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The Measurement of Metacognitive Processes in Psychology Research – A Review

Abstract

21st century skills, like self-regulation, metacognition, communication, collaboration, digital and critical thinking skills become increasingly relevant in every life domain. Metacognitive processes contribute to the adequate planning and execution of activities, time-management, adaptive emotion regulation. In this review several online and offline measurement methods are demonstrated, highlighting the advantages, strengths and disadvantages, weaknesses of the most often used instruments for the assessment of metacognition, namely of the self-reported questionnaires. One of the most frequently applied offline self-reported instruments for the study of metacognition is the Metacognitive Awareness Inventory developed by Schraw and Dennison in 1994. The inventory measures five metacognitive regulation skill: planning, information management strategies, comprehension monitoring, debugging strategies, evaluation and three types of metacognitive knowledge: declarative, procedural and conditional knowledge. However, the results regarding the factorial structure, subcomponents and item structure of the inventory are very contradictory. Some possible explanations of these contradictory results are also discussed.

Keywords: metacognition, assessment, metacognitive knowledge, metacognitive regulation, Metacognitive Awareness Inventory

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Introduction

Metacognition, as a form of self-regulation, is one of the most researched higher-order cognitive abilities of the 21st century. Metacognitive processes involve not only understanding our cognitive processes and activities but also regulating them for adaptive problem-solving and successful adaptation in all areas of life.

Metacognitive processes are investigated within numerous psychological areas (Norman et al. 2019). Research in the field of educational psychology highlighted the role of metacognition and its development in learning and achievement. Experimental psychologists, investigating the effect of metacognitive judgements on different cognitive activities, confirmed the relationships between metacognition and other higher order cognitive processes, like problem solving, critical thinking. In clinical psychology the role of metacognition in mental health and its modification opportunities are examined. Research regarding developmental psychology studies the progress of metacognition and its application in different situations at different periods of life. Personality and social psychology studies focus on the recognition and control of mental processes that could affect attitudes and interpersonal relationships. The aim of cognitive neuropsychology research is the identification of the brain regions responsible for metacognitive activities (Norman et al. 2019).

The measurement of metacognition is difficult because it cannot be defined as an explicit behaviour, nor as a fully implicit process, because we are aware of our metacognitive processes to a certain degree. Metacognitive processes could not be observed in a direct manner. It is a complex mental process that contains metacognitive knowledge and regulation, but also includes momentary motivational and emotional aspects that could affect the control of cognitive processes (Lai 2011).

For the measurement of metacognition researchers apply extensively self-report questionnaires, inventories (Altindağ–Senemoğlu 2013; Çetinkaya–Erktin 2002; O'Neil–Abedi 1996; Pedone et al. 2017; Schraw–Dennison 1994; Sperling et al. 2002; Yildiz et al. 2009), interviews (Bosch et al. 2021; Pellecchia et al. 2015; Semerari et al. 2012), performance ratings (Filevich et al. 2020; Pennington et al. 2021), systematic observations (De Backer et al. 2021; Escolano-Pérez et al. 2019; Lai 2011; Ozturk 2017), and think-aloud strategies (Jordano–Touron 2018; Schellings–Broekkamp 2011; Schellings et al. 2013). The application of think-aloud strategies is very time-consuming because of the individual observation and evaluation (Akturk–Sahin 2011).

Online and offline methods for the measurement of metacognition

For the measurement of metacognition online and offline instruments are distinguished. The online tools measure metacognition during the solution of a task or during learning, such as think-aloud protocols, when the participant needs to think aloud and phrase the strategies applied for task solution. Another online measurement is judgement regarding the actual performance, which is compared with the real performance, for the measurement of metacognitive accuracy. Offline tools do not measure metacognition during the execution of the task or during the learning situation, but before or after the accomplishment of the exercise. During metacognitive interviews participants are asked about the metacognitive strategies applied earlier. Similarly, in case of questionnaires the individual needs to judge and decide whether different aspects of metacognition were present or not, or to what degree were they present during the execution of the task, or how they were manifested in general. There is no significant relationship between the results of online and offline measurements of metacognition, thus the results are influenced by the instrument applied for the measurement of metacognition (Craig et al. 2020; Schellings et al. 2013).

Another controversial question is the timing of the instrument for the measurement of metacognition. The offline measurement of metacognition with questionnaires or interviews before the execution of the task implies several biases, like response bias for example. During the measurement of metacognition after the completion of the task, the participant has the opportunity to retrospect and analyse the knowledge and skills applied in the current task. However, the online measurements of metacognition, that are more reliable than offline measurements, are not appropriate for the measurement of all metacognitive processes, for example the evaluation of the achievement or problem-solving process is possible only after task completion (Craig et al. 2020).

Self-report questionnaires for the measurement of metacognition

For the measurement of metacognition several questionnaires were developed. The advantages of self-report questionnaires include their simple application on huge samples, time effectiveness, cost effectiveness of the data processing, the possibility of quick and objective evaluation of the results (Akturk–Sahin 2011; Roth et al. 2016;

Schellings – Van Hout-Wolters 2011; Schellings et al. 2013). Besides these advantages there are also several disadvantages. Many questionnaires examine general learning strategies, participants need to judge how they learn in general, independently of the context or the task. The answers to the items are affected by the participants' memory functions because they need to recall from their long-term memory the mental processes and activities applied by them during learning. Therefore, the questionnaires measure not concretely the applied metacognitive strategies, but the judgements or memories of the participants about the activated metacognitive processes in general learning or exercising situations. Similarly, the working memory and verbal skills of participants could also affect the responses (Akturk–Sahin 2011; Araka et al. 2020; Lai 2011; Schellings – Van Hout-Wolters 2011; Schellings et al. 2013).

During the application of self-report questionnaires response bias could appear, participants could overestimate their abilities (Akturk–Sahin 2011; Araka et al. 2020; Craig et al. 2020; Schellings – Van Hout-Wolters 2011), the answers might be influenced by the comparison of their abilities to others, they do not want to seem to have weaker or different abilities than others, or they might respond to the questions based on the expectations of the researcher (Craig et al. 2020). During the completion of self-report questionnaires regarding the general learning situation, participants could think about different task types, the context effect appears, thus the generalisability of the results is questionable (Lai 2011; Roth et al. 2016; Schellings – Van Hout-Wolters 2011; Schellings et al. 2013). The items of the questionnaire could also be interpreted differently, it can happen that not everybody understands the questions entirely (Akturk–Sahin 2011). It is not clear whether the respondents mark or evaluate as more characteristic of them the strategies that they consider useful, or the strategies applied by them in practice. There can be a difference between the statements of participants and their actual observed behaviour. The validity of the questionnaires could also be affected by the participants' ability to analyse the learning situation, to identify metacognitive knowledge and the applied strategies (Roth et al. 2016).

The Metacognitive Awareness Inventory (MAI)

The Metacognitive Awareness Inventory (Schraw–Dennison 1994) is an extensively applied instrument for the measurement of metacognition. The instrument was developed to measure metacognitive knowledge (three components: declarative, conditional and procedural knowledge) and metacognitive regulation (planning,

information management strategies, comprehension monitoring, debugging strategies, evaluation) indicators.

As result of unrestricted exploratory factor analysis (EFA), in the first validation study of Schraw and Dennison (1994) was found a six-factor structure, but these factors were uninterpretable from a theoretical point of view. It was concluded that the MAI does not measure the subcomponents of metacognition that were initially hypothesised, thus the presence of the two factors (metacognitive knowledge and regulation) was tested with restricted factor analysis. The aim of their second validation study was testing the validity of MAI, examining students' metacognitive knowledge, regulation and achievement with empirical methods. Metacognitive knowledge was tested with the judgement regarding the monitoring achievement before filling in the test, then participants completed four text comprehension tests. Metacognitive regulation was measured with the participants' confidence indicator in case of every text comprehension question, participants rated their own level of confidence in the correctness of their answer from 0 to 100%. For the investigation of the predictive validity of the instrument, first the researchers tested the two-factor structure that they had also investigated in the first study, then the MAI scores were compared to the previous judgements regarding the monitoring performance, to the text comprehension achievement and to the monitoring accuracy. Monitoring accuracy was calculated as the difference between the confidence in the correctness of the answers and the actual performance on the text comprehension tests. Similarly to the first study, only the two-factor structure of the MAI was confirmed in this study. Both studies found a significant relationship between metacognitive knowledge and metacognitive regulation factors. As a result of the second study, metacognitive knowledge was significantly associated to the judgement regarding the monitoring performance. Previous judgements were positively associated with the achievement, students having more confidence in their monitoring ability also achieved better results at the text comprehension test. Similarly, there was a significant positive relationship between MAI scores and text comprehension performance. However, no significant correlation was found between monitoring accuracy and MAI scores, nor between monitoring accuracy and monitoring judgements (Schraw–Dennison 1994).

In 2016 Ning tested the factorial structure of the instrument separately on students achieving low scores, and on students achieving high scores at the MAI. In case of students with low metacognitive awareness scores only a one-factor structure was revealed, but in case of students with high metacognitive awareness scores the

two-factor structure was confirmed. The results of this study suggest that the level of metacognitive abilities could affect the factorial structure of the instrument (Ning 2016).

The results regarding the subfactors of the two main factors show a high variety among the studies testing the factorial structure of the inventory. In case of MAI, the different studies identified 3, 4, 5, 6 and 8 subcomponents. The eight-factor structure of MAI proposed by Schraw and Dennison was confirmed only on its Persian (Pour–Ghanizadeh 2017) and Turkish (Akin et al. 2007) versions. Among the eight factors three belonged to the metacognitive knowledge and five to the metacognitive regulation factor. Therefore, these studies also confirm the two-factor structure.

One possible explanation for the variety of the results is the low level of metacognitive abilities of the participants that results in a less complex factorial structure (Ning 2016). Another possible explanation is that the age of the participants involved in the studies investigating the factorial structure of MAI moves on a wide range, primary school students cannot put into practice their metacognitive knowledge, respectively they cannot absolutely identify the strategies applied during learning, they have lower metacognitive awareness than secondary school students. Craig and his colleagues (2020), based on 20 included studies in their meta-analysis, concluded that the relationship between metacognitive knowledge and metacognitive regulation increases as the participants' age increases.

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