels; level 1 is composed of 2 trials, and trials increase by one trial in each level. Each trial is composed of a picture of 3 shapes, each in a box presented in a row, one of them is strange (the odd-one-out shape). The child views three shapes, and has to identify the odd-one-out shape. At the end of each trial, the child recalls the location of each odd-one-out shape, in the correct order, by tapping the correct box on the screen.

(2) **Wondrous rabbit test:** In the Wondrous rabbit test, fictitious cartoon figures known as wondrous rabbits were designed to be unfamiliar yet likable to children. The test is composed of 4 levels; level 1 is composed of 1 trial, and trials increase by one trial in each level. Each trial is composed of a picture of 2 pictures of the wondrous rabbit figures. One has a red ribbon and the other has a blue one. The child identifies whether the wondrous rabbit with the red ribbon is holding the ball in the same hand as the wondrous rabbit with the blue ribbon. The wondrous rabbit with the blue ribbon rotated. At the end of each trial, the child has to recall the location of each ball in wondrous rabbits hand in sequence, by pointing to a picture. Wondrous rabbit figures stayed on the computer screen until the child provided a response.

(3) **Location span test:** which is composed of 4 levels; level 1 is composed of 1 trial, and trials increase by one trial in each level. Each trial is composed of a picture of 2 triangles, where the triangle on the right has a red dot on it. The child views the picture, and has to identify whether the triangle on the right is the same as or opposite to the triangle on the left. The triangle with the red dot may also be rotated. At the end of each

Tools

Working Memory Battery

The Automated Working Memory Assessment Battery for Preschool Children:

All 12 tests form the Automated Working Memory Assessment, a computer-based standardized battery for preschool children that provides multiple assessments of phonological loop, visuospatial sketchpad and central executive.

Phonological Loop

Four tests were used to measure phonological loop:

(1) **Digit recall test:** which is composed of 4 levels; each of which is composed of 3 trials. Test trials begin with one number in level 1, and increase by one number in each level. The child listens to each trail and has to recall that trial.

(2) **Word recall test:** which is composed of 4 levels; each of which is composed of 3 trials. Test trials begin with one word in level 1, and increase by one word in each level. The child listens to each trail and has to recall that trial. All the words that have been selected in the test consists of 3 letters.

(3) **Non-word recall test:** which is composed of 4 levels; each of which is composed of 3 trials. Test trials begin with one word in level 1, and increase by one non-word in each level. The child listens to each trail and has to recall that trial.

(4) **Letter recall test:** which is composed of 4 levels; each of which is composed of 3 trials. Test trials begin with one word in level 1, and increase by one letter in each level. The child listens to each trail and has to recall that trial.

and cognitive variables: intelligence, cognitive abilities, creative thinking and all cognitive activities. The researchers conclude some types of relationships between the working memory components and creative thinking indicators for preschool children aged 4-6. It has been noticed in the previous two decades that many psychologists differentiate between: intelligence, creativity, creative thinking, cognitive abilities on one hand and working memory on the other hand, although a huge researches and studies assure that a close relationship between working memory as cognitive process and those variables (Lee, &Therriault. 2013; Hedblom, 2013; Peters, & Laura, 2006; Lépine, Barrouillet, & Camos, 2005).

The aims of this study are to answer those two questions:

1. Are there relatioships between the working memory and its components and with the indicators of creative thinking: initiative, creative learning, creative motivation, and creative leadership?
2. Can modeling the relationships between working memory components and creative thinking indicators reflect causal model?

Procedures:

Participants:

Participants were 54 typically developing children (25 girls and 29 boys) recruited from six kindergartens located in Mansoura city and Zagazig city in Egypt. Children are between 48 and 73 months of age (M = 59.26 months, SD = 8.3). The sample was composed of five groups: 4-year-olds (n=15; M=48 months, SD=0 months; 7 girls and 8 boys), 4.5-year-olds (n=8; M=55.13 months, SD=1.36 months; 2 girls and 6 boys), 5-year-olds (n=10; M=60.9 months, SD=1.45 months; 5 girls and 5 boys), 5.5-year-olds (n=10; M=66 months, SD=0.42 months; 5 girls and 5 boys) and 6-year-olds (n=11; M=72.18 months, SD=0.4 months; 6 girls and 5 boys).

the phonological store from decaying. The phonological loop holds verbal and auditory information. Thus, when you are trying to remember a telephone number or a person's name, or to understand what your cognitive psychology professor is talking about, you are using your phonological loop (Goldstein, 2011: 132). Before 7 years of age, spontaneous rehearsal does not reliably occur; in younger children, the phonological loop therefore consists of the phonological store only (Gathercole, Pickering, Ambridge, & Wearing, 2004: 177-178). It was suggested that young children may employ a more rudimentary of rehearsal than do older children and adults (Gathercole & Hitch. 1993: P. 195). Information gains access to the phonological store, either directly, via auditory presentation of speech stimuli, or indirectly via internally generated phonological codes for nonauditory inputs, such as printed words or familiar visual objects (Gathercole, 2002: 477).

The Visuospatial Sketchpad: is necessary for the system to be able to elaborate the stored information, which may then be used in a variety of complex human activities such as orientation, movement in space, mental imagery, drawing, and so on (Cornoldi & Vecchi, 2003: 44). Logie (1994) has recently proposed that the sketchpad consists of two primary subcomponents: a visual store, in which the physical characteristics of objects and events can be represented, and a spatial mechanism that can be used for planning movements and which may also serve a rehearsal function by reactivating the contents of the visual store (Gathercole, 2002: 481).

The Central Executive: is where the major work of working memory occurs (Goldstein, 2011: 132).It is responsible for controlling the other three subsystems and regulating and coordinating all of the cognitive processes involved in working memory performance, such as allocating limited attentional capacity (Dehn, 2008: 22). Working memory components working as a system activate all mental

Introduction:

Working Memory is a dynamic effective system that is able to manipulate and process information, i.e Workbench by which information is converted handled, combined and transformed (Alzayyat. 1998. P. 370). Working memory is composed of three components, an attentional control system – the central executive – together with two subsidiary storage systems, the phonological loop and the visuospatial sketchpad (Baddeley. 2007. P. 7; Goldstein, 2011. P. 131-132). Creative Thinking means child producing largest possible number of diverse and original ideas towards the position or a specific problem (Galal. 2003. P. 225). **Creative Thinking Indicators** are the behavioral patterns that are issued from the child in terms of initiative for producing new ideas, behaviors and skills, creative learning, creative motivation, and creative leadership. **Initiative** means a child producing a large number of appropriate and extraordinary ideas, behaviors and skills efficiency, and also include the reformulation of the problem, and make it more applicable (Vandeleur, Ankiewicz, Swardt, & Gross, 2001. P. 269). **Creative Learning** means unfamiliar learning, in which the child engages in the experimentation and intelligent challenging tasks. It is characterized by relevance, control, ownership and innovation (Jeffrey, & Woods. 2009. P.13). **Creative Motivation** means Internal energy that motivate the child to perform actively and with pleasure. **Creative Leadership** means Children's guide for working actively with enthusiasm, harmony, and cooperation and creating favorable conditions for generation of creative ideas, behaviors and skills.

Mechanism of working memory:

The **phonological loop** consists of two components: the phonological store, which has a limited capacity and holds information for only a few seconds; and the articulatory rehearsal process, which is responsible for rehearsal that can keep items in

Abstract:

This study investigated the relationships between working memory components and creative thinking indicators. Working memory was tested by using The Automated Working Memory Assessment Battery for Preschool Children and creative thinking indicators were tested by using The Behavioral Indicators Inventory of Creative Thinking for Preschool Children. The researchers prepared all tools. 54 Egyptian children 4-6 years participated. Results show that all working memory components correlate with all creative thinking indicators and it was found that phonological loop positively affected central executive and creative leadership. Visuospatial sketchpad positively affected central executive. Central executive positively affected initiative, creative learning, creative motivation, and creative leadership dimensions. Initiative positively affected creative learning. Creative learning positively affected creative motivation.

الملخص:

بحثت هذه الدراسة العلاقة بين مكونات الذاكرة العاملة ومؤشرات التفكير الابتكاري لدى أطفال ما قبل المدرسة، وتم قياس الذاكرة العاملة باستخدام بطارية قياس الذاكرة العاملة لأطفال المدى العمري (٤-٦) سنوات، وتم قياس مؤشرات التفكير الابتكاري باستخدام قائمة المؤشرات السلوكية للتفكير الابتكاري لأطفال ما قبل المدرسة، وقام الباحثون بإعداد الأداتين، تكونت عينة الدراسة من ٥٤ طفلا وطفلة تراوحت أعمارهم الزمنية ٤-٦ سنوات، وتوصلت النتائج إلى أن جميع مكونات الذاكرة العاملة ترتبط بمؤشرات التفكير الابتكاري، ويوجد تأثير موجب ودال للمكون اللفظي الصوتي على المنفذ المركزي وعلى القيادة الابتكارية، ويوجد تأثير موجب ودال للمكون البصري المكاني على المنفذ المركزي، ويوجد تأثير موجب ودال للمنفذ المركزي على المبادأة والتعلم الابتكاري والدافعية الابتكارية والقيادة الابتكارية، ويوجد تأثير موجب ودال للمبادأة على التعلم الابتكاري، وتأثير موجب ودال للتعلم الابتكاري على الدافعية الابتكارية.

Modeling the Causal Relationships Between Working Memory Components and Four Indicators of Creative Thinking

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