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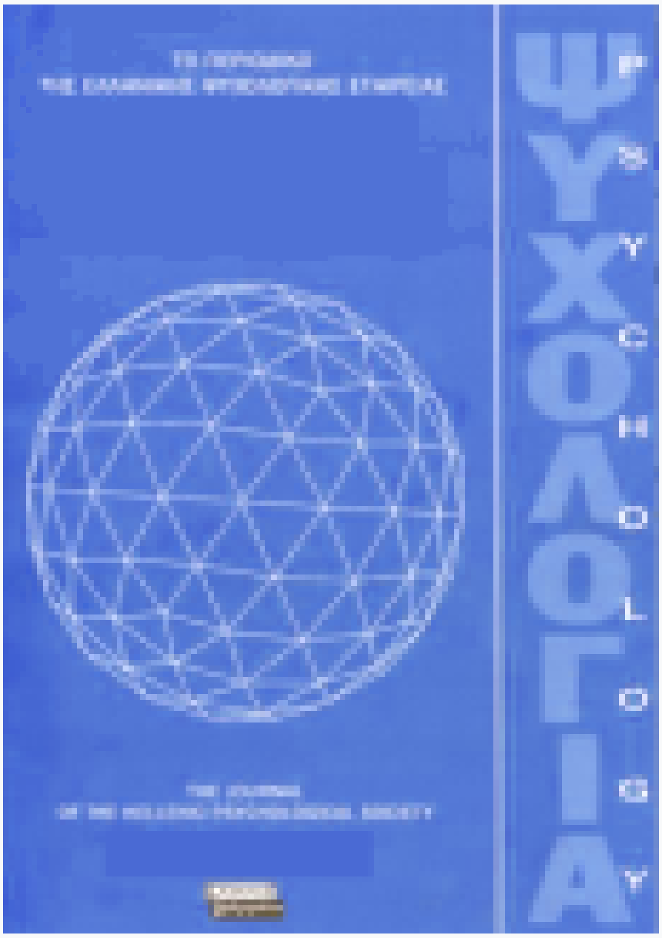

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Feelings and judgments as subjective evaluations of cognitive processing: How reliable are they?

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ABSTRACT

Metacognitive experiences (ME) comprise feelings and judgments / estimates which monitor cognitive processing. They form online metacognition and differ from metacognitive knowledge, i.e., ideas regarding persons, tasks, strategies, which may also be active during problem solving. Feelings have the distinctive feature of pleasantness / unpleasantness and monitor good functioning, i.e., fluency of processing, obstacles or interruptions, and match / mismatch between one's goals or concerns and actual conditions. Metacognitive experiences can be measured with rating scales before or after problem solving (that is, prospectively or retrospectively). The psychometric characteristics of the Metacognitive Experiences Questionnaire are presented, as well as the relations of ME with performance and the effect of task difficulty on ME. The interrelations between ME and performance are discussed, particularly with regard to feeling of difficulty. Despite the occasional low relationship between ME and performance, ME seem to reflect the basic task and processing characteristics as perceived by the person. From this point of view, they form the interface between the person and the task.

Key words: Feelings, Metacognition, Metacognitive experiences.

The measurement of feelings, or more generally speaking, affect, is an emerging issue in psychometric research, but we are not going to deal with all the problems encountered in such an endeavor here. We are only going to deal with a specific type of feelings, which are related to cognitive processing, namely metacognitive feelings. The term "metacognitive feelings" seems perhaps strange and even contradictory, because it brings together two different psychological functions, namely cognition and affect. (In fact, there is another term used to denote the kind of feelings we will be talking about, and this is "cognitive feelings"; see Koriat & Levy-Sadot, 1999). However, there is no real contradiction in terms if we use the term "feeling" not as emotion (although this is one of its meanings) but as awareness or recognition of an appraisal or response to something. Feelings in this sense are awareness of subjective responses or states that are characterized by the quality of pleasure / displeasure (Webster's Third New International Dictionary of the English Language, 1971). They form a specific aspect of conscious experience, which is a response to aspects of cognitive processing. Typical example of metacognitive feelings is feeling of knowing (FOK), that is, the feeling one has that one knows

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the answer to a question although s/he cannot retrieve it at that particular moment (Metcalfe & Shimamura, 1994).

In this presentation we shall, firstly, try to specify the feelings my collaborators and I have been working with at the School of Psychology in Aristotle University of Thessaloniki, Greece, and then give the theoretical framework underlying our research. Following this we shall give some data showing the reliability of the measures used and then we shall discuss the reliability of feelings as subjective evaluations of cognitive processing. Finally, we shall argue that despite the problems identified in the reliability of metacognitive feelings as subjective evaluations, the consideration and measurement of feelings does have pragmatic advantages. This is so because feelings can be related to other empirical observations and thereby can help us understand the participants' perception of a task or situation and their self-regulation. The study of metacognitive feelings is particularly important in understanding the role of conscious experience in ongoing behavior. After all, one of the greatest challenges for the psychological research of our time is the understanding of the function and functioning of consciousness, or to put it differently, the role of subjective experience in the person's behavior.

Feelings and judgments / estimates

Once we accept feelings as subjective responses, which vary along the continuum of pleasantness - unpleasantness, we have to identify the input or the stimuli that give rise to them. According to Frijda (1986), each function generates its own pleasure upon *functioning well*, because well functioning is monitored. Pleasantness and unpleasantness are the outcome of such monitoring (p. 365). Pleasure (and pain as an unpleasant feeling) is the outcome of the match or mismatch between actual conditions and concerns, of the good functioning and the obstacles to it. Their difference from emotions is that emotions are action tendencies whereas in the case of feelings urgency is insufficient to entail activation change.

What is critical in the above definition of feelings is the assumption that there is a monitoring process that informs about good functioning and, specifically about the match / mismatch between actual conditions or current behavior and our concerns or goals. This implies that feelings, which are product of this monitoring process, do not function at the same level as cognition or the various functions of the organism, but at a *meta-level*. This meta-level is a model of the *object-level*, that is, the organism or, in our case, cognition (see Nelson, 1996). This meta-level in current terms is *metacognition*. (Hence the term metacognitive feelings already used in the introduction of this paper).

At this metacognitive level, however, one can identify not only feelings but also other experiences, which play a similar role with them, that is, monitoring of cognition. These are judgments /estimates and ideas related to cognitive processing or cognition. The question is if these judgments / estimates and metacognitive ideas are differentiated from feelings.

As stated above, one of the things that is being monitored in metacognition is the match / mismatch between actual conditions and goals; this presupposes a comparison process which may yield a judgment of the discrepancy between them. A judgment in this sense is the outcome of the same monitoring process as feelings. An example of such a judgment would be to set a goal to memorize a list and then, after studying it, make a judgment of learning, that is, whether you have learnt it and can go on with recall (Nelson, 1993). The difference between a judgment of this type and a feeling related to the same situation (e.g., feeling of satisfaction, feeling of confidence, feeling of knowing, etc.) is the quality of pleasantness / unpleasantness that goes along with the discrepancy detection in the case of feelings. Such a differentiation, however, poses the question where the quality of pleasantness / unpleasantness that characterizes feelings comes from.

A possible explanation could be that affect is *not* influenced directly by the discrepancy between goals and current behavior, but is influenced by the perceived rate of discrepancy reduction and by perceived changes in the rate of discrepancy reduction (Carver, Lawrence, & Scheier, 1996). These changes in rate create positive or negative affect and allow people to balance their attention and effort between various strivings. Obviously there is no definite answer to the above question as yet. Despite the interest of the issue, we have to contend ourselves to the statement that the monitoring process can yield feelings and judgments about cognition and cognitive processing.

Judgments can also reflect estimations of parameters of cognition, such as *when*, *where*, and *how* a piece of knowledge was acquired, how *often* or how *recently* one came across a piece of information, how *much time* was spent on the processing of a task, etc. These judgments or estimates reflect the monitoring of source memory (Johnson, Hashtroudi, & Lindsay, 1993).

Feelings, on the other hand, capture different qualities of cognitive processing. For example, processing fluency, which is attributed to a match/mismatch between a stimulus and relevant representations in memory and which ensures availability of coping actions (Frijda, 1986), leads to *feeling of familiarity* (FOF) (see also Whittlesea, 1993). The accomplishment of a goal according to personal standards (concerns) gives rise to *feeling of satisfaction* (FOS) (Frijda, 1986). *Feeling of confidence* (FOC), on the other hand, is related to the perceived probability that the response produced is correct (Nelson, 1996). There is one more feeling, on which little research has been done up to now, namely *feeling of difficulty* (FOD), on which Efklides and her collaborators have worked (Efklides, Papadaki, Papantoniou, & Kiosseoglou, 1997, 1998, 1999. Efklides, Samara, & Petropoulou, 1999). Presumably it is related to the obstacles, interruptions, or lack of fluency of processing. According to Frijda (1986), difficulty, as an independent variable, is related to autonomic response that accompanies changes in action readiness in which actual response preparation is involved. Autonomic response is necessary when action is not expected to run off smoothly or with plenty of time.

To sum up, the metacognitive feelings and metacognitive judgments or estimates we are going to deal with in this paper are subjective experiences that result from the monitoring of cognitive processing and the person's appraisals or evaluations regarding the antecedents or outcomes of the processing. They are experiences that constitute aspects of online metacognition. They are, in other words, *metacognitive experiences* (ME) (Efklides & Vauras, 1999; Flavell, 1979).

However, there is one more component of online metacognition that one could come across during cognitive processing as mentioned above. This is the ideas about goals, persons, tasks, and strategies related to the task at hand (Flavell, 1979). These ideas or knowledge have a different origin than feelings and jugdments / estimates but they are also metacognitive in nature since they refer to and model cognition. In order to understand how the different aspects of online metacognition relate to each other and with cognition and behavior, a theoretical model of metacognition will be presented. This constitutes the theoretical framework of our work.

The theoretical framework

The concept of metacognition was introduced into psychology by Flavell (1976) and Brown (1978) and refers to our knowledge of cognition. According to Flavell (1979), metacognition takes the form of metacognitive knowledge and metacognitive experiences. However, since these components of metacognition serve the monitoring rather than the control of cognition (Brown, 1978), one could refer to yet another aspect of metacognition, one that serves the control of cognition, namely, metacognitive skills. *Metacognitive knowledge* is knowledge we retrieve from memory; it regards what the person knows or believes about him/herself and the others as cognitive beings and their relations with various cognitive tasks, goals, actions or strategies as well as the experiences he/she has had in relation to them. *Metacognitive experiences* (ME), on the other hand, is what the person experiences during a cognitive endeavor, be it metacognitive knowledge, ideas, or feelings. Metacognitive experiences form the *online* awareness of the person as he/she is performing a task. *Metacognitive skills*, finally, refer to conscious control processes such as planning, monitoring of the progress of processing, effort allocation, strategy use and regulation of cognition. They are related to self-regulation and presumably make use of both metacognitive knowledge and metacognitive experiences.

The above forms of metacognition reflect its double role, namely monitoring and control. According to Nelson (1996), metacognition is a representation, a model of cognition and is related to cognition in two ways: it *monitors* cognition (thus giving rise to metacognitive knowledge and metacognitive experiences) and *controls* cognition, through control processes such as strategy use (or metacognitive skills). We shall concentrate only on the two monitoring forms of metacognition. Metacognitive experiences and metacognitive knowledge differ between them in the process that underlies their formation and their function (Efklides, 2001). Metacognitive experiences are online and highly specific in their scope, that is, they tap some specific aspect of online cognitive or task processing, and involve working memory. On the contrary, metacognitive knowledge is retrieved from long term memory, is general in scope, and refers to abstractions based on tasks or persons across different situations or occasions. Even when metacognitive knowledge is used in relation to a specific task, it is a top down process through which already existing knowledge is being specialized in the context of a particular task. Such a conceptualization of metacognitive experiences and metacognitive knowledge implies that when we have measures of the two forms of metacognition, even at the online level, their different nature should be reflected in the structure of the measures used.

The measurement of metacognitive experiences and metacognitive knowledge

Measurement of subjective states, namely feelings, judgments / estimates, or ideas, depends on verbal reports and this poses all the problems related to introspection. These problems are known to psychology since the beginning of this century and pertain to the lack of reliability of verbal reports and, consequently, inability for prediction and control of behavior. However, the use of subjective reports along with other criterion responses, e.g., performance or physiological variables, allows the assessment of the effect of the independent variable on the ME and on behavior or the criterion response. It also allows the assessment of the degree of relationship between the criterion response and the ME measured. This relationship gives us a measure of the correspondence between the two types of response, e.g., performance and ME, and an estimate of the accuracy of the ME. This can be represented schematically in Figure 1 (see Nelson, 1996).

Our means for the measurement of ME is rating scales which capture the presence and/or intensity or strength of the feeling or judgment / estimate. Examples of such rating scales depicting feelings would be: "How familiar (or difficult) is this word (or task)?" 1: not at all; 2: a little; 3: enough; 4: very; or "How confident are you this is the correct answer?" (not at all; little; enough; very; 10%, 20%, ..., 50%, ... 100%); or "How

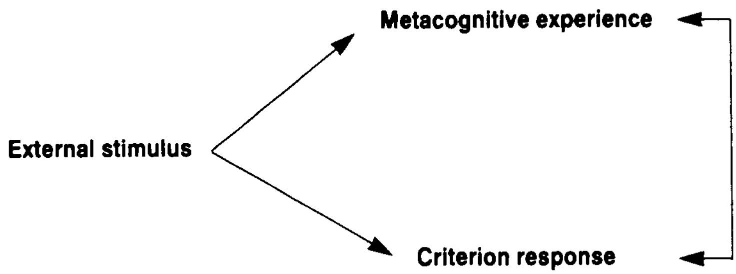

Figure 1
A schematic representation of the effects and relations to be studied in research on metacognitive experiences.

satisfied are you with the answer you gave? (not at all; little; enough; very); or «How recently did you encounter this word (or task)?" (more than a year ago; during the last 6 months; during the last month; this week). Of course, depending on the goal of the task, one could produce more detailed rating scales or comparative scales [e.g., "How similar do you think these two tasks are?" (not at all; little; enough; very)], etc. Furthermore, one could focus only on one ME or include measures of more ME related to the same task. In the latter case, the question is if we will treat the measures of the various ME as one single questionnaire addressing the multiple manifestations of the same underlying monitoring process or as a set of independent measures that capture different aspects of cognitive processing and which are not necessarily related to each other. An example of such a questionnaire investigating ME in problem solving is the following Metacognitive Experiences Questionnaire:

Metacognitive Experiences Questionnaire

The Metacognitive Experiences Questionnaire (MEQ) was constructed by Efklides and her collaborators and consists of two parts, the prospective with 12 items and the retrospective part with 11 items. The Metacognitive Experiences Questionnaire (MEQ) can be used to measure judgments / estimates and feelings (in the form of judgment regarding the relevant feeling) *prospectively*, that is, as soon as the person comes across the task (or problem to be solved) and before giving his/her answer. It can also be used after the planning of the solution to the problem and before the execution of the planned actions (or computations) (that is, during the solution). It can also be used *retrospectively*, that is, after the completion of the answer (or solution). The distinctive feature of the prospective and retrospective part is not only the time perspective (future or past) but the fact that some estimates are specific to the prospective part (e.g., the items regarding the familiarity[1] with the task) and some specific to the retrospective (e.g., the confidence and satisfaction items). Other items can be used both prospectively and retrospectively (e.g., the difficulty of the task / question). The Metacognitive Experiences Questionnaire (MEQ) can be restricted to measure estimates / judg-

Note 1. Feeling of familiarity in essence is a retrospective report regarding the person's past encounters with a stimulus or task. It is included, however, in the part of the questionnaire administered before actual problem solving, as prospective reform, because it regards the specific tasks to be solved.

ments and feelings only or be extended to include online ideas related to strategies used or to be used for the solution of the task. It is as follows:

I. Prospective reports

A. Measures of feelings and judgments / estimates

1. How familiar are you with this problem?
2. How frequently did you encounter such a problem in the past?
3. How recently did you encounter such a problem?
4. How much do you like this (kind of) problem?
5. How difficult do you think (or feel) the problem is?
6. How much effort do you think you need to exert in order to solve the problem?
7. How much time do you think you need in order to solve the problem?
8. How correctly do you think you can solve this problem?

B. Measures of metacognitive ideas

1. How much do you think you need to "think" in order to solve the problem?
2. How much do you think you need to use some rules in order to solve the problem?
3. How much do you think you need to do the computations right?
4. How much do you think you need to have help from someone else in order to solve the problem?

II. Retrospective reports

A. Measures of feelings and judgments / estimates

1. How much did you like this problem?
2. How difficult do you think this problem was?
3. How much effort did you have to exert in order to solve this problem?
4. How much time did you need in order to solve this problem?
5. How correctly do you think you solved this problem?
6. How confident are you that you solved it correctly?
7. How satisfied are you with the solution you provided?

B. Measures of metacognitive ideas

1. How much did you have to "think" in order to solve this problem?
2. How much did you need to use rules in order to solve this problem?
3. How much did you need to do the computations right?
4. How much did you need help from someone else in order to solve it?

The answers to the questions are all on 4-point scales similar to the one given above, e.g., 1: not at all; 2: a little; 3: enough; 4: very.

Variations of this questionnaire were used in our studies, with the exact wording or number of items depending on the goals of the study (Dermitzaki & Efklides, 2000; Efklides, Pantazi, & Yazkoulidou, 2000; Efklides, 1998; Efklides, Papadaki et al., 1997, 1998, 1999; Efklides, Samara, & Petropoulou, 1999; Georgiadis & Efklides, 2000; Metallidou & Efklides, 1999, 2000).

The structure of the Metacognitive Experiences Questionnaire

According to the theoretical framework outlined above, since metacognition is different from cognition, which is responsible for performance outcome, metacognitive measures should load a different factor than performance. Furthermore, one would expect MEQ to be multidimensional. Specifically, metacognitive knowledge (i.e., ideas) even measured at the online level, should form its own system, independent from ME (i.e., feelings and judgments / estimates). The rationale is that it originates from different processes than feelings and it is serving different purposes.

A second issue regards the estimates of the episodic aspects of cognition, which are not directly involved in the monitoring of goal attainment. For instance, the estimates of *where*, *when* and *how* of a piece of knowledge may be related to feeling of familiarity but not necessarily to feeling of difficulty, confidence or satisfaction, which are more directly related to fluency of processing and the match / mismatch between goal and current conditions.

A third issue raised with regard to MEQ pertains to the differentiation between prospective and retrospective reports. According to Nelson (1996), frontal lobe processing is critical for prospective monitoring judgments although not for retrospective monitoring judgments (p. 110). This implies that if diferent processes are involved in prospective and retrospective ME, then the prospective and retrospective part of MEQ should form distinct factors. However, it is not clear if the items, such as feeling of difficulty, which can be asked both prospectively and retrospectively, will be differentiated according to the phase of processing (pre/post problem solving) or a different factor.

Finally, independently of the structure of MEQ, which is determined by the specific features of metacognitive experiences, another factor that might influence the structure and reliability of metacognitive experiences measures is stimulus characteristics themselves. Frijda (1986) identified (task) difficulty as a condition directly related to the elicitation of emotions. In our research (Efklides, Papadaki et al., 1997, 1998, 1999; Efklides, Pantazi, & Yazkoulidou, 2000; Efklides, Samara, & Petropoulou, 1999; Ευκλείδη, Σαμαρά, & Πετροπούλου, 1996) we systematically worked with tasks of different levels of difficulty. Task difficulty was defined in terms of procedural or conceptual complexity in mathematical problems and in the case of verbal material, i.e., words, in terms of association value.

The above considerations lead to the following predictions:

1. If MEQ is used along with performance measures, MEQ items should load different factors than cognitive performance, because they tap metacognition rather than cognition. Furthermore, if metacognitive measures are used along with measures of emotion, they should also load different factors.

2. The prospective part of MEQ should load a different factor than the retrospective part.

3. The estimates regarding episodic aspects of cognitive processing should form their own factor.

4. Feelings and estimates related to cognitive processing, i.e., metacognitive experiences, should form a different factor than metacognitive knowledge.

5. The above structure should be influenced by task difficulty.

Findings. Previous research of ours involving a questionnaire on cognitive aspects of the self (metacognitive knowledge) and ME showed that metacognitive knowledge was differentiated from ME, although they were both explained by a higher-order latent factor, namely metacognition (Dermitzaki & Efklides, 2000; Metallidou & Efklides, 2000). Furthermore, metacognition was differentiated from cognitive performance measures, a finding that confirms the assumed distinction between the two constructs. Metallidou and Efklides (2000) also showed that measures of emotion (e.g., anxiety and fear of failure) loaded a different latent factor than either cognition or metacognition. This finding confirms the metacognitive character of feelings rather than the emotional. However, in these studies metacognitive knowledge was not measured at the online level. Therefore the question of the differentiation between ME and metacognitive ideas remained.

In the three studies we are going to discuss here, ME and metacognitive knowledge were measured at the online level. These studies are: Efklides, Pantazi, and Yazkoulidou (2000), Efklides, Samara, and Petropoulou (1999), and Metallidou and Efklides (1999). The first study involved verbal tasks, whereas the second mathematical tasks, namely fractions and mathematical expressions. The third study involved mathematical word problems. The participants in the three studies were students of secondary school or university students. Separate factor analyses were performed on the data of the "easy" and "difficult" task in each study, in order to identify the possible task effects on the structure of the subjective reports. It should be noted, of course, that the "difficulty" of the tasks was always relative, that is, characterizing one task relative to the other. Exploratory factor analysis with principal component solution and varimax rotation was used to the data of each of the above studies. The findings of the factor analyses are shown in Tables 1 to 3.

With regard to the differentiation of cognition from metacognition, it was found that metacognitive measures loaded different factors than cognitive performance in the Efklides, Pantazi, and Yazkoulidou (2000) study, in which three performance measures were used. In the other two studies, there was only one performance item and this usually loaded the same factor with *retrospective* reports. Secondly, the prospective part of MEQ tended to load a different factor than the retrospective part (in all three studies) and, thirdly, the frequency and recency estimates tended to form their own factor which might also involve the familiarity item (Efklides, Pantazi, & Yazkoulidou, 2000).

Fourthly, items of feelings and estimates also tended to load different factors than online metacognitive knowledge items. However, this pattern was more clear in the Efklides, Samara, and Petropoulou (1999) study. In the Metallidou and Efklides (1999) study it was not so clear and the metacognitive knowledge items loaded different factors rather than one of their own.

Fifthly, retrospective feeling of difficulty tended to load the same factor with some metacognitive knowledge items. This implies a relationship of feeling of difficulty with control-related ideas as the ones tapped in the metacognitive knowledge items. Furthermore, feeling of difficulty tended to load the same factor with estimate of time spent on the task, or effort expenditure, which again reflect control decisions.

Finally, task difficulty did have some effect on the constitution of the factors although the pattern described above was preserved. Therefore it can be concluded that the predictions stated above were confirmed. Of course, more research is needed to confirm the structure of MEQ in studies with different samples or tasks.

The reliability of the Metacognitive Experiences Questionnaire

Having pointed out the structure of MEQ and the two basic distinctions between (a) prospective and retrospective reports and (b) ME (that is, feelings and judgments / estimates) and metacognitive knowledge / ideas, it is interesting to see how reliability indices vary along these two dimensions. Table 4 shows the variability of Cronbach's α reliability indices[2] as a function of task difficulty. Inspection of Table 4 reveals that the reliability indices ranged from about .40 to .90, but there is an easily discernible pattern in them. Firstly, prospective reports had lower α than the retrospective ones. Secondly, the reliability of the Metacognitive Experiences part of MEQ was higher than of the Metacognitive Knowledge part. This is understandable since the ideas involved in the questionnaire addressed different strategies, probably conflicting between them. Another plausible reason for the lack of satisfactory reliability of the Metacognitive Knowledge part of MEQ is that these ideas are called in from memory and the person is not always aware of the sources of his/her difficulty in processing and the strategies s/he is using to overcome the obstacles. Thirdly, task difficulty did affect the reliability indices of both the Metacognitive Expe-

Note 2. For the estimation of Cronbach's alpha, the negatively worded items, namely feeling of difficulty, estimate of effort, and estimate of time were transformed so that the property tapped by MEQ was processing fluency.

Table 1a
Factor analysis of MEQ in the easy task of the Efklides, Pantazi and Yazkoulidou (2000) study (*N* = 249), which involved verbal material

Phase items	Factor 1	Factor 2	Factor 3	Factor 4
Pre FOF		.765		
EOF		.589		
EOR		-.363		
FOK		.792		
FOD			.575	
FOC	.451	.677		
Performance (a)				.670
Performance (b)				.748
Performance (c)				.822
Post FOK	.600	.539		
FOD(a)			.751	
EOC(a)	.811			
FOS(a)	.799			
EOT(a)	.656			
FOD(b)			.766	
EOC(b)	.691			
FOS(b)	.808			
EOT(b)	.673			
FOD(c)			.656	
EOC(c)	.800			
FOS(c)	.784			
EOT(c)	.677			
Eigenvalue	8.220	2.110	1.550	1.364
% of variance	37.4	9.6	7.0	6.2

Note: The abbreviations used are as follows: FOF = Feeling of familiarity; EOF = Estimate of frequency; EOR = Estimate of recency; FOK = Feeling of knowing; FOL = Feeling of liking; FOD = Feeling of difficulty; EOT = Estimate of time; EOC = Estimate of solution correctness; FOC = Feeling of confidence; FOS = Feeling of satisfaction; (a) = Feeling or estimate while performing an associations task; (b) = Feeling or estimate while performing a sentence production task; (c) = Feeling or estimate while performing a definitions task; Pre = Before problem solving (prospective report); Post = After problem solving (retrospective report).

riences and the Metacognitive Knowledge parts, although not in a predictable way, because objective task diffuculty was not matched across studies. Finally, the reliability of the Metacognitive Experiences part of MEQ, when both the prospective and retrospective parts were taken together was very satisfactory ($\alpha > .800$).

It can be concluded then that the reliability data of MEQ caution us as to the use of metacognitive measures: Measures of online

Table 1b
Factor analysis of MEQ in the difficult task of the Efklides, Pantazi and Yazkoulidou (2000) study (*N* = 249), which involved verbal material

Phase items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Pre FOF		.866				
EOF		.547				-.484
EOR						.856
FOK		.826				
FOD			.485	-.478		
FOC		.809				
Performance (a)					.636	
Performance (b)					.710	
Performance (c)					.751	
Post FOK		.675				
FOD(a)			.684			
EOC(a)	.513					
FOS(a)	.744					
EOT(a)	.435			.622		
FOD(b)			.828			
EOC(b)	.588					
FOS(b)	.662					
EOT(b)				.765		
FOD(c)			.744			
EOC(c)	.828					
FOS(c)	.813					
EOT(c)	.508			.553		
Eigenvalue	6.363	2.252	1.817	1.495	1.071	1.021
% of variance	28.9	10.2	8.3	6.8	4.9	4.6

Note: The abbreviations used are as follows: FOF = Feeling of familiarity; EOF = Estimate of frequency; EOR = Estimate of recency; FOK = Feeling of knowing; FOL = Feeling of liking; FOD = Feeling of difficulty; EOT = Estimate of time; EOC = Estimate of solution correctness; FOC = Feeling of confidence; FOS = Feeling of satisfaction; (a) = Feeling or estimate while performing an associations task; (b) = Feeling or estimate while performing a sentence production task; (c) = Feeling or estimate while performing a definitions task; Pre = Before problem solving (prospective report); Post = After problem solving (retrospective report).

feelings and judgments / estimates are reliable whereas the measures of online metacognitive knowledge pertaining to the strategies related to mathematical problem solving are not.

However, despite the low reliability of the Metacognitive Knowledge part of MEQ it can be useful to include it in studies in which the relations between monitoring and control are investigated. This was done in the Efklides, Samara, and Petropoulou (1999) study, in which

Table 2a
Factor analysis of MEQ in the easy task of the Efklides, Samara and Petropoulou (1999) study (N = 277), which involved fractions

Phase items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Pre FOF			.373				
EOF						.723	
EOR						.732	
FOL							.776
FOD			-.436				
During FOD			-.761				
FOC	.445		.682				
EOC	.468		.624				
EOT			.638				
Need for rule				.700			
Need for correct operations				.576			
Need for practice				.737			
Need to think				.625			
Need for help from others					.771		
Performance	.472						.461
Post FOD		.717					
FOC	.840						
EOC	.816						
EOT	.309	-.607					
FOS	.806						
Difficulty of rule		.561					
Difficulty of operations		.583					
Need for correct operations	.714						
Need for practice				.408			
Need to think				.444			
Need for help from others					.836		
Eigenvalue	7.797	2.549	1.826	1.540	1.419	1.113	1.032
% of variance	26.0	8.5	6.1	5.1	4.7	3.7	3.4

Note: The abbreviations used are as follows: FOF = Feeling of familiarity; EOF = Estimate of frequency; EOR = Estimate of recency; FOK = Feeling of knowing; FOL = Feeling of liking; FOD = Feeling of difficulty; EOT = Estimate of time; EOC = Estimate of solution correctness; FOC = Feeling of confidence; FOS = Feeling of satisfaction; Pre = Before problem solving (prospective report); Post = After problem solving (retrospective report).

Table 2b
Factor analysis of MEQ in the difficult task of the Efklides, Samara and Petropoulou (1999) study (N = 277), which involved mathematical expressions

Phase items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Pre FOF					.683		
EOF					.818		
EOR					.836		
FOL			.473				
FOD			-.475				
During FOD			-.645				
FOC			.728				
EOC	.418		.728				
EOT			.554				
Need for rule				.712			
Need for correct operations					.772		
Need for practice				.725			
Need to think				.680			
Need for help from others						.663	
Performance							.677
Post FOD		.812					
FOC	.817						
EOC	.816						
EOT	.628						
FOS							
Difficulty of rule		.749					
Difficulty of operations		.766					
Need for correct operations	.785						
Need for practice	.416						
Need to think		.577					
Need for help from others						.779	
Eigenvalue	8.456	3.462	2.219	1.809	1.250	1.173	1.058
% of variance	28.2	11.5	7.4	6.0	4.2	3.9	3.5

Note: The abbreviations used are as follows: FOF = Feeling of familiarity; EOF = Estimate of frequency; EOR = Estimate of recency; FOK = Feeling of knowing; FOL = Feeling of liking; FOD = Feeling of difficulty; EOT = Estimate of time; EOC = Estimate of solution correctness; FOC = Feeling of confidence; FOS = Feeling of satisfaction; Pre = Before problem solving (prospective report); Post = After problem solving (retrospective report).

Table 3a
Factor analysis of MEQ in the easy task of the Metallidou and Efklides (1999) study (*N* = 572), which involved mathematical word problems

Phase items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Pre FOF		-.487				
EOF						.882
EOR						.815
FOL		-.354		.749		
Intention				.826		
FOD		.739				
EOE		.790				
EOT		.777				
EOC		-.596				
Need for rule					.707	
Need for correct operations					.524	
Need for practice						
Need to think						
Need for help from others		.605				
Performance	.700					
Post FOL	.476	.489		.634		
FOD	-.628	-.614	.403			
EOE	-.442	-.454	.620			
EOT			.710			
EOC	.851	.815				
FOC	.856	.815				
FOS	.843	.826				
Need for rule					.748	
Need for correct operations					.623	
Need for practice						
Need to think			.641			
Need for help from others			.742			
Eigenvalue	8.037	2.275	1.780	1.439	1.292	1.132
% of variance	32.1	9.1	7.1	5.8	5.2	4.5

Note: The abbreviations used are as follows: FOF = Feeling of familiarity; EOF = Estimate of frequency; EOR = Estimate of recency; FOK = Feeling of knowing; FOL = Feeling of liking; FOD = Feeling of difficulty; EOE = Estimate of effort; EOT = Estimate of time; EOC = Estimate of solution correctness; FOC = Feeling of confidence; FOS = Feeling of satisfaction; Pre = Before problem solving (prospective report); Post = After problem solving (retrospective report).

Table 3b
Factor analysis of MEQ in the difficult task of the Metallidou and Efklides (1999) study (*N* = 572), which involved mathematical word problems

Phase items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Pre FOF	-.424				.431		
EOF					.794		
EOR					.865		
FOL				.762			
Intention				.838			
FOD	.805						
EOE	.736						
EOT	.687						
EOC	-.543	.420					
Need for rule						.793	
Need for correct operations							.829
Need to think							
Need for help from others	.664						
Performance	-.435						
Post FOL		.418		.613			
FOD		-.511	.552				
EOE			.769				
EOT			.792				
EOC		.819					
FOS		.854					
FOC		.814					
Need for rule				.792			
Need for correct operations							.723
Need for practice		.478					
Need to think			.693				
Need for help from others						.442	
Eigenvalue	7.181	2.824	1.796	1.381	1.218	1.112	1.034
% of variance	28.7	11.3	7.2	5.5	4.9	4.4	4.1

Note: The abbreviations used are as follows: FOF = Feeling of familiarity; EOF = Estimate of frequency; EOR = Estimate of recency; FOK = Feeling of knowing; FOL = Feeling of liking; FOD = Feeling of difficulty; EOE = Estimate of effort; EOT = Estimate of time; EOC = Estimate of solution correctness; FOC = Feeling of confidence; FOS = Feeling of satisfaction; Pre = Before problem solving (prospective report); Post = After problem solving (retrospective report).

Table 4
Cronbach's α reliability indices of MEQ

		Pre			Post			Pre and Post		
Study	Task	ME	MK	Both	ME	MK	Both	ME	MK	Both
1	E	.636	–	–	.887	–	–	.842	–	–
	D	.500	–	–	.855	–	–	.893	–	–
2	E	.663	.632	.541	.853	.323	.452	.812	.647	.644
	D	.851	.666	.733	.878	.553	.668	.890	.694	.777
3	E	.771	.451	.446	.905	.509	.683	.890	.673	.728
	D	.791	.518	.719	.729	.520	.656	.887	.625	.729

Note: Study 1: Efklides, Pantazi, and Yazkoulidou (2000) (N = 274); Study 2: Efklides, Samara, and Petropoulou (1999) (N = 249); Study 3: Metallidou and Efklides (1999) (N = 572); E = easy; D = difficult; ME = metacognitive experiences; MK = metacognitive knowledge; Pre = prospective report; Post = retrospective report.

was found that feeling of difficulty was related to different strategies or control ideas depending on the phase of processing and task difficulty.

Relations of metacognitive measures with performance

We already mentioned in the chapter on the measurement of ME and metacognitive knowledge that in studies in which metacognitive responses are investigated, we are interested in two types of effects: (a) the effect of the independent variable on the ME and the criterion response and (b) the degree of relationship between the criterion response and the ME studied. This relationship is a measure of the accuracy of the ME. We already showed that there can be reliable measurement of ME. Therefore, the question is if the ME we measured were also reliable evaluations of cognitive processing. That is, if they reveal the effects of the independent variable and if there is relationship between ME and performance.

Effect of the independent variable. The independent variable we studied was objective task difficulty. We already saw the effect of this variable on both the structure and reliability of MEQ, which means that there is such an effect of the independent variable on ME. Mean scores of the various ME were also found to differ significantly between tasks differing in their level of difficulty (see Efklides, Papadaki et al. 1997, 1998, 1999) and phases of task processing (Efklides, Samara, & Petropoulou, 1999; Ευκλείδη, Σαμαρά, & Πετροπούλου, 1996). Table 5 and 6 show the findings of two of our studies: Efklides, Samara, and Petropoulou (1999) and the Efklides, Pantazi, and Yazkoulidou (2000) study.

As shown in Tables 5 and 6, task difficulty did have an effect on both performance and ME. Performance on difficult tasks was lower than performance on the easy tasks: metacognitive experiences followed a similar pattern: higher estimates of feeling of difficulty and lower estimates of feeling of familiarity, confidence and satisfaction for the difficult task in comparison to the easy one. However, there is a notable exception to these data. The "easy" task in the Efklides, Samara, and Petropoulou (1999) study was obviously a deceptively "easy" task, since performance on it was as low as on the difficult

Table 5
Mean performance and metacognitive experiences measures and standard deviations (in parentheses) as a function of task and phase of processing in the Efklides, Samara, and Petropoulou (1999) study

Phase / Task	Pre E	Pre D	During E	During D	Post E	Post D	Performance E	Performance D
FOF	3.416 (1.772)	3.212 (1.847)					.609 (.744)	.781 (.687)
FOL	2.350 (1.035)	2.182 (1.036)						
EOR	2.307 (.873)	2.668 (.907)						
EOF	2.161 (.849)	2.434 (.896)						
FOD	1.467 (.722)	2.215 (.839)	1.613 (.666)	2.161 (.854)	1.876 (.838)	2.095 (.917)		
EOC			3.263 (.714)	2.891 (.875)	3.044 (.905)	2.836 (.971)		
FOC			3.292 (.733)	2.916 (.814)	2.953 (.878)	2.803 (.929)		
FOS					3.015 (.895)	2.799 (.968)		

Note: The abbreviations used are as follows: FOF = Feeling of familiarity; EOF = Estimate of frequency; EOR = Estimate of recency; FOL = Feeling of liking; FOD = Feeling of difficulty; EOC = Estimate of solution correctness; FOC = Feeling of confidence; FOS = Feeling of satisfaction; Pre = Before problem solving (prospective report); Post = After problem solving (retrospective report). E = Easy; D = Difficult.

task, but the prospective ME indicated that it was considered an easy task. This was probably due to the fact that students were familiar with fractions but the procedures required for the solution of the task were not available. Yet, these initial estimates were revised as processing progressed and thus the retrospective reports were much more realistic. That is, retrospective feeling of difficulty was higher than the prospective. These findings suggest that prospective ME are quite reliable indicators of the subjective evaluations of the task requirements in processing but they can be misleading in some cases.

Relationship of metacognitive experiences with performance. As regards the relationship of ME with performance, in this presentation we shall concentrate only on research findings regarding the relationship of feeling of difficulty (FOD) with performance. In the Efklides, Papadaki et al. study (1997, 1998) we found that this relationship is generally low to very low. In fact, it is nonexistent in the case of very difficult tasks; the best correspondence being in the case of moderate difficulty tasks (see Figure 2). Does this imply that FOD is a non-reliable or inaccurate indicator of cognitive processing? At first sight, yes.

Table 6

Mean performance and metacognitive experiences measures and standard deviations (in parentheses) as a function of task and phase of processing in the Efklides, Pantazi, and Yazkoulidou study

Phase /	Pre		Post		Performance	
Task	E	D	E	D	E	D
FOF	3.137 (.964)	1.774 (.862)				
EOR	1.782 (.873)	2.661 (1.203)				
EOF	2.750 (.914)	1.625 (.759)				
FOD	1.810 (.940)	2.601 (1.048)				
FOC	2.907 (.967)	1.746 (.822)				
FOK	2.940 (.961)	1.766 (.887)	2.871 (1.026)	1.544 (.752)		
FOD(a)			2.194 (1.047)	2.964 (1.096)		
EOC(a)			2.621 (.947)	1.887 (1.000)		
FOS(a)			2.564 (1.020)	1.855 (1.028)		
EOT(a)			2.891 (1.069)	2.105 (1.112)		
FOD(b)			2.064 (.992)	2.875 (1.202)		
EOC(b)			2.661 (.989)	1.750 (.962)		
FOS(b)			2.637 (.991)	1.742 (.943)		
EOT(b)			2.613 (1.066)	2.004 (1.118)		
FOD(c)			2.153 (1.030)	2.673 (1.235)		
EOC(c)			2.577 (.974)	1.689 (.920)		
FOS(c)			2.665 (1.008)	1.718 (.927)		
EOT(c)			2.754 (1.113)	1.863 (1.032)		
Performance associations					1.319 (1.622)	.319 (.980)
Performance sentences					.690 (.996)	.008 (.090)
Performance definitions					.569 (.711)	.137 (.490)

Note: The abbreviations used are as follows: FOF = Feeling of familiarity; EOF = Estimate of frequency; EOR = Estimate of recency; FOK = Feeling of knowing; FOD = Feeling of difficulty; EOT = Estimate of time; EOC = Estimate of solution correctness; FOC = Feeling of confidence; FOS = Feeling of satisfaction; (a) = Feeling or estimate while performing an associations task; (b) = Feeling or estimate while performing a sentence production task; (c) = Feeling or estimate while performing a definitions task; Pre = Before problem solving (prospective report); Post = After problem solving (retrospective report). E = Easy; D = Difficult.

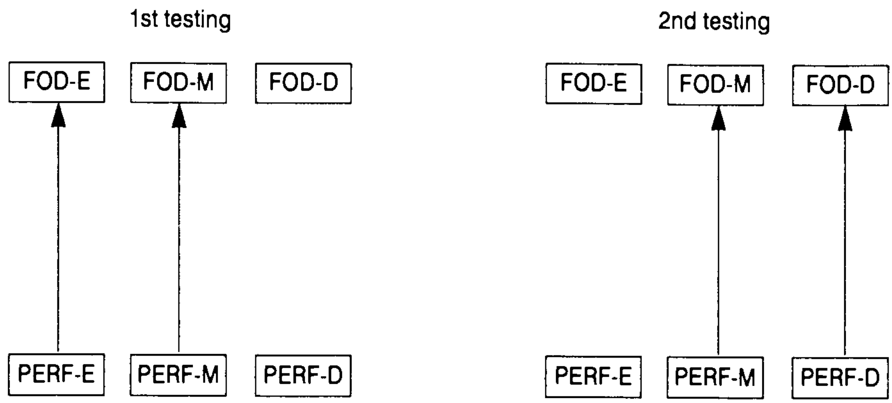

Figure 2
The relations between feelings of difficulty and performance (adapted from Efklides, 2001).

Note: The abbreviations used are as follows: FOD = Feeling of difficulty; PERF = Performance; e = Easy; M = Modevate; Δ = Difficult.

Indeed, people can have illusions about their cognitive processing (see Nelson, 1996; Whittlesea, 1993). They may consider a stimulus familiar because it looks like a stimulus that is already known (perceptual similarity), although they have never come across this particular stimulus before. Also, people may consider a task more or less difficult than it actually is, depending on how familiar it looks and how smooth processing seems to be. As a consequence, the metacognitive report does not always correlate with the criterion response or performance.

This lack of close relationship between FOD and performance is due to the fact that metacognition is a model of cognition and is influenced by factors not necessarily affecting current performance. For example, in our research FOD was found to be influenced, besides task difficulty, by cognitive ability and personality factors such as anxiety (Efklides, Papadaki et al., 1997, 1998, 1999), and by one's self-concept (Dermitzaki & Efklides, 2000). Furthermore, we found that ME are interrelated and form their own system (Efklides, Papadaki et al., 1997, 1998, 1999.) For example, feeling of familiarity influences FOD, and FOD influences the confidence and satisfaction from the solution produced as well as the estimates of effort (EOE) and time spent on the task (EOT). In fact, these interrelations can be stronger than the relations with performance. This suggests that ME are relative in nature, that is, they are influenced by other estimates and feelings experienced during cognitive processing. This explains the good reliability of MEQ, particularly of its retrospective part. The retrospective reports reflect a better grasp of the interrelations between ME and actual processing.

On the other hand, the nature of FOD itself explains why FOD is not systematically related to performance. Feeling of difficulty is an indicator of processing interruption. It does not guarantee that processing will be resumed and will be successful. It may or it may not activate sufficient control processes.

Therefore, if we stick to correlation between

FOD and performance and look only at the inconsistency of these data or their low values, then we may conclude that FOD (and probably other feelings) are not reliable indicators of cognitive processing. However, if we look at their function, that is, the monitoring of online cognitive processing and the initiation of the control processes needed, it is obvious that they are particularly important for cognitive processing. This is so because as processing goes on, ME are revised in face of new processing data (see Efklides, Samara, & Petropoulou, 1999; Ευκλείδη, Σαμαρά, & Πετροπούλου, 1996). Thus, even if the person is ill-informed about the prospects of cognitive processing at the beginning, as s/he gets involved into cognitive processing, the monitoring of data processing is becoming all the more accurate and the control decisions more appropriate. With one exception: Students who turn to others for help right from the beginning of problem solving, they may not benefit from their own revised subjective experiences, because they remain, even after problem solving, to their initial conception of the problem as being difficult and out of their control.

Conclusions

The issue we raised in this presentation regarded the reliability of subjective evaluations of cognitive processing. These subjective evaluations take the form of ME, that is, feelings and judgments / estimates that are experienced before, during and after cognitive processing. Their role is to monitor cognitive processing and trigger control decisions aiming at the securing of the achievement of the goal set. These control decisions can be made automatically or consciously based on the information provided by one's feelings, judgments and ideas.

Our data showed, firstly, that it is essential to distinguish prospective from retrospective reports. The core elements of the prospective experiences is feeling of familiarity, which informs the person about the expected fluency of processing, and feeling of difficulty which informs about the possible obstacles to the processing. These two feelings, and particularly feeling of familiarity, contribute to the formation of the feeling of knowing, of liking and the intention to go on or give up the processing of the task. Feeling of difficulty, on the other hand, is related to estimates (and decisions) on the effort and time to be spent on the task and the strategies to be used. Feeling of difficulty, however, unlike familiarity, is present throughout the processing of the task and is critical for control decisions.

Upon completion of the processing of the task, the evaluations regarding the achievement of the goal set prevail. The estimate of solution correctness is critical. This estimate is related to both feeling of confidence and feeling of satisfaction experienced with respect to the solution produced. Solution correctness has to do with the execution of the planned solution and the carrying out of the computational requirements of it. Based on the estimated solution correctness and the interruptions occurred during processing, that is, the feeling of difficulty (and possibly the estimate of effort and time required for completing the computations), the feeling of confidence on the solution produced is formed. The feeling of satisfaction is then formed based on both estimated solution correctness and feeling of confidence, because these two experiences reflect the extent to which the goal requirements and the accomplishment of the standards set were satisfied. Therefore, going beyond the distinction of "prospective-retrospective", one could argue for three main sets of ME: The first is around feeling of familiarity, the second around feeling of difficulty and the third around the estimate of solution correctness, feeling of confidence and feeling of satisfaction.

Secondly, our data showed that measures of ME, to a large extent, reflect differences between tasks or stimuli and correlate with performance. From this point of view they are reliable indicators of subjective evaluations or appraisals of cognitive processing. However, ME may be mistaken. They can be wrong in the case of very easy tasks where cognitive processing is automatic and there is no awareness of it, or in the case of unknown difficult tasks in which the person cannot define the goal, means and standards of the correct solution. They can also be wrong in the case of tasks where, despite high feeling of familiarity, the necessary procedures are not available in memory. Thus the person, based on the familiarity information, sets out confident that the goal will be achieved but during actual processing, when faced with interruption, s/he is forced to revise the original appraisals, particularly the ones regarding the difficulty of the task. Of course, revision of the initial evaluations occurs even in the case of difficult tasks, so that when they are solved, the person lowers the estimate of difficulty felt. After repeated involvement with difficult tasks, the evaluations are adapted and the person becomes better aware of task processing requirements. In this way the subjective evaluations or appraisals become more realistic.

Thirdly, ME are not a function of stimulus characteristics only. They are also influenced by one's cognitive ability and personality, as well as by one's self-concept and self-efficacy beliefs. They are also influenced by one's expertise in a domain and by individual difference factors, such as gender. Boys are usually more confident and more satisfied with the solution they produced than girls, at least in mathematical problems, although their performance is equal or lower than this of girls (Δερμιτζάκη, 1997; Efklides et al. 1997, 1998, 1999; Μεταλλίδου, 1996; Metallidou & Efklides, 1999). This implies that ME are a response of the perceived task characteristics and the person's perceived capability to deal with the task. They involve not only cognitive evaluations but also affective ones and this is exactly the feature that makes them unique.

In conclusion, the study of metacognitive feelings and / or judgments has important implications not only for experimental psychology and neuropsychology, but also for educational and social psychology, and for decision making. Of particular interest is the interaction of personal feelings with the feelings of others. The relation of feelings with coping responses and self-regulation is another area of interest. It seems that the decade of 1990s has paved the way for the integrated study of the person or, in other words, the cognitive, affective, and volitional aspects of the "psyche".

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