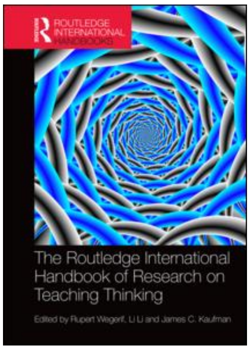

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Rupert Wegerif, Li Li, James C. Kaufman

Thinking about metacognition improves thinking

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Marcel V. J. Veenman
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Thinking about metacognition improves thinking

Marcel V. J. Veenman

INSTITUTE FOR METACOGNITION RESEARCH (*IMR*), THE NETHERLANDS

Introduction

Halpern (1998) defined critical thinking (CT) as conscious, purposeful, and goal-directed reasoning to attain a desirable outcome when solving complex problems, making inferences, analyzing assumptions, estimating likelihoods, and making decisions. CT entails the use of cognitive strategies and skills for reasoning, as well as metacognitive skills for monitoring and controlling the reasoning process. Halpern's work cleared the way for appreciating the role of metacognition in CT (Dwyer, Hogan, & Stewart, 2014).

Metacognition is referred to as 'cognition about cognition' (Flavell, 1979) or 'thinking about thinking' (Weinert, 1987). The concept of metacognition is rooted in developmental psychology with Piaget and Flavell as its progenitors. Metacognition research initially focused on the developing child's thinking about cognition and mental states. In particular, meta-memory research addressed children's increasing knowledge of how memory operates (Flavell & Wellman, 1977). Later, Brown (1978; Brown & DeLoache, 1978) extended the conceptualization of metacognition with self-regulation. Metacognitive strategies and skills for goal setting, planning, monitoring, and evaluation coordinate the execution of cognitive processes. Current definitions of metacognition still make this distinction between metacognitive declarative knowledge about one's cognitive system on the one hand, and metacognitive skills for regulating cognitive processes on the other (Schraw & Moshman, 1995; Veenman, Van Hout-Wolters, & Afflerbach, 2006).

Metacognitive knowledge

According to Flavell (1979), metacognitive knowledge refers to one's declarative knowledge about the interplay between person, task, and strategy characteristics. For instance, a person may think that s/he (person) has difficulties with inferential reasoning (task) and, consequently, that s/he should carefully consider causality in relations between phenomena (strategy). Conversely, another person may optimistically appraise his/her competency for inferential reasoning, thus putting less effort in disentangling causal relationships. Some researchers presume that metacognitive knowledge should be accurate and flawless by definition (Schraw &

Moshman, 1995). Metacognitive knowledge, however, may be incorrect when a person overestimates or underestimates his/her competences, relative to the subjectively perceived task complexity (Veenman et al., 2006). For instance, a person may take a task with inferential reasoning from pictorial information too lightly, whereas another person may shy away from inferential reasoning with symbols because they bear a resemblance to mathematical formulas. Metacognitive knowledge is in the eye of the beholder. Moreover, even correct metacognitive knowledge does not guarantee an adequate execution of appropriate metacognitive skills, as students may lack the motivation or capability to do so. Alexander, Carr, and Schwanenflugel (1995) noticed a discrepancy between children's knowledge about monitoring and their application of monitoring skills. Winne (1996) argued that knowledge has no effect on behavior unless that knowledge is actually used. Consequently, metacognitive knowledge often poorly predicts performance outcomes (Veenman, 2005). Metacognitive knowledge is part of a person's belief system, which contains broad, often tacit ideas about the nature and functioning of the cognitive system (Flavell, 1979). Individual beliefs are personal and subjective by nature, and so remains metacognitive knowledge when it is not put to the test by the actual execution of strategies or skills.

A developmental process that paves the way for metacognitive knowledge is the emergence of Theory of Mind (ToM). ToM pertains to children's knowledge about mental states such as beliefs, desires, and intentions. Crucial to the development of ToM is the awareness of a child older than 4 years that another person may not know what the child knows. A longitudinal study of Lockl and Schneider (2006) revealed that ToM at the age of 4 to 5 years is a precursor of later metacognitive knowledge about how memory operates by the age of 5 to 6 years. According to Flavell (2004), ToM is prerequisite to *thinking* about mental states. Thus, ToM is a stepping-stone for children to take different perspectives, to understand that ideas may be incompatible, and to differentiate between fact, belief, and fiction.

Metacognitive knowledge emerges from experiences in everyday life or, more particularly, from *thinking* about these experiences. Metacognitive experiences are situations or events that elicit a person to think about one's mental processes and behavior. For instance, a young child goes to a grocery shop and, then, learns that s/he has forgotten what items to buy. Such an experience becomes metacognitive by nature when one is thinking of its implications for understanding one's cognitive system (Efklides, 2008). Thus, from the child's thinking about the experience at the grocery store, a metacognitive awareness may arise that memory is fallible. Such awareness accumulates self-knowledge about required and available resources for potential strategy use (Kuhn, 1999; Zohar & Ben-David, 2008). The child in our example may come to understand that remembering a list of shopping items is difficult and that, consequently, one should either rehearse or write down the list before going to the store. Ertmer and Newby (1996) argued that 'reflective thinking' is required for building up a coherent body of declarative, metacognitive knowledge about *what* strategies to use, *when* and *why*. This conditional knowledge for strategy use, however, is still declarative by nature and may not warrant actual strategy use when a person lacks the procedural knowledge for *how* to enact a strategy (Veenman, 2011). Consider a child taking a first ride on a bike. Knowing what a bike is, what the handlebars are, and what to do with the pedals, the child still has to learn how to ride one with ups and downs. In fact, conditional knowledge provides an entry to the first stage of skill acquisition, where a metacognitive strategy has to be built from the available conditional knowledge. This strategy is then consciously applied step-by-step and gradually transformed into a skill (Veenman, 2011). Thus, conditional knowledge is a prerequisite, albeit insufficient condition for the acquisition of metacognitive skills.

Metacognitive skills

Metacognitive skills pertain to the acquired repertoire of procedural knowledge for monitoring and controlling one's cognitive processes (Veenman, 2011). Halpern (1998) emphasizes the role of metacognitive planning, monitoring, and evaluation activities in critical thinking (CT). A broad array of metacognitive skills may guide CT throughout the process. Orienting activities at the onset of a task are preparatory to subsequent task performance. First, one should thoroughly read the assignment, which could contain vital information for later goal setting. Next, prior knowledge about the topic should be activated from memory. Activating prior knowledge not only supports thinking about problems or arguments, it also facilitates monitoring for flawed reasoning. Relevant information in the task assignment (and other materials) should be sorted out at the expense of irrelevant information. Once an overall picture of the problem or argument is formed, one should set a goal for thinking. For instance, one could focus on causality in reasoning, on recognizing and criticizing assumptions, or on the completeness and depth of argumentation. Through planning, appropriate cognitive strategies and skills are selected for reaching that goal, along with concrete steps for executing the strategy or skill. For instance, one could decide to apply inductive, deductive, or analogical reasoning to a problem. During task performance, monitoring processes may detect errors made in the execution of cognitive strategies and skills, as well as misconceptions and weaknesses in one's own reasoning. Monitoring may also help to keep track of effort expenditure and progress being made towards the goal (cf. Halpern, 1998). Once a conclusion is reached, the outcome of the thinking process should be evaluated against one's original goal. Such evaluation may result in reorientation on the task assignment or goal settings, or in rethinking the process that led to the conclusion. Finally, reflection on how the task was performed may improve thinking processes in the future. Reflection may take both metacognitive skills and cognitive thinking skills as its object. Thus, reflection could result in, for instance, a metacognitive intention to read future assignments more thoroughly or to set clear goals, as well as conclusions about the appropriateness of certain thinking skills. Students substantially differ in the quantity and quality of metacognitive skills used, both across age groups as well as within age groups (Van der Stel & Veenman, 2014; Veenman, Wilhelm, & Beishuizen, 2004).

The implementation of metacognitive skills necessarily draws on cognitive processes (Veenman, 2011). The analysis of the task assignment requires reading and reasoning processes, activating prior knowledge is driven by memory processes, planning involves processes of serialization and sequencing, while monitoring, evaluation, and reflection rely on cognitive processes of making comparisons. Metacognitive skills without appropriate cognitive activity could be metaphorically seen as a conductor without an orchestra. In the same vein, the application of metacognitive skills in CT is intertwined with the execution of cognitive thinking skills. A relevant issue, then, is how cognitive thinking skills and the metacognitive skills that coordinate those thinking skills could be represented in the cognitive system.

Model of metacognitive skills as self-instructions

In a process model of metacognitive skills, cognitive activity is discerned from metacognitive activity. Nelson distinguished an 'object level' from a 'meta level' in the cognitive system (Nelson & Narens, 1990). At the object level, lower-order cognitive processes are executed, such as basic processes for memory, reading, and problem solving. Also component processes of more complex thinking skills, such as comparing, reasoning, and making inferences, are located at the object level. Higher-order processes of evaluation and planning at the meta level govern the object level. Nelson postulated two flows of information between the meta level and the object level. Information about the state of the object level is conveyed to the meta level through monitoring processes, while directions from the meta level are transferred to the object level through control processes. Thus, if an error occurs on the object level, a monitoring process will alert the meta level and control processes will be activated to resolve the problem. Basically, this is a bottom-up model because metacognitive control processes are merely triggered by anomalies in cognitive activity (Veenman, 2011).

Veenman (2011) extended Nelson's bottom-up model with a top-down approach, in which metacognitive skills are conceived as an acquired program of self-instructions for initiating and regulating cognitive processes at the object level. This program of self-instructions is activated whenever the individual is faced with task performance. Self-instructions can be represented by a production system of condition-action rules (Anderson, 1996), which contains conditional knowledge about when to apply a particular metacognitive skill and procedural instructions for how to implement the skill at the object level. For instance, goal setting can be represented by the rule: 'IF you have identified the nature of the task, THEN determine what your goal is in performing that task.' A subsequent planning rule could be: 'IF you have ascertained a goal, THEN choose an appropriate strategy for reaching that goal.' In contrast with Nelson's view, self-instructions from the meta level are self-induced, that is, they need not necessarily be triggered by anomalies in task performance. The monitoring flow serves to identify which conditions are satisfied for activating self-instructions. Metacognitive skilled persons have an orderly set of self-instructions available that will help them work through the task. The output of an implemented self-instruction will subsequently satisfy conditions for the next self-instruction.

Such a program of self-instructions is acquired through experience and training, similar to how cognitive skills are learned (Veenman, 2011). According to ACT-R theory (Anderson, 1996), skill acquisition passes through three successive stages of rule induction. In the cognitive stage, *declarative* knowledge of conditions and actions is interpreted and arranged in order to allow for a verbal description of a strategy (*What* to do, *When*, *Why*, and *How*; Veenman et al., 2006). Metacognitive knowledge, in particular conditional knowledge, is incorporated in this verbal description. In fact, conditional knowledge of the *Why* and *When* define the IF-side of a production rule. The *What* and *How* constitute the THEN-side of a production rule. Initially, the metacognitive strategy needs to be consciously performed step-by-step, while being prone to error. Conscious execution of a metacognitive strategy at this stage requires effort, which may temporarily interfere with cognitive performance (Veenman et al., 2006). During the second, associative stage, verbal descriptions of the strategy are transformed into a procedural representation. Errors are eliminated and separate procedures are assembled into an organized set. Gradually, strategies turn into more fluent and accurate skills. Finally, skill execution is fine-tuned and automated in the autonomous stage. Most metacognitive skills will not entirely pass through this last stage, as they need to be consciously applied and tuned to the task at hand. For instance, setting goals remains strategic, that is, intentionally and deliberately employed contingent on task characteristics (Alexander & Jetton, 2000). Some planning processes, however, may become automated or habitual (Borkowski, Carr, & Pressley, 1987), while monitoring processes may run in the background until an error or anomaly in thinking occurs (Samuels, Ediger, Willcutt, & Palumbo, 2005; Veenman, 2011). In fact, the repertoire of metacognitive self-instructions should become good practice, albeit adaptively applied.

Development of metacognitive skills

Although metacognitive skills are assumed to emerge around the age of 8 to 9 years (Veenman, 2011), children younger than 8 years may employ proto-metacognitive skills if tasks are tailored to their level of understanding. Even 5-year-old children may demonstrate elementary forms of planning and self-correction in playful situations, such as distributing dolls over a limited number of chairs (Whitebread et al., 2009). Apparently, metacognitive skills develop at a basic level during early childhood, but they become more sophisticated and academically oriented when formal education requires the utilization of a metacognitive repertoire (Veenman, 2011). From the age of 8 years on, children show a steep increase in frequency and quality of metacognitive skills (Alexander et al., 1995; Schmitt & Sha, 2009; Veenman & Spaans, 2005; Veenman et al., 2004). This growth of metacognitive skills persists well into adulthood (Veenman et al., 2004; Weil et al., 2013). At all ages, however, huge individual differences in metacognitive skills can be observed in same-age students, indicating a differential developmental pace of metacognitive skills.

Until the age of 14, children's metacognitive skills have a substantial domain- or task-specific orientation. Children may vary in metacognitive skills they apply to reading, problem solving, or discovery learning tasks (Van der Stel & Veenman, 2010; Veenman & Spaans, 2005). Veenman and Spaans (2005, p. 172) asserted that: 'metacognitive skills may initially develop on separate islands of tasks and domains that are very much alike.' At the age of 14, however, metacognitive skills merge into a generalized repertoire across tasks and domains (Van der Stel & Veenman, 2014). There is ample evidence for the generality of metacognitive skills beyond the age of 15 (Schraw, Dunkle, Bendixen, & Roedel, 1995; Schraw & Nietfeld, 1998; Veenman & Beishuizen, 2004; Veenman, Elshout, & Meijer, 1997; Veenman & Spaans, 2005; Veenman & Verheij, 2003; Veenman et al., 2004). The transition into general metacognitive skills may have implications for CT. According to Halpern (1998), CT skills should be applicable across multiple contexts. Transfer of CT skills, however, may be constrained by the developmental trajectory of metacognitive skills. Before the age of 14, transfer of CT skills may be restricted by the contextual dependency of metacognitive skills, as the latter skills coordinate the execution of thinking skills.

Metacognitive skills in CT

Halpern (1998) proposed a comprehensive four-part model for CT. A first, motivational component concerns the disposition for effortful thinking. Persons should be inclined to recognize the need for a particular thinking skill, to invest effort in pursuing that skill, and to persevere in complex thinking. The second component refers to a broad range of cognitive thinking skills. Halpern distinguished verbal reasoning skills, argument-analysis skills, hypothesis-testing skills, skills for estimating likelihoods or uncertainties, and decision making or problem-solving skills. Taxonomies of such CT skills are often captured under the headings of skills for analysis, evaluation, and inference (Dwyer et al., 2014). The third component consists of metacognitive skills for planning, monitoring, and evaluation of thinking processes. Finally, the fourth component entails a structured approach to thinking tasks in order to promote transfer. When experiencing the applicability of thinking skills over multiple tasks and contexts, persons should decontextualize thinking skills by recognizing the underlying structural characteristics of tasks. Thus, the ultimate objective of CT is to surpass tasks and domains.

Empirical studies have investigated the relation between metacognitive skills and CT skills. Magno (2010) first administered the MAI, a self-report questionnaire for assessing metacognition, and one month later the Watson-Glaser Critical Thinking Appraisal test to 240 university students. Metacognitive knowledge and regulation components of the MAI appeared to correlate moderately with subscales of the WGCTA for CT performance. Self-reports, however, are not valid measures of metacognitive skills for various reasons (Veenman, 2011). Self-reports need to be reconstructed from memory by the student and, consequently, they are subject to memory failure, distortion, and interpretive reconstruction. When comparing self-reports of metacognition with think-aloud measures of metacognitive skills during task performance in a multi-method design, correlations between both measures were approximately zero (Veenman, 2005). Self-reports may perhaps capture elements of metacognitive knowledge, but they certainly do not assess the use of metacognitive skills in CT. Ku and Ho (2010), on the other hand, gathered think-aloud protocols of 10 university students (5 high and 5 low in previous CT) who performed a series of CT tasks. Protocols were analyzed on metacognitive skills, while performance on the tasks was coded separately. Students high on previous CT outperformed students low on previous CT, with respect to both metacognitive skills and task performance. Although correlations between metacognitive skills and actual task performance were not presented, Ku and Ho concluded that better metacognitive skills resulted in improved CT.

More specifically, Veenman et al. (Veenman & Elshout, 1991; Veenman et al., 1997, 2004; Veenman, Bavelaar, De Wolf, & Van Haaren, 2014; Veenman & Spaans, 2005) investigated the predictive value of metacognitive skills for inductive reasoning in students from different age groups and educational backgrounds. Participants had to perform experiments in computerized environments in order to discover principles of biology, geography, physics, statistics, and chemistry. According to Halpern (1998), these tasks would require hypothesis-testing skills. During the Otter task (Veenman et al., 2004, 2014), for instance, participants had to discover the complex relation between five independent variables (habitat, environmental pollution, public entrance, setting out otters, and feeding fish) and the dependent variable of otter-population size. In each experiment, participants had to assign values to the five independent variables before the computer calculated the size of the otter population for that particular setting. A series of experiments would allow them to reason about the separate and combined effects of independent variables on the population size. Metacognitive skillfulness was assessed with thinking aloud and registration of behavior in computer logfiles. The outcome of inductive reasoning was measured with a learning posttest, as participants were tested for drawing correct conclusions and making valid inferences about how independent variables affected population size. In all studies, metacognitive skillfulness appeared to be a strong predictor of inductive reasoning outcomes. Moreover, the contribution of metacognitive skills to inductive reasoning remained substantial when controlled for the intellectual ability of participants.

From the aforementioned studies, it was concluded that metacognitive skills are prerequisite to adequate performance on CT tasks. Microgenetic studies have shown that repeated performance on different inductive reasoning tasks improved metacognitive skills and enhanced task performance over time (Kuhn, Garcia-Mila, Zohar, & Andersen, 1995; Veenman et al., 2004). Thus, the metacognitive experience of performing an inductive learning task refined the application of metacognitive skills, which in turn may have enriched the thinking process. Moreover, the explicit training of metacognitive skills also resulted in better performance on inductive reasoning tasks (Veenman, Elshout, & Busato, 1994; Zohar & Ben-David, 2008) or on complex learning tasks in general (Veenman, 2013). It cannot be ruled out, however, that repeated performance or metacognitive training also directly affected CT, that is, not entirely through improved metacognitive skills. In order to properly investigate causality in the relation between metacognition and CT, one should separately train metacognitive skills and measure its effect on CT, as well as train CT and measure its effect on metacognition. Such a design would disentangle mutual influences of metacognitive skills and thinking skills.

Higher-order nature of CT skills

Cognitive thinking skills are executed on the object level of Nelson's model, like any other cognitive process. Designating complex thinking skills as higher-order skills (Halpern, 1998; Zohar, 2013) suggests that these higher-order thinking skills orchestrate the cognitive processes at the object level. In turn, higher-order thinking skills are coordinated by processes on the meta level. These assumptions would suggest a three-level model with lower-order cognitive processing at the object level, higher-order thinking at an intermediate level, and metacognitive regulation at the meta level on top. As the flows of information among the three levels become very complicated, such a three-level model is not plausible. Therefore, it would be preferable to denote the cognitive thinking skills of Halpern (1998) merely as complex cognitive skills on the object level. Thus, thinking skills at the object level may vary in complexity from basic, single units of thought to complex, composite thinking skills. Metaphorically speaking, the object level can be seen as the shop floor of a factory. Some employees repeatedly perform one simple action, whereas others handle complex procedures with composite actions as a team. The manager of the factory, representing the metacognitive processes at the meta level, is responsible for process control. At the meta level appropriate thinking skills are selected and initiated, the execution of composite thinking skills is monitored and controlled, and evaluation of thinking outcomes is instigated. Thus, the higher-order nature attributed to thinking skills would actually reside in the repertoire of metacognitive self-instructions at the meta level. This higher-order orchestration function makes metacognitive skills indispensable to CT.

Conclusion

Thinking processes are critical to the acquisition of metacognitive knowledge and skills. The development of ToM by the age of 5 allows for reasoning about one's thoughts, one's behavior, and its consequences. Hence, declarative metacognitive knowledge about the nature of one's cognitive system, task requirements, and the potential use of strategies is accumulated. Thinking processes are further required to arrange conditional knowledge and refine procedures during the acquisition of metacognitive skills. The result is a repertoire of metacognitive self-instructions for monitoring and controlling task performance. Thus, higher-order metacognitive skills at the meta level orchestrate and regulate cognitive thinking processes at the object level. Without metacognitive coordination, thinking processes would go adrift. In turn, CT processes may bring about further refinements of metacognitive knowledge and skills. CT may enhance conditional knowledge about *what* thinking skills to apply *when* and, as a consequence, make metacognitive skills more effective in the orchestration of CT skills. In conclusion, the relation between metacognition and CT is not unidirectional. Metacognitive and CT processes mutually affect one another, in the effort of lifting cognitive performance to a higher level.

References

Alexander, J. M., Carr, M., & Schwanenflugel, P. J. (1995). Development of metacognition in gifted children: Directions for future research. *Developmental Review*, *15*(1), 1–37.

Alexander, P. A., & Jetton, T. L. (2000). Learning from text: A multidimensional and developmental perspective. In M. L. Kamil, P. B. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research. Volume III* (pp. 285–310). Mahwah, NJ: Erlbaum.

Anderson, J. R. (1996). *The architecture of cognition.* Mahwah, NJ: Erlbaum.

Borkowski, J. G., Carr, M., & Pressley, M. (1987). 'Spontaneous' strategy use: Perspectives from metacognitive theory. *Intelligence*, *11*(1), 61–75.

Brown, A. (1978). Knowing when, where, and how to remember: A problem of metacognition. In R. Glaser (Ed.), *Advances in instructional psychology, Vol. 1* (pp. 77–165). Hillsdale, NJ: Erlbaum.

Brown, A. L., & DeLoache, J. S. (1978). Skills, plans, and self-regulation. In R. S. Siegel (Ed.), *Children's thinking: What develops?* (pp. 3–35). Hillsdale, NJ: Erlbaum.

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2014). An integrated critical thinking framework for the 21st century. *Thinking Skills and Creativity*, *12*, 43–52.

Efklides, A. (2008). Metacognition. Defining its facets and levels of functioning in relation to self-regulation and co-regulation. *European Psychologist*, *13*(4), 277–287.
Ertmer, P. A., & Newby, T. J. (1996). The expert learner: Strategic, self-regulated, and reflective. *Instructional Science*, *24*(1), 1–24.
Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, *34*(10), 906–911.
Flavell, J. H. (2004). Theory-of-Mind development: Retrospect and prospect. *Merrill-Palmer Quarterly*, *50*(3), 274–290.
Flavell, J. H., & Wellman, H. M. (1977). Metamemory. In R. V. Kail & J. W. Hagen (Eds.), *Perspectives on the development of memory and cognition* (pp. 3–33). Hillsdale, NJ: Erlbaum.
Halpern, D. F. (1998). Teaching critical thinking for transfer. Dispositions, skills, structure training, and metacognitive monitoring. *American Psychologist*, *53*(4), 449–455.
Ku, K. Y. L., & Ho, I. T. (2010). Metacognitive strategies that enhance critical thinking. *Metacognition and Learning*, *5*(3), 251–267.
Kuhn, D. (1999). Metacognitive development. In L. Balter & C. S. Tamis-LeMonda (Eds.), *Child psychology. A handbook of contemporary issues* (pp. 259–286). Philadelphia, PA: Psychology press.
Kuhn, D., Garcia-Mila, M., Zohar, A., & Andersen, C. (1995). Strategies of knowledge acquisition. *Monographs of the Society for Research in Child Development*, *60*(4), 1–128.
Lockl, K., & Schneider, W. (2006). Precursors of metamemory in young children: The role of theory of mind and metacognitive vocabulary. *Metacognition and Learning*, *1*(1), 15–31.
Magno, C. (2010). The role of metacognitive skills in developing critical thinking. *Metacognition and Learning*, *5*, 137–156.
Nelson, T. O., & Narens, L. (1990). Metamemory: A theoretical framework and new findings. In G. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 26, pp. 125–173). San Diego, CA: Academic Press.
Samuels, S. J., Ediger, K. M., Willcutt, J. R., & Palumbo, T. J. (2005). Role of automaticity in metacognition and literacy instruction. In S. E. Israel, C. C. Block, K. L. Bauserman & K. Kinnucan-Welsch (Eds.), *Metacognition in literacy learning* (pp. 41–59). Mahwah, NJ: Erlbaum.
Schmitt, M. C., & Sha, S. (2009). The developmental nature of meta-cognition and the relationship between knowledge and control over time. *Journal of Research in Reading*, *32*(2), 254–271.
Schraw, G., Dunkle, M. E., Bendixen, L. D., & Roedel, T. D. (1995). Does a general monitoring skill exist? *Journal of Educational Psychology*, *87*(3), 433–444.
Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review*, 7(4), 351–371.
Schraw, G., & Nietfeld, J. (1998). A further test of the general monitoring skill hypothesis. *Journal of Educational Psychology*, *90*(2), 236–248.
Van der Stel, M., & Veenman, M. V. J. (2010). Development of metacognitive skillfulness: A longitudinal study. *Learning and Individual Differences*, *20*(3), 220–224.
Van der Stel, M., & Veenman, M. V. J. (2014). Metacognitive skills and intellectual ability of young adolescents: A longitudinal study from a developmental perspective. *European Journal of Psychology of Education*, *29*(1), 117–137.
Veenman, M. V. J. (2005). The assessment of metacognitive skills: What can be learned from multi-method designs? In C. Artelt & B. Moschner (Eds.), *Lernstrategien und Metakognition: Implikationen für Forschung und Praxis* (pp. 75–97). Berlin: Waxmann.
Veenman, M. V. J. (2011). Learning to self-monitor and self-regulate. In R. Mayer & P. Alexander (Eds.), *Handbook of research on learning and instruction* (pp. 197–218). New York: Routledge.
Veenman, M. V. J. (2013). Training metacognitive skills in students with availability and production deficiencies. In H. Bembenutty, T. Cleary & A. Kitsantas (Eds.), *Applications of self-regulated learning across diverse disciplines: A tribute to Barry J. Zimmerman* (pp. 299–324). Charlotte, NC: Information Age Publishing.
Veenman, M. V. J., Bavelaar, L., De Wolf, L., & Van Haaren, M. G. P. (2014). The on-line assessment of metacognitive skills in a computerized environment. *Learning and Individual Differences*, *29*, 123–130.
Veenman, M. V. J., & Beishuizen, J. J. (2004). Intellectual and metacognitive skills of novices while studying texts under conditions of text difficulty and time constraint. *Learning and Instruction*, *14*(6), 619–638.
Veenman, M. V. J., & Elshout, J. J. (1991). Intellectual ability and working method as predictors of novice learning. *Learning and Instruction*, *1*(4), 30–317.
Veenman, M. V. J., Elshout, J. J., & Busato, V. V. (1994). Metacognitive mediation in learning with computer-based simulations. *Computers in Human Behavior*, *10*(1), 93–106.

Veenman, M. V. J., Elshout, J. J., & Meijer, J. (1997). The generality vs. domain-specificity of metacognitive skills in novice learning across domains. *Learning and Instruction*, 7(2), 187–209.

Veenman, M. V. J., & Spaans, M. A. (2005). Relation between intellectual and metacognitive skills: Age and task differences. *Learning and Individual Differences*, *15*(2), 159–176.

Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning*, *1*, 3–14.

Veenman, M. V. J. & Verheij, J. (2003). Identifying technical students at risk: Relating general versus specific metacognitive skills to study success. *Learning and Individual Differences*, *13*, 259–272.

Veenman, M. V. J., Wilhelm, P., & Beishuizen, J. J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning and Instruction*, *14*(1), 89–109.

Weil, L. G., Fleming, S. M., Dumontheil, I., Kilford, E. J., Weil, R. S., Rees, G., Dolan, R. J., & Blakemore, S. (2013). The development of metacognitive ability in adolescence. *Consciousness and Cognition*, *22*, 264–271.

Weinert, F. E. (1987). Introduction and overview: Metacognition and motivation as determinants of effective learning and understanding. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 1–16). Hillsdale, NJ: Erlbaum.

Whitebread, D., Coltman, P., Pasternak, D. P., Sangster, C., Grau, V., Bingham, S., Almeqdad, Q., & Demetriou, D. (2009). The development of two observational tools for assessing metacognition and self-regulated learning in young children. *Metacognition and Learning*, *4*(1), 63–85.

Winne, P. H. (1996). A metacognitive view of individual differences in self-regulated learning. *Learning and Individual Differences*, *8*(4), 327–353.

Zohar, A. (2013). Challenges in wide scale implementation efforts to foster higher order thinking (HOT) in science education across a whole school system. *Thinking Skills and Creativity*, *10*, 233–249.

Zohar, A., & Ben-David, A. (2009). Paving a clear path in a thick forest: A conceptual analysis of a metacognitive component. *Metacognition and Learning*, *4*(3), 177–195.