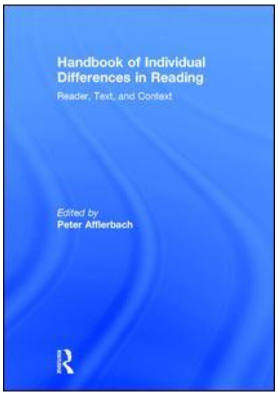

Handbook of Individual Differences in Reading Reader, Text, and Context

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Metacognition

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Introduction

Metacognition refers to the descriptive knowledge of, and the regulatory control over one's cognitive system (Veenman, van Hout-Wolters, & Afflerbach, 2006). The relevance of metacognition for reading has been recognized early on (Baker & Brown, 1984). Reading not only pertains to studying texts and textbooks, as reading activities are omnipresent in various school tasks. When writing a paper, students have to search for information in the library or on the Internet. Even problem solving in physics or mathematics requires thorough reading of the problem statement. Many students, however, fail to exert adequate metacognitive control while reading (Veenman, 2013a). A literature review by Wang, Haertel, and Walberg (1990) revealed that metacognition is the most important predictor of learning outcomes, surpassing other cognitive and motivational characteristics of students. In an overview of studies with students (9–26 years) performing different tasks in various school domains, Veenman (2008) estimated that metacognitive skillfulness accounted for 40 percent of learning outcomes. The impact of individual differences in metacognition is also acknowledged in reading research (Baker, 2005; Pressley & Afflerbach, 1995; Veenman & Beishuizen, 2004).

The concept of metacognition has its roots in developmental psychology with Piaget and Flavell as progenitors. Metacognition initially focused on the developing person's thinking about cognition. In particular, metamemory research addressed children's increasing knowledge of how memory operates (Flavell & Wellman, 1977). Brown (1978; Brown & DeLoache, 1978) added self-regulation to the conceptualization of metacognition. Metacognitive strategies and skills for goal setting, planning, monitoring, and evaluation coordinate the execution of cognitive processes. 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, is recurrent in definitions of metacognition (Schraw & Moshman, 1995; Veenman et al., 2006).

Metacognitive Knowledge

Metacognitive knowledge refers to one's declarative knowledge about the interplay between person, task, and strategy characteristics (Flavell, 1979). For instance, a student may think that s/he (person) has difficulties with reading complex texts (task) and, consequently, that s/he should invest more effort in thoroughly reading a scientific article (strategy). Conversely, another student may positively evaluate his/her reading proficiency, thus putting less effort into reading the same article. Some researchers presume that metacognitive knowledge only refers to correct knowledge, derived from earlier experiences (Schraw & Moshman, 1995). The assumption is that only accurate and flawless knowledge can be truly metacognitive by nature. Metacognitive knowledge, however, may be incorrect when learners overestimate or underestimate their competences, relative to the subjectively perceived task complexity (Veenman et al., 2006). For instance, students sometimes erroneously think that they only have to read a textbook once in preparation for an exam, even after repeatedly failing on earlier exams. Such flawed self-knowledge may prove resistant to change, especially when students misattribute their failure to external causes such as poor teachers or unfair exams. Even correct metacognitive knowledge does not guarantee an adequate execution of appropriate skills, as students may lack the motivation or capability to do so. Alexander, Carr, and Schwanenflugel (1995) found a discrepancy between children's knowledge about monitoring and their application of monitoring skills. Winne (1996) argued that knowledge has no effect on behavior until that knowledge is actually used. Consequently, metacognitive knowledge often poorly predicts learning 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. The proof of the pudding is in the eating, not in the recipe.

Metamemory

Metamemory initially referred to the declarative knowledge about one's memory capabilities and about strategies that affect memory processes (Flavell & Wellman, 1977). It was assumed that knowledge of memory processes would affect memory performance, although mediated by memory strategies such as selective attention and rehearsal. Indeed, moderate correlations between declarative metamemory and reading comprehension have been reported (Van Kraayenoord, Beinicke, Slagmüller, & Schneider, 2012). Later, the focus shifted from declarative metamemory to procedural metamemory with monitoring as a key process (Schneider, 2008). Judgment of Learning (JOL) and Feeling of Knowing (FOK) refer to a person's predictions of future test performance, either on items that have been learned (JOL), or on items that are to be studied (FOK). Accuracy of predictions is calculated from the discrepancy between predictions and actual performance on items of a memory test, such as vocabulary tests (Nelson & Narens, 1990). As FOKs and JOLs are the result of monitoring item difficulty and evaluating memory content, procedural metamemory is part of metacognitive skillfulness, instead of metacognitive knowledge (Veenman, 2011a).

Conditional Knowledge

A noteworthy component of metacognitive knowledge is conditional knowledge (Schraw & Dennison, 1994; Veenman, 2011a). Conditional knowledge pertains to declarative knowledge about when a particular metacognitive strategy should be applied and to what purpose. Poor readers often are not aware of *what* strategy should be deployed *when* during reading, or *why* the strategy should be used. Adequate conditional knowledge, however, does not warrant actual strategy use because students may lack the procedural knowledge for *how* to enact the strategy. It is like taking your first driving lesson, when you know many useful things about a car but you still have to learn how to drive one. 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 (Afflerbach, Pearson, & Paris, 2008; Veenman, 2011a). Thus, conditional knowledge is a prerequisite, yet insufficient condition for the acquisition of metacognitive strategies and skills.

Metacognitive Strategies and Skills

Metacognitive strategies and skills pertain to the acquired repertoire of procedural knowledge for monitoring and controlling one's learning behavior (Veenman, 2011a). The essential difference between a strategy and a skill is that strategies require deliberate, conscious effort, whereas the execution of skills is (partly) automatized (Afflerbach, Pearson, & Paris, 2008; Alexander & Jetton, 2000). Pressley and Afflerbach (1995) discerned some 150 different activities in detail for constructively responsive reading, most of which are representative of metacognitive strategies and skills. They based their taxonomy on an exhaustive analysis of thinking aloud protocols from expert readers. Such an extensive taxonomy, however, may be too sophisticated for analyzing the metacognitive reading behavior of secondary-school students (Meijer, Veenman, & van Hout-Wolters, 2006) or university students (Veenman & Beishuizen, 2004). These students enact metacognitive strategies and skills on a more global level while studying a text, leaving out many detailed activities from Pressley and Afflerbach's taxonomy. Therefore, a global description of metacognitive strategies and skills is presented here. A distinction is made between metacognitive activities at the onset of a reading task, during the reading task, and at the end of the reading task (Pressley & Afflerbach, 1995; Veenman, 2013a; Zimmerman, 2000).

Orientation and Planning at the Onset of Reading

At the onset of a task, orienting activities are preparatory to reading or studying a text. First, students should properly read the assignment, if any, to understand what is expected from the reading task. The assignment could provide vital information for later goal setting. Next, students should read the title of the text, which contains essential information about the topic of the text. They should read the abstract, whenever available, to get an overview of the text. Once the topic of the text is known, students can activate prior knowledge about the subject matter from memory. Activating prior knowledge is helpful in understanding the text while reading, but it also facilitates storage of new information in long-term memory. Then students may scan the text for subheadings, paragraph structure, and text length to get an impression of the reading task that lies ahead of them, and to estimate the text difficulty and time needed for reading the text. Students ought to set reading goals, depending on the nature of the reading task. It makes a difference whether one is reading a text in preparation for an exam, whether one is looking for specific information needed for writing a paper, or whether one is reading a novel for leisure. Such reading goals should specify what kind of information in the text is relevant to the student, which is the point of departure for planning one's reading activities. Reading plans pertain to focusing on relevant parts of the text, the allocation of reading time, and selecting methods for processing the content (e.g., by making schemas or concept maps). Students may diverge in reading goals and plans. For instance, when reading a history text, some students are devoted to memorizing dates and events, whereas others emphasize the causes and consequences of historical events (Van der Stel & Veenman, 2010). Armed with such a reading plan, students may enter the arena of reading.

A participant from the study of Van der Stel and Veenman (2010) may illustrate the orientation behavior of metacognitive proficient readers. This participant first read the title of a history text on the American civil war to grasp the major theme and used this information to recollect prior knowledge about the topic. Thus, concepts like North versus South, slavery, and the assassination of Lincoln were activated. Next, he skimmed the text for subtitles and paragraphs to get an overview of the text structure. Then, he deliberately turned to reading the conclusion, because he wanted "to know what the text is heading for." After reading the conclusion paragraph, he noticed that he did not understand all of it, but he had a global idea of directions for reading the text. For instance, he wanted to know more precisely how slavery affected the civil war. In fact, this is an expression of goal setting. Subsequently, he returned to the first page and devised a reading plan for mapping particular concepts and their relations, before actually starting to read. In contrast, poor metacognitive readers tend to skip the title of the text and immediately start reading linearly, from beginning to end (Van der Stel & Veenman, 2010; Veenman & Beishuizen, 2004).

Monitoring and Selecting Methods for Processing Text During Reading

During reading, metacognitive proficient readers keep a close watch on their reading behavior. They monitor their comprehension of words, sentences, and paragraphs (Baker & Brown, 1984; Markman, 1985). Whenever they encounter confusions or miscomprehensions, they take actions to remedy their lack of understanding by consulting a dictionary, by backtracking and rereading the text carefully, or by purposefully navigating through the text in search of information (Pressley & Afflerbach, 1995; Puntambekar & Stylianou, 2005; Veenman & Beishuizen, 2004). Students with poor monitoring skills, on the other hand, either do not detect miscomprehension or they do not take action to resolve the problem. For instance, they may replace an unknown word with an incorrect familiar one without noticing, even when the familiar word does not fit in with the context (Veenman, 2013a). Monitoring also refers to whether progress is made towards reading goals (Veenman, 2013a). During reading, metacognitive proficient students keep track of whether their understanding of the text brings them closer to what they want to know. If not, they may decide to change their reading plan, to reset reading goals, or to abandon reading when the required information is absent.

Metacognitive proficient students also select methods for actively processing text during reading. They close read and paraphrase difficult text parts, they generate self-questions, they draw conclusions and make inferences, they relate new information to prior knowledge, they take notes and selectively highlight or underline text, and they draw up schemas or concept maps (Pressley & Afflerbach 1995; Veenman, 2013a). Poor metacognitive students, on the other hand, do not actively process the text or they do so ineffectively. For instance, when first-year psychology students at Leiden University open their books, many pages appear to be entirely colored yellow with a marking pen. This unselective marking of pages indicates an inability to distinguish relevant from irrelevant information, partly due to a lack of content knowledge, but ultimately due to deficient metacognition (Veenman & Beishuizen, 2004). Metacognitive proficient readers only highlight main concepts, definitions, and findings, leaving most of the page unmarked (Veenman, 2013a).

Evaluation and Recapitulation After Reading

After reading, metacognitive proficient students evaluate their comprehension of the text against their reading goals. For instance, they consider whether the text was sufficiently studied to pass the exam, or whether they obtained the required information. They may generate "end-of-the-chapter" questions to test the consistency and completeness of their comprehension (Pressley & Afflerbach, 1995). If not, they may reread certain parts of the text or review their notes. Moreover, they often make a concise summary of the text, recapitulating the central theme, arguments pro and con, evidence or decisive events, and important conclusions drawn (Pressley & Afflerbach, 1995; Veenman, 2013a). Finally, they may reflect on the reading process to improve their reading for future occasions (Veenman, 2013a). Poor metacognitive students, especially younger students, tend to adhere to the full stop after reading the last word of the text by saying "ready."

The execution of metacognitive strategies and skills before, during, and after reading is a cyclic process, rather than being strictly linear (Veenman, 2013a; Zimmerman, 2000). While reading, students may come to the conclusion that the text content is not corresponding to their prior expectations. This may lead to reorientation on the reading task, and to adjusting or fine-tuning reading goals and plans. Moreover, students may already draw conclusions and summarize paragraphs while reading, in advance of later recapitulation. After reading, evaluation of text comprehension may result in reorientation on the task assignment or reading goals, or in rereading text parts.

Model of Metacognitive Skills as Self-Instructions

In a process model of metacognitive skills, cognitive activity should be distinguished from metacognitive activity. When students are thinking aloud during reading, this distinction becomes manifest as they may express their intention to apply a particular metacognitive skill while enacting the cognitive behavioral consequences of that skill. During silent reading, however, metacognitive skills remain covert mechanisms that have to be inferred from their behavioral consequences (Veenman et al., 2006). For instance, when a student consults a dictionary, it is assumed that a preceding monitoring process has made the student aware of an unfamiliar word or phrase, and that a local planning process resulted in looking for a dictionary. Thus, higher-order metacognitive skills draw on lower-order cognitive processes. Metaphorically speaking, metacognitive skills represent the driver, while cognitive processes make up the vehicle for employing those skills (Veenman, 2011a).

In his model of metacognition, 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 decoding, parsing, and lexical access for reading. In addition, component processes of more complex reading skills, such as relating, comparing, 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 linking the meta-level to 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. Nelson's model can be metaphorically conceived as the production unit of a company, where the shop floor symbolizes the object-level and the manager overlooking the shop floor personifies the meta-level. The manager monitors activity on the shop floor to detect errors that may obstruct the production process, upon which the manager's instructions restore production at the shop floor. Basically, this is a bottom-up model because metacognitive control is triggered by anomalies in cognitive activity (Veenman, 2011a).

Veenman (2011a) 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 learner is faced with performing a task. 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, activating prior knowledge after reading the title of the text can be represented by the rule: "IF you have inferred the topic or theme from the title of the text, THEN retrieve all that you know about the topic from memory." 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 students 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, much in the same way as cognitive skills are learned (Veenman, 2011a). According to ACT-R theory (Anderson, 1996), skill acquisition passes through three successive stages. In the cognitive stage, *declarative* knowledge of condition 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 strategy at this stage requires extra effort, which may temporarily interfere with cognitive performance (Puntambekar & Stylianou, 2005; 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, the execution of skills is fine-tuned and automated in the autonomous stage. Some 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, goal setting remains strategic, that is, intentionally and deliberately employed contingent on task characteristics (Afflerbach et al., 2008; Alexander & Jetton, 2000). Monitoring processes, on the other hand, may run in the background until an error or anomaly is detected (Samuels, Ediger, Willcutt, & Palumbo, 2005). Consciously checking the meaning of every word or phrase would interfere with reading fluency. Yet, proficient readers are alerted whenever they encounter unknown words or inconsistencies in the text. In the same vein, some planning processes may become automated or habitual (Borkowski, Carr, & Pressley, 1987), such as skimming a text before reading, or rereading a sentence when one does not grasp its meaning. In fact, the repertoire of metacognitive self-instructions should become good practice, albeit adaptively applied.

Development of Metacognition

Many students spontaneously acquire a repertoire of self-instructions, either by themselves through reading practice, or by observing good reading models (parents, teachers, etc.). Skill acquisition, however, is constrained by the developmental trajectory of metacognition. In a nutshell, the development of metacognition can be characterized by the emergence of metamemory at the age of 5 to 6 years, followed by an expansion of metacognitive knowledge in early childhood, and the incremental use of strategies and skills from late childhood into adolescence (Veenman, 2011a). Earlier developmental processes of Theory of Mind (ToM) and Executive Functions (EF), however, pave the way for metacognitive development.

Precursors of Metacognition

Theory of Mind (ToM) pertains to children's knowledge about the mind and, in particular, knowledge about mental states such as beliefs, desires, and intentions. Crucial to the development of ToM is the perception 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) evidenced that ToM at the age of 4 to 5 years is a precursor of later metamemory performance at 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 readers to take different perspectives, to understand the different positions of protagonists in a story, and to differentiate between fact, belief, and fiction.

Executive functions (EF) refer to processes of inhibition, selective attention, working memory efficiency, and elementary forms of planning. EF capacity is related to the maturation of the prefrontal cortex from early childhood throughout adolescence. Blair and Razza (2007) established that especially inhibitory control is a strong predictor of early literacy in children of 3 to 5 years old. Inhibition may prevent readers from rushing through a text while ignoring relevant features. In general, EF processes could be conceived as basic building blocks for later development of metacognitive skills, such as planning ahead and monitoring one's reading activities.

Development of Metacognitive Knowledge

The acquisition of declarative metamemory sets the stage for the development of metacognitive knowledge (Flavell & Wellman, 1977; Schneider, 2008). Preschool children already experience that they sometimes forget or inaccurately recollect knowledge or events. Once in primary school, children become aware of task demands and memory strategies, such as rereading or rehearsing difficult materials. Children, however, do not effectively use strategies for restudying materials before the age of 10 (Metcalfe & Finn, 2013). Metamemory rapidly increases with age until it reaches a peak in late adolescence (Schneider, 2008). A longitudinal study by Kurtz and Borkowski (1987) indicated that metamemory of children in the age of 7 to 9 years facilitates the acquisition of summarization skills for reading comprehension at the age of 10 to 12 years. Thus, declarative metamemory indirectly affects later memory performance through the acquisition of strategies.

During the early school years, the scope of metacognitive knowledge is gradually broadened to other aspects of cognitive functioning. Children learn to differentiate tasks and demands, they become aware of their own capacities and limitations, and they increasingly recognize conditions for strategic behavior. Studies have shown that metacognitive knowledge of reading strategies increases with age, and that this knowledge is predictive of later reading comprehension (Paris & Flukes, 2005). This conditional knowledge is the overture to the development of metacognitive reading-comprehension skills in successive years. Strategic behavior, however, is initially obstructed or frustrated by the inadequacy of conditional knowledge (Annevirta & Vauras, 2006). Moreover, the educational focus on technical reading during early primary-school years

(Chall, 1979) draws less on higher-order strategy use. Once children have learned to read more or less fluently, a shift from technical to comprehensive reading calls for the actual application of metacognitive strategies.

Development of Metacognitive Strategies and Skills

Children younger than 8 years are not entirely devoid of metacognitive strategies or skills if tasks are made appropriate to their interest and level of understanding. Even 5-year-old children may demonstrate rudimentary forms of planning and self-correction in playful situations, such as distributing dolls over a limited number of chairs (Whitebread et al., 2009). In the same vein, children of 6 to 8 years may occasionally notice that they do not understand task instructions and ask for clarification, provided that they possess an adequate level of metacognitive knowledge (Annevirta & Vauras, 2006). Furthermore, children may engage in comprehension-monitoring activities before they are fluent readers, when prompted to do so (Baker, 2005). Apparently, metacognitive skills already develop at a basic level alongside metacognitive knowledge during preschool or early primary-school years, but they become more sophisticated and academically oriented when formal educational requires the utilization of a metacognitive repertoire (Veenman, 2011a). From the age of 8 years on, children give evidence of a steep increase in frequency and quality of metacognitive skills (Alexander et al., 1995; Schmitt & Sha, 2009; Van der Stel & Veenman, 2010; Veenman & Spaans, 2005). This development of metacognitive skills continues well into adulthood (Veenman, Wilhelm, & Beishuizen, 2004; Weil et al., 2013). At all ages, however, profound individual differences in the execution of metacognitive skills can be observed, indicating a differential developmental pace of metacognitive skills among students (Veenman et al., 2004; Van der Stel & Veenman, 2014). Without further instruction, some students hardly acquire or learn to produce metacognitive skills, while others spontaneously expand and refine their repertoire over time.

Domain-Specificity Versus Generality of Metacognitive Skills

Until the age of 14, the metacognitive skills of children have a substantial domain- or task-specific orientation. The same students may vary in metacognitive skills applied to reading, problem-solving, or discovery-learning tasks (Van der Stel & Veenman, 2010; Veenman & Spaans, 2005). Veenman and Spaans (2005, p. 172) concluded that "metacognitive skills may initially develop on separate islands of tasks and domains that are very much alike." Between the age of 14 and 15 years, however, metacognitive skills generalize across tasks and domains. In a longitudinal study, Van der Stel and Veenman (2014) followed 12-year-olds for three successive years while they performed a reading task in history and a problem-solving task in mathematics each year. Principal-component analysis on metacognitive-skill measures for both tasks extracted a general component accounting for 44 percent and 41 percent of variance in the first two years, and a weaker domain-specific component, fading out from 22 percent down to 17 percent of variance accounted for. At the age of 15 years, however, only a general component remained with 48 percent of variance accounted for. Apparently, the partially separate repertoires for the two tasks and domains were merged into one general repertoire. More evidence for the domain-general nature of metacognitive skills beyond the age of 15 has been obtained in other studies (cf., Veenman & Beishuizen, 2004; Veenman & Spaans, 2005; Veenman et al., 2004). Around the age of 15, students have attained a personal repertoire of self-instructions at the meta-level that they tend to apply whenever they encounter a new task. Obviously, the implementation of generalized self-instructions at the object-level requires an adaptation to constraints of the task and domain at hand (Veenman, 2011a). Tuning metacognitive skills to task constraints characterizes expert reading. This notion of generalized metacognitive skills has implications for the instruction, training, and transfer of metacognitive skills across tasks and domains.

Assessment of Metacognitive Reading Strategies and Skills

Off-line Versus On-line Assessments

When assessing metacognitive skills, off-line methods should be distinguished from on-line methods that are administered concurrent to task performance (Veenman, 2005, 2011b). Off-line methods pertain to self-report instruments, such as questionnaires and interviews, administered either prior or retrospective to reading. Frequently used questionnaires for strategy use in reading or text studying are the MSLQ (Pintrich & De Groot, 1990) and the MAI (Schraw & Dennison, 1994). Students have to answer questions about their strategy use and skill application on a Likert-type scale. Off-line self-reports, however, suffer from validity problems. When answering questions, students have to consult their memory to reconstruct earlier strategic processes in reading, a reconstruction process which is susceptible to memory failure and distortions (Veenman, 2011a). Moreover, questions may prompt the recall of strategy use that never occurred (Veenman, 2011b). Questions may evoke an illusion of familiarity with strategies that are inquired for and students may respond by labeling their behavior accordingly. Finally, when rating their strategy use on Likert-type scales, students have to compare themselves with others (peers or teachers). Individual reference points may vary between students, yielding disparate data (Veenman, 2011a).

On-line methods, on the other hand, register metacognitive strategies and skills that are actually employed while reading, according to a standardized coding system. The essential difference between off-line and on-line methods is that off-line measures merely rely on subjective self-reports, whereas on-line measures entail the coding of actual reading behavior on externally defined criteria. Typical on-line methods for reading tasks are thinking aloud, eye-movement registration, and computer-logfile registrations (Veenman, 2013b). Thinking aloud means that students merely verbalize the content of working memory while performing a reading task, such verbalization does not distort the ongoing cognitive processes (Ericsson & Simon, 1993). Thinking aloud is used for analyzing reading processes, for assessing metacognitive skills of participants in reading research, as well as for diagnosing metacognitive deficiencies in readers (Veenman, 2013a).

Recently, computers allow for unobtrusive on-line registration of reading activities in logfiles. In *gStudy*, a hypermedia environment with logfile registration (Hadwin, Nesbit, Jamieson-Noel, Code, & Winne, 2007), readers are provided with tools for making notes, highlighting text, and making links across concepts during reading. Trace data of study events are stored in a logfile, from which frequencies and patterns of study activities over time can be produced. Logfile registration, however, only collects concrete reader activities at the object level, which implies that self-instructions at the meta-level need to be inferred by the researcher without verbal accounts from readers. Consequently, logfile measures should be triangulated with other on-line measures (Veenman, 2013b).

Validity of Metacognitive Assessments

When considering measurement validity, many researchers only address internal consistency (Veenman, 2005). A more relevant criterion, however, is construct validity, which is supported when different methods yield converging data (Baker & Brown, 1984; Veenman, 2011b). Studies with multi-method designs have shown that off-line measures hardly correlate with on-line measures of metacognitive skills in reading (Veenman, 2005; Winne & Jamieson-Noel, 2002). Moreover, correlations among similar off-line measures are low, in contrast with high correlations among on-line measures (Veenman, 2005). In conclusion, perceived strategy use in off-line self-reports does not adequately represent actual strategy use while reading. Therefore, on-line methods are indispensable to assessing metacognitive strategies and skills for reading.

Instruction and Training of Metacognitive Skills

Given the impact of metacognitive skills for reading and the huge individual differences that persist over the course of development, metacognitive poor readers need to be explicitly instructed and trained. There are three principles for effective instruction of metacognitive skills (Veenman et al., 2006). According to the principle of *embedded instruction*, metacognitive instruction should be integrated within the context of a reading task. Embedded instruction enables the student to connect conditional knowledge of which skill to apply when (the IF-side of production rules) to the procedural knowledge of how the skill is applied (the THEN-side) in a concrete task setting. According to the principle of *informed instruction*, students should be informed about the benefit of applying metacognitive skills in order to make them exert the extra effort that instructed skills initially require. In fact, reading performance may be temporarily impaired due to the effort expenditure needed for skill acquisition (Magliano, Trabasso, & Graesser, 1999; Puntambekar & Stylianou, 2005). Students may be inclined to abandon the instructed skills, unless they appreciate why metacognitive skills eventually facilitate reading. The third principle of *prolonged training* aims at a smooth and sustained application of metacognitive skills. As a rule, a longer duration yields better training results (Dignath & Büttner, 2008). Required duration of instruction, however, may vary with the number and complexity of skills instructed, and the reading competency of individual students (Veenman, 2011a). Veenman et al. (2006) referred to these three principles as the *WWW&H* rule for extensive metacognitive instruction. Students should be instructed, modeled, and trained *when* to apply *what* skill, *why* and *how* in the context of a task (Borkowski et al., 1987; Brown, 1978). In the same vein, Veenman (2013a) provides a step-by-step action plan for training a sequence of concrete metacognitive activities for reading.

Examples of Metacognitive Instruction and Training Programs

A groundbreaking example of a metacognitive training program for reading comprehension is Reciprocal Teaching (Brown & Palincsar, 1987). During 20 training sessions, students with poor reading-comprehension skills collaboratively read texts in small groups with a teacher. In the first sessions, the teacher modeled four metacognitive strategies for reading comprehension (questioning, summarizing, clarifying, and predicting) according to the informed-training principle. Next, the teacher provided adaptive support to the students, contingent on their mastery of strategies. Support was gradually reduced over time as students took over responsibility for group discussions. Due to this scaffolding, students eventually could apply the four strategies independent of the teacher. Moreover, pre and post-test comparisons revealed that Reciprocal Teaching substantially improved the students' reading comprehension. Later researchers have fruitfully adopted Reciprocal Teaching in training studies.

Pressley and Gaskins (2006) developed a teaching method on a special school for students with low reading abilities. Throughout the day, teachers of all school disciplines addressed students with metacognitive reading instructions. Teachers incessantly explained, modeled, and stimulated the use of metacognitive strategies, such as establishing the purpose for reading, grasping the theme and main ideas of the text, predicting further developments in the text, relating new information to prior knowledge, monitoring understanding through self-questioning, resolving incomprehension by rereading, summarizing the text, and reviewing the reading process. After spending several years at this special school, students returned to regular education with above average reading scores, compared to same-age students.

Azevedo, Greene, and Moos (2007) asked students to study a complex hypermedia text about the blood circulatory system. Half of the students received metacognitive prompts from a human tutor, instigating them to set goals, activate prior knowledge, plan time and effort allocation, monitor comprehension and progress, and to apply strategies such as summarizing, hypothesizing, and drawing diagrams. Prompted students employed more self-regulatory activities and attained higher levels of reading comprehension, relative to control students without prompts.

These successful studies have in common that they advance the execution of metacognitive strategies and skills in line with the aforementioned three principles and the WWW&H rule. Many training studies, however, suffer from an incomplete design. They only present instructional effects on reading comprehension, but they fail to report effects on metacognitive behavior. Instructional effectiveness is accounted for by the causal chain of instruction leading to improved strategy use and, thus, to enhanced reading comprehension (Veenman, 2013a). Otherwise, instructional effects on comprehension measures could equally be attributed to, for instance, extended time on task due to compliance with instructions. To ensure that lasting effects are attained in reading research and practice, it is imperative that both dependent measures of metacognitive skillfulness and reading comprehension are assessed subsequent to training.

Availability versus Production Deficiencies

Not all students are alike in their need for instruction. Students who display poor metacognitive behavior may suffer from availability or production deficiencies (Veenman, Kerseboom, & Imthorn, 2000). Students with an availability deficiency do not have metacognitive skills at their disposal. They lack the conditional and procedural knowledge of metacognitive self-instructions and, consequently, they need to be fully instructed according to the WWW&H rule. Students with a production deficiency, on the other hand, have metacognitive skills available, but they do not spontaneously apply self-instructions for some reason (Brown & DeLoache, 1978). For instance, they do not recognize the relevance of metacognitive skills for a particular task, or test anxiety obstructs the execution of skills (Veenman et al., 2000). Production deficiencies may arise, for instance, when difficult texts are read under time pressure (Veenman & Beishuizen, 2004). These students need not be fully trained in *how* to employ metacognitive skills as they are capable of producing the skills on familiar tasks or when relieved of performance pressure. Prompting or cueing will remind production-deficient students of applying metacognitive skills, but it will leave the metacognitive behavior of availability-deficient students unaffected (Veenman et al., 2000).

Concluding Remarks

Reading is a basic intellectual function in school learning and in everyday life. In order to become proficient readers, students not only need to acquire lower-order skills for fluent reading, they also have to adopt metacognitive skills for reading comprehension. A theoretical framework of metacognitive self-instructions accounted for how metacognitive skills are acquired and employed by students. Metacognitive self-instructions make up a well-organized repertoire of strategies and skills at the meta-level that actively controls and regulates cognitive reading activities at the object-level. From a developmental perspective, it was depicted how declarative metacognitive knowledge of reading strategies contributes to the formation of self-instructions. Thus, declarative metacognitive knowledge only indirectly affects reading comprehension through the application of metacognitive strategies and skills. Moreover, task-specific metacognitive skills merge into a general repertoire of metacognitive self-instructions across tasks and domains.

These notions have implications for the assessment and training of metacognitive strategies and skills. Off-line self-reports, such as questionnaires and interviews, suffer from validity problems and they do not reflect the students' actual metacognitive behavior during reading. Consequently, the assessment of metacognitive strategies and skills should resort to on-line methods. Thinking aloud provides direct access to both metacognitive self-instructions at the meta-level and their implementation on the object-level. On-line measures that only assess behavior at the object-level, which may or may not be instigated by metacognitive self-instructions, ought to be validated before they are used for assessing metacognitive reading behavior (Veenman, 2013b).

In order to be successful, metacognitive instruction and training should follow the principles of embedded, informed, and prolonged instruction. Instruction should explicitly address the *what*, *when*, *why*, and *how* that constitute a metacognitive self-instruction. An additional challenge to instruction is that task- and domain-specific metacognitive skills merge into a general repertoire of self-instructions in the course of development. Therefore, instruction and training of metacognitive strategies and skills should be extended to reading for multiple tasks and disciplines (Pressley & Gaskins, 2006; Veenman et al., 2004). Diversity of reading tasks would allow for "high-road transfer," that is, bridging and synchronizing the conditions and actions of skills across tasks and disciplines (Salomon & Perkins, 1989). Especially for students of 13 to 15 years, variety in reading tasks during instruction may foster the generalization of metacognitive self-instructions. Such a general repertoire of metacognitive reading skills is a powerful tool for managing new reading tasks when entering academic education or when applying for a new job.

Finally, the notion of availability versus production deficiencies stresses an individual approach to instruction and training of metacognitive skills. It is not just a matter of educational efficiency that instruction should be attuned to the individual needs of students. Production-deficient students may get bored or frustrated by extensive instruction and, consequently, they may adversely abandon the use of strategies and skills. Therefore, individualized assessments of metacognitive deficiencies are prerequisite to adaptive instruction. After all, the ultimate goal is to make students metacognitively proficient, constructively responsive readers.

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