Mental Synthesis and Creative Thinking in Learning Disabled Children

M.E. De Caroli, E. Sagone

Abstract — The aim of this study was focused on the relationship between mental synthesis and creative thinking in learning disabled children. Creative Mental Synthesis task (CMS) was used to analyze the mental synthesis of visualized forms and Test of Creative Thinking (TCT) to explore fluency, flexibility, elaboration, and originality. Results showed that the more learned disabled children were able in mental synthesis and, specifically, in dimension, superimposition, and inclusion, the more they better performed in originality than control group. Future research could deepen the role of mental imagery in development of creativity through school programs specialized on strategies for strengthening the processes related to mental imagery.

Index Terms — Creative thinking, learning disability, mental synthesis, children.

1 Introduction

The studies focused on the relationships between mental imagery (in particular, mental synthesis) and creativity in developmental age reported little evidence of the functioning of these two processes in disabled children. For this reason 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 learning disabled children compared to children with typical development in Italian school context.

After the illustration of the principal theoretical perspectives on definition and nature of mental imagery and its components linked to creative processes (such as visual images and mental synthesis), this paper will provide the description of creative thinking and its factors useful to assess the capacity of adapting oneself to a change, of producing a variety of ideas concerning possible solutions to problems, of shifting the function of familiar objects, and so on. These processes will be considered the theoretical background for the current investigation in which typically developed and learning disabled children will be involved. The Creative Mental Synthesis task and the Test of Creative Thinking will be used. The comparisons between performance of typically developed children and those of learning disabled children will be analyzed.

2 Mental synthesis as creative process of thinking

Mental imagery is a very important process studied in developmental and cognitive psychology [1], [2], [3], [4], [5].

According to the classic definition proposed by Richardson, "mental imagery refers to all those quasi-sensory and quasi-perceptual experiences of which we are self-consciously aware and which exist for us in the absence of those stimulus conditions that are known to produce their genuine sensory or perceptual counterparts, and which may be expected to have different consequences from their sensory or perceptual counterparts" [2: 2-3].

Finke described the mental imagery as "the mental invention or recreation of an experience that in at least some respects resembles the experience of actually perceiving an object or an event, either in conjunction with, or in absence of, direct sensory stimulation" [5: 2].

In addition to understanding the significance of mental imagery, it has been also necessary to know the "emergence" of this process according to the developmental perspective, as reported by Piaget and Inhelder [3]. The authors described the two main periods of images development: "the images of the first period (before 7 to 8 years) remain essentially static and consequently unable to represent even the results of movements or transformations and a fortiori unable to anticipate processes not yet known […] about 7 to 8 years a capacity for imaginative anticipation makes its first appearance, enabling the subject to reconstitute kinetic or transformation processes" [3: 358]. With reference to this developmental trend, Kosslyn and colleagues [4] compared the performance of 5-, 8- and 14-year-old children, and adults involved in four imagery tasks (image generation, image maintenance, image scanning, and image rotation); results demonstrated a different developmental trend of imagery maintenance

only compared with the other processes: 5-year-old children showed performances similar to those of older children and adults.

Mental imagery included various components or functions as mental rotation and transformation, scanning, extrapolation, visual images, and mental synthesis.

Mental synthesis refers 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" [6: 183] and, more recently, it has been considered as "an active voluntary process of synthesizing a never-before-seen image from several images generated from memory" [7: 23].

According to the creative cognition approach [8], [9], mental synthesis has been considered part of creative process of thinking, the "generative process of cognitive structures", which included memory retrieval and visualization [10], [11], [12], association [13], mental and physical transformation or rotation [14], [15], [5], [16], analogical transfer [17], and categorization [9], [18].

Together with the "exploration process", which has been referred to other cognitive processes as functional inference, contextual shifting [19], hypothesis testing [20], and searching for limitations [9], mental synthesis has been included in the *Geneplore Model* (the combination between 'generation' and 'exploration' process), elaborated by Finke and his colleagues. In this model authors reported that, in the initial generative phase of the creative process, individuals construct mental representations (the preinventive structures) 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 [9: 17]. If initial exploration produced a satisfactory solution, the preinventive 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 exploratory process.

Finke and his colleagues identified the properties of "preinventive structures" (such as novelty, ambiguity, implicit meaningfulness, emergence, incongruity, and divergence) and some of these properties are useful to recognize creative products and processes: originality (or frequency of response), practicality, sensibility, productivity (or fluency), flexibility, inclusiveness, and insightfulness.

The preinventive structures can be thought in terms of internal precursors to the externalized creative products and are linked to the ability of creative visualization which is different from the arbitrary interpretation of forms in a creative way: in fact, as reported by Finke, "people can mentally synthesize simple visual forms to make unexpected and creative discoveries" [9: 15]. 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 [21], [22]: 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 [8] and, subsequently, by Finke, Pinker, and Farah [23]. In reference to the experiment carried out by Finke and Slayton [8], the authors demonstrated that subjects 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, they might be given a circle, a triangle, and the letter 'P' and asked to imagine combining the parts to make a recognizable shape. The creative discoveries that emerged in these experiments were seldom anticipated by knowledge of the parts. Most subjects reported that they performed the task by exploring in their imagination different combinations of the parts and seeing if something interesting emerged.

Using the paradigm of Finke and Slayton [8], Finke [24] used a procedure similar to previous ones in order to discover creative inventions through the mental synthesis of visualized forms. In a typical experiment, subjects were given three of object parts, which were selected at random and designated by name. The subjects 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. The only restrictions were that they could not alter the shape of the parts and that all three parts had to be used. The subjects 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

- *Maria E. De Caroli is with the Department of Educational Processes, University of Catania, Italy. E-mail: m.decaroli@unict.it*
- *Elisabetta Sagone is with the Department of Educational Processes, University of Catania, Italy. E-mail: esagone@unict.it*

some kind of practical object belonging to that category. They described their inventions and these were rated for two independent aspects: originality and practicality. The objects that scored highly on both of these aspects were classified as 'creative inventions'.

The experimental paradigm of Finke and his colleagues has been recently used also by the following researchers: Durling [25] with designers; Kokotovich and Purcell [26] with design and law students; Heylighen et al. [27] with architecture students.

Little evidence about visualization, mental rotation and, specifically, mental synthesis in children was found [28], [16], [29], [30]. In all these researches, it was possible to notice that boys showed better performance than girls (children aged 7-13 years).

With reference to learning disabled children (LD), literature reported some studies focused on deficit in strategies for information processing: for example, in van Garderen' research [31], subjects with learning disability scored low in visual imagery representation, spatial visualization ability, and mathematical problem solving.

More recently, Schiff and colleagues [32] found that children with verbal (VLD) and non-verbal learning disability (NVLD) typically showed deficits in analogical reasoning (the capacity to perceive similarities in different situations and to transfer such information in other domains), compared to non-LD children.

3 CREATIVITY

Creativity is one of the most salient process to produce novelty, generate new ideas, and realize uniqueness.

The most famous researchers interested in divergent thinking [33], creative performances [20] and both affective and cognitive factors of creativity [34], [35], have investigated the meaning of this process involved in cognition.

Guilford thought that *creativity* was an individual characteristic associated with novel ideas which may emerge in the form of tangible products and within the frame of reference of the thinking person. Torrance believed that it was a process of becoming sensitive to problems, gaps in knowledge, missing elements, and disharmonies. According to Torrance's perspective, *fluency* ("ideational productivity") refers to the ability to produce a variety of ideas concerning possible solutions to problems; *flexibility* is linked to the capacity of adapting oneself to a change, to be free from the 'inertia of thought', and to use a variety of approaches; *originality* is the ability to generate uncommon responses, remote and unconventional associations; *elaboration* is the capacity to redefine and reorganize in new ways what one sees, to shift the function of familiar objects, and to transform something well known into a new context; *resistance to premature closure* refers to the ability to keep an 'open mind' while processing the information and, finally, *abstractness of ideas*, that is, synthesizing processes of thinking.

Scientific literature agreed with the existence of some factors of creative thinking, i.e. fluency, flexibility, and originality, measured by psychometric tasks, for example, the "alternative uses", "similarities", "word association", "brick uses", "product improvement", "production of rhymes", "gestalt completion", "consequences and just suppose test", "invention of stories", "analogies" and so on [36], [37].

3.1. Creative thinking in Williams' model

The framework of the present study for the analysis of creative thinking is represented by the model of Williams [34], [38], based on the three dimensions that integrated the affective aspects of creativity (willingness to take risks, imagination, curiosity, and complexity) with cognitive ones (fluent, flexible, original, and elaborative thinking). Specifically, this model is composed by the interrelationship between one or more strategies used by teachers (Dimension 2), across various subject areas of the curriculum (Dimension 1), in order to elicit a set of four cognitive and four affective children behaviors (Dimension 3).

For Dimension 1, the application of this model was in relation to different school curricula (as, for example, art, social studies, arithmetic) and grade levels (as elementary, high school, and college). With reference to Dimension 2, the teaching strategies employed for implementing creative behaviors in classroom were referred to eighteen styles as analogies, example of change, tolerance for ambiguity, visualization skill, creative listening and writing skill, and so on.

About Dimension 3, a set of four cognitive factors of creative thinking consisted of *fluency*, relating to the generation of a large number of ideas and production of meaningful responses; *flexibility*, connected to changing ideas passing from one category to a different one; *originality*, linked to the capacity to produce rare and infrequent ideas, and finally, *elaboration*, that is the capacity to develop, embellish, and enrich ideas with details. In addition, a set of four affective factors of

creativity included *curiosity* (the willingness), *risk taking* (the courage), *complexity* (the challenge), and *imagination* (the intuition).

On the basis of his model, Williams elaborated the Creative Assessment Packet, including two different tests to measure cognitive (Test of Creative Thinking) and affective factors of creativity (Test of Creative Feeling). This model was created for implementing cognitive-affective behaviors in the classroom [38], [39].

The paradigm of Williams has been used to measure the factors of creativity in Italian children and adolescent [40], and in children with mild mental retardation [41]. In reference to this last study, De Caroli and Sagone [41] found that at the pre-operational and concrete operational cognitive level (measured with cognitive tasks of seriation, numeration, and classification), mentally retarded children have scored lower on flexibility, originality, and elaboration than children with typical development.

3.2 Mental synthesis and factors of creative thinking

The relationship between imagery and creativity has been assessed by several researchers.

Forisha [42] investigated the relationship between vividness and control of imagery and figural and verbal creativity in psychology students. González, Campos, and Pérez [43] studied the relationship between imagery (through Spatial Test of Primary Mental Ability and Test of Visual Imagery Control) and creative thinking (with the Torrance Test of Creative Thinking) in high school students, confirming that imaging ability had significant effects on fluency, originality, elaboration, and resistance to premature closure.

The linkage between mental synthesis and creative processes has been investigated in adults by Finke and Slayton [8], using the Creative Mental Synthesis task (CMS), and by Finke, Pinker and Farah [23] with the Directed Mental Synthesis task (DMS). Little evidences of these relations were found in children as reported in the study carried out by Campos and Pérez [44]: the authors found low correlations between factors of creativity and visual imagery in children.

4 HYPHOTESES

The aim of the present study was to explore the relationship between mental synthesis and creativity in learning disabled children compared to typically developed children in Italian school context and to verify the differences for sex both in mental synthesis and creative performance.

The following hypotheses were tested:

MENTAL SYNTHESIS

Hypothesis H_o. *There were no differences on mental synthesis performance for the two groups of children.*

Hypothesis H_1. *It was predicted that learning disabled children (LD) would score lower on mental synthesis performance than typically developed children (NLD).*

CREATIVE THINKING

Hypothesis H_o. *There were no differences on creative performance for the two groups of children.*

Hypothesis H_2. *It was predicted that learning disabled children (LD) would score lower on creative performance than typically developed children (NLD).*

5 METHODOLOGY

5.1 Participants

One hundred Italian children aged from 6 to 12 (*M*=9,3, *sd*=1,4) participated in this study and were divided into two balanced groups for sex (Table 1): 50 children with learning disability (Gr-LD: 34 boys and 16 girls) and 50 children with typical development as control group (Gr-NLD: 34 boys and 16 girls). Both the groups were randomly chosen from all classes of State Primary Schools in Catania, Sicily (Italy).

TABLE 1
DISTRIBUTION OF SAMPLE:
FREQUENCY FOR GR-LD AND GR-NLD

Type of group	Boys	Girls	Range age	*N*
Gr-LD*	34	16	7 yrs. 3 mo. - 11 yrs. 8 mo.	50
Gr-NLD**	34	16	6 yrs 10 mo. - 12 yrs	50

Note: Gr-NLD (control group); Gr-LD (children with learning disability)
** Mean age Gr-LD: M=9,4, sd=1,3*
*** Mean age Gr-NLD: M=9,2, sd=1,6*

Learning disabled children were recruited from specialized centres to perform rehabilitative activities. They were matched with typically developed subject in relation to age and sex: these variables were used to obtain a group of children with learning disability comparable to those with typical development.

5.2 Materials and procedure

We used the Creative Mental Synthesis task to analyze the mental synthesis ability [8] in the simplified for children version developed by Antonietti [29] and the Test of Creative Thinking of Williams [45] to study the creative performance of children. Each task was individually administered to children during school time and in a room specifically set aside for the investigation.

The Creative Mental Synthesis task 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.

Four scores for measuring the capacity to mental synthesis were obtained: 1) rotation; 2) dimension; 3) superimposition; 4) inclusion. The "rotation" scores were the total number of rotations applied to the stimuli or parts of them. The "dimension" scores were the total number of variations (reduction or enlargement) applied to the size of each stimulus. The "superimposition" scores were 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. The "inclusion" scores were obtained by calculating the total number of stimuli enclosed into each other.

For the exploration of creativity, we used the Italian version of the Test of Creative Thinking developed by Williams. 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, and elaboration.

The "fluency" score was the total number of meaningful pictures created by children (range from 1 to 12 points).

The "flexibility" score was the number of changes of ideas from one category to a different one (range from 1 to 11 points).

The "originality" score was the total number of pictures drawn inside or outside each incomplete stimulus placed in the frames (range from 1 to 36 points); 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 the number of asymmetric pictures drawn by children (range from 1 to 36 points): 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.

4.3 Data analysis

Statistical analyses were carried out by using SPSS Version 15.0 (Statistical Package for Social Science), with multivariate analysis of variance (MANOVA), followed by two-tailed *t* tests, to investigate the differences between LD and NLD both in creative performance and in mental synthesis abilities.

Linear regressions with stepwise method were used to analyze the effect of mental synthesis abilities on creativity.

The type of group and sex were considered as independent variables and scores obtained in creative and mental synthesis performance as dependent variables.

5. RESULTS

5.1 Mental synthesis

In relation to mental synthesis performed by children, *t* tests showed statistically significant differences between Gr-LD and Gr-NLD; children with learning disability scored lower on dimension ($t_{(98)}$=2,51, p=.002) and superimposition ($t_{(98)}$=2,33, p=.022) than children with normal development (Table 2).

TABLE 2
COMPARISON BETWEEN GR-LD AND GR-NLD IN MENTAL SYNTHESIS TASK

Elements	Type of group	Mean	SD
Rotation	Gr-NLD	2,56	1,3
	Gr-LD	2,12	1,3
Dimension	Gr-NLD	2,24	1,4
	Gr-LD	1,76	1,1
Superimposition	Gr-NLD	,60	0,8
	Gr-LD	,28	0,6
Inclusion	Gr-NLD	1,88	1,5
	Gr-LD	1,68	1,3

Note: Gr-NLD (control group); Gr-LD (children with learning disability)

This results could be explained with the typically recognized difficulty in these subjects

related to spatial visualization and mental transformation performance.

No significant differences for sex were found.

5.2 Creative thinking

A 2 (type of group) x 2 (sex of children) x 4 (factors of creativity) multivariate analysis of variance was carried out on the mean scores obtained in creative performances by children (Table 3), revealing significant effects for type of group ($F_{(4,93)}$=4,40, p=.003) and sex separately ($F_{(4,93)}$=4,77, p=.002).

No interaction effects for the two independent variables (F(4,93)=2,13, p=.083).

TABLE 3
CREATIVE THINKING: DIFFERENCES FOR SEX AND TYPE OF GROUP

Factors of creativity	Sex	Type of group	Mean	SD
Fluency	boys	Gr-NLD	11,00	1,3
		Gr-LD	11,12	1,1
	girls	Gr-NLD	12,00	0,0
		Gr-LD	11,88	0,3
Flexibility	boys	Gr-NLD	6,94	2,0
		Gr-LD	8,29	1,6
	girls	Gr-NLD	8,25	1,5
		Gr-LD	8,50	0,7
Originality	boys	Gr-NLD	21,18	4,3
		Gr-LD	23,24	4,6
	girls	Gr-NLD	24,75	2,2
		Gr-LD	25,38	2,8
Elaboration	boys	Gr-NLD	7,41	3,6
		Gr-LD	8,24	3,4
	girls	Gr-NLD	7,38	2,6
		Gr-LD	10,88	3,2

Note: Gr-NLD (control group); Gr-LD (children with learning disability)

Statistically significant differences for type of group were found in flexibility ($F_{(4,93)}$=5,16, p=.025), originality ($F_{(4,93)}$=3,50, p=.05), and elaboration ($F_{(4,93)}$=9,17, p=.003): this result indicated that Gr-LD scored higher on the capacity to shift mental set, to produce novelty, and to enrich ideas than Gr-NLD.

For sex effect (see Table 3), statistically significant differences in fluency ($F_{(4,93)}$=15,9, p<.001), flexibility ($F_{(4,93)}$=4,60, p=.034), and originality ($F_{(4,93)}$=11,35, p=.001) were found: boys scored lower than girls on the capacity to produce a large number of ideas, to pass from mental set to different one, and to embellish ideas.

5.3 Relation between mental synthesis and creative thinking

Significant correlations (Pearson' r) were found between elements of mental synthesis and factors of creativity only in Gr-LD (Table 4). Fluency was positively correlated with dimension and superimposition; flexibility was positively correlated with dimension and inclusion; originality was positively correlated with dimension, superimposition, and inclusion; finally, elaboration was positively correlated with superimposition.

TABLE 4
CORRELATIONS BETWEEN MENTAL SYNTHESIS AND FACTORS OF CREATIVITY: GR-LD

	I	II	III	IV
Fluency	,03	,30*	,31*	,24
Flexibility	,04	,42**	,02	,37**
Originality	,01	,43**	,39**	,41**
Elaboration	-,11	,01	,29*	-,02

Note: I=Rotation; II=Dimension; III=Superimposition; IV=Inclusion.
*** Correlation is significant at the 0.01 level.*
** Correlation is significant at the 0.05 level.*

No significant correlations between elements of mental synthesis and factors of creativity in Gr-NLD were found (Table 5).

TABLE 5
CORRELATIONS BETWEEN MENTAL SYNTHESIS AND FACTORS OF CREATIVITY: GR-NLD

	I	II	III	IV
Fluency	-,24	,03	-,17	,22
Flexibility	-,11	-,01	-,07	,07
Originality	-,05	-,06	-,12	,02
Elaboration	,05	,06	-,15	-,02

Note: I=Rotation; II=Dimension; III=Superimposition; IV=Inclusion.
*** Correlation is significant at the 0.01 level.*
** Correlation is significant at the 0.05 level.*

Statistical analyses carried out with linear regressions partially confirmed the previous results: in fact, only for originality, the more learning disabled children were able in the process of mental synthesis and, specifically, in dimension (β=,429, t=3,29, p=.002), superimposition (β=,391, t=2,946, p=.005), and inclusion (β=,410, t=3,11, p=.003), the more they showed high scores in creative originality.

6 CONCLUSION

The main points of the current paper have regarded the different performance between learning disabled children and typical development ones in mental synthesis and creativity in Italian school context.

As predicted, learning disabled children scored lower on mental synthesis than control group and this result confirmed the evidence emerged in the studies by van Garderen [31] and Schiff [32]. The highlighted differences between Gr-LD and Gr-NLD in the present investigation could be explained through the difficulty to process mental transformation from physical stimuli or objects typically individuated in learning disabled subjects. In fact, as reported by Kolligian and Sternberg [46], learning disabled subjects' inability to (a) selectively encode and combine information, or (b) automatic information processing could be considered an obstacle to adequate application of cognitive strategies.

On the contrary, in relation to creativity, learning disabled children showed better performance on flexibility, originality, and elaboration than typically developed children. It means that they seem to be particularly able in the capacity to shift mental set, to produce novel ideas, and to enrich with details the creative product.

With reference to sex difference, our results expressed a superiority of boys respect to girls in creative performance (but not in mental synthesis), as noted in Kerns and Berenbaum [27], Vederhus and Krekling [16], and Geiser et al. [30].

About the significant relationship between mental synthesis and creativity, the more learning disabled children were able in the capacity to mentally modify and transform the offered stimuli, the more they are proficient in the capacity to produce uncommon, original, and rare ideas.

The present work suggests the necessity to realize future research projects for deepening of the role of mental imagery in development of creativity also through school programs specialized on strategies for strengthening the processes related to mental imagery.

ACKNOWLEDGMENT

The authors wish to thank all children who participated to this investigation. This work was supported by a grant from Department of Educational Processes, University of Catania (Sicily), Italy.

REFERENCES

[1] J.S. Bruner, R.R. Olver, and P.M. Greenfield, *Studies in Cognitive Growth*. New York: Wiley, 1966.
[2] A. Richardson, *Mental Imagery*. New York: Springer, 1969.
[3] J. Piaget and B. Inhelder, *Mental Imagery in the Child*. New York: Routledge & Kegan Paul, 1971.
[4] S.M. Kosslyn, *Image and Mind*. Cambridge, Mass.: Harvard Univ. Press, 1980.
[5] R.A. Finke, *Principles of Mental Imagery*. Cambridge, MA: The MIT Press, 1989.
[6] D.G. Pearson and R.H. Logie, "Effects of Stimulus Modality and Working Memory Load on Mental Synthesis Performance," *Imagination, Cognition and Personality*, vol. 23, no. 2 & 3, pp. 183-191, 2004.
[7] A. Vyshedskiy, *On the Origin of the Human Mind*. Canada: Mobile Reference, 2008.
[8] R. Finke and K. Slayton, "Explorations of Creative Visual Synthesis in Mental Imagery," *Memory and Cognition*, vol. 16, pp. 252-257, 1988.
[9] R.A. Finke, T.B. Ward, and S.M. Smith, *Creative Cognition. Theory, Research, and Application*. Cambridge, MA: The MIT Press, 1992.
[10] S.M. Smith, "Fixation, incubation, and insight in memory and creative thinking," *The Creative Cognition Approach*, S.M. Smith, T.B. Ward, and R.A. Finke, eds., Cambridge, MA: The MIT Press, pp.135-156, 1995.
[11] T.B. Ward, "What's Old about New Ideas?," *The Creative Cognition Approach*, S.M. Smith, T.B. Ward, and R.A. Finke, eds., Cambridge, MA: The MIT Press, pp. 157-178, 1995.
[12] R.J. Sternberg and T.I. Lubart, "An Investment Theory of Creativity and Its Development," *Human Development*, vol. 34, no. 1, pp. 1-31, 1991.
[13] S.A. Mednick, "The Associative Basis of the Creative Process," *Psychological Review*, vol. 69, no. 3, pp. 220-232, 1962.
[14] R.N. Shepard and J. Meltzer, "Mental Rotation of three-dimensional objects," *Science*, vol. 171, pp. 701-703, 1971.
[15] G.S. Marmor, "Mental rotation and number conservation: are they related?," *Developmental Psychology*, vol. 13, no. 8, pp. 320-325, 1977.
[16] L. Vederhus and S. Krekling, "Sex Differences in Visual Spatial Ability in 9-year-old children," *Intelligence*, vol. 23, no. 1, pp. 33-43, 1996.
[17] D.R. Needham and I.M. Begg, "Problem-Oriented Training Promotes Spontaneous Analogical Transfer Memory-Oriented Training Promoted Memory for Training," *Memory and Cognition*, vol. 19, no. 5, pp. 5453-5557, 1991.
[18] E. Rosch, C.B. Mervis, W.D. Gray, D.M. Johnson, and P. Boyes-Braem, "Basic Objects in Natural Categories," *Cognitive Psychology*, vol. 8, no. 3, pp. 382-439, 1976.
[19] L.W. Barsalou, "The Instability of Graded Structure: Implications for the Nature of Concepts," *Concepts and Conceptual Development: Ecological and Intellectual Factors in Categorization*, U. Neisser, ed., Cambridge: Cambridge University Press, pp.101-140, 1987.
[20] E. P. Torrance, *Explorations in Creative Thinking in the Early School Years: VI. Highly Intelligent and Highly Creative Children in a Laboratory School*. Minneapolis: Bureau of Educational Research, Univ. of Minnesota, 1959.
[21] S. Pinker and R.A. Finke, "Emergent Two-Dimensional Patterns in Images Rotated in Depth," *Journal of Experimental Psychology*: *Human Perception and Performance*, vol. 6, pp. 244-264, 1980.
[22] B. Roskos-Ewoldsen, M.J. Intons-Peterson, and R.E. Anderson, *Imagery, Creativity, and Discovery:*

A Cognitive Perspective. Amsterdam: Elsevier, 1993.
[23] R.A. Finke, S. Pinker, and M.J. Farah, "Reinterpreting visual patterns in mental imagery," *Cognitive Science*, vol.13, pp. 51-78, 1989.
[24] R.A. Finke, *Creative Imagery: Discoveries and Inventions in Visualization*. Hillsdale, NJ: Erlbaum, 1990.
[25] D. Durling, "Horse or cart? Designer creativity and personality," *Proc. Fifth European Academy of Design Conf.*, Barcelona, Spain, pp. 1-11, 2003.
[26] V. Kokotovich and T. Purcell, "Mental Synthesis and Creativity in Design: An Experimental Examination," *Design Studies*, vol. 21, no. 5, pp.437-449, 2000.
[27] A. Heylighen, P. Deisz, and I.M. Verstijnen, "Less is more original?," *Design Studies*, vol. 28, no. 5, pp.499-512, 2007.
[28] K.A. Kerns and S.A. Berenbaum, "Sex Differences in Spatial Ability in Children," *Behavior Genetics*, vol. 21, no. 4, pp. 383-396, 1991.
[29] A. Antonietti, "Stimolare la scoperta cognitiva attraverso la visualizzazione mentale," *Mente e Immaginazione*, S. Di Nuovo, ed., Milano: Franco Angeli, pp. 173-195, 1999.
[30] C. Geiser, W. Lehmann, M. Corth, and M. Eid, "Quantitative and Qualitative Change in Children's Mental Rotation Performance," *Learning and Individual Differences*, vol. 18, no. 4, pp. 419-429, 2008.
[31] D. van Garderen, "Spatial Visualization, Visual Imagery, and Mathematical Problem Solving of Students with Varying Abilities," *Journal of Learning Disabilities*, vol. 39, no. 6, pp. 496-506, 2006.
[32] R. Schiff, N. Bauminger, and I. Toledo, "Analogical Problem Solving in Children with Verbal and Nonverbal Learning Disabilities," *Journal of Learning Disabilities*, vol. 42, no. 1, pp. 3-13, 2009.
[33] J.P. Guilford, "Creativity," *American Psychologist,* vol. 5, no. 1, pp. 444-454, 1950.
[34] F.E. Williams, *Seminar on Productive Thinking in Education*. Creativity Project, Macalester College, Saint Paul, Minnesota, 1966.
[35] F.E. Williams, "The Cognitive-Affective Interaction Model for Enriching Gifted Programs," *Systems and Models for Developing Programs for the Gifted and Talented*, J.S. Renzulli, ed., Highett, Vic.: Hawker Brownlow, pp. 461-484, 1993.
[36] J.P. Guilford, *Creativity, Intelligence, and Their Educational Implications*. San Diego, CA: EDITS/Knapp, 1968.
[37] E.P. Torrance, *Torrance Tests of Creative Thinking: Directions Guide and Scoring Manual*. Massachusetts: Personal Press, 1974.
[38] F.E. Williams, *Classroom Ideas for Encouraging Thinking and Feeling*. Buffalo, NY: D.O.K. Publisher, 1970.
[39] F.E. Williams, *A Total Creativity Program for Individualizing and Humanizing the Learning Process: Identifying and Measuring Creative Potential*. Englewood Cliffs, NJ: Educational Technology, vol. 1, 1972.
[40] M.E. De Caroli, *Pensare, essere, fare creativamente*. Milan, Italy: FrancoAngeli, 2009.
[41] M.E. De Caroli and E. Sagone, "A Study on Creative Performance in Italian Children with Learning Disability," *INFAD – Revista de Psicología*, vol. 3, no. 1, pp. 855-862, 2010.
[42] B.L. Forisha, "Mental Imagery and Creativity: Review and Speculations," *Journal of Mental Imagery*, vol. 2, no. 1, pp. 209-238, 1978.
[43] M.A. González, A. Campos, and M.J. Pérez, "Mental Imagery and Creative Thinking," *The Journal of Psychology*: *Interdisciplinary and Applied*, vol. 131, no. 4, pp. 357-364, 1997.
[44] A. Campos and M.J. Pérez, "High and Low Imagers and Their Scores on Creativity," *Perceptual and Motor Skills*, vol. 68, pp. 403-406, 1989.
[45] F.E. Williams (ed. it.), *Test della creatività e del pensiero divergente*. Trento: Centro Studi Erickson, 1994.
[46] J. Kolligian and R.J. Sternberg, "Intelligence, Information Processing, and Specific Learning Disabilities," *Journal of Learning Disability*, vol. 20, no. 1, pp. 8-17, 1987.

Maria E. De Caroli is Full Professor of Developmental and Educational Psychology at the University of Catania, Sicily (Italy). From 2003 to 2010 she directed the Specialization Course for Teachers serving with Special Needs Students at the University of Catania. Her current research interests include the study of creative thinking in children with typical and atypical development, the analysis of creative personality in adolescence, the investigation on prejudicial attitudes of teachers and peers towards disabled students, and gender stereotypes. She has published over 60 papers in national and international books and scientific journals as Psychological Reports, INFAD-Revista de Psicologia, and so on.

Elisabetta Sagone is Ph.D in Developmental and Educational Psychology at Department of Educational Processes and she works in the Faculty of Educational Sciences of the University of Catania, Sicily (Italy). Her research interests regard the investigation of creativity in children and adolescents, the analysis of bullying in school context and social attitudes towards ethnic in-group and out-group, and the exploration of gender stereotypes in developmental age. She is author of over 30 papers published in scientific journals (Psychological Reports, INFAD-Revista de Psicologia) and national and international books.