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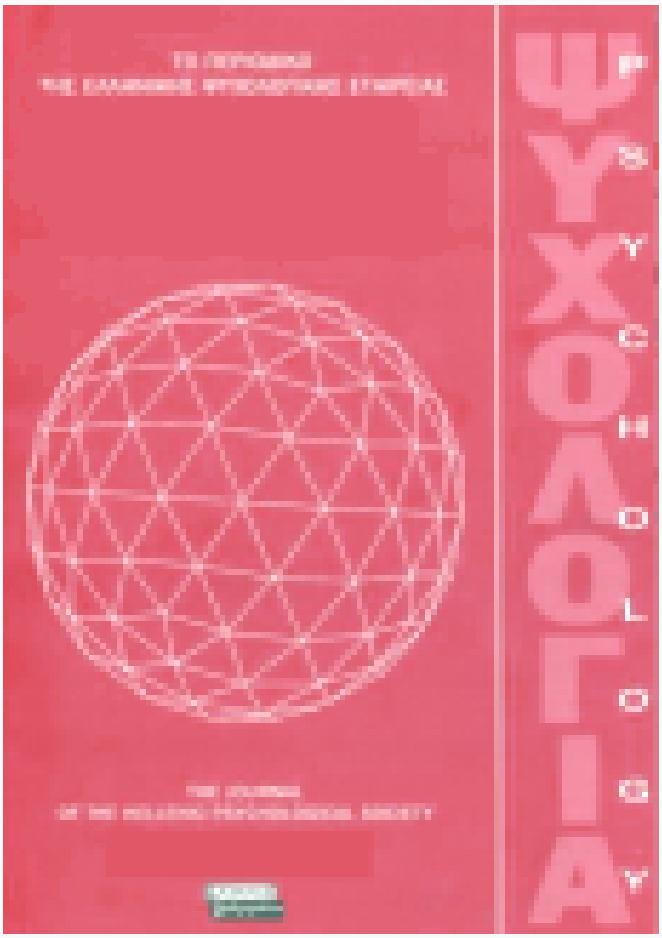

Metacognitive aspects of self, cognitive ability and affect: Their interplay and specificity

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Metacognitive aspects of self, cognitive ability, and affect: Their interplay and specificity

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ABSTRACT This study aimed at studying the relations between metacognitive aspects of the cognitive self pertaining to (a) general modes of information processing, such as semantic and visual memory, (b) specific cognitive domains, such as quantitative (mathematical) and causal reasoning, and (c) task-specific metacognitive experiences, i.e., what the person experiences during actual problem solving. Specifically, our assumption was that all of the above three aspects of metacognition will form a system which is related to, but is independent from cognitive performance, and from affect, such as anxiety and need achievement. Furthermore the three aspects of metacognition will be differentiated between them, because they tap aspects of cognition differing in their scope or generality. A total of 411 participants, aged 12-16 years, were tested in groups with a battery of four cognitive tasks, two quantitative-relational and two causal-experimental. After solving the tasks, the participants were asked to rate on a four-point scale how correct the solution given was and their satisfaction with this solution. They were also asked to respond to a series of inventories tapping metamemory (one's use of semantic and visual memory), metacognitive domain-specific knowledge (*math-self* and *causal-self*), and affect (test anxiety and need achievement motive). Confirmatory Factor Analysis, using the EQS statistical program and the nested factors method, showed that cognition, metacognition and affect form different systems, which retain their autonomy and at the same time communicate and interrelate. Additionally, the results of a series of ANOVAs supported the above findings showing that the cognitive, metacognitive, and affective systems follow different developmental courses.

Key words: Affect, Cognition, Metacognition.

In the last decade a number of researchers have started to study the interplay between cognition and affect combining different research traditions; the aim is to provide a unified approach for the understanding of performance in achievement settings. Cognition involves all those mechanisms that make the person capable of processing a cognitive task. Affect encompasses all those non cognitive factors which take the form of feelings, beliefs, emotions, goals, needs/drives, etc. (McLeod, 1989). All these affective factors have motivational power as they influence task choices, intensity of effort and persistance in face of obstacles in a given achievement situation (Pintrich, Garcia, & DeGroot, 1994). Thus, they are considered to be of great importance for children's learning processes and task performance (see Ames & Ames, 1984; Nicholls, 1984). Moreover, cognitive and motivational/affective processes are considered by many theorists and researchers as inseparable and synergistic as they operate together in a dynamic way to produce combined effects (for a review see Sorrentino & Higgins, 1986). However, in order to understand this interplay between cognition and motivation we need a reference to the self, as an

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explanatory and organizing framework that provides the person with a sense of individual identity and continuity (Cantor, Markus, Neidenthal, & Nurius, 1986).

James (1890) was the first psychologist who made the distinction between self as a subject ('I'-self as knower) and self as an object of what is known ('me'). The self as knower has an executive function as it organizes and interpretes experience in a subjective way while the self as an object consists of the perception of this experience. The self as an object is reflected in the self-concept. James considered the global self as simultaneously both a subject which is distinct from other persons' selves and an object which involves the image of self as this is formed by the self as a subject. Although the properties of the self is a rather controversial issue, there is a consensus that the subjective feeling of having a self is a very significant empirical phenomenon that needs further investigation. In short we could say that the self as a hypothetical, explanatory construct has three crucial functions (see Epstein, 1973): (a) to preserve inner consistency (e.g., in personal beliefs, attitudes), (b) to interprete and organize experience in a way that gives predictability and meaning to life and (c) to formulate future expectancies.

Self-concept, on the other hand, has been investigated as a system of knowledge structures about the self; in most of the studies the self is measured through the self-concept as an object and not as the subject that forms and experiences beliefs, feelings, thoughts, etc. Recent theoretical approaches, however, stress both the cognitive aspect of the self-concept and the emotional one, namely self-esteem. Thus, the self-concept is considered a superordinate structure which is multidimensional (e.g., academic self, social self, etc.) and comprises various domains or categories (e.g., goals, past actions, future self, ideal self, etc.) and aspects (e.g., self-perception, self-esteem, self-efficacy, etc.); furthermore, this structure is dynamic and changes with experience (see Burns, 1982; Harter, 1982; Κωσταρίδου-Ευκλείδη, 1995; Λεονταρή, 1996; Marsh, 1993). This means that not only is the self "a continuing process of information search, interpretation, and assimilation" but also the background structure that "contributes to the structure of the self-concept" (Cantor, Markus, Neidenthal, & Nurius, 1986).

Following the above rationale, we have to see persons as "self systems" which are equipped with thinking, feeling, and acting mechanisms. Persons have abilities (cognition), but also goals, fears, beliefs, motives, etc. (affect/motivation); they also have mechanisms which are responsible for the representation of these cognitive (and/or affective) qualities (metacognition), aiming at the monitoring, control, and modification of cognition and action taken in a given situation (self-regulation).

Recently there has been given a lot of emphasis on metacognition as the interface between cognition and affect and its essential role in self-regulation in achievement settings (Boekaerts, 1991, 1995). Metacognition can be defined as knowledge of cognition (Flavell, 1979) as well as skills that permit the effective regulation and monitoring of one's own behavior (Baker & Brown, 1984). It has, in this sense, a static and a strategic aspect. Static knowledge is everything people state about cognition in a verbal form and strategic knowledge involves all those steps that people take in order to regulate, control and modify their actual cognitive activity.

Metacognition refers to the person's awareness of his/her self dealing with problems in various domains. According to Flavell (1979), it takes either the form of metacognitive knowledge, that is, information we recall from memory to guide our cognitive activity, or the form of metacognitive experiences, that is, metacognitive knowledge, ideas and feelings that occur *online* (while we are engaged in a cognitive endeavour). Metacognitive knowledge consists of knowledge or beliefs that have to do with people's goals, tasks, actions, and experiences, and as such it can lead to selection, evaluation or abandoning of whole categories of cognitive tasks, goals, and strategies.

Metacognitive knowledge, according to the same analysis, can be part of the various metacognitive experiences that help the person appraise and regulate behavior in a specific cognitive enterprise. These metacognitive experiences are

very important as they can affect the metacognitive knowledge-base by adding to or deleting from it pieces of information. The role of metacognitive experiences for self-regulation is crucial because they reflect the person's cognitive and affective reactions to the current situation, but also more general person characteristics. It has been found that the various subjective experiences function at the task-specific level but they are also influenced by more general cognitive ability and affect (Efklides, Papadaki, Papantoniou, & Kiosseoglou, 1997, 1998).

Given the above theoretical analysis of metacognition, its relationship to cognition and affect, particularly in learning situations, is obvious. However, despite Flavell's influencial work on metacognition, there is still little empirical verification that metacognitive knowledge and metacognitive experiences actually constitute a unifying system which is distinct from cognition and is characterized by a continuing flow of information from cognition and affect; furthermore, there is no work differentiating metacognition from self reports or estimates of the person's affective state. Specifically, the question raised at this point is if cognition, metacognition, and affect are best conceptualized as systems which are interrelated under one common underlying construct (which could be the "self") or if they form totally different and independent systems.

It is, also, worthwhile to investigate if self-reports (that is, metacognitive and affective reports) are differentiated according to the generality of the object they refer to. Specifically, in the metacognitive domain self-reports can refer to general modes of information processing (i.e., semantic memory) or to more specific aspects of the cognitive self (i.e., one's ability in a specific cognitive domain), and to even more narrow aspects (i.e., metacognitive experiences that are task-specific). Accordingly, in the affective domain, self reports can refer to general personality dispositions (i.e., anxiety-trait) and/or to more situation-specific characteristics (i.e., anxiety-state) (see Spielberger, 1972a, b). Finally, it is interesting to test the hypothesis that if the above three systems are distinct, then their development would also follow different courses.

The present study

The present study aimed at answering the above questions. In order to delimit the structure and relations between cognition, metacognition and affect, in the domain of cognition we included cognitive tasks which tap two different ability domains, namely, quantitative and causal reasoning. In the domain of affect we tried to combine two theoretical traditions, those of achievement motivation and test anxiety. Achievement motive and test anxiety refer to relatively stable personality characteristics which are considered to influence task choices and performance in achievement settings (see Heckhausen, 1991). Specifically, they are conceptualized either as energizers (e.g., need to achieve) that affect the person's intention to learn and to invest effort in a cognitive endeavour, and which reinforce positive thinking (Krau, 1982), or as inhibitors (e.g., fear of failure and test anxiety) which permit negative self-centered thoughts to penetrate and have a detrimental effect on performance (Heckhausen, 1982; Wine, 1971, 1982). We also took into account the theoretical distinction that refers to the generality of test anxiety. Most theories of test anxiety differentiate test anxiety as trait from test anxiety as state (see Spielberger, 1972a, b). Anxiety trait represents a more stable individual difference characteristic. Some individuals experience more anxiety across various testing situations in comparison to others. Anxiety state is more situation-specific. To our knowledge, only little work has been done on the relations between one's affective characteristics and one's task-specific feelings and ideas about the quality of his/her cognitive processing while working in an achievement setting (Efklides, Papadaki, Papantoniou, & Kiosseoglou, 1997).

Finally, as regards metacognition we included three different measures, varying in scope or generality. For this reason, self-reports that refer, firstly, to general modes of information processing were included in the study. These reports referred to the ideas the persons have about themselves as cognitive processors who use mental functions, such as memory (semantic and visual), during

problem solving. For the middle level of generality we included metacognitive knowledge which captures the ideas the persons have about their processing of tasks in specific cognitive domains (e.g., quantitative and causal). Finally, for the task-specific level we used measures of metacognitive experiences. We were interested in the relation between the general and middle level metacognitive ideas about the self and the feelings and estimates which are task-specific and evoked during and/or at the end of the processing of a cognitive task (judgement of solution correctness and feeling of satisfaction). Specifically, we wanted to examine if one's ideas of one's own self as a cognitive processor, the ideas of self in specific cognitive domains and one's metacognitive experiences form a single construct rather than a set of independent constructs.

Hypotheses. The hypotheses tested were the following: Cognitive performance would be explained by a second-order factor, namely cognition, which loads two narrow factors, one representing the quantitative and one the causal reasoning performance (Hypothesis 1).

Our second assumption was that the various aspects of affect would form a second-order affective factor, which reflects general personality characteristics. This factor, in turn, would load more narrow factors, namely the achievement motive and the test anxiety factors mentioned above, which would further load even more narrow factors, corresponding to the constituents of the middle level factors (Hypothesis 2).

Hypothesis 3 predicted that metacognition would form a second-order factor, which loads three lower-order factors, namely, metacognitive knowledge regarding general modes of memory (independent of domain-specific processing), metacognitive knowledge regarding domain-specific processing, and metacognitive experiences (i.e., feelings), as they function at different levels of generality. Furthermore, each of these lower-order metacognitive factors would load more narrow or specific factors, namely, the various aspects of metacognitive knowledge as well as the various aspects of metacognitive experiences.

As for the relations between cognition, metacognition, and affect, the hypothesis was that the above three systems would retain their relative autonomy and functional characteristics and at the same time they would communicate and interrelate, permitting the person to regulate and modify, when necessary, one's own actions (see also Efklides, Papadaki, Papantoniou, & Kiosseoglou, 1997). They would constitute three aspects of one underlying single factor, which would load all items representing cognition, metacognition, and affect (Hypothesis 4).

Finally, the relative autonomy of these three systems was expected to be reflected also in their development. Specifically, we expected age to influence mainly the cognitive and the metacognitive experiences aspects of persons' achievement behavior, since these experiences are task-specific and related to actual performance and they would follow the cognitive change occuring in the age span tested (see Demetriou & Efklides, 1989; Demetriou, Efklides, & Platsidou, 1993). As for the metacognitive aspects of the cognitive self and affect we expected age to influence more those aspects of the self that refer to cognitive ability in specific cognitive domains, as a result of the persons' progressive familiarity with the demands of tasks from these domains rather than affect, which relates to personality characteristics, such as achievement motive and test anxiety (Hypothesis 5).

Method

Participants

Four hundred eleven participants, aged 12 to 16 years, of both genders (236 girls and 175 boys), were tested in groups in their classrooms. Specifically, 76 students of 7th grade, 78 of 8th grade, 67 of 9th grade, 70 of 10th grade (Lyceum), 69 of 11th grade (Lyceum), 21 of 10th grade (Technical Lyceum), and 30 of 11th grade (Technical Lyceum). The participants came from four different schools, three from the city and one from the suburbs of Thessaloniki, Greece.

Tasks

Three different sets of tasks were used.

Cognitive tasks. The battery of cognitive tasks comprised two quantitative-relational and two causal-experimental ones; the tasks in each category were of two levels of difficulty. The quantitative-relational tasks were mathematical word problems and required understanding of proportional relations. Regarding the causal experimental tasks, the first was a task of hypothesis testing, comparing two hypotheses, formulating a new one, and testing it. The second task required participants to isolate the variables responsible for a certain effect. Performance on each task was measured on a four-point scale, ranging from 0: no answer or wrong answer, 1: making only the first step of the solution, 2: partially correct answer, 3: fully correct answer (for further details regarding scoring see Μεταλλίδου, 1996).

Affecive questionnaires. The questionnaires tapping affective factors were: (a) Nygard and Gjesme's (1973) *Achievement Need Questionnaire.* It consists of two questionnaires, one concerning Need Success (nSuc) and the other Fear of Failure (fFail). (b) Spielberger's (1980) *Test Anxiety Inventory* (TAI), with its two basic components, namely, Worry and Emotionality, was used as a measure of anxiety trait. (c) Sarason's *Cognitive Interference Questionnaire* (Sarason, Sarason, Keefe, Hayes, & Shearin, 1986), was used as a measure of anxiety state (examples of all the questionnaires are given in the Appendix). In the first two questionnaires participants were asked to rate on a four-point scale ranging from: 1: not at all, 2: a little, 3: enough, 4: very, how much was each of the statements given representative of themselves. In the anxiety state questionnaire there was a five-point scale, ranging from: 1: not at all, 2: rarely, 3: a little, 4: enough, 5: very. The reliability indices were: Gronbach's α = .82 (Need Success), α = .83 (Fear of Failure), α =.81 (Anxiety Worry), α =.89 (Anxiety Emotionality) and α =.76 (Anxiety State). For further details regarding the structure and reliability of the questionnaires see Μεταλλίδου (1996).

Metacognitive questionnaires. The third set of tasks was the battery of metacognitive questionnaires. It involved, first, questionnaires tapping general memory processing and metacognitive domain-specific knowledge. Namely, the *General Memory Questionnaire* involved statements concerning one's semantic and visual memory (remotely related to the cognitive tasks at hand). This questionnaire tapped general aspects of cognitive processing. The *Metacognitive Domain-specific Questionnaire* tested one's ability to handle mathematical and causal relations; this questionnaire comprised items more directly related to the cognitive tasks at hand. These questionnaires were constructed by the authors for the purposes of the present study. Participants were asked to rate how much each statement was true for them. Answers were given on a 4-point scale ranging from 1: not at all, 2: a little, 3: quite, 4: very. The corresponding reliability indices were: Gronbach's α = .365 (Semantic Memory), α = .515 (Visual Memory), α = .762 (Math Self) and α = .706 (Causal Self).

Second, after solving the cognitive tasks, participants were asked to rate the correctness of the solution given to each task and their satisfaction from the solution produced. Answers were given on a four-point scale ranging from: 1: not at all, 2: a little, 3: quite, 4: very. These two questions tapped metacognitive experiences, namely, a judgement about the correctness of the solution produced to the task and the feeling of satisfaction derived from the solution produced. The former is more cognitive in nature whereas the latter is more affective.

Results

Structure and relations between cognitive ability, metacognition, and affect

In order to test our hypotheses regarding the structure and the relations between cognition, metacognition, and affect, confirmatory factor analysis with the nested factors method (Gustafsson, 1994) was applied using the EQS

statistical program (Bentler, 1993). With this method one starts by introducing the most general factor and then progressively introduces more specific factors in order to capture all the variance explained by both the broad and the narrow factors. In this way one identifies both the commonalities and the interrelations between variables but also their relative autonomy and specificity. Table 1 represents the change of x^2 and CFI indices as a function of the introduction of factors to the model.

Specifically, we firstly introduced a general factor which explained part of the variance of all the cognitive, metacognitive, and affective variables (see Table 2). In the second, third and fourth step of the analysis we introduced successively three factors more narrow in scope, corresponding to each of the three systems, mamely, the cognitive, the metacognitive, and the affective system.

Table 1

The change of x^2 and CFI indices as a function of the introduction of factors to the model

Factors	x^2	*df*	*CFI*	*p*	*D* x^2	*Ddf*	*p*
General (Self)	3938.220	420	.371	.001			
Ceneral Cognitive	3737.133	416	.406	.001	201.087	4	.001
General Meta/ve	2345.944	398	.652	.001	1391.189	18	.001
Affective (anxiety)	1972.384	391	.717	.001	373.560	7	.001
Cognitive self	1609.368	380	.780	.001	362.916	11	.001
Meta/ve Exper.	1475.330	372	.803	.001	134.038	8	.001
Q Meta/ve Exper.	1372.261	368	.820	.001	103.070	4	.001
C Meta/ve Exper.	1291.525	364	.834	.001	80.736	4	.001
Sem Metamemory	1280.998	362	.836	.001	10.527	2	.01
Vis Metamemory	1215.748	360	.847	.001	65.250	2	.001
Math Self	1141.395	358	.860	.001	74.353	2	.001
Causal Self	1126.308	356	.862	.001	15.087	2	.001
Need Success	1109.318	354	.865	.001	16.990	2	.001
Fear Failure	899.144	352	.902	.001	210.174	2	.001
Anxiety Worry	865.197	350	.908	.001	33.947	2	.001
Anxiety Emotion.	834.216	348	.913	.001	30.971	2	.001
Anxiety State	675.614	346	.941	.001	158.602	2	.001
Causal Ability	669.175	344	.942	.001	6.439	2	.05
Quant/ve Ability	668.013	342	.942	.001	1.162	2	NS
Quant/ve Correct.	641.937	339	.946	.001	26.076	3	.001
Causal Correct.	614.000	337	.950	.001	27.937	2	.001
Quant/ve Satisf.	611.050	335	.951	.001	2.950	2	NS
Causal Satisf.	604.335	334	.952	.001	6.729	1	.01

Note: The symbols General.....Causal Satisf. stand for the following factors: General Self, General Cognitive, General Metacognitive, Cognitive Self, Anxiety, Metacognitive Experiences, Quantitative Metacognitive Experience, Causal Metacognitive Experience, Semantic Metamemory, Visual Metamemory, Math Self, Causal Self, Need Success, Fear Failure, Anxiety Worry, Anxiety Emotionality, Anxiety State, Causal Ability, Quantitative Ability, Quantitative Correctness, Causal Correctness, Quantitative Satisfaction, and Causal Satisfaction factor, respectively.

It should be mentioned that at this point of the analysis we tested two different hypotheses regarding the factors which loaded the metacognitive and the affective variables. First, we tested a model in which we hypothesized the existence of a general metacognitive factor which explained part of the variance of both the affective and the metacognitive variables, since all these variables regarded self-reports about different aspects of the self, $x^2(390) = 2248.699$, $p = .001$, $CFI = .668$. It was found that most of the loadings of the anxiety and the fear of failure variables were very low or non significant. Only the need success variables had quite high loadings on this factor. Thus the model was modified and the affective variables, except for the need success variables,

Table 2
The structure of cognitive, metacognitive, and affective factors identified by confirmatory factor analysis with the nested factors method

Variables	General Factor/ Self	General Cognitive Factor	General Meta/ive Factor	Affective Factor (Anxiety)	Cognitive Self	Meta/ive Exp[erien Factor	Quant Meta/ive Experien.	Causal Meta/ive Experien.
M Sem.1	.350*		.511*		.293*			
M Sem. 2	.322*		.378*		.224*			
M Vis. 1	.140*		.390*		.272*			
M Vis. 2	.145*		.461*		.335*			
Math Self 1	.360*		.642*		-.381*			
Math Self 2	.400*		.526*		-.241*			
Caus. Self 1	.219*		.309*		.422*			
Caus. Self 2	.197*		.423*		.283*			
N Success 1	.386*		.612*		-.127*			
N Success 2	.349*		.626*		.080			
F Failure 1	-.207*			.401*				
F Failure 2	-.263*			.440*				
Anxiety W 1	-.344*			.745*				
Anxiety W 2	-.291*			.829*				
Anxiety E 1	-.204*			.826*				
Anxiety E 2	-.256*			.806*				
Anxiety S 1	-.155*			.467*				
Anxiety S 2	-.168*			.555*				
Quant. 1	.488*	.351*						
Quant. 2	.479*	.514*						
Causal 1	.564*	.250*						
Causal 2	.433*	.504*						
Q Correct 1	.652*		.173*			.285*	.260*	
Q Correct 2	.606*		.026			.442*	-.252*	
C Correct 1	.661*		-.078			-.045		.613*
C Correct 2	.145*		.208*			.519*		.736*
Q Satisfact 1	.569*		.282*			.317*	.647*	
Q Satisfact 2	.503*		.168*			.384*	-.390*	
C Satisfact 1	.499*		-.022			-.204*		.415*
C Satisfact 2	.112*		.209*			.218*		.315*

Table 2 (cont.)

Variables	Semantic Meta/ory	Visual Meta/ory	Math Self	Causal Self	Need Success	Fear of Failure	Anxiety Worry	Anxiety Emotion	Anxiety State
M Sem.1	.098								
M Sem. 2	.427*								
M Vis. 1		.529*							
M Vis. 2		.423*							
Math Self 1			.178						
Math Self 2			.474*						
Caus. Self 1				.582*					
Caus. Self 2				.602*					
N Success 1					.465*				
N Success 2					.487*				
F Failure 1						.727*			
F Failure 2						.685*			
Anxiety W 1							.319*		
Anxiety W 2							.064		
Anxiety E 1								.333*	
Anxiety E 2								.345*	
Anxiety S 1									.681*
Anxiety S 2									.608*
Quantit. 1									
Quant. 2									
Causal 1									
Causal 2									
Q Correct 1									
Q Correct 2									
C Correct 1									
C Correct 2									
Q Satisfact 1									
Q Satisfact 2									
C Satisfact 1									
C Satisfact 2									

were assumed to load a different factor (affective-anxiety factor), $x^2(398) = 2345.944$, $p = .001$, $CFI = .652$. This modification, although it caused a drop in the fit of the model, it was necessary in order to clarify the structure of the three systems and to make the relative factors strong.

In the next step of the analysis we tested three different models, in order to uncover the structure of the metacognitive system. Firstly, we tested a model in which we hypothesized the existence of three narrow metacognitive factors, which corresponded to metacognitive aspects of the self differing in generality. Specifically, in the three following steps of the analysis we successively introduced (a) a "general memory metacognitive" factor, which referred to general modes of information processing (semantic and visual memory), (b) a "metacognitive domain-specific

Table 2 (cont.)

Variables	Quant/ve Cognitive	Causal Cognitive	Quant/ve Correcteness	Causal Correcteness	Quant/ve Satisfaction	Causal Satisfaction
M Sem.1						
M Sem. 2						
M Vis. 1						
M Vis. 2						
Math Self 1						
Math Self 2						
Caus. Self 1						
Caus. Self 2						
N Success 1						
N Success 2						
F Failure 1						
F Failure 2						
Anxiety W 1						
Anxiety W 2						
Anxiety E 1						
Anxiety E 2						
Anxiety S 1						
Anxiety S 2						
Quantit. 1	.389*					
Quant. 2	-.135*					
Causal 1		.407*				
Causal 2		.324*				
Q Correct 1			.173			
Q Correct 2			-.079			
C Correct 1				-.391*		
C Correct 2				.315*		
Q Satisfact 1					.276*	
Q Satisfact 2					.647*	
C Satisfact 1						.376*
C Satisfact 2						.634*

x^2 (334) = 604.335, *NFI* = .900, *NNFI* = .937, *CFI* = .952, p = .001.

Note: The symbols M Sem...C Satisfact stand for Memory Semantic, Memory Visual, Math Self, Causal Self, Need Success, Fear Failure, Anxiety Worry, Anxiety Emotionality, Anxiety State, Quantitative Ability, Causal Ability, Correctness of the solution of Quantitative tasks, Correctness of the solution of Causal tasks, Satisfaction with the solution of Quantitative tasks, and Satisfaction with the solution of Causal tasks, respectively

knowledge" factor, which corresponded to a middle level of generality, as it captured the ideas the person has about his/her processing of tasks in specific cognitive domains (quantitative and causal), and (c) for the task specific level we introduced a "metacognitive experiences" factor, which referred to feelings that were task-specific and evoked during or/and at the end of the processing of the cognitive task (judgement of solution correctness and feeling of satisfaction),

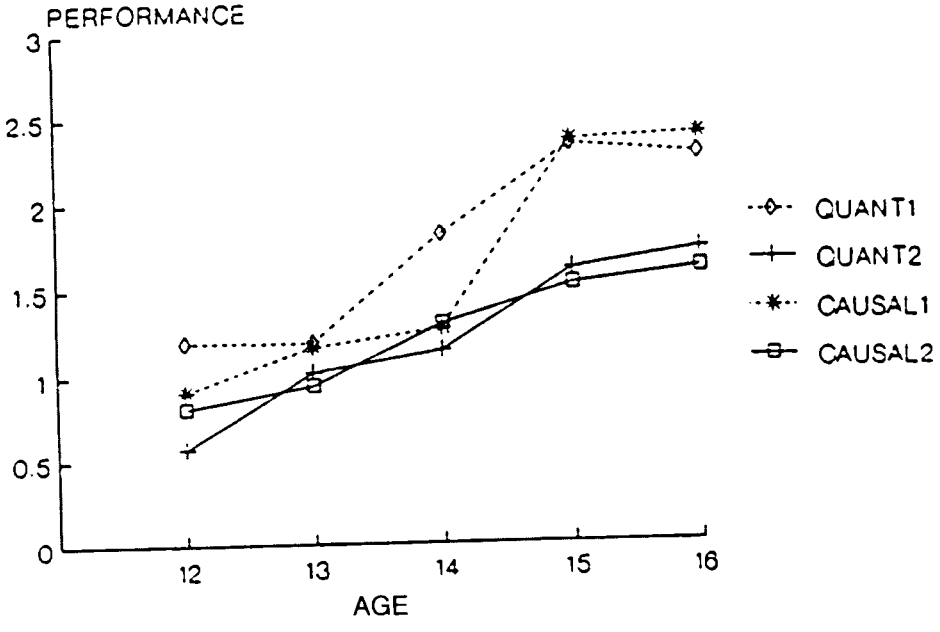

Figure 1: Cognitive performance as a function of age.

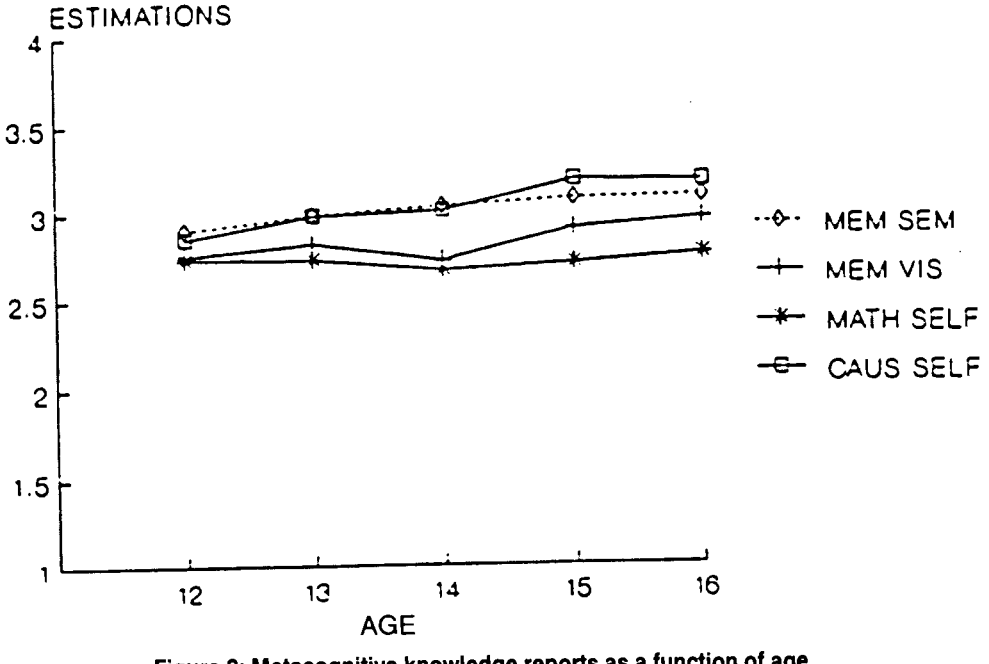

Figure 2: Metacognitive knowledge reports as a function of age.

$x^2(375) = 1549.938$, $p = .001$, $CFI = .790$.

In the second model we tested, we introduced two metacognitive factors instead of three. Namely, one "cognitive self" metacognitive factor, referring to metacognitive knowledge, which explained the general memory, the domain-specific metacognitive knowledge, and the need success variables. The other factor was again the "metacognitive experiences" factor $x^2(372) = 1475.330$, $p = .001$, $CFI = .803$. This modification improved significanly the fit of the model, so we kept the second model $Dx^2 = 74.608$, $Ddf = 3$, $p = .001$. It should be mentioned here that we also tested a model similar to the one we kept but without loading the need success variables on the "cognitive self" metacognitive factor. However, this modification caused a significant drop in the fit of the model $x^2(375) = 1569.069$, $p = .001$, $CFI = .786$, (the fit of the model) and $Dx^2 = 93.739$, $Ddf = 3$, $p = .001$, and as result it was rejected.

In the next two steps we introduced two even more narrow "metacognitive experiences" factors specific to the cognitive tasks at hand, one refering to the quantitative tasks and the other to the causal tasks.

Finally, in the following steps of the analysis we introduced successively the more specific factors, which represented each of the specific aspects of cognition, metacognition and affect that were tested (see Table 2).

The fit of this model was relatively good, the fit indices being: $x^2(334) = 604.335$, $p = .001$, Bentler- Bonett Normed Fit Index (*NFI*) = .900, Bentler-Bonett Non Normed Fit Index (*NNFI*) = .937, Comparative Fit Index (*CFI*) = .952.

Looking closely at the loadings of the variables included in the model, one should note that the first factor, the most general one, although it explained part of the variance of all the variables, it loaded mainly the cognitive variables and the variables referring to the metacognitive expe-

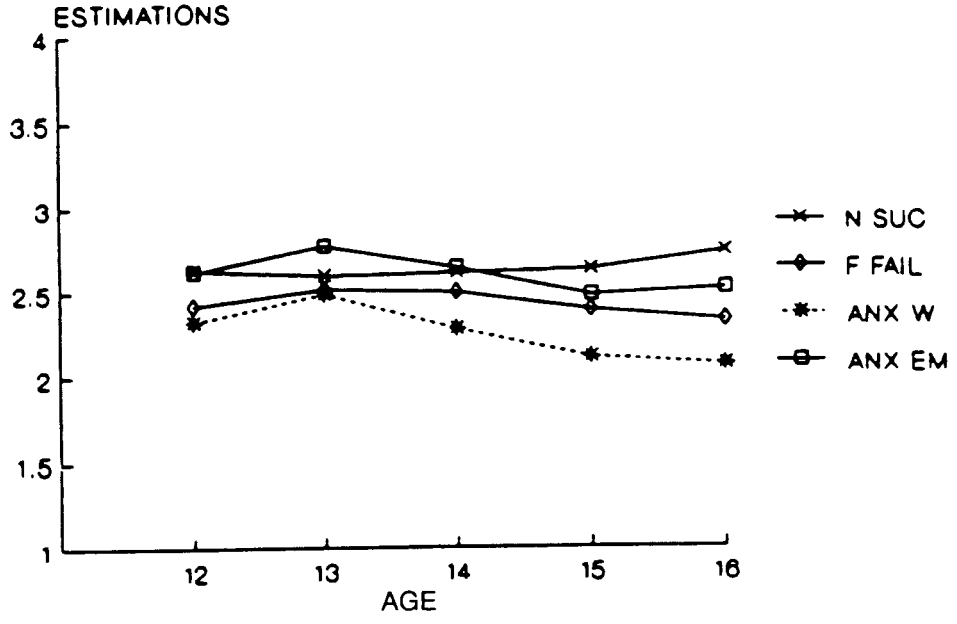

Figure 3: The effect of age on the affective self reports.

riences following cognitive performance. We could say then, that this general factor reflects the "self" as a processing system which consists of cognitive, metacognitive and affective elements, which are interwined in an achievement setting having the person's cognitive functioning as point of reference. Thus, Hypothesis 4 was confirmed.

As for the factors representing cognition, metacognition, and affect, our results showed that they form different systems (as suggested by Hypotheses 1, 2, and 3), which retain their autonomy, although they have a common underlying core, as mentioned above. It is noteworthy that these three factors are quite strong as shown by the loadings of the corresponding variables. Furthermore, Hypothesis 1 was confirmed since the cognitive factor comprised two lower-level cognitive factors, the quantitative and causal. However, Hypothesis 2 was not confirmed as regards the constituents of the second-order affective factor. Only the anxiety and fear of failure measures loaded the affective factor and not the need success items.

Finally, it is quite interesting that the general metacognitive factor was mainly defined by the variables referring to the cognitive aspects of self and its need to succeed in achievement settings and not by the variables concerning the metacognitive experiences. Instead, it was found that metacognitive experiences form their own system, which is affected by the demands of the specific tasks at hand. These findings are contrary to Hypothesis 3.

Therefore, our results, firstly, revealed both the unity and specificity of the factors comprising the self-system. Secondly, results showed the lack of a single affective factor that comprises all aspects of motivation or personality, and, thirdly, the different nature of metacognitive knowledge from metacognitive experiences.

Developmental changes

In order to test the respective hypothesis, a series of ANOVAs were performed on the data. These analyses are reported below separetely for each system.

Cognitive performance-metacognitive experiences. In order to test Hypothesis 4, that is, the effect of age along with the effect of other individual difference factors, a series of 5 (Age) x 2 (Sex) x 3 (SES) x 2 (Cognitive Domains) x 2 (Levels of Difficulty) MANOVAs were performed on the data in order to uncover the effect of age on participants' performance in the four cognitive tasks. In this article we will present only the results regarding the effect of age and the level of difficulty (for the complete results of the analysis see Μεταλλίδου, 1996). The main effect of age was found significant, $F(4, 330) = 46.78$, $p = .000$, as well as the interaction between age and level of difficulty of the cognitive tasks $F(4, 330) = 7.86$, $p = .000$. As can be seen in Figure 1, there was a gradual improvement of the participants' performance as they were getting older, especially in the case of the easy tasks independently of their domain of application, namely, quantitative or causal. However, it is very interesting that there was a drastic improvement in performance at about the age of 13-14 years; this probably reflects a more general cognitive change which takes place at about this age.

As for the metacognitive experiences, it was found that they followed a quite similar developmental pattern with that of cognitive performance. Specifically, the main effect of age was found significant in both cases, $F(4, 330) = 17.71$, $p = .000$ (judgement about the correctness of the solution) and $F(4, 330) = 11.18$, $p = .000$ (feeling of satisfaction) as well as the interaction between age and level of difficulty of the cognitive tasks, $F(4, 330) = 4.26$, $p = .002$ (judgement about the correctness of the solution) and $F(4, 330) = 4.67$, $p = .001$ (feeling of satisfaction)] (for more details see Metallidou & Efklides, 1998).

General memory and domain-specific metacognitive knowledge. A series of 5 (Age) x 2 (Sex) x 3 (SES) x 4 (Aspects of Cognitive Self, i.e., semantic, visual, quantitative, and causal processing) MANOVAs showed that the main effect of age was not significant, but there was a significant interaction between age and the aspects of cognitive self, $F(12, 990) = 2.26$, $p = .008$. Specifically, the effect of age

was significant only in the case of causal self, $F(4, 330) = 3.48$, $p = .008$. As shown in Figure 2, increasing age gave participants a slightly more positive image of their abilities only in this aspect of processing. It is noteworthy that, in general, participants' image of their cognitive self was found to be much more stable in comparison to their actual cognitive performance over the age span from 12 to 16 years of age.

Affect. With regard to the effect of age on participants' reports of their achievement motivation and test anxiety, a series of 5 (Age) x 2 (Sex) x 3 (SES) x 4 (Affective Factors, i.e., need success, fear of failure, anxiety worry, and anxiety emotionality) MANOVAs showed that the main effect of age was again not significant, $F(4, 330) = 2.21$, $p = .068$. As we can see in Figure 3, as participants get older they don't change significantly the reports they give about their achievement motivation and test anxiety. This, we could say, was expected since the above affective factors represent relatively stable personal characteristics. However, a significant age effect was found only in the case of the anxiety-worry component of anxiety trait $F(4, 330) = 3.52$, $p = .008$. Participants reported less negative thoughts about themselves in testing situations, especially after the age of 13. This may be due to the fact that older participants, on the one hand, are more familiar with various testing situations and, on the other hand, they have a more accurate perception of their cognitive potential in different domains of thought. In general, as can be seen in Figure 3, there is a tendency in participants' affective estimations to get slightly lower in the case of anxiety and fear of failure, especially after the age of 13 years. Finally, in the case of anxiety state we conducted another MANOVA, because of the different scale used in estimating anxiety in this specific testing situation. Again, the effect of age was not found significant, $F(4, 330) = 1.69$, $p = .151$.

In conclusion, we could say that the cognitive, metacognitive, and affective systems follow different developmental courses. It was found that the drastic positive change of cognitive performance after the age of 13 was followed only by changes in metacognitive experiences, which were task-specific and affected by cognitive processing itself. The more global metacognitive and affective aspects of cognitive self, which are products of reflection on performance on different tasks in various instances, seem to be far more stable in comparison to changes in actual performance in the age span tested. Therefore, our results showed that development of the three systems is controlled by different factors, which have to do with the processes underlying their formation.

General Discussion

This study aimed at investigating the structure and the relations between cognition, metacognitive aspects of the cognitive self differing in generality, and affect. The results of the confirmatory factor analysis confirmed to a large extent our hypotheses about the structure and relations between the above three systems. Specifically, it confirmed Hypothesis 1 regarding cognition and partly confirmed Hypothesis 2 regarding affect. With regard to affect, the results of the analysis showed that the anxiety and the fear of failure variables formed as expected a second-order affective system, which in this case expresses the degree in which negative self-centered cognitions and emotions occur in the specific cognitive occasion. However, this second-order factor was mainly defined by the test anxiety as trait components (worry and emotionality) and not so much by the fear of failure and the test anxiety as state reports, as can be seen from the relative loadings. Instead these affective aspects were found to form strong factors on their own, thus pointing out the multidimensionality of the affective system. Therefore, both the lack of loading of need success on the general affective factor and the differentiation of loadings of the anxiety items on it suggest that the affective system does not have the cohesiveness of the cognitive system.

As regards metacognition, the same analysis showed that it forms a unifying second-order

system which, nevertheless, is mainly defined by metacognitive knowledge referring to the self as a cognitive processor, who is equipped with general modes of information processing and specific cognitive abilities. However, general memory reports and domain-specific knowledge reports were not found to form two distinct metacognitive subsystems, as expected (Hypothesis 3). This, may due to the fact that both these self-related reports refer to metacognitive knowledge which represents, on the one hand, the persons' conception of themselves as cognitive processors in achievement situations and, on the other hand, ideas about competence and efficacy in specific cognitive domains. Perhaps this is the reason why the achievement need self-reports were found to be loading on the "general metacognitive factor" instead of the "affective factor". Specifically, we could say that the need success reports reflect not only one's need to get involved in an achievement situation but also the belief/idea one has about one's ability to handle effectively a demanding situation. In accordance to our hypothesis, metacognitive experiences were found to actually form their own metacognitive subsystem, which is basically affected by the demands of the specific tasks at hand (quantitative or causal). This is an indication that metacognitive experiences are distinct from metacognitive knowledge as regards their scope and/or nature. Although, they are influenced by the level of the domain-specific cognitive ability, at the same time they function at the task-specific level, and they are directly related to performance (see also Efklides, Papadaki, Papantoniou, & Kiosseoglou, 1997, 1998).

The same analysis confirmed our fourth hypothesis showing that the three aspects of the self (cognitive, metacognitive, and affective) are distinct constructs; this does not imply a total independence, because at the same time they function as a whole while the person is engaged in a cognitive endeavour (Hypothesis 4). Thus one gets the impression that there does exist an underlying organizing construct which provides to the self system coherence and permits a continuing flow of information from one system to the others. This reminds us of James' "self as a subject" which has an executive function and organizes and interprets experience in a subjective way while the "self as an object" consists of the descriptions of this experience. Of course, this conclusion needs to be further investigated in order to be clarified the terms of the interplay between cognition, metacognition, and affect.

However, the above results can be seen as an empirical confirmation of the assumption that the self is an affective-cognitive-metacognitive superordinate construct, which is hierarchically organized and comprises of subordinate, multidimensional systems. Thus, at the intermediate level of generality, cognition, metacognition, and affect constitute three aspects of the self which in turn involve lower order, more specific aspects within each domain (i.e., causal vs. quantitative self, semantic vs. visual memory, feeling of satisfaction, anxiety-worry, anxiety emotionality, etc.). This implies that in a specific achievement situation all these aspects of the self feed the self-system with information about its cognitive, metacognitive and affective state. This information is taken into consideration in order the person to appraise the situation and regulate his/her action. Self can be seen, then, as a structure and as a process at the same time.

The above results, which were based on structural analyses, are supported by the developmental results which showed that these three systems (cognition, metacognition, and affect) have quite different developmental courses, as expected. Specifically, while cognitive performance and metacognitive experiences improved significantly along with development, the effect of age on more general aspects of cognitive self was smaller. Specifically, development affected mainly those aspects of cognitive self which were sensitive to less well established abilities, as for example the ability to handle causal relations. However, development did not affect significantly in most cases the affective aspects of the self which concerned rather stable personality characteristics, except for the anxiety-worry aspect in which the cognitive element is prevailing. It

seems that adolescents have a rather stable image of their affective characteristics in achievement situations (Hypothesis 5). The above results imply that the formation of these three subsystems of the self follows different developmental and functional principles, which are worthwhile to be further investigated in a longitudinal perspective. This would help educational psychologists and teachers to design and carry out successful intervention programmes in order to develop a positive image of the self as regards various cognitive, metacognitive, and affective aspects of self.

In the same fashion, future research should be concerned with the possible developmental changes in the web of the interrelations between the cognitive, the metacognitive, and the affective system, and the changes in the way these systems interact; the effect of the specific features of the various achievement situations, which may be either cognitively or affectively charged, should also be taken into account.

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Appendix

Examples

A. Achievement Need Questionnaire

a) I like to strive with problems that I am not sure I will be able to solve (need success)

b) I don't like working in situations where I am quite uncertain whether I will fail or not (fear of failure)

B. Test Anxiety Inventory (TAI)

a) Thoughts of doing poorly interfere with my concentration on tests (worry)

b) I feel very jittery when taking an important test (emotionality)

C) Cognitive Interference Questionnaire

I was thinking the difficulty of the problem

D) Metacognitive Questionnaires

a) When I hear a conversation, I remember its content well (semantic memory)

b) Every time I think of something I have read, I have the picture of the page in my eyes (visual memory)

c) I can apply easily the mathematical rules I have been taught (math self)

d) I like to search for every possible cause in order to explain an event (causal self)