Available online at www.sciencedirect.com
SCIENCE DIRECT®
Educational Research Review 1 (2006) 3–14
Educational Research Review
www.elsevier.com/locate/EDUREV

Metacognition and affect: What can metacognitive experiences tell us about the learning process?☆

Anastasia Efklides *

School of Psychology, Aristotle University of Thessaloniki, 541 24 Thessaloniki, Greece

Received 24 September 2005; received in revised form 11 November 2005; accepted 22 November 2005

Abstract

This paper aims at highlighting the importance for learning of one of the facets of metacognition, namely metacognitive experiences (ME) that comprise feelings, judgments or estimates, and online task-specific knowledge. The emphasis is on the affective character of ME, which has received little attention in the past. Unlike online task-specific knowledge, which is conscious and analytic, the other ME are products of nonconscious, nonanalytic inferential processes. Because of their nature, ME can trigger either rapid, nonconscious control decisions or conscious analytic ones. However, ME can make use of both the affective and the cognitive regulatory loops, and this has a series of implications for learning. Evidence is presented regarding the relations of ME with affect and cognition, and the implications of the lack of accuracy of ME for the self-regulation of learning. Particular emphasis is given on judgment of learning, feeling of difficulty, and feeling of confidence. The challenges for future research on metacognition are underscored.

Keywords: Affect; Learning; Metacognition; Metacognitive experiences; Self-regulation

The title of this article refers to two distinct categories of psychological phenomena, namely metacognition and affect, and their effect on the learning process. The term "metacognition" is used to denote *cognition of cognition* (Flavell, 1979), whereas "affect" is a generic term for emotions and other mental states that have the quality of pleasant-unpleasant, such as feelings, mood, motives, or aspects of the self, e.g., self-esteem (Forgas, 1994). The relation of metacognition with learning was first posited by Flavell (1979) and, since then, there is growing research evidence that qualifies this relationship. Affect is also related to learning, as extant research on emotions has shown (Efklides & Volet, 2005; Pekrun, Goetz, Titz, & Perry, 2002). However, most of the studies focus either on metacognition or on affect, independently from each other.

The emphasis of this article is different. It is on one of the facets of metacognition, namely, on *metacognitive experiences* (ME; Efklides, 2001; Flavell, 1979), which have received little attention as regards their implications for the learning process—that is, from the moment the person comes across a learning task to its end. What I shall try to show is that ME and, especially, metacognitive feelings (Koriat & Levy-Sadot, 2000), have a dual character, that is, a cognitive and an affective one. This dual character gives them access to the respective regulatory loops that involve

☆ This paper is based on the keynote address of the author at the 10th Conference of the European Association for Research on Learning and Instruction, Padova, Italy, 2004.

* Tel.: +30 2310 997374; fax: +30 2310 997384.
E-mail address: efklides@psy.auth.gr.

1747-938X/$ – see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.edurev.2005.11.001

different processes for the self-regulation of behavior. Also, this dual character renders ME different from other facets of metacognition or from affect and, therefore, their study can lighten learning behaviors that were difficult to explain up to now.

In what follows I shall refer, first, to metacognition and its various facets; second, to metacognitive experiences and their conceptualization; third, to the relations of metacognitive experiences with affect, and fourth, to the implications of the functioning of ME for learning.

1. The facets of metacognition

Despite the fuzziness in the conceptualization of the term “metacognition” (Flavell, 1987), it is generally accepted that metacognition is a *model of cognition*, which acts at a meta-level and is related to the object-world (i.e., cognition) through the monitoring and control functions. The meta-level is informed by the object-world through the monitoring function and modifies the object-world through the control function (Nelson, 1996; Nelson & Narens, 1994). Thus, metacognition has a dual role: (a) It forms a representation of cognition based on monitoring processes; and (b) exerts control on cognition based on the representation of cognition. Yet, metacognition has many facets making difficult the distinction between monitoring and control and the setting of the line between these two functions. There are two basic manifestations of the monitoring function, namely, metacognitive knowledge and metacognitive experiences (Flavell, 1979). Metacognitive skills or use of strategies, on the other hand, are manifestations of the control function (Brown, 1978). (See Table 1 for a summary of the three facets of metacognition and their manifestations.)

Specifically, metacognitive knowledge (MK) is declarative knowledge about cognition, which we derive from long-term memory (Flavell, 1979). It comprises implicit or explicit knowledge or ideas, beliefs, and ‘theories’ about the *person* him/herself and the others as cognitive beings, and their relations with various cognitive tasks, goals, actions, or strategies. It also comprises knowledge of *tasks* (i.e., categories of tasks and their processing) as well as knowledge of *strategies* (i.e., general ways of task processing) (Flavell, 1979). Besides this, MK involves knowledge (i.e., beliefs, ideas, theories) about the various cognitive functions, such as memory or thinking, regarding what they are and how they operate, e.g., metamemory, metaattention, etc. (Fabricius & Schwanenflugel, 1994; Miller, 1985; Nelson, Kruglanski, & Jost, 1998; Wellman, 1983). It also comprises knowledge of the criteria of validity of knowledge, what is being called “epistemic cognition” (Kitchener, 1983). One could argue that theory of mind (see Bartsch & Wellman, 1995) is also an instance of MK, although the theorists in the field do not make this connection. The importance of MK is that it provides a framework for understanding one’s as well as the others’ cognition and thus guides the interpretation of situational data so that proper control decisions are made (see Nelson et al., 1998).

Table 1
The facets of metacognition and their manifestations as a function of monitoring and control

Monitoring		Control
Metacognitive knowledge	Metacognitive experiences	Metacognitive skills
Ideas, beliefs, ‘theories’ of	Feelings	Conscious, deliberate activities and use of strategies for
Person/self	Feeling of familiarity	Effort allocation
Task	Feeling of difficulty	Time allocation
Strategies	Feeling of knowing	Orientation/monitoring of task requirements/demands
Goals	Feeling of confidence	Planning
Cognitive functions (e.g., memory, attention, etc.)	Feeling of satisfaction	Check and regulation of cognitive processing
Validity of knowledge	Judgments/estimates	Evaluation of the processing outcome
Theory of mind	Judgment of learning	
	Source memory information	
	Estimate of effort	
	Estimate of time	
	Online task-specific knowledge	
	Task features	
	Procedures employed	

Metacognitive skills (MS) is procedural knowledge. It is what the person deliberately does to control cognition. They are part of the so called "executive processes" (Brown, 1987) or "metacognitive strategies" (Lompscher, 1994). They comprise activities such as orientation/monitoring the comprehension of task requirements, planning the steps to be taken for task processing, checking and regulating cognitive processing when it fails, and evaluating the outcome of processing (Veenman & Elshout, 1999). Pintrich, Wolters, and Baxter (2000) consider these skills as part of the self-regulation process, although we should be aware that self-regulation cannot be reduced to MS (Efklides, Niemivirta, & Yamauchi, 2003).

The critical question for the application of MS, however, is how does the person know when s/he needs to apply MS. Specifically, which are the cues making the person aware that the mode of processing, i.e., automatic cognitive processing, needs to be changed into a consciously controlled one? Extrinsic feedback can play this role. But there is also intrinsic feedback based on one's metacognitive experiences (Efklides & Dina, 2004; Flavell, 1979; Robinson, 1983). Metacognitive experiences (ME) comprise metacognitive feelings and metacognitive judgments/estimates that are based on the monitoring of task-processing features and/or of its outcome. They also involve online task-specific knowledge (Efklides, 2001).

Metacognitive experiences, or "concurrent metacognition" according to Hertzog and Dixon (1994), differ from MK and from MS. This is so because ME are present in working memory (Lories, Dardenne, & Yzerbyt, 1998), they are specific in scope – because they focus on very specific aspects of cognitive processing (Efklides, 2001) – and they can be affectively charged – in the case of metacognitive feelings, as the term "feeling" denotes (Frijda, 1986). According to Frijda (1986), feelings are products of the monitoring of good functioning and have the quality of pleasant or unpleasant. Thus, metacognitive feelings inform the person about a feature of cognitive processing, but they do it in an experiential way, that is, in the form of a feeling, such as feeling of knowing, feeling of confidence, etc. However, people make metacognitive judgments – such as judgment of learning (Dunlosky & Nelson, 1992) – as well as judgments about their metacognitive feelings and their source, e.g., the source of feeling of familiarity regarding a stimulus (Yzerbyt, Dardenne, & Leyens, 1998). They also make metacognitive judgments about the demands of cognitive processing, e.g., how much effort or time is needed (or was spent) for the processing of a task, or whether the outcome produced is correct (Efklides, 2001, 2002a).

Metacognitive feelings and metacognitive judgments are products of nonanalytic, nonconscious inferential processes (Bless & Stack, 1998; Koriat, 2000; Koriat & Levy-Sadot, 2000; Yzerbyt et al., 1998), particularly when there are conditions that do not allow full analysis of the situation, such as time pressure or lack of access to memory information, or under conditions of uncertainty. Yet, there are other metacognitive judgments that are products of analytic processes, such as those concerning task characteristics or demands and the procedures to be applied, as evidenced in online task-specific knowledge to be discussed later on (Efklides, 2001).

To illustrate how metacognitive feelings function, let us take an example. A person working on a learning task feels that the task is familiar and that task processing runs smoothly. Thus, task processing continues, without any change to it. On the contrary, the person feels unpleasantly if the task is difficult and the progress made in task processing is not the desired one. This negative affect, be it feeling of difficulty or feeling of dissatisfaction, calls for control decisions. These control decisions can be triggered automatically, without conscious awareness (Reder, 1987; Reder & Schunn, 1996), or consciously through the analysis of the situation based on one's MK (Efklides, Samara, & Petropoulou, 1999).

Online task-specific knowledge (Efklides, 2001) is indicative of conscious and analytic metacognitive judgments. It refers to what the person heeds when given a task. It is awareness of task characteristics and task-related MK regarding the task and strategies. It is present in thinking aloud verbal reports (Berardi-Coletta, Buyer, Dominowski, & Rellinger, 1995), in task comparisons, or in the analysis of worked out examples (Efklides, Kiorpelidou, & Kiosseoglou, in press-a; Renkl, 1999). Borkowski, Chan, and Muthukrishna (2000) use the term "task analysis" to refer to online task-specific knowledge, and consider this kind of analytical process as part of the executive processes, that is, of MS. This does not mean that online task-specific knowledge is not part of what the person is aware of during task processing. From this point of view, it is part of one's ME. The difference from other ME is that it focuses on the task and the procedures related to its processing rather than on the person's affective response to features of cognitive processing, such as fluency or interruption. This kind of online task-specific knowledge differentiates experts from novices (Chi, Bassok, Lewis, Reimann, & Glaser, 1989). Experts right from the beginning of task processing identify the critical task features and information, whereas novices refer to superficial task characteristics irrelevant to the procedures needed to deal with the task.

2. Metacognitive experiences

In our research we studied the role of ME in learning. The emphasis was on metacognitive feelings and metacognitive judgments/estimates that are present in learning situations such as problem solving in maths or text processing. Specifically, we use a series of single item measures tapping different features of task processing (Efklides, 2002a) at different points of task processing. These items refer to the following ME.

Feeling of familiarity, which regards the previous occurrence of a stimulus and denotes fluency of processing (Nelson et al., 1998; Whittlesea, 1993). *Feeling of difficulty* (Efklides, Papadaki, Papantoniou, & Kiosseoglou, 1997; Efklides, Papadaki, Papantoniou, & Kiosseoglou, 1998; Efklides et al., 1999), which monitors the conflict of responses (van Veen & Carter, 2002) or the interruption of processing, i.e., whether there is an error or lack of available response (Mandler, 1984). It ensues that the person needs to invest more effort, to spend more time on task processing, or to reorganize his/her response. Thus, whereas feeling of familiarity is associated with positive affect arising from the fluency in the accessibility[1] of the respective information, feeling of difficulty[2] is associated with negative affect (Efklides & Petkaki, 2005) arising from lack of fluency due to interruption of processing.

Feeling of difficulty is the product of the interaction of a variety of factors. These factors include:

(i) The objective task difficulty, in terms of task complexity or of conceptual demands (Efklides et al., 1997, 1998). Conceptual demands have to do with the content of the task and are a function of one's developmental level and/or of domain-specific knowledge. Cognitive load (Sweller, van Merrienboer, & Paas, 1998) is also a factor that has an impact on objective task difficulty (Efklides et al., in press-a).
(ii) Task context, that is, presence of other tasks (Efklides et al., 1997, 1998).
(iii) Person's characteristics, such as cognitive ability (Efklides et al., 1997, 1998).
(iv) One's self-concept (Dermitzaki & Efklides, 2001; Efklides & Tsiora, 2002).
(v) Affective factors, such as mood (Efklides, Kourkoulou, Mitsiou, & Ziliaskopoulou, in press-b; Efklides & Petkaki, 2005).
(vi) The affective tone of instructions, such as 'interesting' or 'difficult' (Efklides & Aretouli, 2003).
(vii) Extrinsic feedback valence (Efklides & Dina, 2004), i.e., whether it is positive or negative.

Furthermore, as task processing goes on initial feeling of difficulty ratings change, because they get updated depending on processing features such as fluency or interruption of processing. Thus, the reported feeling of difficulty during or after task processing can be higher, similar, or lower than the initial one (Efklides, 2002a; Efklides, Samara, & Petropoulou, 1996). It is also important that there can be "illusions of feeling of difficulty", meaning that objectively easy or difficult tasks are felt as difficult or easy, respectively (Efklides, 2002a). One source for such an illusion of feeling of difficulty is feeling of familiarity, which leads to an expectation of fluency of processing despite the objective task difficulty.

Two metacognitive judgments associated with feeling of difficulty are *estimate of effort* and *estimate of time* required for problem solving. The estimate of effort is mainly influenced by feeling of difficulty as well as by individual difference factors regarding effort allocation policy and mood (Efklides et al., in press-b; Efklides & Petkaki, 2005).

Other ME present in a problem solving situation are *judgment of solution correctness* along with *feeling of confidence* (Costermans, Lories, & Ansay, 1992) and *feeling of satisfaction* (Efklides, 2002a, 2002b). These three ME monitor the outcome of processing. Specifically, judgment of solution correctness focuses on the quality of the answer (correct or incorrect), while feeling of confidence monitors how the person reached the answer (fluently or with interruptions). Feeling of satisfaction monitors if the answer meets the person's criteria and standards regarding the quality of the answer (Efklides, 2002b).

[1] For the importance of accessibility as a cue in metacognitive judgments see Koriat (1997) and Metcalfe (2000) and also Kahneman (2003).

[2] A related judgment in metamemory research is *ease of learning* (Nelson & Narens, 1994), which is a prospective judgment regarding how easy it will be to learn a new material. Feeling of difficulty, however, is an affective reaction before, during, and after task processing, based on the monitoring of interruption of task processing rather than on cues related to the memorability of items to be learnt. Pintrich et al. (2000) identify ease of learning with judgment of task difficulty. However, a judgment of task difficulty can be an analytic judgment of task features (e.g., complexity) that is not identical to what the person experiences as ease of learning or feeling of difficulty.

The above description of ME suggests that they form clusters around the three basic phases of cognitive processing, that is, *initiation*, *planning and execution*, and *output* (Efklides, 2002a, 2002b). Specifically, feeling of familiarity is interrelated with the estimate of recency and of frequency of previous encounters with the stimulus as well as with other source memory judgments (Efklides, Pantazi, & Yazkoulidou, 2000; Efklides et al., 1996; for source memory see also Mitchell & Johnson, 2000). Feeling of difficulty correlates with the estimate of effort expenditure and time (to be) spent on the task, while the estimate of solution correctness correlates with feelings of confidence and satisfaction (Efklides, 2002a). Furthermore, feeling of familiarity is negatively related to prospective feeling of difficulty ratings, and retrospective feeling of difficulty is negatively related to the estimate of solution correctness and feeling of confidence (Efklides et al., 1996).

To sum up, metacognitive experiences form a distinct facet of metacognition, which is present when the person is processing a task. Our evidence suggests that ME are influenced by person, task, and context characteristics and, despite their interrelations, each of them conveys different information about features of cognitive processing. Thus, they form the interface between the task and the person, and inform the person on his/her progress on task processing and on the outcome produced.

3. Metacognitive experiences and affect

The presentation of feeling of difficulty and of other ME has made clear that ME are products of complex inferential processes that inform the person about features of cognitive processing. Specifically, ME monitor the progress being made towards one's goal and they convey this information in an affective or cognitive manner, as we shall see in what follows. This information can trigger the affective regulatory loop and/or the cognitive one, thus guiding the self-regulatory process in both the short and the long run.

Traditionally, emotion and cognition were considered separate, independent processes. However, all the more it is being realized that, at least in specific types of task, cognition and emotion co-exist in the processing of information and regulation of behavior (cf. Cacioppo & Berntson, 1999). Furthermore, there is growing neuropsychological evidence that the anterior cingulate cortex is associated with the regulation of both cognitive and emotional processing (Bush, Luu, & Posner, 2000). This is exactly the area also involved in metacognitive processes (Fernandez-Duque, Baird, & Posner, 2000). Thus, in order to understand the functioning of ME we need to take into consideration both the cognitive and affective loop of regulation.

One theory that links affect with "meta-" level processes and explains the role of affect in the regulation of cognition is the one proposed by Carver and Scheier (1998) and Carver (2003). This theory posits two basic types of feedback loops: one feedback loop informs on the attainment of one's goal, whereas the second monitors the rate of progress toward one's goal. This is a metalevel feedback loop that manifests subjectively as affect and as a hazy sense of expectancy. Positive affect arises when the rate is faster than anticipated and negative when it is slower. If the rate is as anticipated, no affect is experienced.

From a metacognitive point of view, ME that monitor the outcome of processing – namely, estimate of solution correctness, feeling of confidence, and feeling of satisfaction – are presumably products of the feedback loop that is related to goal attainment. Metacognitive experiences possibly related to the metaloop that monitors the rate of progress towards goal attainment is feeling of familiarity, feeling of difficulty, estimate of time and estimate of effort. In this case we can assume that the cue that informs about the rate of progress towards goal attainment is fluency or interruption of processing—"error signal" in Carver's (2003) terms. Affective valence is the subjective manifestation of the error signal (Carver, 2003), whereas awareness of high concentration on the task, or of high intensity of effort are subjective indicators of the process of adjustment of the progress rate. Negative feelings inform the person that more effort is needed in order to attain his/her goal or even that the goal should be abandoned if the experienced difficulty cannot be surpassed (Carver & Scheier, 1998). Positive feelings, on the other hand, inform that there is a discrepancy in the positive direction and, therefore, effort can be reduced. This easing on effort brings back the system to the desired rate of progress towards the focal goal and, at the same time, frees resources to be invested in the achievement of other possible goals. Of course, as positive affect fades away, the person goes back to the focal goal activity, or turns to another goal domain if the initial goal has been attained, or an unexpected opportunity is identified (Carver, 2003).

Is there evidence in ME research that supports such a conception of the role of positive affect? Our study (Efklides & Dina, 2004) on the effect of extrinsic feedback (EF) on ME seems to do so. In this study we found that positive EF (i.e., success EF, which presumably raised positive affect) lowered the reported feeling of difficulty right after EF was administered; it also led to lower reports of effort exertion. On a second testing, about two weeks later, on the same tasks, the reported feeling of difficulty was substantially increased and so did the estimate of effort. Thus, there was resumption of effort when the students came across the actual demands of the task. In the negative EF group (i.e., failure EF, which presumably raised negative affect) there was increase of the reported feeling of difficulty right after EF was administered. This initial high level of feeling of difficulty was relatively decreased in the second testing, when task demands were reassessed, but still the overall reported feeling of difficulty was higher than that of the positive EF group. The reported estimate of effort in this group was maintained at the same levels as in the initial testing. This finding suggests no easing on effort when negative affect is present. It is worth noting that there was no increase of effort, as one would expect. One possible reason is that negative affect limits the available resources to be invested in the task, so no extra effort was allocated to it. Finally, the reported feeling of difficulty and estimate of effort in the control group (i.e., no EF group) remained more or less the same in the two testing waves. This finding suggests that students did not experience significant changes of affect that would lead them to revise their ME and the ensued control decisions regarding effort.

On the other hand, Fredrickson (2001) maintained that pleasure is a sign to continue one's ongoing activity, to go deeper in processing, to get more engaged with it. Such a function of affect seems contrary to the easing on effort and coasting behavior (Carver, 2003) that imply a temporary disengagement from one's focal goal. Our findings in the above study (Efklides & Dina, 2004) suggest that both viewpoints about positive affect are valid. The initial easing on effort is restored at subsequent encounters with the same task, and because positive affect is a cue that things run smoothly and are manageable, the person can immerse more deeply into task processing without feeling any strain.

In another of our studies (Efklides & Petkaki, 2005), we found that interest and feeling of liking of a task after the person had concluded working on it were predicted by positive mood. The estimate of effort was also predicted by positive mood, only that the relation was negative. These findings suggest that positive affect, on the one hand, eases the person's effort exertion and, on the other, increases interest and feeling of liking, thus supporting future engagement with the same or similar tasks. At the same time, positive mood counteracted the effects of negative mood on feeling of difficulty and feeling of confidence, and predicted the reported feeling of satisfaction from the outcome of task processing. These findings imply that positive and negative affect, through their interaction with ME, have an immediate effect on the self-regulation of ongoing activity as well as on the person's emotions that endorse engagement with or disengagement from one's goal. Considering that ME feed back on one's self-concept (Efklides & Tsiora, 2002) and have an impact on causal attributions (Metallidou & Efklides, 2001), it becomes evident that task-specific affect, as experienced in ME, influences personality characteristics and through them the long-term regulation of behavior.

The beneficial effects of positive affect and of self-beliefs on one's experiences (in our case ME) has been also noted by Aspinwall (1998) and Isen (2000), who claim that positive affect enriches one's resources and this permits people to confront problem situations. Research in social psychology has shown that positive affect related to a task can have an effect on the processing of other tasks as well (Trope & Pomerantz, 1998). Thus, it allows people to go beyond their current goal, be creative, use divergent and unusual associations, elaborate more, and thus increase cognitive flexibility (Fredrickson, 2001; Isen, 2000; Kuhl, 2001). On the contrary, negative affect increases critical thinking and narrows attentional focus so that resources are used to face the problematic situation (Fredrickson, 2001; Kuhl, 2001). It is interesting that in the Efklides and Petkaki (2005) study the estimate of solution correctness was predicted by negative affect, probably because one needs to employ his/her critical abilities in order to assess the correctness of the outcome of task processing. Also, in the Efklides and Dina (2004) study, when extrinsic feedback was inconsistent with students' performance and, therefore, inconsistent to their intrinsic feedback, as reflected in the ME, there was increase of anxiety state. This is an emotion that narrows attention to a situation that can be potentially harmful (for a discussion see Carver, 2003).

To sum up, I presented evidence from research on ME which is consistent with theories on affect and which suggests that ME can be part of both the negative- and positive-affect regulatory loop. However, we need to remember that ME are different from free-floating affect, such as mood, as well as from emotions that arise in response to stimuli other than those that trigger ME (for the differential theory of emotions, see Izard, 1977). Metacognitive experiences convey different information than other affective responses do and their 'privileged' access to the cognitive loop of regulation gives them the possibility to use other forms of control of behavior than affect does, as we shall see below.

4. Metacognitive experiences and cognition

As Flavell (1979) and other early researchers on metacognition (Brown, 1978; Robinson, 1983) had suggested, ME have a direct effect on cognition. This is done through their effect on metacognitive knowledge as well as on control decisions regarding strategy use. Efklides et al. (1999) showed that as task processing progressed the relations of students' feeling of difficulty with metacognitive knowledge regarding strategies used in maths problem-solving changed. Thus, students' responses indicated different priorities of strategies before solving the problem, during the planning of the solution, and after problem solving.

The regulatory function of ME through the cognitive loop has been extensively studied. What is less investigated is the effect of ME on other's cognition. Iiskala, Vauras, and Lehtinen (2004) showed that collaborating peers in problem solving co-regulate their learning on cues from ME of their partner. Salonen, Vauras, and Efklides (2005) further showed this effect of ME that reveals the social aspect of metacognition. Thus, ME are an essential component of the self-regulation process as well as of the co-regulation or shared-regulation of cognition. This is so, because the experiential part of metacognition as reflected in nonverbal behaviors, such as gaze, pause, smile, etc., other manifestations of ME, e.g., false alarm versus correct responses (Brown, 1978), and the person's verbal utterances are cues for the person's underlying cognition and affect. This kind of metacognitive and cognitive information is important for the successful communication and co-regulation of the joint activity of interacting persons. Thus, ME are products of the monitoring of the person's cognition and have an effect on the control of both the person's and the others' cognition.

It can be concluded, then, that ME through their association with affect and cognition have a unique place in the self-, as well as in the co-regulation of behavior. In what follows, we shall concentrate on specific ME and their impact on learning.

5. Implications for the learning process

Having outlined the affective and cognitive modes of regulation through which ME effect behavior, we come now to some intuitive or counterintuitive implications the functioning of ME has for the learning process. There are two issues that are of importance here: the accuracy of ME and the effects of the particular ME on learning.

The accuracy of ME (Efklides, 2002a; Nelson, 1996) is a very important issue because it has a bearing on the efficiency of the control decisions in learning situations with respect to effort allocation, time investment, or strategy use. The accuracy of ME is defined in terms of the correlation of ME with performance (Nelson, 1996). Extant evidence suggests that the accuracy of ME is often low, but improves with practice on the task. This is a calibration process that helps people tune their ME with performance.

There are various possible reasons why a metacognitive judgment is not accurate. The first one is that ME are based on nonconscious, heuristic, inferential processes that make use of various cues, which regard the task and its presentation or the fluency of processing (Koriat, 1997; see also Whittlesea, 1993). People take into consideration the following cues (see Koriat, 1997): (a) *Extrinsic*, such as the number of learning trials or time allowed, the context, etc. (b) *Intrinsic*, such as the features of the learning material (that is, whether it is connected or not), particular words used, etc. (c) *Mnemonic*, such as fluency in the retrieval of the answer, effort invested on a task, etc. Furthermore, there are personality characteristics and other individual-difference factors that have an impact on ME (Efklides et al., 1997, 1998; Efklides & Tsiora, 2002), probably through their effect on the fluency of processing and/or on attributional processes.

Evidently, the salience of any of the above cues or the prevalence of a personality characteristic can bias the person's judgment towards particular cues at the expense of others. This issue is the object of research related to judgment of learning and effort allocation (Koriat, 1997; Mazzoni & Cornoldi, 1993; Nelson, 1993; Nelson & Dunlosky, 1991). Effort allocation in this case has to do with spending more time on the study of items that are hard to memorize. Thus, if we ask students to make a judgment of learning while the required information is in their short-term memory, the mnemonic cue of fluency is highly salient and leads students to report a high judgment of learning. However, if recall is made after 10 min of the presentation of the task (i.e., when the information has to be retrieved from long-term memory), then the required information may not be easily accessible or available. As a consequence, there is mismatch between the initial judgment of learning and performance (Nelson & Dunlosky, 1991). On the other hand, the accuracy of judgment of learning is improved if the phrasing of the respective question leads the person to use mnemonic cues specific to the information that should be recalled. For example, the question "*How many* instances of X category will you be able to recall . . .?" leads to more accurate judgment of learning as compared to the question "How confident are you that you will recall members of X category . . .?" (Keleman, 2000).

The implications of the above findings for learning in the classroom are straightforward. If the teacher's timing or phrasing of the questions regarding judgment of learning is such that leads to an inaccurate judgment, then the student will regulate effort accordingly, and this will have effects on their learning. For instance, young students often cannot accurately judge how well they learnt a lesson. They think they have learnt the lesson in school, and do not want to study more at home, simply because they had fluently answered the teacher's question on it in the classroom as soon as he/she had provided the relevant information and it was available in their short-term memory. As a consequence, they fail to retrieve that piece of information when they are tested, later on, because it is not available in long-term memory. Furthermore, this memory failure may lead students to attribute it to the time that elapsed between presentation and recall and, thus, to believe that they should study only right before the exam (or the testing) in order to be able to recall it. This is not, however, a strategy that is conducive to comprehension and deeper elaboration of concepts. Thus, students gradually – possibly with the help of teachers or parents – learn to differentiate the meaning of their ME as well as their beliefs and strategies so that they match the demands of the tasks and the situations. In this way, metacognitive knowledge regarding the functioning of memory is getting enriched and students develop a multitude of strategies to achieve learning (Brown, 1978; Fabricius & Schwanenflugel, 1994).

Another important for learning ME is feeling of difficulty. As we have found, it usually correlates with performance (Efklides et al., 1997, 1998). This finding suggests that feeling of difficulty is fairly accurate. However, the correlation is higher in the case of objectively moderate difficulty tasks than in the case of objectively low or high difficulty tasks. In the case of easy tasks, the required response is immediately available and, therefore, there is no basis for a judgment on experienced difficulty. If there is any feeling of difficulty at all, this might be due to extrinsic cues rather than to mnemonic ones. Thus, the reported feeling of difficulty has nothing to do with the procedural knowledge that controls performance.

On the other hand, if the task is very difficult there are three possibilities: (a) Feeling of difficulty is high, and because it is associated with negative affect, the person quits the task. (b) The negative affect is high but there are some mnemonic cues regarding the source of difficulty, and this facilitates access to procedures that one can use to overcome the difficulty. This may lead to successful or unsuccessful performance, a situation that renders to the correlation between the reported feeling of difficulty and performance low. (c) Feeling of difficulty is low, despite the objective difficulty of the task, because there is an illusion of feeling of difficulty. This illusion manifests because the task looks familiar to the student or the student does not understand the task demands. As a consequence, the student fails to invest the necessary effort in order to deal successfully with the task and performance is low. For all the above reasons, there is no association between the reported feeling of difficulty and performance on objectively very difficult tasks.

However, there is a calibration of the reported feeling of difficulty in case the person is repeatedly exposed to the task or develops expertise (Efklides et al., 1997, 1998). This calibration is associated with higher feeling of familiarity, better analysis and comprehension of task demands and, consequently, to better regulation of behavior and action.

On the other hand, the teacher's scaffolding of students' learning or peers' cognitive and metacognitive support can alleviate feeling of difficulty through the instructions or hints that make students aware of critical cues regarding the required information or procedures for the solution of the problem. Worked out examples is one such means that can help students (Renkl, 1999). However, as we found (Efklides et al., in press-a) worked out examples can increase feeling of difficulty, rather than decrease it, in case the cognitive load they impose is too much for the students. Of course, if students rely completely on ready made answers for the solution *of* problems or on other people's help for dealing with a task, then they do not capitalize on their ME, they do not elaborate on the source of difficulty, and they do not associate their ME with strategies or with procedural knowledge that can resolve the problem they face (Efklides et al., 1999). Thus, students do not 'learn' from their ME and cannot regulate their future behavior and action successfully.

Feeling of confidence is another ME that has significant implications for learning. Confidence is a very powerful cue regarding the reliability of one's knowledge (Allwood & Granhag, 1996). Lack of confidence or underconfidence makes the person either hesitant to further pursue a goal or even to uncritically adopt other people's viewpoints particularly when these people are very confident in their views. High feeling of confidence or overconfidence, on the other hand, makes one more decisive but at the same time less critical of one's decisions. This may lead to lowered vigilance, incomplete examination of data and evidence, and increased number of mistakes. Brown (1978) found that children often require a high degree of confidence in order to give an answer, at least in recognition tasks, but what is even more interesting is that there are children who develop "underconfidence" as a personality trait of themselves as learners

(Bouffard et al., 2004). These children believe that they cannot learn although both their ability and performance is satisfactory. Conversely, there are children, as well as adults, who are overconfident in their response although they are totally ignorant of a topic. This overestimation of their knowledge or of their abilities suggests lack of metacognitive awareness of their deficits in knowledge and leads to ineffective self-regulation (Kruger & Dunning, 1999).

Calibration of feeling of confidence is, consequently, very important. Awareness of alternative options, hypotheses, or answers to a question makes the person more confident in their response, and the reported feeling confidence is highly accurate. Underestimation of alternative answers leads to overconfidence (McKenzie, 1998). What is counter-intuitive, however, is that repetition of a task and excessive practice may lead to underconfidence (Koriat et al., 2002). This may be due to the fact that repetition of the task, although the person is doing well on it, leads to an attribution of lack of ability that leads to underconfidence.

To sum up, the impact of ME on the self-regulation of learning is significant, but not always positive. Future research should investigate the conditions that render ME accurate and beneficial for learning. The role of person characteristics, the task, the context, as well as of the others in the accuracy of ME is a particularly challenging research issue.

6. Conclusions

As we mentioned in the introductory section, the aim of this article was to bring to the fore ME, particularly metacognitive feelings, which have a distinct characteristic, namely the connection with both the cognitive and affective regulatory loops. The affective nature of ME has not been widely recognized up to now, but a growing body of research evidence in neuropsychology of metacognition and in self-regulation supports such a notion (Carver, 2003; Carver & Scheier, 1998). Thus, metacognitive feelings and metacognitive judgments are products of nonconscious, nonanalytic inferential processes and lead to nonconscious rapid control decisions (Reder & Schunn, 1996) that can be mediated by affective processes, or to conscious, explicit decisions (Koriat & Levy-Sadot, 2000) based on analytical processes. Also, ME are transitory and highly sensitive to person, task, situation and context effects, rendering them highly variable. As a consequence, the information they convey is not always accurate, or may go unnoticed or, even, be misinterpreted. This implies that one has to 'learn' the meaning of his/her ME and understand the conditions that give rise to them if s/he is to be in charge of his/her cognition. This assumption does not mean that the use of the affective or the cognitive regulatory mode, in exclusion of the other, leads to better learning outcomes than the use of both. Both regulatory modes have positive and negative implications for learning. It is evident that more research is needed in this regard.

A key concept in ME research that may help our understanding of their functioning is calibration. It seems that increased knowledge and expertise in a domain lead to better calibration of the ME. We should bear in mind, however, that personality factors as well as social factors, in the form of extrinsic feedback, collaborative interaction, or even simple exposure to information about other people's performance and affect (de Carvalho Filho & Yuzawa, 2001) influence the calibration process.

Finally, we should be aware of the benefits or pitfalls of metacognition. As Paris (2002) pointed out, metacognition can be helpful, benign, or debilitating. Research on ME supports this contention and provides evidence on the mechanism responsible, at least, for some of these effects. However, more research is needed in this direction and, particularly, on the role of instruction and of others in the regulation of the person's ME and behavior. Shared-metacognition as well as social processes involved in metacognition are of paramount importance in this respect.

References

Allwood, C. M., & Granhag, P. A. (1996). Considering the knowledge you have: Effects of realism in confidence judgments. *European Journal of Cognitive Psychology*, *8*, 235–256.

Aspinwall, L. G. (1998). Rethinking the role of positive affect in self-regulation. *Motivation and Emotion*, *22*, 1–32.

Bartsch, K., & Wellman, H. M. (1995). *Children talk about the mind*. New York: Oxford University Press.

Berardi-Coletta, B., Buyer, L. S., Dominowski, R. L., & Rellinger, E. R. (1995). Metacognition and problem solving: A process-oriented approach. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 205–223.

Bless, H., & Stack, F. (1998). Social influence on memory. In V. Y. Yzerbyt, G. Lories, & B. Dardenne (Eds.), *Metacognition: Cognitive and social dimensions* (pp. 90–106). London: Sage.

Borkowski, J. G., Chan, L. K. S., & Muthukrishna, N. (2000). A process-oriented model of metacognition: Links between motivation and executive functioning. In G. Schraw & J. C. Impara (Eds.), *Issues in the measurement of metacognition* (pp. 1–43). Lincoln, NE: Buros Institute of Mental Measurements.

Bouffard, T., Vaillacourt, M.-E., Fleury-Roy, M.-H., & Marcotte, G. (2004, September). Illusion of incompetence in elementary school. In C. Dupeyrat & C. Escribe (Eds.), *Motivational, affective, and cognitive sources and consequences of self-beliefs*. Symposium conducted at the 9th International Conference on Motivation, Lisbon, Portugal.

Brown, A. L. (1978). Knowing when, where and how to remember: A problem of metacognition. In R. Glaser (Ed.), *Advances in instructional psychology* (pp. 77–165). New York: Halsted Press.

Brown, A. L. (1987). Metacognition, executive control, self-regulation and other more mysterious mechanisms. In F. Weinert & R. Kluwe (Eds.), *Classroom management* (pp. 144–181). Hillsdale, NJ: Erlbaum.

Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulated cortex. *Trends in Cognitive Sciences*, *4*, 215–222.

Cacioppo, J. T., & Berntson, G. G. (1999). The affect system: Architecture and operating characteristics. *Current Directions in Psychological Science*, *8*, 133–137.

Carver, C. S. (2003). Pleasure as a sign you can attend to something else: Placing positive feelings within a general model of affect. *Cognition and Emotion*, *17*, 241–261.

Carver, C. S., & Scheier, M. F. (1998). *On the self-regulation of behavior*. Cambridge, UK: Cambridge University Press.

Chi, M. T. H., Bassok, M., Lewis, M. W., Reimann, P., & Glaser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. *Cognitive Science*, *13*, 145–182.

Costermans, J., Lories, G., & Ansay, C. (1992). Confidence level and feeling of knowing in question answering: The weight of inferential process. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *18*, 142–150.

de Carvalho Filho, M. K., & Yuzawa, M. (2001). The effects of social influences and general metacognitive knowledge on metamemory judgments. *Contemporary Educational Psychology*, *26*, 571–587.

Dermitzaki, I., & Efklides, A. (2001). Age and gender effects on students' evaluations regarding the self and task-related experiences in mathematics. In S. Volet & S. Jarvela (Eds.), *Motivation in learning contexts: Conceptual advances and methodological implications* (pp. 271–293). Amsterdam: Elsevier.

Dunlosky, J., & Nelson, T. O. (1992). Importance of the kind of cue for judgments of learning (JOLs) and the delayed-JOL effect. *Memory and Cognition*, *20*, 373–380.

Efklides, A. (2001). Metacognitive experiences in problem solving: Metacognition, motivation, and self-regulation. In A. Efklides, J. Kuhl, & R. M. Sorrentino (Eds.), *Trends and prospects in motivation research* (pp. 297–323). Dordrecht, The Netherlands: Kluwer.

Efklides, A. (2002a). Feelings as subjective evaluations of cognitive processing: How reliable are they? *Psychology: The Journal of the Hellenic Psychological Society*, *9*, 163–184.

Efklides, A. (2002b). The systemic nature of metacognitive experiences: Feelings, judgments, and their interrelations. In M. Izaute, P. Chambres, & P.-J. Marescaux (Eds.), *Metacognition: Process, function, and use* (pp. 19–34). Dordrecht, The Netherlands: Kluwer.

Efklides, A., & Aretouli, E. (2003). Interesting, difficult, or an exercise for the mind? The effect of the affective tone of the instructions on metacognitive experiences and self-concept. In A. Efklides, A. Stogiannidou, & E. Avdi (Eds.), *Scientific Annals of the Faculty of Philosophy, School of Psychology, Aristotle University of Thessaloniki: Volume in memory of M. Maniou-Vakali: Vol. 5* (pp. 287–322). Thessaloniki, Greece: Art of Text [In Greek].

Efklides, A., & Dina, F. (2004). Feedback from one's self and the others: Their effect on affect. *Hellenic Journal of Psychology*, *1*, 179–202.

Efklides, A., Kiorpelidou, K., & Kiosseoglou, G. Worked-out examples in mathematics: Effects on performance and metacognitive experiences. In A. Desoete & M. J. Veenman (Eds.), *Metacognition and mathematical problem solving*. Hauppauge, NY: Frank Columbus Nova Science, in press-a.

Efklides, A., Kourkoulou, A., Mitsiou, F., & Ziliaskopoulou, D. Effort regulation, effort perceptions, mood, and metacognitive experiences: What determines the estimate of effort expenditure?, Metacognition and Learning, in press-b.

Efklides, A., Niemivirta, M., & Yamauchi, H. (2003). Motivation and self-regulation: Processes involved and context effects—A discussion. *Psychologia: An International Journal of Psychology in the Orient*, *46*, 38–52.

Efklides, A., Pantazi, M., & Yazkoulidou, E. (2000). Factors influencing the formation of feeling of familiarity for words. *Psychology: The Journal of the Hellenic Psychological Society*, *7*, 207–222.

Efklides, A., Papadaki, M., Papantoniou, G., & Kiosseoglou, G. (1997). The effects of cognitive ability and affect on school mathematics performance and feelings of difficulty. *American Journal of Psychology*, *110*, 225–258.

Efklides, A., Papadaki, M., Papantoniou, G., & Kiosseoglou, G. (1998). Individual differences in feelings of difficulty: The case of school mathematics. *European Journal of Psychology of Education*, *13*, 207–226.

Efklides, A., & Petkaki, C. (2005). Effects of mood on students' metacognitive experiences. *Learning and Instruction*, *15*, 415–431.

Efklides, A., Samara, A., & Petropoulou, M. (1996). The micro- and macro-development of metacognitive experiences: The effect of problem-solving phases and individual factors. *Psychology: The Journal of the Hellenic Psychological Society*, *3*(2), 1–20 [In Greek].

Efklides, A., Samara, A., & Petropoulou, M. (1999). Feeling of difficulty: An aspect of monitoring that influences control. *European Journal of Psychology of Education*, *14*, 461–476.

Efklides, A., & Tsiora, A. (2002). Metacognitive experiences, self-concept, and self-regulation. *Psychologia: An International Journal of Psychology in the Orient*, *45*, 222–236.

Efklides, A., & Volet, S. (Eds.). (2005). Feelings and emotions in the learning process. *Learning and Instruction*, *15*(5) [Whole issue].

Fabricius, W. V., & Schwanenflugel, P. J. (1994). The older child's theory of mind. In A. Demetriou & A. Efklides (Eds.), *Intelligence, mind, and reasoning: Structure and development* (pp. 111–132). Amsterdam: Elsevier.

Fernandez-Duque, D., Baird, J. A., & Posner, M. I. (2000). Executive attention and metacognitive regulation. *Consciousness and Cognition*, *9*, 288–307.

Flavell, J. H. (1979). Metacognition and cognitive monitoring—A new era of cognitive-developmental inquiry. *American Psychologist*, *34*, 906–911.

Flavell, J. H. (1987). Speculations about the nature and development of metacognition. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation and understanding* (pp. 21–29). Hillsdale, NJ: Erlbaum.

Forgas, J. P. (1994). The role of emotion in social judgments: An introductory review and an Affect Infusion Model (AIM). *European Journal of Social Psychology*, *24*, 1–24.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist*, *56*, 218–226.

Frijda, N. (1986). *The emotions*. Cambridge, UK: Cambridge University Press.

Hertzog, Ch., & Dixon, R. A. (1994). Metacognitive development in adulthood and old age. In J. Metcalfe & A. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 227–251). Cambridge, MA: Bradford.

Iiskala, T., Vauras, M., & Lehtinen, E. (2004). Socially-shared metacognition in peer learning? *Hellenic Journal of Psychology*, *1*, 147–178.

Isen, A. M. (2000). Positive affect and decision making. In M. Lewis & J. M. Haviland-Jones (Eds.), *Handbook of emotions* (2nd ed., pp. 417–435). New York: Guilford.

Izard, C. E. (1977). *Human emotions*. New York: Plenum.

Kahneman, D. (2003). A perspective on judgment and choice. *American Psychologist*, *58*, 697–720.

Keleman, W. L. (2000). Metamemory cues and monitoring accuracy: Judging what you know and what you will know. *Journal of Educational Psychology*, *92*, 800–810.

Kitchener, K. S. (1983). Cognition, metacognition and epistemic cognition: A three level model of cognitive processing. *Human Development*, *4*, 222–232.

Koriat, A. (1997). Monitoring one's own knowledge during study: A cue-utilization approach to judgments of learning. *Journal of Experimental Psychology: General*, *126*, 349–370.

Koriat, A. (2000). The feeling of knowing: Some metatheoretical implications for consciousness and control. *Consciousness and Cognition*, *9*, 149–171.

Koriat, A., & Levy-Sadot, R. (2000). Conscious and unconscious metacognition: A rejoinder. *Consciousness and Cognition*, *9*, 139–202.

Koriat, A., Sheffer, L., & Ma'ayan, H. (2002). *Comparing objective and subjective learning curves*: *Judgments of learning exhibit increased underconfidence with practice*. (IIPDM Report No 171). Haifa, Israel: University of Haifa, Institute of Information Processing and Decision Making.

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, *77*, 1121–1134.

Kuhl, J. (2001). A functional approach to motivation: The role of goal enactment and self-regulation in current research on approach and avoidance. In A. Efklides, J. Kuhl, & R. M. Sorrentino (Eds.), *Trends and prospects in motivation research* (pp. 239–268). Dordrecht, The Netherlands: Kluwer.

Lompscher, J. (1994). Learning strategies: An essential component of learning activity. *Lern-und Lehrforschung*, *7*, 78–95.

Lories, G., Dardenne, B., & Yzerbyt, V. Y. (1998). From social cognition to metacognition. In V. Y. Yzerbyt, G. Lories, & B. Dardenne (Eds.), *Metacognition: Cognitive and social dimensions* (pp. 1–15). London: Sage.

Mandler, G. (1984). *Mind and body*. New York: Norton.

Mazzoni, G., & Cornoldi, C. (1993). Strategies in study time allocation: Why is study time sometimes not effective? *Journal of Experimental Psychology: General*, *122*, 47–60.

McKenzie, C. R. M. (1998). Taking into account the strength of an alternative hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *24*, 771–792.

Metallidou, P., & Efklides, A. (2001). The effects of general success-related beliefs and specific metacognitive experiences on causal attributions. In A. Efklides, J. Kuhl, & R. Sorrentino (Eds.), *Trends and prospects in motivation research* (pp. 325–347). Dordrecht, The Netherlands: Kluwer.

Metcalfe, J. (2000). Metamemory: Theory and data. In E. Tulving & F. I. M. Craik (Eds.), *The Oxford handbook of memory* (pp. 197–211). Oxford, England: Oxford University Press.

Miller, P. H. (1985). Metacognition and attention. In D. L. Forrest-Presley, G. E. MacKinnon, & T. G. Waller (Eds.), *Metacognition, cognition, & human performance: Instructional practices: Vol. 2* (pp. 181–221). New York: Academic.

Mitchell, K. J., & Johnson, M. K. (2000). Source monitoring: Attributing mental experience. In E. Tulving & F. I. M. Craik (Eds.), *The Oxford handbook of memory* (pp. 179–195). Oxford, UK: Oxford University Press.

Nelson, T. O. (1993). Judgments of learning and the allocation of study time. *Journal of Experimental Psychology: General*, *122*, 269–273.

Nelson, T. O. (1996). Consciousness and metacognition. *American Psychologist*, *51*, 102–116.

Nelson, T. O., & Dunlosky, J. (1991). When people's judgments of learning (JOLs) are extremely accurate at predicting subsequent recall: The "delayed-JOL effect". *Psychological Science*, *2*, 267–270.

Nelson, T. O., Kruglanski, A. W., & Jost, J. T. (1998). Knowing thyself and others: Progress in metacognitive social psychology. In V. Y. Yzerbyt, G. Lories, & B. Dardenne (Eds.), *Metacognition: Cognitive and social dimensions* (pp. 69–89). London: Sage.

Nelson, T. O., & Narens, L. (1994). Why investigate metacognition? In J. Metcalfe & A. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 1–25). Cambridge, MA: Bradford.

Paris, S. G. (2002). When is metacognition helpful, debilitating, or benign? In M. Izaute, P. Chambres, & P.-J. Marescaux (Eds.), *Metacognition: Process, function, and use* (pp. 105–120). Dordrecht, The Netherlands: Kluwer.

Pekrun, R., Goetz, T., Titz, W., & Perry, R. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist*, *37*, 91–105.

Pintrich, P. R., Wolters, C. A., & Baxter, G. P. (2000). Assessing metacognition and self-regulated learning. In J. C. Impara, G. Schraw, & J. C. Impara (Eds.), *Issues in the measurement of metacognition* (pp. 43–97). Lincoln, NE: University of Nebraska-Lincoln.

Reder, L. M. (1987). Strategy selection in question answering. *Cognitive Psychology*, *19*, 90–138.

Reder, L. M., & Schunn, C. D. (1996). Metacognition does not apply: Strategy choice is governed by implicit learning and memory. In L. M. Reder (Ed.), *Implicit memory and metacognition* (pp. 45–78). Hillsdale, NJ: Erlbaum.

Renkl, A. (1999). Learning mathematics from worked-out examples: Analyzing and fostering self-explanations. *European Journal of Psychology of Education*, *XIV*, 477–488.

Robinson, E. (1983). Metacognitive development. In S. Meadows (Ed.), *Developing thinking: Approaches to children's cognitive development* (pp. 106–141). London: Methuen.

Salonen, P., Vauras, M., & Efklides, A. (2005). Social interaction: What can it tell us about metacognition and co-regulation in learning? *European Psychologist*, *10*, 199–205.

Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, *10*, 251–296.

Trope, Y., & Pomerantz, E. M. (1998). Resolving conflicts among self-evaluative motives: Positive experiences as a resource of overcoming defensiveness. *Motivation and Emotion*, *22*, 53–72.

van Veen, V., & Carter, C. S. (2002). The timing of action-monitoring process in the anterior cingulate cortex. *Journal of Cognitive Neuroscience*, *14*(4), 593–602.

Veenman, M., & Elshout, J. J. (1999). Changes in the relation between cognitive and metacognitive skills during the acquisition of expertise. *European Journal of Psychology of Education*, *XIV*, 509–523.

Wellman, H. M. (1983). Metamemory revised. In M. Chi (Ed.), *Trends in memory development research: Contributions to human development* (pp. 31–51). Basel, Switzerland: Karger.

Whittlesea, B. W. A. (1993). Illusions of familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*, 1235–1253.

Yzerbyt, V. Y., Dardenne, B., & Leyens, J.-Ph. (1998). Social judgeability concerns in impression formation. In V. Y. Yzerbyt, G. Lories, & B. Dardenne (Eds.), *Metacognition: Cognition and social dimensions* (pp. 126–156). London: Sage.