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Mental attention in gifted and nongifted children

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*The relationship between the construct of mental attention and "giftedness" is not well established. Gifted individuals could make effective use of their executive functions and this could be related to their mental attentional capacity. The dialectic constructivist model developed by Pascual-Leone introduced the concept of mental attention or "effort", relating it to mental capacity. The aim of this study is to investigate whether the measurement of mental capacity (M-measurement) is differential for a group of children with high IQs. 110 students between 4 and 18 years old participated in this study. Some were Gifted (*n=*70) and others Non-Gifted (*n=*40). Wechsler-R Scale and the Figural Intersection Test were administered to all participants. An interesting pattern was found in the younger groups. The gifted scored higher than the non-gifted in the Figural Intersection Test and much higher than their theoretical M. The non-gifted scored quite close to their theoretical M (based on age). In the oldest group, the gifted again achieved higher scores, but now they scored at the theoretical level, and the non-gifted underperformed.*

Introduction

The dialectic constructivist model progressively developed by Pascual-Leone (1970, 1984), Pascual-Leone, Baillargeon, Lee, and Ho (1994), and Greenberg and Pascual-Leone (2001) introduced the concept of mental attention (*M*) or "effort", relating it to that of working memory,

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in the sense of mental capacity. This concept, historically seen to some extent in Spearman's (1927) pioneering research work, was of no significance to psychologists until it was reintroduced as the construct "*M*-operator" (Pascual-Leone & Baillargeon, 1994). These authors, following an exhaustive review of the detail behind the construct and its historical criticisms, presented a procedure to measure mental attention involving tasks requiring mental effort.

Pascual-Leone (1987) has proposed a model of mental attention that includes both activation and inhibition processes. "The activation component (called *M* capacity) is seen as a limited capacity to boost activation of schemes relevant for task performance. *M* capacity is measured in terms of the maximal number of mental schemes – not directly activated by the input – that a person can actively keep in mind (i.e., within mental attention) at any one time (Pascual-Leone, 1970). *M* capacity is related to the notion of working memory but is not the same as working memory. We can define working memory as all the schemes in a person's repertoire that momentarily are sufficiently activated to affect the ongoing mental processing. *M* capacity would be one source of activation for these schemes, but because additional sources of activation exist (e.g., affect, over learning, field factors), the size of working memory is likely to be greater than *M* capacity" (Johnson, Im-Bolter, & Pascual-Leone, 2003, p. 1594). Pascual-Leone proposed that the activation power of *M* increases with maturation during normal development in childhood. When measured behaviourally, this capacity grows by one mental unit every 2 years, from a capacity of one at 3 to 4 years of age to a capacity of seven at 15 to 16 years and older (Johnson, Fabian, & Pascual-Leone, 1989; Pascual-Leone, 1987).

The measurement of mental attention is undertaken by Pascual-Leone and Baillargeon (1994) through the use of the Figural Intersection Test (FIT) within a framework of developmental theory. This maintains that an organism possesses some dialectically organized functions and some operators that modulate the mental system (Pascual-Leone, 1990). The organism therefore consists of different modular memories, aimed at generating mental attention. Pascual-Leone (1990) considers that mental capacity should be a biologically developed issue in children. However some evidence is necessary in order to establish this statement and this is the rationale for this study.

The relationship between the construct of mental attention and giftedness is not well established. If it is true that people of high intellectual abilities make effective use of their executive functions (Jausovec, 2000; Ritchhart, 2001), this could be dynamically related to their mental attentional capacity. Prior research by Pascual-Leone and Johnson (1998) and Pascual-Leone, Johnson, Baskind, Dowrsky, and Serverston (2000), predicted that gifted children would score higher than nongifted children on the *M* measures.

The aim of this study is to investigate whether the measurement of mental capacity (*M*-measurement) is different for a group of gifted children. The rationale for this study is that if *M* increase with maturation during normal development in childhood, differences between gifted and non gifted children could not be expected. However, if it is function of their cognitive processes different scores between gifted and non gifted children should be found. The *M*-measurement was undertaken using the revised version of the Figural Intersection Test (FIT) (Johnson, 1982; Pascual-Leone et al., 1994), and psychometric intelligence was measured using the Revised Wechsler Intelligence Scale (Wechsler, 1981). The reason for choosing a sample of gifted children is to understand the structural relationship between the cognitive functions involved in undertaking the Wechsler test (Watkins, Greenawalt, & Marcell, 2002) and the cognitive resources required by the Figural Intersection Test (FIT). This is considered within a framework of the development of operational functioning in gifted children (Planche & Gicquel, 2000).

Method

Participants

A total of 110 middle-class children aged between 4 and 18 from Cadiz (Spain) schools district participated in this study. The mean age of the participants was 10.3 (*sd.*=3.55); 84

(76.4%) were male and 26 female (23.6%). There were proportionally more boys than girls in both samples. This generally reflected the proportions in the classrooms. They were divided into two groups: Gifted Children (*n*=70) and Non-Gifted (*n*=40). All the participants assigned to the Gifted Children's group were required to have an IQ total on the Wechsler-R scale of 124 or more (range of Gifted Children 124 to 149; *Mean*=135; *sd*=5.74). The Non-Gifted group were students with normal intelligence with an IQ of less than 124 (Mean IQ of the Non-gifted group=108.6; *sd*=7.06; IQ range of 97 to 122). They attended school, came from middle-class family backgrounds and were socially adapted. Given that the age of participants is of interest in this type of study, the following frequencies of age were available: 20 (16 male and 4 female) 4 to 8 years old gifted students group; 20 (15 male and 5 female) 4 to 8 years old non-gifted students group; 25 (20 male and 5 female) 9 to 12 years old gifted students group; 10 (7 males and 3 female) 9 to 12 years old non-gifted students; 25 (19 male and 6 female) 13 to 18 years old gifted students group; and 10 (7 male and 3 female) 13 to 18 years old non-gifted. Informed consent was obtained from the parents of the participants.

Material (Testing material)

The Wechsler Intelligence Scale (1981) (version revised and standardized for the Spanish population) and the Pascual-Leone and Baillergeon (1994) version of the Figural Intersection Test (FIT) were used.

The Figural Intersection Test is a paper-and-pencil-test that consists of 37 items, following several introductory practice items. Each item presents two sets of geometric shapes. On the right-hand side of the page there are a number of separate geometric shapes which are the task's relevant shapes. The number of discrete shapes on the right indicated the class of an item (e.g., four shapes indicated a Class 4 item, two shapes indicated a Class 2 item, etc.; Figure 1 illustrates a Classes 3 and 5 items).

The number of these shapes varies randomly between 2 and 8, and this number defines the equivalence class of each item. On the left-hand side of each sheet there is a figural compound with all the geometric components overlapping to form a common total intersection. In some items this figural compound may contain an irrelevant shape that is not found on the right-hand side of the page. This is intended to be a distractor that should be ignored by the participant. Each item has two sub-tasks: (1) to put a dot in each of the shapes on the right-hand side of the page to ensure the adequate exploration of all the relevant shapes and (2), on the left-hand side of the page, to put a single dot inside the intersection of all the relevant shapes. FIT has a total of 8 classes of items: Inside plus same shape; same proportions; different size; intersection plus rotation; multiple dots; irrelevant figures (a); three figures; and, irrelevant figures (b). The level of difficulty of the items is due to three factors: firstly, the level of M required by each item (for example, the number of relevant shapes that must be remembered); secondly, the dynamic Gestaltist patterning created by the geometric composition and thirdly, the number and complexity of the strategies elicited by the context of each item. FIT is a well-studied measure of M capacity (Baillargeon, Pascual-Leone, & Roncadin, 1998; Pascual-Leone & Baillargeon, 1994; Pascual-Leone & Ijaz, 1989; Pascual-Leone & Johnson, 2001). The *M*-capacity tasks were nonspeeded, and instructions for these tasks emphasized accuracy only.

The FIT was administrated following the standardized procedure by authors Pascual-Leone and Johnson (2001). Each item is scored as either correct or incorrect. A total performance (S1T) score is computed summing the number of correct items in classes 3 to 8. Proportion pass scores are computed for each class of item by summing the numbers of items passed in a class and dividing by the total number of item of the class that were presented. When the number of correct FIT responses per participant and their position within the classes of problems included in the test are considered, the final score can be established in terms of probability. The *M* value is obtained from the two indicators (*e*) and (*k*). (*e*) is a constant that represents the child's mental capacity. This capacity serves as a boost that activates the executive processes used as a consequence of the mental effort required by the tasks in the

Figural Intersection Test. (*k*) increases at a rate of one unit per year of development, from age 3 to adolescence (Pascual-Leone & Ijaz, 1989). (*k*) is established by estimation according to the results obtained in the Figural Intersection Test, in a way that its last value corresponds to the stimulus class in which a child has achieved 75% correct responses. (k) allows the theoretical score (S1-theoretical, or S1T) to be identified. This score is based on the well-established assumption that children can only solve those items that are equal to or below their mental capacity. For example, if a child has a mental capacity of 3, he or she could correctly solve all those items in class 2 and 3, but not those of class 4 or above. The score S1T is calculated by first adding up the number of items solved correctly in the classes 2 to 7. Within this system of evaluation, the last value S1T would correspond to the child's mental capacity, in accordance with the score distribution table in the Figural Intersection Test administration manual. Construct validity of FIT as a measure of M power (k) was established by examining the percentage of items of each class with are passed by each of several age groups (% range from .86 to .90). FIT reliability was .90 using Cronbach's α (Pascual-Leone, & Baillergeon, 1994, p. 172; Pascual-Leone & Johnson, 2001).

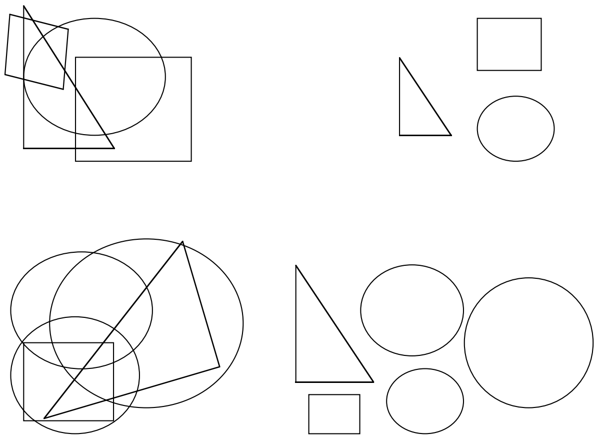

Figure 1. Example of a class 3 and a class 5 item from Figural Intersection Test (FIT)

Procedure

Tests were administered individually to each participant with the relevant prior agreement of both participants and their parents. The Wechsler Scale was administered in two different sessions of 60 minutes, at least 24 hours apart. Two days later, the Figural Intersection Test was administered in individual sessions of 30 minutes. The participants took the test seated at individual desks in a quiet, motivating school context during school hours. They were given a version of the test on paper and given a red pencil, as suggested in the FIT instruction manual. All participants completed all tasks.

Results and discussion

Two different measurements were taken for each participant: their Wechsler Intelligence Scale and Figural Intersection Test scores. The minimum IQ value was 96 and the maximum 149 (*Mean*=125; *sd*=14.4). In the case of correct FIT responses the mean is 23.4 (*sd*=7.9). An unequal number of participants for 9 to 12 and 13 to 18 groups of aged were distributed. However al least 10 participant (25 gifted; 10 non-gifted) were assessed in each group.

In order to achieve a deeper statistic analysis of the results, the full sample was divided into three age-groups: 4-8, 9-12 and 13-18, considering that M should improve according to age. Using these data, a MANOVA was calculated according with the following algorithm: $\gamma=\mu+\alpha+\beta+\varepsilon$, where ($\gamma$)=Theoretical Mental capacity score (M-t) calculated after FIT score; (α)=gifted and non gifted groups; (β)=Aged (4-8, 9-12, 13-18 year-old). M-t is used because correlation SIT and M-t were significant (r=.964; p<0.01). As predicted, gifted children scored higher than nongifted children. Mean scores for the nongifted children were consistent with age-based theoretical predictions (Pascual-Leone, 1970), but gifted children scored at least one *M* level higher than predicted for the total population. A main effect for age group was found (IQ-M-t, F=45.69; p<.0001). Other significant comparision was between Age groups and *M*. Theoretical Mental capacity after SIT scores increase with age (F=75.25; p<.0001) (Table 1). According to Pascual-Leone theory, those data would be coherent because *M* is not a function of IQ but cognitive functioning or developmental maturity (Pascual-Leone & Johnson, 1999).

Table 1

Age-group and gifted, non-gifted groups and (M-t) Theoretical Mental capacity after SIT scores MANOVA

		Age			*Groups*	
		4-8	9-12	13-18	Gifted	Non gifted
M-t	*Mean*	*3.7*	*5.3*	*6.4*	5.7	3.9
	Sd	1.1	0.96	.85	*1.2*	*1.4*
	F	75.25***			45.69***	

	Effect	Multivariate tests: Value	Multivariate tests: *F*	Error df	Sig
Intercept	Pillai's trace	.973	1913.785	106	.000
	Wilks λ	.027	1913.785	106	.000
	Hotelling's trace	36.109	1913.785	106	.000
	Roy's largest root	36.109	1913.785	106	.000
Age	Pillai's trace	.699	122.942	106	.000
	Wilks λ	.301	122.942	106	.000
	Hotelling's trace	2.320	122.942	106	.000
	Roy's largest root	2.320	122.942	106	.000
Gifted/Non-gifted	Pillai's trace	.791	201.111	106	.000
	Wilks λ	.209	201.111	106	.000
	Hotelling's trace	3.795	201.111	106	.000
	Roy's largest root	3.795	201.111	106	.000

Note. ***p<.0001.

In the FIT S1T scores plot (Figure 2), an interesting pattern arises in the younger groups. The gifted score higher than the non-gifted and much higher than their theoretical *M*. The non-gifted, however, score quite close to the theoretical *M* (based on their ages). In the oldest group, the gifted again achieve higher scores than the non-gifted, but now they score at the theoretical level, and the non-gifted underperform. Gifted students always scored higher that expected, independently ages.

There is an interesting comparison between the scores obtained by participants in the Figural Intersection Test (% R) and the percentage of items that they are expected to solve correctly (% E), as a function of age and item class. In this way we are able to estimate if the results obtained by the gifted vary or not from the parameters obtained by participants during the Figural Intersection Test validation processes. Gifted students obtained higher FIT scores per item class than estimated per group of age. However, non gifted students' real scores are closer to the estimated FIT item class scores (Table 2).

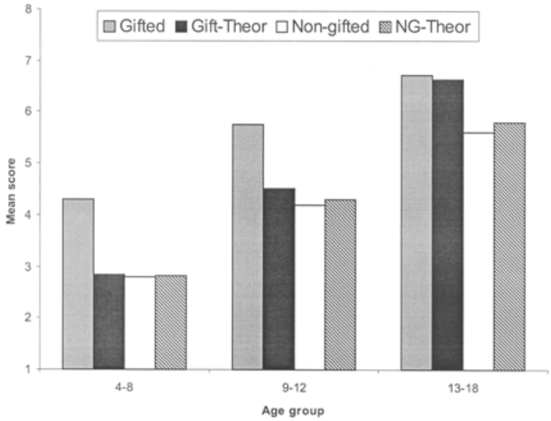

Figure 2. Mean Figure Intersection Test S1T real and theoretical scores for entire sample

Table 2

Real mean percentage (% R) of correct responses obtained by the participants in both groups and estimated percentage (% E) according to chronological age for each of the Figural Intersection Test item classes

		Figural Intersection Test Item Class											
		3		4		5		6		7		8	
		Mean		Mean		Mean		Mean		Mean		Mean	
		% R	% E	% R	% E	% R	% E	% R	% E	% R	% E	% R	% E
Gifted	13-18	100	94	100	83	100	70	80	54	100	43	20	30
	9-12	100	86	100	67	100	61	40	37	20	28	0	11
	4-08	100	78	80	50	80	49	40	23	40	16	0	1
Non-gifted	13-18	100	99	100	100	80	98	100	90	80	84	60	70
	9-12	100	94	80	83	60	70	40	54	40	43	20	30
	4-08	40	78	20	50	0	49	0	23	0	16	0	1

Undertaking an analysis of correlations between the real values established and those estimated, the differences are significant. This suggests certain interdependence between the intelligence scores and the executive functions demonstrated through the use of the Figural Intersection Test. Mental may be more dependent on cognitive functioning than other maturity processes. Gifted children may strategically moderate their speed of response to suit the demands of the task (e.g., Reams Chamrad, & Robinson, 1990; Sternberg & Davidson, 1982), suggesting a superior executive know-how (Johnson, Im-Bolter, & Pascual-Leone, 2003, p. 1609). The research literature suggests that gifted children have superior executive abilities: For example, they quickly develop problem-solving strategies and are flexible in their strategy use (Shore, 2000). Other data suggests that gifted children may more readily apply strategies that can reduce the capacity demand of FIT items (Bauer, 2003, referenced by Johnson, et al., 2003).

Finally, variation indices were established between the Wechsler Scale scores and the value *M* (S1T) of the Figural Intersection Test. These variations, which aimed to establish whether relationships exist between both scores, resulted in a correlation between the intelligence scores and those obtained as value S1T of r=.292 (p<.01; $F(69)$=165.6 (p<.0001) for the Gifted group. However, for the Non-Gifted group the results do not appear to be statistically significant (r=.1; p ns; $F(39)$=.387; p ns). For the most part, young gifted children performed at similar levels to older nongifted children, suggesting that gifted children were developmentally advanced in the processes tested here. This was the case in the *M* measure.

Table 3

Correlations (r) between the results obtained in each class in the Figural Intersection Test and the estimated percentages that would correspond to the students according to their chronological age, both for the Gifted r (g) and Non-Gifted r (ng)

	Estimated % in Class 8	Estimated % in Class 7	Estimated % in Class 6	Estimated % in Class 5	Estimated % in Class 4	Estimated % in Class 3
% in Class 8	*r*(g)=.562* *r*(ng)=.327					
% in Class 7		*r*(g)=.575* *r*(ng)=.48				
% in Class 6			*r*(g)=.717* *r*(ng)=.632*			
% in Class 5				*r*(g)=.576* *r*(ng)=.512		
% in Class 4					*r*(g)=.557* *r*(g)=.647*	
% in Class 3						*r*(g)=.561* *r*(ng)=5.51*

Note. *$p<.01$.

The data suggests that, for most participants, the estimated FIT results (based on their chronological age) were below the data obtained by the study, particularly for those children under 13. The participants with very high IQs achieved results above those estimated. This did not occur with participants with average IQs. Gifted children often outperform their nongifted peers on M-capacity task. This is consistent with findings that gifted children often excel on working memory span (Saccuzzo, Johnson, & Guertin, 1994) and that working memory is highly related to the general factor of intelligence in adults (Kyllonen, 2002). In accordance with neo-Piagetian theory (Pascual-Leone, 1987), in addition to skills and abilities, there are certain *capacities* that are developmentally determined (op. cit., p. 146) and that form part of our general-purpose mental resources. Skills and abilities are very dependent on context and are well measured by IQ tests given that they are part of the notion of a child's learning potential. However, mental capacity can be considered as being context free, reflecting the general resources of the organism (for example, certain characteristics of cerebral architecture) that affect information processing mechanisms and executive planning processes. Perhaps the differences found between the real results obtained by gifted students and their estimated FIT results point towards the idea that mental capacity can be evaluated via a procedure like the Figural Intersection Test that allows participants to use attentional resources to solve the tasks. Mental attentional capacity is applied to relevant schemes and structures that stimulate their use. These schemes can be over-activated thereby reaching conscience level. In other contexts this has been called temporary functional change from long-term memory to working memory (Pascual-Leone, & Johnson, 1999). We agree with Johnson, Im-Bolter, and Pascual-Leone, (2003) statement that gifted children excel at executive control of effortful mental-attentional processes. The current data leave open the question of whether gifted children have greater resources for holding relevant information active. Within a developmental model, the traditional psychometric perspective of intelligence has centred almost exclusively on the nature of skills, focusing on the complete range of knowledge, abilities and/or processing capacities that can be assessed. However, an alternative model to this paradigm is possible (Ritchhart, 2001). Intelligence could be constructed as a collection of cognitive processes that can be organized in certain thought patterns. This concept requires more widespread research in order to evaluate its viability and could be studied more deeply using gifted individuals that demonstrate more effective executive control. Clearly, however, much further work investigating such a view of the relation between Mental attentional capacity provided by gifted children is necessary.

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*La relation entre le concept de l'attention mentale et l'intelligence supérieure n'est pas très bien établi. Les personnes ayant des capacités élevées pourraient faire une utilisation très habile de leurs fonctions exécutives et ceci peut être en rapport avec la capacité d'attention mentale. Ce concept est dénommé: le modèle constructiviste dialectique développé par Pascual-Leone, celui-ci a introduit le concept d'attention mentale rattaché à la capacité mentale. L'objectif de ce travail est d'étudier si la mesure de la capacité mentale (M) est différente pour un groupe de garçons et filles qui présentent une haute ponctuation en intelligence psychométrique. Dans cette étude ont participé 110 élèves de 4 à 18 ans. Certains enfants étaient surdoués (*n*=70) et d'autres non (*n*=40). L'échelle Wechsler-R et il Figural Intersection Test a été administrée à tous les participants. Les résultats trouvés montrent que les participants plus jeunes, ont obtenu de meilleurs résultats avec le FIT. De même, les enfants de capacité élevée ont une ponctuation M supérieure à ce que l'on pourrait espérer pour leur âge.*

Key words: Figural intersection test, Gifted children, M-measurement, Mental attention.

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Current theme of research:

Mathematical development and cognition. Individual differences in arithmetic abilities in children and interventions to help children with mathematical difficulties.

Most relevant publications in the field of Psychology of Education:

Aguilar, M., & Navarro, J.I. (2000). Aplicación de una estrategia de resolución de problemas matemáticos en niños. *Revista de Psicología General y Aplicada*, *53*, 63-83.

Aguilar, M., Navarro, J.I., & Alcalde, C. (2003). El uso de esquemas figurativos para ayudar a resolver problemas aritméticos. *Cultura y Educación*, *15*(4), 385-397.

Aguilar, M., Navarro, J., López, J., & Alcalde, C. (2002). Pensamiento formal y resolución de problemas matemáticos. *Psicothema*, *14*(2), 382-386.

Navarro, J.I., Aguilar, M., Alcalde, C., & Howell, R. (1999). Relationship of arithmetic problem solving and reflective-impulsive cognitive styles in third-grade students. *Psychological Reports*, *85*, 179-186.

Navarro, J.I., Aguilar, M., Alcalde, C., Marchena, E., & Ruiz, G. (2000). Experimental prototype of a computer assisted learning to train the labour abilities of disabled people. *International Journal of Psychology*, *35*(3-4), 378.

Juan Montero. School Counselor, Campo de Gibraltar-2, Algeciras-Cadiz, Spain. E-mail: juan.montero@ono.com

Current theme of research:

Gifted children.

Most relevant publications in the field of Psychology of Education:

Montero, J., Navarro, J.I., & Ramiro, P. (2005). Estilos cognitivos dependencia-independencia de campo, reflexividad-impulsividad y superdotación intelectual. *Faisca* (submitted for revision).

Montero, J., Navarro, J.I., Aguilar, M., & Ramiro, P. (2005). La inteligencia psicométrica y operatoria en alumnos con altas capacidades (Constructivist and IQ approaches in gifted elementary school children). *Revista Mexicana de Psicología* (submitted for revision).

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Current theme of research:

Gifted children and cognition.

Most relevant publications in the field of Psychology of Education:

Aguilar, M., Ramiro, P., & López Pavón, J.M. (2002). Conocimiento numérico en una muestra de niños y niñas de cinco años. In Rafael Gómez-Caminero García (Dir.), *La educación infantil, una apuesta de futuro* (pp. 343-356). Granada: Grupo Editorial Universitario.

Marcilla, A., Alcalde, C., & Ramiro, P. (1993). Organización, recuerdo y olvido. Estrategias de uso de la memoria. In J.I. Navarro (Coord.), *Aprendizaje y memoria humana. Aspectos básicos y evolutivos* (pp. 171-208). Madrid: McGraw-Hill.

Navarro, J.I., & Ramiro, P. (1995). Evaluación de niños superdotados. El cuestionario Renzulli-Smith. In F. Lara (Coord.), *Psicología Evolutiva y de la Educación* (vol. 2, pp. 469-476). Burgos: Universidad de Burgos.

Ramiro, P., Fernández, A.M., & Navarro Guzmán, J.I. (1999). El alumno superdotado. *Revista Latinoamericana de Psicología*, *31*(3), 537-546.

Ramiro, P., Braza, P., & Sánchez, J.L. (1996). Superdotación, autoconcepto y disincronía. In M. Marín (Coord.). *Sociedad y Educación* (pp. 587-592). Sevilla: Editorial Eudema.

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Current theme of research:

School motivation.

Most relevant publications in the field of Psychology of Education:

Acosta, M. (1998). *Motivación escolar.* Huelva: Servicio de publicaciones de la UHU.

Acosta, M. (1999). *Dimensiones psicológicas del aprendizaje*. Huelva: Hergue.

Martín, C., Acosta, M. Aranda, S., Machargo, J., Aguilar, M. Luján, M.J., & Navarro, J.I. (1999). *Psicología de la educación y del desarrollo en la edad escolar.* Valladolid: Eudema.

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Current theme of research:

Gifted children.

Most relevant publications in the field of Psychology of Education:

Aguilar, M., Ramiro, P., & López, J.M. (2002). Conocimiento numérico en una muestra de niños y niñas de cinco años. In Rafael Gómez-Caminero García (Dir.), *La Educación Infantil, una apuesta de futuro* (pp. 343-356). Granada: Grupo Editorial Universitario.

Aguilar, M., Navarro, J., López, J., & Alcalde, C. (2002). Pensamiento formal y resolución de problemas matemáticos. *Psicothema*, *14*(2), 382-386.

López, J.M., Alcalde, C., Navarro, J.I., & Marchena, E. (2004). Descripción de un prototipo informático para la evaluación de conceptos básicos en Educación Infantil. International *Journal of Psychology and Psychological Therapy*, *4*(1), 1-11.