Metacognitive Effects on Clinical Decision-Making

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ABSTRACT Metacognition, which is the capacity to monitor, evaluate, and regulate one's own cognitive processes, is an important determinant of clinical decision quality. Clinicians who fail to monitor their reasoning are more susceptible to the systematic cognitive biases that contribute to many diagnostic errors. In this narrative review, we integrated theoretical models of metacognition, presented research on intuitive and analytical clinical reasoning, showed empirical studies of cognitive bias in medicine, and described educational interventions targeting metacognitive skills. The review is built on the monitoring–control framework in which monitoring is what clinicians notice about their own reasoning and control is what they do in response. Two monitoring signals are most directly relevant to diagnosis: confidence, which is often poorly calibrated to actual accuracy, and the feeling of rightness, which determines whether an initial diagnosis is reconsidered. Using clinical examples of anchoring, premature closure, availability bias, overconfidence, and confirmation bias, we specified what the clinician needed to monitor and the control action for each bias. We described a diagnostic time-out, an active search for disconfirming evidence, a discriminating test, or consultation, that monitoring should have triggered. Structured reflection and calibration feedback have shown benefit, whereas bias education alone has shown limited effect on diagnostic accuracy. Metacognitive capacity is a modifiable, teachable competency. Its development is a patient safety imperative, and medical education programs should incorporate explicit metacognitive training, which are linked to concrete clinical cues and actions, as a core component of clinical reasoning curricula.

IMAJ 2026; 28: 701–708

KEY WORDS: calibration, clinical reasoning, cognitive bias, feeling of rightness, metacognition

Metacognition, which is broadly defined as thinking about thinking, refers to the capacity of individuals to monitor, evaluate, and regulate their own cognitive processes. The term was introduced by Flavell [1], who described it as a new domain of cognitive-developmental inquiry with broad implications for learning and performance. In the clinical setting, metacognition has particular salience because medical decisions are made under conditions of uncertainty, time pressure, and cognitive load, precisely the conditions under which unmonitored reasoning is most vulnerable to error.

Diagnostic error is a recognized patient safety problem of substantial magnitude. Cognitive failures are present in approximately 74% of internal medicine diagnostic errors, and diagnostic errors contribute to an estimated 10–15% of adverse events. These figures are established in the review by Flugelman and Riskin in this issue of the *Israel Medical Association Journal (IMAJ)* and are considered reliable [2,3]. Many of these failures reflect not only a knowledge deficit but also a reasoning failure: a clinician who possesses the relevant knowledge but fails to deploy or monitor it appropriately.

In this review, we examine the theoretical foundations of metacognition, its relationship to intuitive and analytical modes of clinical reasoning, its role in generating and correcting cognitive biases, and the practical and educational implications of these relationships for clinical practice. Its distinctive contribution within this issue of *IMAJ* is the metacognitive analysis of biases whose definitions and clinical manifestations are established elsewhere in the issue. To make the practical implications concrete, the analysis is organized around clinical examples: for each bias, we specify what the clinician needed to monitor and which control action that monitoring should have triggered.

METACOGNITION: DEFINITIONS AND FRAMEWORK

Metacognition encompasses what individuals know about their own cognitive processes and how they regulate those processes during cognitive engagement [1,4]. Two primary dimensions are consistently identified in the literature [5].

Metacognitive knowledge encompasses what a clinician knows about the limits and capabilities of their own

cognition, the demands of different clinical tasks, and the strategies most effective for navigating diagnostic uncertainty. Clinicians who recognize that they tend to anchor on the first plausible diagnosis under time pressure possess relevant metacognitive knowledge about their own reasoning patterns.

Metacognitive regulation encompasses the planning, monitoring, and evaluation that occur during cognitive engagement. In clinical terms, this includes monitoring one's evolving confidence during a workup, recognizing when uncertainty warrants pausing to seek additional information or consultation, and evaluating the quality of a diagnostic conclusion before acting on it [5].

The relationship between these two dimensions is not merely additive. Nelson and Narens [6] proposed a formal framework in which metacognitive monitoring–the ongoing assessment of one's cognitive state–generates signals that direct metacognitive control. Clinicians who monitor their confidence during a diagnostic encounter and recognize that it is insufficiently grounded can, if their regulatory skills are adequate, respond by expanding differential, ordering additional tests, or consulting colleagues.

Metacognition, which is the monitoring and regulating one's own thinking, is one of the unifying mechanisms through which cognitive biases arise in clinical practice and through which they can be corrected.

Throughout this review these two terms (metacognitive knowledge and metacognitive regulation) are used in a specific, practical sense. Monitoring is what clinicians notice about their own reasoning; for example, how confident they are, how quickly a diagnosis came to mind, or whether a finding fails to fit. Control is what they do in response; for example, keeping the differential open, ordering a discriminating test, re-examining the patient, or calling a senior colleague. Metacognitive failure can therefore occur at either step: a warning signal that is never noticed (a monitoring failure), or a signal that is noticed but not acted upon (a control failure).

MONITORING SIGNALS RELEVANT TO DIAGNOSIS: CONFIDENCE AND THE FEELING OF RIGHTNESS

Other monitoring judgments described in the metacognition literature, such as ease-of-learning judgments, judgments of learning, and feeling-of-knowing judgments, are mostly studied in learning and memory research [5,6]. They concentrate mainly on how clinicians learn rather than on how they diagnose. The two monitoring signals that are important for diagnosis, which will be discussed later, are confidence and the feeling of rightness.

Confidence ratings are retrospective judgments of how likely an answer (i.e., a diagnosis) is to be correct [6]. Clinicians whose confidence reliably tracks their accuracy are described as well calibrated, reflecting strong metacognitive awareness [7]. Calibration matters because confidence is the signal that governs control. In a vignette study of 118 internists, diagnostic accuracy fell from 55.3% on easier cases to 5.8% on more difficult ones, whereas mean confidence fell only from 7.2 to 6.4 on a 10-point scale. Higher confidence was associated with fewer requests for additional diagnostic tests [8]. A poorly calibrated confidence signal not only misrepresents the case but also switches off the very behaviors of ordering further testing and consultation that could correct an error.

The feeling of rightness (FOR) is the subjective sense, arising together with an initial answer, that the answer is correct [9]. FOR is driven largely by the fluency with which an answer comes to mind rather than by its correctness [9]. Research using the two-response paradigm in which participants give a fast first answer and are then allowed to reconsider it has shown that when FOR is high, individuals spend less time rethinking their initial answer and are less likely to change it, even when revision would improve accuracy [9,10]. The clinical analogue is a diagnosis that "jumps out": its very fluency produces a strong FOR, which in turn suppresses the deliberate re-examination the case may require that most directly determine whether a diagnosis is reconsidered, they are the focus of the analysis of biases below.

METACOGNITION AND HELP-SEEKING

An important metacognitive control behavior is help-seeking: recognizing that one's current knowledge or confidence is insufficient and actively seeking expertise or consultation. Undorf and colleagues [11] demonstrated that metacognitive monitoring accuracy predicts the appropriateness of help-seeking decisions. Individuals with higher monitoring accuracy sought help more efficiently and selectively. By extension, clinicians who are well calibrated should be better placed to seek consultation at the right junctures, capitalizing on distributed expertise rather than relying on potentially flawed individual judgment. Conversely, high confidence is associated with fewer requests for additional diagnostic resources [8].

INTUITIVE AND ANALYTICAL REASONING: WHY MONITORING MATTERS

Clinical reasoning is often described as combining two modes: a fast, intuitive mode, in which a diagnosis is recognized almost automatically from a familiar pattern of findings, and a slower, analytical mode, in which hypotheses are deliberately generated and tested [12,13]. In the psychological literature these are commonly termed System 1 (Type 1) and System 2 (Type 2) processes. The framework is presented by Flugelman and Riskin in this issue of *IMAJ* [2]. Marcum [14] linked it explicitly to metacognition. Whether the two modes reflect distinct cognitive systems is debated [15], and errors can arise in either mode [16]. The argument of the present review does not depend on resolving this debate. What matters clinically is a simpler observation: most diagnoses are reached rapidly and intuitively, usually appropriately, and errors tend to arise when an intuitive answer is accepted in a situation that called for analytical checking [12,17]. Deciding whether an initial impression can be trusted or needs to be checked is itself a metacognitive judgment, driven by the monitoring signals of confidence and FOR. Expertise, from this perspective, lies not only in knowledge but also in recognizing when to slow down.

Common diagnostic errors including anchoring, premature closure, and overconfidence often reflect failures of metacognitive monitoring and control, and not only gaps in knowledge.

Clinical example: an intuitive diagnosis accepted without checking (chest pain)

A 58-year-old man presented with chest pain radiating to the left arm. The emergency physician, pattern-matching rapidly, initiated a myocardial infarction workup. The electrocardiogram is unremarkable, but the physician's FOR is high. He does not pause to broaden the differential. The troponin returns negative. Thirty minutes later, a chest radiograph ordered for a different indication revealed a widened mediastinum. The patient had an aortic dissection. A structured metacognitive pause: "Is my current level of certainty justified by the evidence?" might have prompted earlier consideration of the alternative diagnosis.

Monitoring and control

What the physician needed to monitor was not only the test results but their own certainty. A strong feeling of rightness had formed before any discriminating evidence was available, and it persisted when the electrocardiogram and the first troponin failed to support the working diagnosis. A result that does not confirm the leading diagnosis is a monitoring cue. It should lower confidence rather than leave it unchanged. The control action that this cue should trigger is a deliberate broadening of the differential to the dangerous causes of chest pain, including aortic dissection and pulmonary embolism, with a targeted history and examination (e.g., the character of the pain and a blood pressure difference between the arms) and early imaging when indicated.

COGNITIVE BIASES IN CLINICAL REASONING AND THE ROLE OF METACOGNITION

Croskerry [18] catalogued more than 40 distinct cognitive biases identified in clinical decision making. These biases represent systematic failures of reasoning that arise when metacognitive monitoring is insufficient to detect and correct errors in the application of cognitive heuristics. The biases are defined, mechanistically explained, and clinically illustrated in the review of cognitive biases and heuristics in this issue of *IMAJ* [19]. What follows is not a second catalogue but an analysis of each as a specific failure of monitoring or regulation. For each bias, a clinical example is used to specify the monitoring cue (what the clinician needed to notice about their own reasoning) and the control action. These links are summarized in [Table 1].

ANCHORING BIAS

Anchoring [19] can be understood as a metacognitive failure. It reflects a breakdown in the monitoring process by which a clinician appraises the adequacy and confidence of their own reasoning. In clinical practice this is seen as premature diagnostic commitment in which an impression formed during triage or initial assessment becomes the interpretive lens for every subsequent finding.

Clinical example: anchoring bias (the psychiatric label)

A 32-year-old woman with a known anxiety disorder presented repeatedly to her family physician over 6 months with fatigue, palpitations, and weight loss. At each visit the symptoms were ascribed to anxiety, and the tachycardia was read as a somatic expression of it. Critically, each encounter added evidence (e.g., progressive weight loss and worsening palpitations) that should have raised questions about the working hypothesis, yet the metacognitive alarm never sounded. The prior psychiatric label anchored interpretation and shielded it from revision, suppressing any consideration of endocrine causes. She was ultimately diagnosed with Graves' disease only after presenting to the emergency department in thyroid storm.

Table 1. Metacognitive monitoring and control for the biases discussed in this review

Bias (clinical example)	How the bias operates metacognitively	Monitoring: what the clinician needs to notice	Control: the action the cue should trigger
High feeling of rightness after rapid pattern recognition (chest pain; aortic dissection)	The fluency of an initial diagnosis is mistaken for evidence of its correctness	Certainty that formed before discriminating evidence was available; results that fail to confirm the leading diagnosis	Broaden the differential to dangerous alternatives; targeted history, examination, and imaging
Anchoring (anxiety label; Graves' disease)	The initial frame is not re-appraised as new findings accumulate	Findings the working diagnosis does not predict; repeated or worsening presentations	Diagnostic time-out ("What does not fit?"); discriminating test (thyroid function)
Premature closure (chest wall pain; pulmonary embolism)	The search stops when one finds a fit, before alternatives are excluded	The moment of closure itself; risk factors left unexplained	Check that the diagnosis explains all key findings; structured pretest probability assessment and testing
Availability (recent pulmonary embolism cases; over-investigation)	Ease of recall is mistaken for probability	A diagnosis that comes to mind unusually quickly after a recent or memorable case	Estimate pretest probability from the patient's own features; apply a validated decision rule
Overconfidence (transient synovitis; septic arthritis)	Felt certainty substitutes for active checking and suppresses help-seeking	Mismatch between certainty and evidence; a plausible, time-critical dangerous alternative	Pre-committed exclusion of the dangerous alternative; default consultation for high-risk presentations
Confirmation (suspected appendicitis; mesenteric adenitis)	Data collection and interpretation are tuned to the working hypothesis	Evidence that uniformly supports the hypothesis; unintegrated observations from others; pending results	Ask what would be expected if the diagnosis were wrong; review team observations; await discriminating results before escalation

Monitoring and control

The harm of anchoring lies less in forming an early hypothesis than in the absence of self-monitoring that would flag its growing incongruence with the clinical picture. What the physician needed to monitor were the findings that the working diagnosis did not predict such as weight loss, which anxiety does not readily explain, and persistent tachycardia. The pattern of repeated, worsening presentations, which is itself a signal that the current explanation may be wrong also was not addressed. Once noticed, these cues should trigger a control action: a structured diagnostic time-out at the return visit, prompted by questions such as: "What does not fit this diagnosis?" or "Would I reach the same conclusion if I were seeing this patient for the first time?", followed by a simple discriminating test such as thyroid function tests.

PREMATURE CLOSURE

Premature closure [19] is, metacognitively, a confidence-driven stopping rule. Hypothesis generation ceases not because the differential has been exhausted but because the leading diagnosis feels sufficiently right. Metacognitive regulation can interrupt it by prompting the diagnostic pause: Have I considered the diagnoses I would not want to miss?

Clinical example: premature closure

A 32-year-old woman visited the clinic with sudden shortness of breath and sharp chest pain after a long-haul flight. The physician noted that she was anxious and had chest wall tenderness on palpation. She is diagnosed with musculoskeletal chest wall pain and prescribed rest. Two days later she collapsed and was diagnosed with a large pulmonary embolism. The physician found one matching clue–chest wall tenderness–and stopped the search, while the high-risk clue of a long flight was never weighed. A metacognitive check "What else could explain both the shortness of breath and the recent flight?" would have prompted a work-up for pulmonary embolism.

Monitoring and control

Premature closure is primarily a failure of control rather than of perception. The relevant history was available, but it did not influence the decision to stop searching. The monitoring cue is the moment of closure itself, the point at which the clinician feels ready to stop. Because that feeling is generated by the fit of a single finding rather than by the exclusion of alternatives, the moment of closure should be treated as a checkpoint. Does the leading diagnosis explain all the key findings, including the risk factors? Have the dangerous alternatives been actively excluded? Here, the control action would have been a

structured assessment of the pretest probability of pulmonary embolism, followed by D-dimer testing or computed tomography pulmonary angiography as appropriate.

AVAILABILITY BIAS

Availability bias [19] represents a failure to monitor the source of a diagnostic impression rather than its content. A physician who has recently managed several cases of pulmonary embolism may overestimate its probability in subsequent patients presenting with dyspnea, resulting in unnecessary imaging and anticoagulation. Metacognitive awareness of this tendency "Am I thinking of this diagnosis because it fits the patient or because it is prominent in my memory?" is the key debiasing move.

Monitoring and control

The cue to monitor is the origin of the hypothesis. A diagnosis that comes to mind unusually quickly, particularly one encountered recently or memorably (e.g., a recent case, a missed diagnosis, a morbidity and mortality conference), should prompt the question. The control action is to ground the estimate in the patient rather than in memory, by explicitly estimating the pretest probability from the patient's own features and using a validated clinical decision rule where one exists before ordering tests or starting treatment.

Linking specific monitoring cues (what to notice) to specific control actions (what to do) translates metacognition into bedside practice. Structured reflection and calibration feedback support this idea, whereas bias education alone has limited effect.

OVERCONFIDENCE BIAS

Overconfidence is the systematic tendency to rate one's confidence higher than one's actual accuracy. It is perhaps the most studied bias in the metacognition literature [7]. Berner and Graber [7] reviewed evidence showing that physicians are poorly calibrated across specialties, systematically overestimating the accuracy of their diagnoses. Overconfidence directly impairs the metacognitive monitoring function. A clinician who is certain that they are correct does not seek disconfirming evidence and does not consult.

Clinical example: overconfidence bias (child's knee pain)

A 4-year-old is admitted after 2 days of fever, irritability, and refusal to walk on his left leg. The on-call overnight pediatric resident examines the child, notes mild warmth and tenderness around the left knee, and orders basic laboratory tests and a radiograph. The radiograph is interpreted as unremarkable, the white cell count is mildly elevated, and C-reactive protein is moderately raised. The resident concludes transient synovitis of the hip with referred knee pain, which is a common, self-limiting condition, and plans symptomatic management with follow-up in clinic. She documents her impression with notable certainty and does not call the on-call senior, reasoning that the picture is classic. Overnight the child deteriorates: fever spikes, the leg becomes diffusely swollen, and repeat examination the next morning reveals limited range of motion across multiple planes, prompting urgent imaging and blood work that lead to a diagnosis of septic arthritis of the knee with early osteomyelitis, requiring emergency surgical drainage.

The resident almost certainly knew that septic arthritis and transient synovitis can look similar. The failure was at the level of monitoring. Her confidence led her to discount the evidence localized to the knee, the warmth and tenderness, and to attribute the symptoms to referred pain from the hip. Once transient synovitis felt right, she stopped weighing it against the alternative. Rather than weighing the cost of an unnecessary call against the cost of a missed diagnosis, she decided not to call the on-call senior.

Monitoring and control

The cue the resident needed to notice was a mismatch between the strength of her certainty and the evidence. Findings localized to the knee, together with fever and raised inflammatory markers, do not fit comfortably with a benign, self-limiting diagnosis. A useful self-check is: "If I am wrong, what is the most dangerous alternative, and what would missing it cost the patient?" When that alternative is plausible and time-critical, as septic arthritis is, the control response should not depend on felt confidence; it should be a pre-committed, explicit plan to exclude the dangerous diagnosis (e.g., joint ultrasound and aspiration of any effusion) and a call to the on-call senior. Making consultation the default for defined high-risk presentations, rather than a decision left to individual confidence, protects against exactly the situation in which overconfidence suppresses help-seeking [11].

CONFIRMATION BIAS

Confirmation bias is treated in three complementary places in this issue of *IMAJ*, and in a fourth review in a forthcoming one. The canonical phenomenon, selective search and selective interpretation, is described in the review of cognitive biases and heuristics [19]; the motivated evaluation

of evidence quality, in which methodologically equivalent studies are judged differently according to prior belief, is treated as biased assimilation in the review of under-recognized psychological processes [20]. What is distinctive metacognitively is the search/test asymmetry. Because the bias operates at the point of data collection and not only at interpretation, a clinician can accurately report what they find and still hold a biased dataset. This is why confirmation bias is unusually resistant to self-monitoring, and why its correction depends on metacognitive knowledge, knowing that one is susceptible to this pattern, combined with deliberate strategies to actively seek disconfirming evidence.

Clinical example: confirmation bias (classic appendicitis)

A 6-year-old presents to the pediatric emergency department with 3 days of abdominal pain, low-grade fever, and decreased appetite. The triage note already reads "appendicitis?", and the examining resident finds right lower quadrant tenderness and a mildly elevated white cell count, both of which he takes as confirmatory. A nurse's earlier observation of migrating, diffuse pain plus exudative pharyngitis and cervical lymphadenopathy does not make it into the resident's note. A rapid streptococcal swab is ordered per department protocol, but the resident does not chase the result before consulting surgery. The surgical fellow re-examines the child, notices the throat findings, and the diagnosis is revised to mesenteric adenitis from streptococcal infection, sparing an unnecessary appendectomy.

The bias operated at the point of data collection, not only interpretation. Once appendicitis became the working hypothesis, the examination and documentation were selectively tuned to it. The nurse's disconfirming observations existed in the system but never entered the resident's mental model, a team-level failure layered on an individual one, and the mildly elevated white cell count, equally consistent with a streptococcal or viral process, was read as supportive only because the hypothesis was already in place. The same evidence would have been read differently under a different working hypothesis, which is precisely the asymmetry the bias produces.

Monitoring and control

Because confirmation bias shapes which data are collected, introspection alone is unlikely to detect it: the clinician's dataset feels complete and consistent. Monitoring must therefore be directed at the process rather than at the conclusion. Two cues are useful: noticing that every piece of evidence gathered so far supported the working diagnosis (in an ambiguous presentation, a picture that is "too clean" is a warning sign), and noticing information from others, such as a nurse's observation, a pending test result, or a parent's report, that had not yet been integrated. The control actions are deliberate: asking "What would I expect to find if this were not appendicitis, and have I looked for it?", reviewing other team members' observations before committing, and waiting for results that can discriminate between hypotheses, in this case the streptococcal test, before escalating to a surgical consultation.

METACOGNITION AS A COMMON CORRECTIVE MECHANISM

While these individual biases differ in their mechanisms and triggers, they share a common feature: they reflect failures to adequately monitor and regulate the reasoning process. Metacognition is therefore one of the central mechanisms through which debiasing becomes possible [9,17,21,22]. It is not, however, the only one. Clinical knowledge, experience, and system-level safeguards also contribute [16]. Croskerry and colleagues [20] proposed that cognitive debiasing operates through metacognitive awareness of one's own bias susceptibilities combined with the deliberate activation of System 2 reasoning to override erroneous System 1 outputs. Failures to notice obvious alternative solutions are predicted by insufficient metacognitive monitoring and not only by lack of knowledge [9,17,21,22].

Across these clinical examples, a common sequence emerges: a monitoring cue (i.e., a finding that does not fit or the moment of closure itself) followed by a control action (e.g., a diagnostic time-out or consultation) [Table 1]. Seen in this way, metacognition is not an abstract disposition but a set of specific, teachable links between what a clinician notices and what she does next.

CLINICAL AND EDUCATIONAL IMPLICATIONS

Consistent with the division of debiasing content across this issue, the following interventions address the mechanism specific to this review: metacognitive checkpoints.

- *Calibration feedback:* providing clinicians with systematic information about the correspondence between their confidence ratings and their actual diagnostic accuracy is the most direct metacognitive intervention and has demonstrated efficacy in improving calibration across clinical settings [7,23]. This approach is feasible in simulation-based training, case conference formats, and structured clinical review.
- *Structured reflection:* deliberate post-hoc review of difficult or erroneous cases with explicit attention to the reasoning process promotes metacognitive regulation and has been shown to reduce diagnostic error

rates in medical students and residents [24,25]. Mamede and Schmidt [25] demonstrated that physicians who engaged in structured reflection on diagnostically challenging cases showed significantly fewer errors on similar subsequent cases.

- *Explicit bias training:* teaching clinicians to recognize and name the specific cognitive biases to which they are vulnerable enhances metacognitive knowledge. Croskerry and colleagues [21] outlined a two-stage model of cognitive debiasing. First, the clinician must recognize that a bias is operating. Second, metacognitive regulation must be activated to correct the error. Explicit bias education is intended to support both stages. However, evidence that teaching about biases alone reduces diagnostic error is limited, whereas strategies that strengthen and reorganize clinical knowledge have shown small but consistent benefits [16]. Bias education is therefore best viewed as a complement to case-based practice in recognizing specific monitoring cues and rehearsing the corresponding control actions, rather than as a substitute for it.
- *Consultation culture:* fostering an organizational culture in which seeking consultation is normalized and supported, rather than perceived as a sign of weakness or inefficiency capitalizes on the metacognitive control behavior of help-seeking [11,26]. Undorf and colleagues [11] demonstrated that metacognitive monitoring accuracy predicts appropriate help-seeking. Institutional structures that support consultation amplify the behavioral consequences of accurate monitoring.

Educational programs targeting metacognitive development should begin early in medical training. Hong et al. [27] found that first-year medical students with stronger baseline metacognitive skills performed better clinically and were better able to identify gaps in their own knowledge. Ku and Ho [28] demonstrated that explicit instruction in metacognitive strategies improved critical thinking performance across educational settings, and Kuiper [29] showed that reflective use of self-regulated learning strategies enhanced metacognitive monitoring in nursing students.

DISCUSSION AND CONCLUSIONS

Metacognition occupies a central but underappreciated position in the architecture of clinical decision making. It is one of the key mechanisms through which the balance between intuitive and analytical reasoning is regulated, through which cognitive biases are detected and corrected, and through which help-seeking and consultation are appropriately triggered. Its failure is not occasional but systematic, and its consequences are not academic but clinical.

Several limitations of the current evidence base warrant acknowledgment. Much of the foundational metacognition literature derives from educational and cognitive psychology settings. Direct clinical validation of specific interventions is more limited. Measurements of metacognition in clinical contexts remain methodologically challenging, and few large randomized trials have examined metacognitive training as an isolated intervention on patient outcomes. The relative contribution of cognitive biases, in contrast to knowledge deficits, to diagnostic errors in practice also remains debated [16]. The two approaches are better regarded as complementary than as competing. The clinical examples we presented are illustrative. They are intended to demonstrate the monitoring–control sequence rather than to provide evidence of its effectiveness. These gaps represent priorities for future research.

Nevertheless, the theoretical framework is coherent, and the available evidence is convergent. Metacognition is a modifiable, teachable competency [28-30]. Its development in clinicians is not merely a cognitive enhancement, rather it is, as Croskerry [18] has argued for two decades, a patient safety imperative. Diagnostic errors are not random, they are patterned. That pattern is, to a substantial extent, metacognitive in origin, and its correction is, in large part, metacognitive in mechanism.

Developing metacognitive capacity in clinicians should therefore be recognized as a core goal of medical education in addition to the transmission of biomedical knowledge and the acquisition of technical skills.

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If there be such a thing as truth, it must infallibly be struck out by the collision of mind with mind.

William Godwin (1756–1836), English journalist, political philosopher and novelist;
considered one of the first exponents of utilitarianism and the first modern proponent of anarchism

Capsule

The dual roles of uterine monocytes in regulation of tissue homeostasis throughout reproductive cycles in health and disease

Shahzad and colleagues investigated how monocytes contribute to the remarkable cycles of inflammation, tissue breakdown, repair, and remodeling occurring in the uterus. They found that circulating inflammatory monocytes enter uterine tissue and subsequently differentiate into functionally distinct macrophage populations according to the reproductive-cycle stage. IFN-γ promotes differentiation toward a pro-inflammatory phenotype, whereas TGF-β favors pro-repair macrophages. In human endometrium, monocyte abundance peaked immediately before the implantation window, consistent with the requirement for controlled inflammation during implantation. Uterine monocytes also displayed cytotoxic activity and participated in regulating epithelial-cell apoptosis. Receptor-ligand analyses identified monocytes as major mediators of communication between myeloid cells and fibroblasts. Importantly, this physiological rhythmicity was disturbed in uterine fibrosis, where inflammatory monocytes/macrophages accumulated abnormally. The authors identified monocyte plasticity as a central mechanism coordinating inflammation and tissue repair in the cycling uterus and suggests that disruption of this balance may contribute to reproductive pathology.

Nat Immunol 2026; 27: 2058
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