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Mental synthesis and creative thinking in typically developed Italian

Elisabetta Sagone[a *], University of Catania , Catania, Italy https://orcid.org/0000-0001-5283-4603
Maria Elvira De Caroli [b], University of Catania , Catania, Italy https://orcid.org/0000-0003-4227-5689
Rossella Falanga[C], University of Catania , Catania, Italy https://orcid.org/0000-0001-6928-0811
Maria Luisa Indiana[d], University of Catania , Catania, Italy

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Abstract

The study concerns the relationships between mental synthesis and creative thinking in typically developed Italian children. Creative Mental Synthesis task was applied to analyze the mental synthesis of visualized forms (Finke, Ward, & Smith, 1992) by means of rotation, dimension, superimposition, and inclusion. It consisted of a paper-pencil protocol with three stimuli, a capital letter V, a square, and a circle: each child was instructed to imagine combining the stimuli to make meaningful objects and was allowed to imagine the stimuli in any size and to combine them in anyway, without altering or modifying the structural shapes. Test of Creative Thinking (Williams, 1994) was used to measure fluency, flexibility, elaboration, originality, and verbal production; it was made up of a protocol with 12 frames, containing incomplete graphic stimuli shown to children who were asked to draw a picture. Results: the more the children were able in mental synthesis and, mainly, in inclusion and superimposition of visual forms, the more they better performed in elaboration, flexibility, and originality. Future research could deepen the role of mental imagery in development of creativity through curricula focused on strategies for strengthening the processes related to mental imagery.

Keywords: Mental imagery; creative thinking; typical development;

* ADDRESS FOR CORRESPONDENCE: Elisabetta Sagonea, Marmara University, Eğitim, Fahrettin Kerim Gökay Cd., 34722 Kadıköy, İstanbul,
E-mail address: esagone@unict.it

1. Introduction

The relationships between mental imagery and creative thinking in developmental age have been studied both in typically and in atypically developed individuals (De Caroli & Sagone, 2010a, 2010b; Antonietti & Colombo, 2011; Pizzingrilli, Valenti, Cerioli, & Antonietti, 2015). From the analysis of the main perspectives on definition and functioning of mental imagery and its components connected to creative processes (such as visual images and mental synthesis), this paper will proceed dealing with the description of creative thinking and its factors useful to assess the ability to adapt oneself to a change, to produce a variety of ideas concerning possible solutions to problems, and to shift the function of familiar objects (see Torrance, 1989; De Caroli, 2009). These aspects will be taken into consideration as theoretical background for the current study in which typically developed children aged between 6 and 12 yrs will be involved (Evram, 2018).

Most of psychologists conceptualized "mental imagery" as engaging many of the processes used in perception; however, imagery is thought to activate these processes through top-down pathways. According to the Model of Imagery and Visual Processing, Kosslyn (1994) adopted this suggestion, with imagery and perception both activating a visual buffer from either sensory system (that is, perception) or associative memory (that is, imagery). Because imagery engages many of the same psychological processes as perception, the two functions are intimately related. So, imagery is considered useful to provide visual and/or spatial information suitable for higher-level cognitive processing. This model of imagery proposed a prestigious work of organizing and explaining how a previous visual experience with objects can be drawn from memory as an image and subsequently transformed, rotated, folded, scanned, enlarged, or inspected (Shepard & Metzler, 1971; Finke, Pinker, & Farah, 1989) in order to enable performance on a task at hand. These mental operations are likely to understand how people are able to imagine previously unexperienced viewing perspectives. However, considerably less research has examined the spontaneous use of imagery as a "creative exploration" in developmental age. As Kosslyn and colleagues reported (1990), examining age differences in four aspects of visual mental imagery (namely, image generation, maintenance, scanning, and rotation), one or more distinct processes are used to carry out each aspect of imagery and this is true for 5-year-olds, 8-year-olds, 14-year-olds, and adults; there was no evidence that young children have fewer processing components, which become differentiated into more specialized subsystems over age. In addition, young children are relatively poor at scanning, rotating, and generating objects in images, but are relatively good at maintaining images (Chandler, 2019).

Specifically, mental imagery included various components as mental rotation and transformation, scanning, extrapolation, visual images, and mental synthesis. This last element is referred to "a process by which an individual mentally manipulates and transforms visual mental images in order to produce new configurations or to discover novel emergent properties" (Pearson & Logie, 2004, 183) and, more recently, it has been considered as an voluntary process of synthesizing a never-before-seen image from several images generated from memory. Mental synthesis has been included in the Geneplore Model elaborated by Finke and his colleagues in terms of the combination between 'generation' and 'exploration' process. In the initial generative phase of the creative process, Finke et al. (1989) reported that individuals construct mental representations having various emergent properties. These are used to promote creative discovery in the following exploratory phase, in which individuals interpret the initial mental representations in meaningful ways. If exploration produced a satisfactory solution, the initial structures may lead directly to a creative product; on the contrary, the initial mental representation will be modified through the generative process and checked during the exploration phase. The authors identified some properties of the initial structures ("preinventive structures") such as, for example, novelty, ambiguity, implicit meaningfulness, emergence, incongruity, and divergence; some of these properties are useful to recognize the creative products. According this perspective, one can often

discover properties in an image that one was not aware of at the time the image was initially formed: an example of this process is the discovery of emergent features in mentally synthesized forms. The discovery of emergent structures in images was provided by Finke and Slayton (1988) and, subsequently, by Finke (1990). In reference to the experiment carried out by Finke and Slayton, individuals can often take into consideration simple patterns such as letters, numbers, and geometric forms, and imagine combining them in novel ways, and then discover creative patterns and symbols that result from their combination. For instance, individuals might be given a circle, a triangle, and the letter P and asked to imagine combining the parts to make a recognizable shape. Most of individuals reported that they performed the task by exploring in their imagination different combinations of the parts and seeing if something interesting emerged (Zirima & Nkoma, 2018).

Using this paradigm, Finke (1989) used a procedure similar to previous ones in order to discover creative inventions through the mental synthesis of visualized forms. In a classical experiment, individuals were given three of object parts, which were randomly selected and designated by name. Individuals were instructed to imagine combining the parts to make an interesting form. They could vary the size, position, and orientation of any part and combine them in any way. In relation to existing restrictions, individuals could not alter the shape of the parts and all three parts had to be used. Individuals were given the name of a general object category, such as furniture, toys and games, scientific instruments, or transportation, and were asked to try to interpret the created forms as representing some kind of practical object belonging to that category. They described their inventions and these were rated for two independent aspects of creative process: originality and practicality.

The relationship between imagery and creativity has been examined in children by Campos and Perez (1989), in high school students by González, Campos, and Pérez (1997), in adults by Finke, Pinker and Farah (1989) and in college students by Palmiero, Nori, Aloisi, Ferrara, and Piccardi (2015). In detail, González et al. (1997) studied the relationship between imagery (through Spatial Test of Primary Mental Ability and Test of Visual Imagery Control) and creative thinking, confirming that imaging ability had significant effects on fluency, originality, elaboration, and resistance to premature closure. In addition, Finke and Slayton (1988), using the Creative Mental Synthesis task (CMS), and Finke, Pinker and Farah (1989) with the Directed Mental Synthesis task (DMS) verified the linkage between mental synthesis and creative processes. Lastly, Palmiero and his colleagues (2015) found that all measures of creativity (measured with Creative Synthesis Task and Drawing Ability Test) positively correlated with the image transformation imagery ability; practicality of inventions negatively correlated with vividness of imagery (analyzed with the Vividness of Visual Imagery Questionnaire); originality of inventions positively correlated with the visualization cognitive style (valued by the Verbalizer–Visualizer Questionnaire); in detail, this last study confirmed the predictive role of the transformation imagery ability for the originality of inventions and for the graphic ability and esthetic of artistic drawings; the role of visualization cognitive style for the originality of inventions, and that of the vividness of imagery for the practicality of inventions.

Little evidences and updated of these relations were found in children: for example, Campos and Pérez (1989) found differences between high and low imagers in creativity (measured with Torrance Test of Creative Thinking) in a sample of children between 12 and 15 yrs. In addition, LeBoutillier and Marks (2003) observed significant correlations between divergent thinking and vividness of imagery compared to those with transformative ability. More recently, results obtained by Dziedziewicz and colleagues (2013, 2014) showed that creative imagination is more strongly related to originality than to fluency of thinking. According to theoretical model recently proposed by Jankowska and Karwowski (2015) about creative visual imagination, in which creativity and mental imagery are intersected using the application of Test of Creative Imagery Abilities (TCIA), creative imagination is constituted by three interrelated components: 1) vividness (the ability to create images characterized by a high level of complexity and

detail), 2) originality (the ability to produce unique imagery characterized by novelty), and 3) transformative ability (the ability to control and modify imagery). The authors found significant correlations between the three components of imagery and creative thinking in a sample of children aged 5–7 years, using the TCIA-version A and the Test of Creative Thinking-Drawing Production (TCT-DP) (Jellen & Urban, 1986; Urban, 2004). As proposed in TCT-DP by Urban's procedure (2004), children were asked to complete an unfinished drawing consisting of a few shapes that include a half-circle and a dot. Each child was given a score of creative abilities based on the following criteria: (1) continuations, (2) completions, (3) new elements, (4) connections made with a line, (5) connections made to produce a theme, (6) boundary breaking (fragment-dependent), (7) boundary breaking (fragment-independent), (8) perspective, (9) humor and affectivity, (10) manipulation of the material, (11) surreal or abstract drawings, (12) atypical combinations of figures and symbols, (13) non-stereotypical use of a certain element, and (14) speed. Results showed that vividness was the most strongly related component to unconventional manipulation, perspective, and boundary breaking (fragment-independent), all elements measured by means of TCT-DP; in addition, originality was weakly related to abstract and surrealistic elements, new elements into the drawing, continuations of the existing elements, and connections that contribute to a theme; finally, transformativeness was strongly related to new elements into the drawing and boundary-breaking (fragment-independent). On the basis of these empirical evidences in developmental age (see Campos & Pérez, 1989; Antonietti & Colombo, 2011), we decided to deepen the connection between mental imagery and creative thinking also in Italian context in order to suggest alternative curricula at school based on the application of conjunctional model of creative imaging ability (as recently proposed by Dziedziewicz & Karwowski, 2015), in which the key-abilities directly linked to development of creative thinking are those of visualizing, transforming, and enriching of mental imagery. We followed the analysis of the cognitive factors included into the model of creative thinking proposed by Williams (1994), that is, fluency, flexibility, originality, and elaboration. Specifically, fluency is related to the generation of a large number of ideas and production of meaningful responses; flexibility is connected to changing ideas passing from one category to a different one; originality is linked to the ability to produce rare and infrequent ideas, and finally, elaboration is the capacity to develop, embellish, and enrich ideas with details.

2. Purpose of study

The main purpose of the present investigation was to explore the relation between mental synthesis and factors of creativity (according to the Williams' perspective) in children with typical development in Italian school context. Differences for sex and age-group were analyzed in relation to both chosen topics.

2.1. Sample

One hundred and twenty-two Italian children with typical development participated in this study (M = 8.7, SD = 1.8; age range: 6 yrs. 2 mo. - 12 yrs. 4 mo.), divided in 57 boy and 65 girls and, for two age-groups, in Gr-I from 6 yrs. 2 mo. to 8 yrs. 10 mo. and Gr-II from 9 yrs. 2 mo. to 12 yrs. 4 mo. Participants were randomly chosen from all classes of two State Primary Schools in Catania, Sicily (Italy), excluding those with intellectual, sensorial, learning disabilities or another types of disability. Written permission from the parents of the children involved in this study was obtained prior to data collection. All relevant details of the study were provided by researchers and parents were asked to give their informed consent in accordance with art.13 of the Italian Legislative Decree 196/2003 for data privacy (Code Regulating Personal Data Protection). Researchers followed the Ethical Code for Italian psychologists (L. 18.02.1989, n. 56) and the Ethical Code for Psychological Research (reviewed in March 27, 2015) by Italian Psychologists Association.

2.2. Measure and procedure

We administered the Italian version of Creative Mental Synthesis task (CMS) in order to analyze the mental synthesis ability and the Test of Creative Thinking (TCT) to study the creative performance of children.

The Creative Mental Synthesis task (CMS) consisted of a paper-pencil protocol with three stimuli, "V" (capital letter V), "□" (square), and "O" (circle). Each child was instructed to imagine combining the stimuli to make meaningful objects and was allowed to imagine the stimuli in any size and to combine them in anyway; subjects should not alter or modify the structural shape of the stimuli. Considering this task (see De Caroli & Sagone, 2010a), four scores for measuring the abilities of mental synthesis were obtained: 1) rotation; 2) dimension; 3) superimposition; 4) inclusion. The "rotation" score was computed by the total number of rotations applied to the stimuli or parts of them. The "dimension" score was computed by the total number of variations (reduction or enlargement) applied to the size of each proposed stimulus. The "superimposition" score was obtained by computing the total number of superimposition of one or two stimuli on the remaining one until to cover a part of the same. Finally, the "inclusion" score was made by calculating the total number of stimuli enclosed into each other.

For the exploration of creative thinking, we used the Italian version of the Test of Creative Thinking (TCT) developed by Williams (1994) and applied in several researches by De Caroli and her colleagues (2010a, 2010b) with typical and atypical developed children in Italian school context. This test was made up of a protocol with 12 frames, containing incomplete graphic stimuli shown to children who were asked to draw a picture. It was used to measure the mean scores of fluency, flexibility, originality, elaboration, and verbal production. The "fluency" score was obtained by the total number of meaningful pictures created by children (range from 1 to 12 points). The "flexibility" score was made by the number of changes of ideas from one category to a different one (range from 1 to 11 points). The "originality" score consisted of the total number of pictures drawn inside or outside each incomplete stimulus placed in the frames (range from 1 to 36 points); in detail, one point was assigned to each picture drawn outside the stimuli, two points to each picture drawn inside the stimuli, and three points to each picture drawn both inside and outside the incomplete stimuli. The "elaboration" score was obtained by the number of asymmetric pictures drawn by children (range from 1 to 36 points): in particular, 0 points were assigned to the symmetrical pictures, one point to the asymmetric pictures drawn outside the incomplete stimuli, two points to the asymmetric pictures inside the incomplete stimuli, and three points to the asymmetric pictures drawn both inside and outside the stimuli. And, finally, the verbal production (in terms of "production of title" associated with each picture) was the sum of points assigned to each title produced by children: in detail, one point was assigned for simple titles, two points for titles with qualifying and descriptive adjectives, and three points for imaginative titles indicating something beyond the picture drawn by participants (range from 1 to 36 points).

Each task was individually administered to children during school time and in a room specifically set aside for the investigation after obtaining parental consent.

2.3. Statistical analyses

Statistical analyses were carried out by using SPSS v20 (Statistical Package for Social Science), with linear correlations (Pearson's r) and t-tests to investigate the differences for sex and age groups in creative performance and mental synthesis abilities. Age groups and sex were considered as independent variables and scores obtained in creative and mental synthesis performance as dependent variables.

3. Results

Significant correlations were found among abilities of mental synthesis (Table 1); so, rotation was positively correlated both with dimension (for $p < .001$) and inclusion (for $p < .001$); dimension was positively correlated with inclusion (for $p < .001$); and, finally, superimposition was positively correlated with inclusion (for $p < .001$). No significant differences for age groups and sex in the abilities of mental synthesis were found, except for superimposition ($t_{(120)} = -3.187$, $p = .002$): so, girls (M = 1.25, SD = .90) were more able in superimposition of visual imagery than boys (M = 0.72, SD = .92).

Table 1. Abilities of mental synthesis: total sample

CMS	Rotation	Dimension	Superimposition	Inclusion
Rotation	1			
Dimension	.475**	1		
Superimposition	.145	.085	1	
Inclusion	.427**	.500**	.416**	1

Significant correlations emerged among factors of creativity (Table 2). Fluency was positively correlated both with flexibility (for $p < .001$) and originality (for $p < .001$); flexibility was positively correlated with originality (for $p < .001$) and (poorly) with verbal production (for $p = .039$); originality was positively correlated both with elaboration (for $p < .001$) and verbal production (for $p < .001$). As in Table 2, all factors were positively correlated with total scores in creative thinking (all for $p < .001$). Differences for age groups in the factors of creative thinking were found only for fluency ($t_{(120)} = 2.521$, $p = .013$): so, younger children (M = 11.31, SD = 1.03) were more fluent in production of creative ideas than the older ones (M = 10.75, SD = 1.38). Relevant differences for sex in the factors of creative thinking were observed: so, girls scored higher than boys in originality (boys: M = 21.65, SD = 4.15; girls: M = 24.00, SD = 3.94; t= -3.205, $p = .002$), elaboration (boys: M = 7.19, SD = 2.99; girls: M = 8.95, SD = 3.60; t= -2.913, $p = .004$), and total creativity (boys: M = 64.68, SD = 9.96; girls: M = 70.25, SD = 9.73; t= -3.116, $p = .002$).

Table 2. Factors of creative thinking: total sample

TCT	Fluency	Flexibility	Originality	Elaboration	Verbal production
Fluency	1				
Flexibility	.498**	1			
Originality	.376**	.355**	1		
Elaboration	.011	.157	.399**	1	
Verbal production	.039	.187*	.458**	.042	1
Total scores	.375**	.500**	.864**	.546**	.711**

Lastly, significant correlations between abilities of mental synthesis and factors of creativity were observed (Table 3). Rotation was positively correlated with flexibility (for $p = .001$); superimposition was positively correlated with originality and strongly with elaboration (all for $p < .001$); inclusion was positively correlated with fluency, flexibility, originality, and strongly with elaboration (all for $p < .001$); finally, dimension was weakly correlated with fluency (for $p = .040$). The abilities of superimposition and

inclusion were correlated with total scores of creative thinking (both for $p < .001$). About the significant relationship between mental synthesis and creativity, the more the typically developed children were able in the ability to mentally modify and transform the offered stimuli, the more they are proficient in the ability to produce uncommon, original, and rare ideas.

Table 3. Linear correlations between CMS and TCT: total sample

	Rotation	Dimension	Superimposition	Inclusion
Fluency	.128	.186*	.021	.287**
Flexibility	.296**	.060	.137	.353**
Originality	.129	.084	.350**	.352**
Elaboration	.105	.014	.754**	.526**
Verbal production	.035	.067	.031	.033
Total scores	.166	.039	.436**	.426**

4. Conclusion

The present study analyzed the relationships existing between dimensions of mental synthesis as characteristics of mental imagery and factors of creativity in children with typical development in Italian school context and it discovered that abilities of superimposition and inclusion in mental synthesis were correlated with almost all the factors of creative thinking; these findings indicated that the more the children were able to mentally operate, the more they creatively performed and vice versa. Age and sex differences were noted: so, younger children were more fluent in production of creative ideas than the older ones, girls were more able than boys in superimposition of visual imagery, in the ability to produce rare and infrequent ideas, and in the ability to develop, embellish, and enrich ideas with details. Some of these evidences were in line with those reported by Karwowski and Soszyński (2008) and Lau & Cheung (2010). In detail, Lau and Cheung (2010) found sex differences, with rapid growth among boys in grades 4 and 5, a slump in the next three grades, and then a jump again in grade 9; additionally, girls also had clear growth in divergent thinking in grades 4 and 5 and then a slump but they had no resurgence at grade 9.

The findings of this study suggested the necessity to realize future projects for deepening of the role of mental synthesis in development of creativity also through curricula specialized on strategies for strengthening the processes related to mental imagery and problem solving. As suggested by Antonietti and Martini (2000), as well as by Antonietti and Colombo (2011), the use of mental synthesis (that is, the operation of combination of images requiring a child to mentally combine simple shapes) is defined as an efficient strategy for enhancing creative thinking in developmental age. More recently, these authors created the WCR Test to assess the Widening (W), the Connecting (C), and the Reorganizing (R) abilities in children and adolescents (see Pizzingrilli et al., 2015): it consisted of multiple-choice tasks as, for example, “list all possible uses of a book” (W), “quote all things that you think are related to mobile” (C), and “what would happen if colors did not exist anymore?” (R). As reported by the authors (Pizzingrilli et al., 2015, 585), this test can be used to investigate the mental ability “to have an open mind, generating a wide number of different ideas”, “to create unusual combinations between different and known ideas”, and “to catch and restructure new properties of a given situation with the idea to assume a different perspective”.

Generally, the main tools used at kindergarten and elementary schools are based on manual-practical educational activities (e.g., jigsaw puzzle, building blocks, marionettes) with a reduced application of mentally operations of increasing difficulty. The idea of using abstract tools (as geometrical shapes o unstructured forms) with specific instructions based on the application of mental imageries could improve the divergent abilities of children in precocious phases of mental development.

Future research could investigate the role of mental imagery on ability of problem solving and divergent thinking in other typologies of children with special needs (see De Caroli & Sagone, 2010a, 2010b) or with Down's syndrome to understand the makings of these children.

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