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METACOGNITION AS A REGULATOR OF THINKING AND DECISION-MAKING IN COMPLEX COGNITIVE CONTEXTS

Abstract. Cognitive science, broadly understood as enabling one to reflect on and manage one's thinking, has emerged as an essential cornerstone of modern psychology, neuroscience, and educational science. This article provides an extensive theoretical review of metacognition as a regulator of intricate decision-making and learning activities. Based on recent multidisciplinary studies, the article examines the duality of metacognition—monitoring and control—and its functioning in regulating confidence, detecting errors, and adjusting to alter behaviour strategically. The article pays special attention to differences between metacognitive knowledge and metacognitive regulation and how these aspects facilitate cognitive flexibility in dynamic contexts.

In addition, the article covers the recent neuroscientific literature that has implicated the prefrontal cortex, particularly the anterior and dorsolateral areas, as the crucial site of metacognitive ability. In educational settings, metacognition is an important determinant of academic achievement and knowledge transfer. Experiments dealing with measurement limitations are covered, including the shortcomings of tools that rely on the individuals themselves and the emergence of neurocognitive techniques. The article also discusses new models, including creative metacognition and domain-specialised frameworks that express the task-dependent nature of metacognitive management. Although it is beneficial, the article recognises cognitive cost and overconfidence as restrictions on the effectiveness of metacognitive ability. The review concludes by noting the necessity to develop metacognitive expertise through targeted training, particularly in professional and high-stakes decision-making contexts.

Practically, these insights carry far-reaching implications that traverse classrooms, clinics, and corporate boardrooms alike. By delineating the neural and

behavioural scaffolding of metacognitive skills, the review furnishes an evidence-based blueprint for designing interventions that enhance self-regulatory accuracy—whether in young learners grappling with mathematical abstraction, pilots executing real-time course corrections, or physicians weighing differential diagnoses under uncertainty. Embedding metacognitive prompts into adaptive learning platforms can amplify transfer of knowledge across domains, while neuro-feedback protocols targeting prefrontal circuitry promise to fine-tune confidence calibration where lives are on the line. In organisational spheres, cultivating cultures that reward reflective error-checking over blame may mitigate groupthink and catastrophic risk accumulation.

Keywords: metacognition, self-regulation, decision-making, metacognitive monitoring, neurocognition, academic performance, metacognitive accuracy, creative metacognition

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МЕТАКОГНІЦІЯ ЯК РЕГУЛЯТОР МИСЛЕННЯ ТА ПРИЙНЯТТЯ РІШЕНЬ У СКЛАДНИХ КОГНІТИВНИХ СИТУАЦІЯХ

Анотація. Метакогніція — це здатність людини усвідомлювати, оцінювати та регулювати власні когнітивні процеси, що є ключовим елементом сучасних підходів у психології, когнітивній нейронауці та педагогіці. У цій статті здійснено комплексний теоретичний аналіз структури та функцій метакогніції як засобу підвищення ефективності прийняття рішень і навчання в умовах складних когнітивних завдань. Розглянуто дихотомію між метакогнітивним знанням та регуляцією, що дозволяє людині ефективно моніторити власні дії, виявляти помилки та адаптивно змінювати стратегії. Стаття обґрунтовує значення метакогнітивної точності та самоконтролю для академічної успішності та прийняття рішень в умовах невизначеності.

Особлива увага приділена даним когнітивної нейронауки, які свідчать про участь префронтальної кори, зокрема передньої та дорсолатеральної її частин, у реалізації процесів моніторингу й контролю. Проаналізовано проблеми вимірювання метакогніції, включно з обмеженнями анкетних методів та перспективами нейроповедінкових досліджень. У статті також розглянуто новітні концепції творчої метакогніції та контекстуально залежних моделей,

які демонструють варіативність метакогнітивної поведінки залежно від типу завдання. Попри виявлені переваги, акцентовано на обмеженнях метакогніції, зокрема на перевантаженні ресурсів і феномені надмірної впевненості. У підсумку окреслено необхідність розробки програм розвитку метакогнітивних умінь у навчанні, професійній підготовці та кризовому управлінні.

На практиці ці висновки мають далекосяжні наслідки, що охоплюють як навчальні аудиторії, так і клініки та корпоративні кабінети. Завдяки окресленню нейронних та поведінкових основ метакогнітивних навичок, огляд надає обґрунтовану доказами основу для розробки інтервенцій, які покращують точність саморегуляції — як у юних учнів, що борються з абстракціями математики, так і у пілотів, що здійснюють коригування курсу в режимі реального часу, чи лікарів, які приймають рішення між можливими діагнозами в умовах невизначеності. Інтеграція метакогнітивних підказок у адаптивні освітні платформи може посилити перенесення знань між галузями, тоді як нейрофідбек-протоколи, націлені на префронтальні ділянки мозку, відкривають перспективу точнішої калібровки впевненості у критичних ситуаціях. У сфері організаційного управління формування культури, що заохочує рефлексивне виявлення помилок замість звинувачень, може зменшити ризик групового мислення та запобігти накопиченню катастрофічних ризиків.

Ключові слова: метакогніція, саморегуляція, прийняття рішень, метакогнітивний моніторинг, когнітивна нейронаука, академічна успішність, метакогнітивна точність, творче мислення

Problem statement. Metacognition, variously articulated as “thinking about thinking,” has become an organising framework within cognitive psychology, educational theory, and the neuroscience of learning. Since its introduction by Flavell in the 1970s, the construct has taken on an increasingly broad scope, including awareness of one's thinking and the ability to manage it. This twofold aspect—metacognitive knowledge and metacognitive control—makes metacognition influential in modulating learning, decision-making, and problem-solving, especially in situations of high or novel complexity. While the construct has gained increasing attention, metacognition is still characterised by definitional vagueness and conceptual intersection with associated constructs such as self-regulation, executive function, and consciousness (Akturk & Sahin, 2011) [1].

Empirical studies in recent decades have established that metacognitive skillfulness is positively correlated with academic achievement and all-around performance in tasks across the board. Students who know what they know and do not know can check on what they understand, catch errors, and implement correction procedures—outshine students who work on cognition without monitoring (Rhodes, 2019; Veenman, 2006) [10; 12]. Further advances in the neurosciences of the brain, including the prefrontal cortex, have shed light on the brain regions involved in monitoring confidence, detecting uncertainty, and strategically managing decision-

making (Fleming, 2024; Qiu et al., 2018) [4; 9]. These results are consistent with the perspective that metacognition is not an incidental by-product of higher-order reasoning, but is an essential mechanism in and of itself.

The application of metacognition is not only crucial for academic learning but also in professional fields like medicine, engineering, and leadership. Success and failure in high-stakes situations depend on the capacity to determine the trustworthiness of one's judgments and adjust procedures in the face of uncertainty. Moreover, as problems become evermore intertwined and complicated, the demand for people who can oversee their thinking, realise when they are in error, and update accordingly has never been greater. Metacognition allows such responsiveness by offering an executive self-monitoring perspective that dictates how people process information, deal with obstacles, and regulate their conduct.

This article discusses the theoretical underpinnings, the problems of assessment, and the applied consequences of metacognition as described in the modern literature. It discusses influential conceptual models, including the tripartite metacognitive knowledge, monitoring, and control framework; it evaluates the effect of metacognitive accuracy on learning; and it outlines how creative and domain-specific models push the limits of extant metacognitive theory. It concludes by reviewing the persistent challenge to measuring metacognition and the potential for creating effective interventions for cultivating metacognitive awareness and skill in various contexts and populations.

Analysis of Recent Studies and Publications. Recent literature has greatly deepened the understanding of metacognition, and there are new insights to be gained from educational, psychological, and neuroscientific approaches. Researchers, including Rhodes (2019) [10] and Veenman (2015) [11], have reiterated the prominence of metacognitive accuracy and self-regulation in effective learning and problem-solving. On the other hand, Fleming (2024) [4] and Qiu et al. (2018) [9] have developed neurocognitive models, and the precise prefrontal regions implicated in metacognitive monitoring and control were specified. Lebeda and Benedek (2023) [8] have introduced novel metacognition frameworks, proposing that domain-specific metacognitive processes are critical in ill-structured tasks. Even with these advances, there are still limits to the challenge of precise measurement, definitional stability, and the application of theory to practice, suggesting the necessity of an integrative approach between disciplines.

Purpose of the Article. This article aims to examine the theoretical structure, measurement challenges, and applied implications of metacognition, with a particular focus on its role in supporting adaptive thinking, learning, and decision-making across domains.

Presentation of the primary material. The original construct of metacognition, as first coined by John Flavell during the 1970s, has since developed into a sophisticated and multi-faceted construct that crosses the bounds of psychology, education, neuroscience, and philosophy. In essence, metacognition is

the capacity to reflect on, comprehend, and regulate one's thinking. The higher-order thinking capacity differentiates metacognitive participation from first-order, more automated thinking. While there has been much advancement, metacognition is still, as noted by Akturk and Sahin (2011) [1], a "fuzzy" construct—most often differently described between disciplines and usually difficult to define with operational accuracy.

One of the most influential differences in the metacognitive literature is between metacognitive knowledge and metacognitive regulation. Metacognitive knowledge is the knowledge an individual has about their own thinking—what they know about their capabilities, limitations, and learning or decision-making strategies. Metacognitive regulation is the ability to oversee, guide, and modulate thought in the moment. These two elements are described by Veenman (2015) [11] as functioning together: knowledge about thinking informs what one is regulating, and the activities of regulation shape one's knowledge through experience and feedback. This dichotomy has been helpful in explaining learning behaviour and exploring the cognitive architecture behind critical thinking, problem-solving, and flexibility in the face of complexity.

Another particularly fruitful area of investigation is the interaction between confidence and metacognition. In his new synthesis, Fleming (2024) [4] outlines the construct of propositional confidence—a metacognitive belief in the correctness of one's actions or thinking, reflecting an internal model of one's cognitive system and the environment. This explains why metacognitive beliefs might differ from real-world performance; metacognition is inferential, influenced by beliefs, experience, and environmental cues, not the direct readout of accuracy. Thus, confidence operates not as an index of performance but as an action modulator, enabling correction, persistence, or revision in the face of uncertainty.

The educational applicability of metacognition is particularly compelling. Metacognition has reliably been one of the best indicators of academic achievement, sometimes outpacing other cognitive and motivational influences (Veenman, 2008) [12]. Students who can successfully regulate and manage cognitive tactics do so to learn at greater depth, store information for more extended periods, and demonstrate higher knowledge transfer to new realms. This is particularly pronounced with reading comprehension, mathematics, and problem-solving activities—areas where the processing of abstract or complicated content requires extended mental effort. However, despite the established efficacy, studies reveal that many students do not use metacognitive techniques automatically or systematically (Veenman, 2013) [11]. Therefore, acquiring metacognitive ability has become essential in constructing curricula and pedagogical interventions.

One of the long-standing problems with metacognitive research is that it is hard to measure. According to Akturk and Sahin (2011) [1], metacognition is famously hard to quantify since it is often internal and unconscious. The most common measurement techniques fall into one of three categories: self-report

questionnaires, think-aloud protocols, and behavioural indicators. Each has its disadvantages. Self-reports tend to suffer from bias and inaccuracy since people might not know enough about how well (or poorly) they think. Think-aloud protocols are data-dense but can interfere with natural thinking flow and are hard to scale. Behavioural indicators, such as latency or response adjustments, provide indirect indicators of metacognitive processing but need to be interpreted with care to segregate metacognitive thinking from trial-and-error correction.

Rhodes (2019) [10] offers an informative summary of how metacognitive accuracy—how accurately one's learning, performance, or confidence judgments match actual results—can be researched. Monitoring accuracy is proposed as essential to good self-regulation. For example, students who accurately assess what they know and what they do not can best distribute study time, choose learning techniques, and obtain assistance where needed. However, metacognitive accuracy is informed by many factors, including the task's difficulty, domain knowledge, motivation, and even one's state of mind. Therefore, learning to enhance metacognitive calibration (how well confidence and accuracy match) is essential for future investigation.

There is an evolving body of scholarship on creative metacognition. This relatively unexplored topic maps how one tracks and directs the workings of the mind during ideation, exploration, and ambiguity-laden tasks. Lebeda and Benedek (2023) [8] develop a Creative Metacognition (CMC) framework that differentiates between three main elements: metacognitive knowledge, monitoring, and control. These elements function in dynamic interaction across three tiers: the task, the performance, and the response. In creative activities, including writing, designing, or solving, one has to generate, assess, check, and often reframe these nascent ideas in response to changing objectives and limitations. Metacognitive consciousness facilitates the blocking of premature closure, supports divergent thinking, and allows for the iterative selection of strategy.

Fleur et al. (2021). [6] promote neuro-educational synthesis in the science of metacognition because the sciences of education and neuroscience have mainly grown independently, with little conceptual cross-fertilisation. Their review indicates that greater integration is required to answer key questions about how metacognition is built, how metacognition is taught, and how it is represented in the brain. The primary entry points for synthesis comprise the examination of domain-generalness (whether there is transfer of metacognitive skill across subjects), the neural plasticity of metacognitive training, and the developmental changes in the metacognitive circuitry's organisation and functioning. Significantly, various studies have determined certain brain areas engaged in metacognitive monitoring, such as the anterior prefrontal cortex (PFC), which seems to combine decision uncertainty and performance result cues (Fleming, 2024) [4].

Other studies also directed attention to the contribution of metacognitive skills to problem-solving. Güner and Erbay (2021) [7] concluded that students with high

metacognitive skills were much better at solving non-routine maths problems. Their study, combining problem-solving tests on paper with retrospective questionnaires on self-monitoring and interviews, indicated that students who were good at solving the issues used effortful strategies to check answers, appraise the appropriateness of the approach adopted, and realise when they were lost. Of note, many low-performing students thought they had adopted these effortful strategies when they had not, indicating an imbalance between what was perceived and what was done regarding metacognitive engagement. This finding reminds us of the need to develop metacognitive behaviour and metacognitive insight.

The developmental path of metacognition is another area of active investigation. Although young children possess rudimentary awareness of metacognitive status—identifying when they do not know something—their skills become increasingly refined through ageing and experience. Veenman (2008) [12] has demonstrated that participants increasingly use planning, monitoring, and evaluating behaviours that facilitate effective learning and problem-solving between late childhood and early adulthood. The path is not one of inevitability, though: instruction, modelling, and opportunities for reflection are needed. This has meant the introduction of metacognitive scaffolding into the classroom, as students are prompted to ask themselves metacognitive questions before, during, and upon completing intellectual tasks.

Despite this encouraging progress, metacognitive research is confronted with various unresolved tensions. One is the matter of domain specificity and generality. According to one school of thought, metacognitive abilities are mostly domain-specific and tied to specific knowledge or task areas; a student can be very metacognitive in writing but not in mathematics. Others believe there are transferable core competencies, such as detecting errors or evaluating strategy, which are general to various areas. A second tension lies in distinguishing between explicit and implicit metacognition. Although much of the literature centres on conscious, intentional thinking, there is increasing acknowledgement that people manage their cognition in non-conscious or automatic ways. Closing the divide will depend on conceptual resolution and methodological creativity.

Practically speaking, metacognitive instruction has found its way into classrooms ranging from elementary school to corporate executive training with measurable payoffs. Self-explanation, setting goals, reflecting, journaling, and “metacognitive prompts” are techniques shown to increase performance and self-awareness. However, as Rhodes (2019) [10] reminds, metacognition cannot be taught as an “isolated” skill detached from content or context. Instead, it has to be incorporated into genuine tasks where students are motivated to commit errors, reflect on them, and adjust strategies accordingly. Cyclical learning is the approach endorsed by constructivist learning theories and indicates that metacognition is better developed through the iteration of practice, feedback, and guided autonomy.

In summary, metacognition is an essential educational and cognitive construct at the heart of good learning, decision-making, and problem-solving. Although it

covers a broad set of processes—knowledge, awareness, and regulation—metacognition is held together by the function of enabling people to reflect on thinking. Recent investigations emphasise the significance of metacognitive accuracy, context-dependent approach use, and the neurobiological substrates of metacognitive processing. Problems persist, however, regarding the transparency of conception, assessment, and transfer to new contexts. Theoretical models, measurement instruments, and paradigms to integrate neurosciences and education must be consolidated in future endeavours. With the increasing acceptance of new models of metacognition, such as creative metacognition and neuro-educational integration, the construct of metacognition itself will become richer and increasingly valuable for guiding practices in disparate areas such as education, medicine, crisis management, and artificial intelligence.

With the accelerated pace of crises, people are often summoned to take high-stakes decisions with uncertainty, within time limits, and where there is mental overload. The quality of such decision-making is enhanced manifold by the operation of metacognitive processes—those higher-order processes that facilitate individuals to track, analyse, and modulate their cognitive functioning in real-time. While the straightforward processing of information is involved in basic cognition, metacognitive functions include awareness of one's mental functioning and the capacity to modulate it appropriately within fluctuating contexts (Koriat, 2015). Under circumstances of crisis, where the standard heuristics are no good, the contribution of metacognition is not just essential but is critical to adaptive functioning.

At the heart of metacognitive influence on decision-making is the double role of metacognitive monitoring and metacognitive control. Monitoring enables one to gauge one's certainty level, detect errors, or recognise when further information is required before continuing. The function of control, in contrast, allows the person to alter direction—interrupting, revising, or dropping an entire decision path. Yeung and Summerfield (2012) [13] highlight the role of post-decisional processing as it relates to this, observing that metacognitive assessments, including judgments of confidence and the detection of errors, are usually performed after the initial decision. These are not simply reactive functions but exist to inform future decisions, leading to better outcomes over time.

The neurocognitive basis for metacognition also lends further weight to its active and autonomous role in critical decisions. Metacognitive functions consistently recruit the prefrontal cortex (PFC), specifically the anterior PFC and dorsolateral areas. Qiu et al. (2018) [9] identified the dorsal anterior cingulate cortex (dacc) as active during monitoring of metacognitive uncertainty, and the lateral frontopolar cortex (LFPC) as serving to modulate adjustments to decision-making. Their “decision–redecision” paradigm exposed how different networks are activated not to take the decision as such, but to review it based on an internal assessment of uncertainty. This dissociation between decision performance and metacognitive assessment indicates the sophistication and autonomy of metacognitive systems.

In addition to individual metacognition, domain-specific metacognition is equally significant. For example, the metacognition in health care allows clinicians to recognise cognitive bias, assess the adequacy of their data, and adjust thinking under stress. Church and Carroll's (2023) [2] systematic review identified metacognitive techniques like the detection of cognitive bias, the recognition of uncertainty, and reasoning in an integrated fashion as key to sound clinical judgement. The research established that patient care providers who reflect on their cognitions actively commit fewer diagnostic errors, particularly in vague cases. This implies that metacognitive training is no intellectual luxury but an operational requirement in complicated professional settings.

The uncertainty, urgency, and high emotional load undermine normal decision-making processes during crises, disasters, military missions, or organisational failures. During these situations, the identification of uncertainty is an essential metacognitive competence. As Yeung and Summerfield (2012) [13] put it, the “change of mind” is common in humans once the decision is started. This awareness during and after the decision is key to preventing unbridgeable errors. Analogously, experiments on adult financial decision-making by McWilliams (2022) further indicate that metacognitive capacity for perception and memory protects individuals from impulsive or uninformed decisions in turbulent environments.

Crisis decision-making is often driven by naturalistic strategies, prioritising expediency and expertise at the potential cost of bias susceptibility. Metacognitive control assists in redressing this deficit by encouraging critical evaluation and strategic adjustment. Koriati (2015) has described it as the monitoring of judgments by oneself, to the extent that the decision-maker not only reaches a decision but also assesses the trustworthiness of the mental processes involved. This may include adjusting an estimate of confidence, requesting further input, or intentionally withholding a decision pending the availability of additional data.

At the level of the system, metacognition functions as an internal feedback mechanism enabling decision-makers to disengage from automatic pilot and conduct reflective thinking. The model put forward by Okoli and Watt (2018) of crisis fireground management posits that metacognitive awareness enables the meshing together of intuitive and analytical approaches to decision-making to effect fluid switching between modes contingent on situational requirements. This is highly useful in dynamic, rapidly changing situations where strict adherence to one mode or another can prove counterproductive. Thus, metacognition enables cognitive flexibility—the ability to switch adaptively between modes of reasoning.

Recent studies have also looked at metacognition's social and group aspects, commonly referred to as “distributed metacognition” or “team metacognition.” Duffy et al. (2015) explored the cognitive, metacognitive, and affective dynamics of emergency medical teams. They found that good crisis performance was not just reliant on metacognitive awareness at the individual level but on shared

metacognitive processes as well, including mutual monitoring and collective reflection. Team-based metacognition in high-pressure group environments allows for coordination, minimises effort duplication, and allows for early detection of misalignment of cognitions.

Despite its advantages, metacognition is not without limitations. A tendency towards excessive confidence in one's metacognitive ability can contribute to decreased performance, an effect described as the "illusion of knowing." In addition, as Church and Carroll (2023) [2] warn, metacognitive processing uses up mental resources—resources that might be hard to come by in crisis. Therefore, though metacognition provides higher accuracy and flexibility, it must be managed to prevent overburdening the mental system or hindering rapid response. Metacognitive effectiveness, not metacognitive rate, is perhaps the better gauge of its value in timely situations.

There are also significant educational and developmental ramifications. An investigation conducted by Colombo and others (2010) [3] indicated that metacognitive knowledge and consciousness are very dissimilar across different people, as a function of the profession, level of experience, and decision-making situation. The authors administered the Solomon Questionnaire to measure individuals' decision-making awareness and found that participants with responsibility for complex decisions manifested higher metacognitive sophistication. This highlights the possible benefit of early and situation-specific metacognitive training, particularly in areas with risk for critical incidents, including aviation, medicine, or emergency management.

Public health and policy contexts also recognise metacognition's role in decision-making during crisis times. For instance, the use of metacognitive principles in training public health practitioners involved in crisis management was recommended by Kayman and Logar (2016). They argued that training programs should feature technical and procedural knowledge and metacognitive reflective awareness of decision-making. Metacognitive reflection played an essential role in resisting the tendency towards premature closure on action plans and openness to revising the strategy as the situation unfolded in the framework they proposed.

Subsequent neurocognitive work has further improved how metacognitive processing is represented and localised within the brain. Fleming, Huijgen, and Dolan (2012) [5] identified that activation within the right rostrolateral prefrontal cortex (rlpfc) was not only related to the confidence judgments but also to the prediction of metacognitive skill differences between individuals. This provides a biologically plausible rationale for why certain people outperform others on occasions of uncertainty. It also provides the potential for targeted cognitive remediation or biofeedback devices to facilitate the improvement of metacognitive function through training the brain.

In summary, metacognition is both an adaptation mechanism and an improvement accelerator during crisis decision-making. By enabling people to

consider the trustworthiness, fit, and enoughness of what and how they think and act, metacognition transitions between unreflective response and adaptive thinking. Its uses cut across areas, from medicine and emergency response to organisational management and governance, indicative of its universal significance. Its utility, though, needs to be accompanied by significant attention to context, training, and within-person differences. The accumulating body of evidence confirms that, when put to practical use, metacognition is an influential handle for enhancing human judgment in the critical moments it is most needed.

Current synthesis of metacognition literature emphasises the construct's conceptual depth and pragmatic relevance. As the literature exemplifies, metacognition is more than awareness of thinking and includes sophisticated, dynamic monitoring activities, controlled processing, and strategic management. These activities are centrally involved in academic success and adaptive functioning in professional, social, and critical decision-making contexts. Although there is increasing agreement about the relevance of metacognition, its conception, assessment, and use are still controversial and subject to further refinement.

Another key insight from the studies reviewed is the difference between metacognitive knowledge and metacognitive regulation, dichotomies which have become essential to educational and cognitive psychology (Veenman, 2015; Fleur et al., 2021) [6]. While knowledge indicates an awareness of one's thinking, processing, and learning strategies, regulation implies actively adjusting these in the moment. This difference provides conceptual coherence and intervention guidance: teachers and trainers can approach each in turn with different pedagogical devices, such as prompts for self-examination to build knowledge and supported feedback to facilitate the acquisition of regulatory control.

The debate on metacognitive accuracy provides an essential layer of complexity. As Rhodes (2019) [10] points out, metacognitive monitoring is only valid if it is accurate. A well-calibrated learner with confidence aligns with actual performance can most efficiently apportion cognitive resources. Conversely, mis-calibration is associated with mis-assessment of task difficulty, ineffective study routines, or misplaced confidence. The finding is compatible with the outcomes in problem-solving studies, where high-achievers demonstrate higher metacognitive insight and correction behaviours (Güner & Erbay, 2021) [7]. However, the problem is how to guarantee that students reflect metacognitively and do so with metacognitive realism.

Notably, the literature indicates ongoing measurement challenges. As Akturk and Sahin (2011) [1] pointed out, classical methodologies such as think-aloud protocols and self-reports provide incomplete access to unconscious or automated metacognitive functions. Although new behavioural and neuroimaging methodologies—response latency analysis or functional brain mapping—have deepened understanding, these are also bound by task specificity and interpretation vagueness. Therefore, there is a pressing need for more integrative, multimodal

methodologies to measure metacognition in various areas and stages of development with greater validity.

New models such as the Creative Metacognition Framework (CMC) by Lebuda and Benedek (2023) [8] embody the trend towards multi-level, task-specific theorising. Instead of positing one universal metacognitive model, scientists outline how metacognitive components function differently per situation. For example, in tasks related to creativity, metacognition has to deal with ambiguity, ideational fluency, and changing goals, skills not necessarily accounted for by established paradigms optimised for memory or reading. This implies future studies should pay attention to the ecological validity of metacognitive constructs: how exactly these operate in everyday, context-laden situations.

In addition, the studies under review highlight the neuroscientific basis of metacognitive operations. Advances by Fleming (2024) [4], Qiu et al. (2018) [9], and Fleur et al. (2021) [6] indicate the intricate network of prefrontal areas, most notably the anterior and rostrolateral PFC, that are involved in mediating metacognitive monitoring and control. These findings advance theory and indicate avenues for neurocognitive interventions, including targeted cognition training, biofeedback, or neuromodulation. The integration of education and neuroscience is still in its early stages. Further, collaborative and interdisciplinary work is essential to take findings from the lab to the classroom and beyond.

Despite the virtues of metacognition, there are warnings from scholars that one should not assume universal effectiveness. Certain metacognitive activities are resource-hungry, consume mental resources, and are maladaptive in the face of the immediacy demands or the emotional demands of situations (Rhodes, 2019) [10]. Even metacognitive awareness can exist in conjunction with the lack of motivation to manage one's cognition, indicating the necessity to consider values, goals, and emotional and social context in addition to metacognition.

Ultimately, the debate discloses several unresolved tensions within the area. These are the debates between domain-specificity and generality, the implicit-versus-explicit metacognition debate, and the challenge of promoting metacognition in different learner profiles and resolving these poses not just the need for advances in methodology but also the synthesis of theory—bringing together insights of educational psychology, cognitive neuroscience, philosophy of the mind, and applied fields including health and public administration.

In summary, the literature examined confirms that metacognition is the backbone of good learning, decision-making, and adaptive reasoning. Although much has already been achieved in outlining its elements and functions, the future of further work needs to sharpen its definition, broaden its database, and extend its application to real-world settings. A complete theory of metacognition has the potential to not only transcend disciplinary boundaries but also to empower individuals to meet the increasingly complicated intellectual requirements of modern life.

Conclusion. The compiled body of evidence laid out in this review irrefutably places metacognition as an essential construct for explaining human decision-making, learning, and cognition. Characterised by the dual elements of monitoring and regulation, and supported by descriptive knowledge and strategic control, metacognition allows an individual to deal with cognitive demands with greater awareness and flexibility. The capacity for higher-order thinking, correction of errors, calibration of confidence, and flexible use of cognitive strategies on many different tasks and contexts is Held within metacognitive ability.

Empirical studies in psychology, education, and neuroscience have significantly clarified how and why metacognitive processing occurs. The studies indicate that students prone to metacognitive thinking outscore others in academic, problem-solving, and professional contexts. Furthermore, neurocognitive science has given a biological basis to these insights by examining specific areas within the prefrontal cortex as the key to metacognitive processing. This integration across disciplines not only confirms the construct's validity but also opens the doors to how the construct may be improved through training, technology, and intervention.

Despite these advances, the discipline still has critical unresolved problems. Measurement is still an ongoing challenge since existing instruments, at best, provide partial insight into the subtle, frequently implicit nature of metacognitive functioning. Unresolved disputes regarding whether metacognitive models are domain-specific or domain-general and whether metacognitive training is practical in everyday contexts also exist. These tensions indicate that metacognition is best conceived as an array of context-sensitive competences dynamically intertwined with motivation, emotion, and expertise.

The future of metacognitive research is synthesis and application. Theoretical accounts need to become sophisticated enough to reflect the richness of real-world cognition, and applied endeavours should incorporate metacognitive training into school and university curricula, professional training programs, and decision-support tools. Doing so is not about simply encouraging thinking about thinking, but about developing resilient, adaptive thinkers equipped to deal with uncertainty, complexity, and change through mindful and informed management of cognitive engagement. Metacognition is as much a scientific topic as it is an essential ability for personal and collective resilience in an ever-changing world.

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