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Deliberate reflection and clinical reasoning: Founding ideas and empirical findings

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Abstract

Context: The idea that reflection improves reasoning and learning, since long present in other fields, emerged in the 90s in the medical education literature. Since then, the number of publications on reflection as a means to improve diagnostic learning and clinical problem-solving has increased steeply. Recently, concerns with diagnostic errors have raised further interest in reflection. Several approaches based on reflection have been proposed to reduce clinicians' errors during diagnostic reasoning. What reflection entails varies substantially, and most approaches still require empirical examination.

Purpose: The present essay aims to help clarify the role of deliberate reflection in diagnostic reasoning. Deliberate reflection is an approach whose effects on diagnostic reasoning and learning have been empirically studied over the past 15 years. The philosophical roots of the approach will be briefly examined, and the theory and practice of deliberate reflection, particularly its effectiveness, will be reviewed. Lessons learned and unresolved issues will be discussed.

Discussion: The deliberate reflection approach originated from a conceptualization of the nature of reflection practice in medicine informed by Dewey's and Schön's work. The approach guides physicians through systematically reviewing the grounds of their initial diagnosis and considering alternatives. Experimental evidence has supported the effectiveness of deliberate reflection in increasing physicians' diagnostic performance, particularly in nonstraightforward diagnostic tasks. Deliberate reflection has also proved helpful to improve students' diagnostic learning and to facilitate learning of new information. The mechanisms behind the effects of deliberate reflection remain unclear. Tentative explanations focus on the activation/reorganisation of prior knowledge induced by deliberate reflection. Its usefulness depends therefore on the difficulty of the problem relative to the clinician's knowledge. Further research should examine variations in instructions on how to reflect upon a case, the value of further guidance while learning from deliberate reflection, and its benefits in real practice.

1 | INTRODUCTION

The idea of reflection as a useful instrument to improve thinking and reasoning emerged in the medical literature in the early 90s, when the first articles appeared discussing why and how reflection could help students learn from experiences with patients.[1,2] Since then, interest in reflection as a means to improve diagnostic learning and problem solving has grown steadily. According to Clarivate's Web of Science, the number of publications on reflection and reflective practice in six prominent medical education journals jumped from 1 per year in 1991 to 98 in 2021.* However, two-thirds of these articles are descriptive, or present explorations of the concept in various contexts without reference to empirical findings. In fact, in their systematic review of reflective strategies in medical diagnosis, Prakash et al.[3] were only able to find 23 studies in which the influence of reflection on clinical decision making was conducted with sufficient controls.

Nevertheless, and despite a limited knowledge base upon which to build, anticipated benefits of reflection for professional performance have gained interest. This increasing interest is a response to recently growing concerns about diagnostic error and patient safety. Some authors suggest that diagnostic errors are provoked by the intuitive reasoning through which physicians often solve routine problems.[4] Physicians are known to generate diagnostic hypotheses, early in a clinical encounter, by intuitively matching the case at hand with prototypes of diseases or even examples of previous patient stored in memory.[5] An influential account of the causes of errors in problem-solving proposes that such intuitive reasoning may be easily influenced by irrelevant contextual information.[6] For instance, a recent encounter with a patient with a particular disease may lead a physician to confuse a subsequent case that resembles it (but is in fact different) with the disease seen before. Such irrelevant contextual cues may activate incorrect initial diagnoses leading into a mental "cul de sac" from which it is difficult to escape. Various approaches have been proposed to help physicians out of such mental set, all built upon the idea of reflection. Some of them are educational, aiming to develop trainees' clinical reasoning or make physicians less susceptible to flaws in reasoning in the future. Other approaches are to be employed "in action," at the moment a diagnosis is to be made. (See Appendix S1 for descriptions of four such approaches.)

The purpose of the present article is to help clarify the role of *deliberate reflection* in diagnostic reasoning. Deliberate reflection is an approach whose effects on diagnostic reasoning, motivation, and learning have been studied rather extensively over the past 15 years. In addition, two recent reviews of methods to improve diagnostic decision making have pointed at deliberate reflection as one of the few approaches that is effective in this respect.[3,7] First, we will briefly discuss the philosophical roots of reflection as translated into professional practice, a step that we find important to understand the origins of deliberate reflection. Second, we will review theory and practice of deliberate reflection with emphasis on its effectiveness in diagnostic reasoning tasks and its helpfulness in learning to reason diagnostically. In a third section, we will discuss lessons learned with regard to the usefulness of this approach and its limitations.

To be clear, the present article is not a review of the literature on reflection, but rather an effort to summarise the lessons learned from research on deliberate reflection, most of which has come from our own research programme. Other researchers have recently built upon the approach in their studies, as indicated by recent reviews, and their contributions are also examined.

1.1 | The origins of deliberate reflection

The idea of reflection as an activity of mental importance has a long history in philosophy,[8,9] but the moderns roots of reflection as it has been taken up in medical education and practice are usually attributed to Dewey's and Schon's work.

Dewey[10] was the philosopher who introduced reflection into the realm of education. He considered reflection as an active and deliberate process: "active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and further conclusions to which it leads" (p. 118), and he believed that reflection would enhance learning in particular when students would be confronted with problems or puzzles that are initially difficult to grasp. It would lead them to ask questions about *why* things are the way they are and would open avenues for new learning. Kolb and Fry[11] emphasised the importance of concrete practical experiences as the starting point of reflection. In their view, such reflection would lead to abstract conceptualization, when learners interpret their experiences to form new concepts (or revise previous ones) that can in turn enabling experimentation in the real world with a newly acquired understanding.

It was Schön[12] who explicitly linked reflection to professional development and professional practice. He assumed that professionals usually solve routine problems by making largely intuitive judgements based on tacit knowledge ("knowing-in-action"). However, disruption of this usual practice occurs in situations where the professional's knowledge-in-action is not sufficient to explain a problem, or where an action produces unexpected outcomes. In medical practice, for example, physicians may be confronted with an ambiguous or atypical case, or may realise, in an encounter with a patient, that the results of the physical examination are not consistent with the initial diagnosis considered for the problem. A "reflective practitioner" would notice when the problem at hand deviates from the usual practice, suspend judgement, and engage in reflection. A key element of reflection is scrutinising the grounds of one's initial explanation for the problem by searching for discrepancies between what would be expected from it and what is actually present in the problem. This would allow for reframing the problem and generating alternative explanations which can then be tested against the facts in the problem, potentially resulting in better solutions. Besides improving performance on the problem at hand, professionals could also do better in future problems if they revisit a previous experience to reflect upon what can be learned and used in future situations.

The approaches described here have in common that they depict reflection as triggered by a state of doubt, uncertainty or perplexity caused by difficulties to understand a phenomenon or solve a problem. They also consider reflection to involve a conscious attempt to *rethink* an earlier conclusion or decision with the aim of assessing its validity.

In an early study, and influenced by the work of Dewey and Schön, we attempted to translate these ideas into a set of descriptions of behaviours, attitudes, and reasoning processes that would characterise reflection among medical practitioners.[13] Through interviews, we collected a large number of statements describing various aspects of *reflective practice* among experienced physicians. Examples are "I take time to think about a patient after he has left the consulting room" and "After having seen a patient I say to myself: What should I do differently next time?" (scored on a five-point scale from *never* to *always*). We presented these statements in a questionnaire to a large group of physicians and analysed the resulting data through factor analysis. A five-factor solution seemed to describe the data sufficiently well. According to the findings, a reflective physician would tend to show: (1) *Deliberate induction*, that is: returning to the problem to gather more information in search of alternative explanations besides the initial one considered; (2) *Deliberate deduction*, exploring the consequences of these new explanations through predictions of signs and symptoms that should be present if the diagnostic hypothesis generated for the patient problem were correct; (3) *Testing* these predictions extensively against the data present on the problem at hand, which would lead to either hypothesis confirmation or falsification; (4) *Openness towards reflection*, an attitude that makes a physician tolerate uncertainty and engage in thoughtful reasoning when confronted with a challenging problem; and (5) *Meta-reasoning*, the willingness to reflect upon one's own thinking processes and critically review assumptions and conclusions.

This conceptualization of reflective practice among physicians is in line with the theoretical origins of reflection, the idea that individuals engage in reflection as a means to deal with uncertainty and to create knowledge *in* and *on* their own experiences.[14] The first three dimensions—induction, deduction, and testing—expresses what Dewey viewed as the "steps or elementary constituents" of a complete act of thought.[10] Noteworthy, they also describe reasoning strategies that experienced physicians seem to apply, intuitively or willingly.[5,15,16] We focused therefore on these three dimensions to develop an approach—deliberate reflection—that could relatively easily be employed as an instrument to support physicians' reasoning at the moment of the diagnosis. In the next section, we will describe how these ideas are operationalised in the deliberate reflection approach.

2 | DELIBERATE REFLECTION

2.1 | Description of the deliberate reflection approach

Deliberate reflection is an approach to support physicians' diagnostic reasoning by encouraging those engaging with it to systematically deal with a clinical case such as the one depicted in Table 1. Stepwise instructions are provided, which in the illustration case in Table 1 would proceed as follows.

Participants are asked to read the case carefully to arrive at a diagnostic hypothesis. Let us assume that in this case somebody comes up with "asthma" as a tentative diagnosis. He or she is then asked to indicate which signs and symptoms in the case support this hypothesis and write these down in a table. Subsequently, the participant has to indicate which findings *speak against* the asthma hypothesis. As a next step, he or she has to indicate which signs and symptoms should have been present in the case if the diagnostic hypothesis were true, but are not. The participant is then asked to list an alternative hypothesis that has come to mind after the systematic analysis of the findings in the case, for instance "chronic obstructive pulmonary disease". The procedure is repeated for each alternative hypothesis, and a decision on the final diagnosis is reached. In addition, he or she is asked to number the hypotheses in order of likelihood. Table 2 contains the results of such exercise carried out by a fourth-year medical student, and Table 3 summarises the stepwise instructions of deliberate reflection.

TABLE 1 Case of a 48-year-old man

A 48-year-old man, previously healthy, presented to the emergency department after a sudden episode of cough, dyspnea, and a sensation of "chest tightness" that happened while he was climbing the stairs in his apartment. The patient reports two similar episodes during the last month, one when he was cutting threes in the garden and the other while he was repairing a sport court. In all occasions, the symptoms stopped spontaneously in a few hours, without any other intervention besides resting. Between the episodes, the patient felt well, without noticing restrictions to physical exercises.

He smoked 30 cigarettes per day during around 20 years, but stopped completely 3 years ago. He does not use any medication and there is no history of allergy. Family history: His father died due to myocardial infarction when he was 60.

Physical examination:

BP: 120/80 mmHg. Pulse: 90 bpm. Temp: 36.50°C. respiratory: 20 rpm

Patient appeared healthy but in respiratory distress. Jugular veins: no abnormalities. Heart: auscultation without abnormalities. Lungs: bilateral ronchi and wheezes. No other abnormalities in the physical examination.

Laboratory data:

Ht: 45%; leukocytes: 13.5 $\times$ 10^9/L, 82% neutrophils, 11% lymphocytes, 5% monocytes, 2% eosinophyl. Electrolytes, ureum, kreatinine, glucose: Values within normal range. Blood gases (patient breathing environmental air)—pO2: 6.9 kPa, pCO2: 4.6 kPa, pH: 7.44.

ECG: Without abnormalities except non-specific alterations in the ST-segment and T waves.

Blood gases in a subsequent measurement (patient breathing environmental air), after symptoms remission—pO2: 13.5 kPa, pCO2: 4.3 kPa, pH: 7.41.

X-ray:

Thorax: normal cardiac area, clear lung fields. No signs of congestive cardiac insufficiency.

TABLE 2 Deliberate reflection table based on the case presented in Table 1

Diagnostic hypotheses	Findings that speak in favour of this hypothesis	Findings that speak against this hypothesis	Findings expected to be present but not described in the case	Likelihood
Asthma	Chest tightness Dyspnoea Cough Wheezing Attacks after exercise or exposure to allergens Remission of symptoms Hypoxaemia	Age of onset Without history of allergy No family history of asthma	Accessory muscles use Prolongation of expiratory phase	1
Chronic obstructive pulmonary disease (COPD)	Attacks triggered by exercise Age of onset middle-age Long time smoker Dyspnoea Rhonchi, Wheezing Hypoxaemia	Dyspnoea and cough: episodic	Sputum production Chronic, persistent cough Respiratory acidosis Decreased breath sounds	3
Pulmonary embolism	Dyspnoea Wheezing Chest tightness ECG Smoker	Non-pleuritic chest pain (tightness) Normal respiratory frequency Jugular veins: no abnormalities X-ray without abnormalities	Tachypnoea Haemoptysis History of risk factors for DVT (e.g., immobilisation)	2

TABLE 3 Summary of the deliberate reflection approach to systematically review a clinical case

- Read the case and make a diagnostic hypothesis
- Which clinical findings support your hypothesis? List them.
- Which findings speak against your hypothesis? List them.
- Which findings should have been there if your hypothesis were correct and are not? List them.
- Which alternative diagnostic hypothesis would you consider if your initial hypothesis is incorrect? Write it and start over.
- Repeat the procedure for each alternative hypothesis that you would consider.
- Now rate the alternative hypotheses in terms of likelihood and make a final decision: What is the most likely diagnosis for the case?

Deliberate reflection thus concentrates on the relationship of a particular disease with its concomitant signs and symptoms. It tries first to *verify* a particular hypothesis by searching for findings that belong to the underlying illness script. Then looks for findings that *falsify* the script under scrutiny, and finally searches for *omissions* if the script were true. The similarity of deliberate reflection with the ways a scientist tries to find empirical evidence for and against his working hypothesis is obvious. The deduction part of deliberate reflection resides in the seeking of signs and symptoms that would be the consequence of a particular diagnostic hypothesis. The induction part consists of the emergence of new diagnostic hypotheses based on the findings. Finally, testing is operationalised in the matching of findings with the diagnoses.

2.2 | The effectiveness of the deliberate reflection approach: Summary of research

2.2.1 | Does deliberate reflection support diagnostic problem-solving?

Theoretically, engaging in deliberate reflection while diagnosing clinical cases would increase diagnostic performance, particularly under conditions that make the diagnostic task more challenging or increase the chance of generating a wrong initial diagnosis. It would not add to diagnostic accuracy in *routine* cases where a more or less intuitive response is usually sufficient.

These predictions have been supported by experimental evidence. In a study, internal medicine residents were requested to diagnose complex and straightforward cases—straightforward cases being cases that were known to be easy to diagnose based on diagnostic accuracy observed in previous research—either through the best diagnosis they could come up with as fast as possible (here called intuitive diagnosis) or through deliberate reflection. Deliberate reflection substantially increased accuracy on complex cases relative to intuitive reasoning. However, diagnostic performance on straightforward cases was similar regardless of the reasoning mode.[17] These findings were replicated in a subsequent study that had internal medicine residents and intermediate medical students diagnosing simple and complex cases again by either using intuitive reasoning or deliberate reflection. The residents' diagnostic accuracy improved by more than 35% with deliberate reflection, which however did not make a difference on simple cases. A reverse pattern was observed for students. Whereas

they benefited substantially from deliberate reflection on simple cases, their performance was even worse when they reflected on complex cases than when they gave a diagnosis intuitively.[18] Recent studies of deliberate reflection have added to this early research by involving other types of clinical problems. Myung et al.[19] showed the deliberate reflection approach to improve fourth-year medical students' performance within the context of objective structured clinical examinations. Deliberate reflection was also demonstrated to improve diagnostic accuracy in the diagnosis of skin lesions provided by final-year medical students.[20]

A series of studies have investigated the effect of deliberate reflection on diagnostic performance when cases are diagnosed under circumstances that tend to lead diagnostic reasoning astray. For example, availability bias, the tendency to overestimate the likelihood of an event when it comes easily to mind, may cause physicians to misdiagnose a similar-looking (but different) case. In two experimental studies, physicians diagnosed clinical cases either preceded or not preceded by an experience that might induce availability bias. In one study, residents studied a Wikipedia page with information about the pathophysiology and clinical manifestation of a particular disease, either Q-fever or Legionnaire's disease. At a later point in time, they were asked to diagnose a set of "look-alikes," that is, diseases that had a number of symptoms in common with either Q-fever or Legionnaire's disease but a different diagnosis. Residents who read irrelevant information in the morning, diagnosed the look-alikes significantly more often wrongly in the afternoon.[21] In a second study, residents were biased by asking them to check on the accuracy of particular diagnoses. These primes caused participants, when confronted with look-alikes at test to more often make mistakes in line with the primes.[22] However, in both studies, deliberate reflection conducted after the test restored performance to the level observed among those who were not exposed to the bias-inducing experience.

This potential of deliberate reflection to prevent errors has also been observed for other sources of disturbance in diagnostic reasoning. Salient distracting features, findings that may catch physicians' attention because they are strongly associated with a disease that seems plausible at first sight, led physicians to incorrect intuitive diagnoses that were however repaired after they engaged in deliberate reflection.[23] Similar findings were observed for errors induced by patients' disruptive behaviours. In studies that requested physicians to diagnose clinical cases that differed only in the description of the patient's behaviour (either neutral or disruptive), the difficult behaviours showed to hinder processing of clinical findings, causing errors. These errors were however corrected after deliberate reflection.[24,25] The findings of these studies support the notion that diagnostic reasoning can be led astray by salient, seductive features that are in fact irrelevant to the problem at hand, causing physicians to generate a wrong initial diagnosis. They also provide empirical evidence to the claim that deliberate reflection can then help probably by redirecting attention to other features, allowing for the recognition of actually relevant ones that were initially overlooked and re-interpretation of case findings.

Finally, deliberate reflection has been used to help physicians *avoid* bias in diagnostic reasoning. Residents were asked to deliberately reflect on a series of cases that had a particular complaint in common (i.e., jaundice or diarrhoea) with special emphasis on similarities and differences between the cases. One week later, they were biased using either a case of acute viral hepatitis or a case of inflammatory bowel disease, followed by a test with look-alikes. Those who were "immunised" by deliberate reflection 1 week earlier, were demonstrated to be protected against the biasing procedure.[26]

2.2.2 | Does deliberate reflection helps learning to solve new diagnostic problems?

The aforementioned studies investigated the effects of deliberate reflection on the diagnosis of clinical cases, applying "reflection-in-action," to use Schön's expression. However, deliberate reflection has also been tested as an educational approach to help improve *future* diagnostic performance. These experiments typically consist of a learning phase, in which medical students diagnose sets of clinical cases of diseases that share a similar clinical presentation, an immediate test, and a delayed test that requires the diagnosis of new cases of the same (or related) diseases. In the learning phase, students diagnose the cases either by using deliberate reflection or by a more conventional approach such as generating a differential diagnosis. In an early study for instance,[27] fourth-year medical students diagnosed three cases of chest pain and three cases of jaundice. Depending on their assigned condition, they did this by providing the first diagnosis that came to mind (i.e., an immediate diagnosis), by providing an immediate diagnosis and then generating a differential diagnosis, or by providing an immediate diagnosis and then engaging in deliberate reflection. The tests required participants to diagnose a set of six new clinical cases, of which four represented new exemplars of the diseases encountered in the learning phase. On the immediate test, the deliberate reflection group did poorer than the other two groups. However, after 1 week, the performance of this group on new cases was significantly better. In a follow-up experiment,[28] the investigators were able to demonstrate that performance on the delayed test was not only better on new cases of the same diseases but also on look-alike, different but adjacent, diseases: Students in the deliberate reflection condition did not only better on new cases of acute myocardial infarction (the disease for which they practiced) but also on stable angina pectoris (which they did not see before). It seems that deliberate reflection also encourages *transfer*. Why this is so, is presently unknown. We will discuss possible reasons in the Discussion section.

More recent research has examined the added value of providing students with more instructional guidance. As demonstrated previously, while engaged in deliberate reflection students have to provide new diagnostic hypotheses *themselves*. Ibiapina et al.[29] investigated what would happen if one cues advanced students *by providing them* with the diagnostic hypotheses that should be considered. In addition, they included a condition in which students received examples of the reflection of experts. Such modelling of expert performance was meant to reduce cognitive load. Performance after modelling reflection was similar to cued reflection. Both showed to be more

advantageous than reflection without cuing, possibly because they ensured that students would reflect upon the diseases that were actually addressed in the test phase. Similar findings were observed in a subsequent study with novice students who had attended courses on the pertinent diseases but had no clinical experience, suggesting that preliminary knowledge is sufficient to allow students to gain from cued deliberate reflection.[30,31]

What happens to *learning new information* about a set of diseases after being encouraged to deliberately reflect on relevant cases? Ribeiro et al.[32] presented students with two cases of jaundice for which they either had to provide a differential diagnosis or engaged in deliberate reflection. Subsequently, they received a 1200-word text presenting a brief review of bilirubin physiology and physiopathology, followed by comments on the presentation of the clinical cases participants had diagnosed, with the key clinical findings valuable for differentiating between the causes of jaundice. Finally, a cued-recall test was taken to measure how much was remembered from the text. The deliberate reflection group recalled 40% more propositions from the text than the differential diagnosis group. The deliberate reflection group also spent more time on studying the text, suggesting that this procedure caused students to become more motivated with regard to processing the text. In a subsequent study,[33] again after diagnosing cases either by providing a differential diagnosis or engaging in deliberate reflection, students were either free to spend as much time they needed on the text, or were time-constrained. The effect of deliberate reflection on recall was significantly larger (relative to differential diagnosis) under free time, but was also significantly larger under restricted time, suggesting that, in addition to increasing motivation, deliberate reflection also facilitates text processing through a cognitive mechanism, possibly by activating relevant prior knowledge to a larger extent,[34] an effect also observed in text processing studies in the context of problem-based learning.[35,36]

3 | DISCUSSION

3.1 | Possible causes of the deliberate reflection effect

Deliberate reflection has proven to be useful in a number of contexts. It supports physicians in improving their diagnoses by providing the opportunity to assess their findings systematically.[17,18] It assists them in overcoming the influence of salient distractive features in a case[23] and disruption caused by overly emotional or aggressive patients.[24,25] In addition, it helps physicians to avoid or recover from bias.[21,22,26] Students are supported in learning to solve diagnostic problems within a particular set of diseases,[28,29] and deliberate reflection facilitates the understanding of new information about disease.[32] The question is, of course, why this is so.

The reader should bear in mind that clinical reasoning is a profoundly knowledge-based activity. Clinicians operate upon an extensive fund of knowledge consisting of a deep understanding of disease and its associated signs and symptoms, knowledge of the underlying pathophysiological mechanisms[37,38] and even memories of previous patients.[39] This knowledge is suggested to be organised in memory as illness scripts.[5,40] However, different diseases show considerable overlap among their signs and symptoms. In addition, disease manifests itself in different patients with much variability in terms of these signs and symptoms. Finally, the context in which disease emerges plays a decisive role. Overlap, variability of presentation, and context make diagnostic reasoning particularly difficult.

How does deliberate reflection facilitate clinical reasoning and help physicians avoid mistakes? Here we have to be tentative in our judgement because the cognitive processes underlying deliberate reflection are not yet easily understood. The first process that may play a role is more extensive activation of prior disease knowledge. Ribeiro[34] found that when she asked students to recall knowledge of a number of diseases that have jaundice in common, those who diagnosed cases through deliberate reflection produced more accurate propositions than those who diagnosed the same cases leading to a differential diagnosis. This finding suggests that deliberate reflection enables the problem-solver to judge the case against a more extensive knowledge base. Second, deliberate reflection provides diagnosticians with explicit instructions to process a clinical problem several times guided by a new hypothesis generated by the diagnostician in each round of analysis (see Table 3). This enables them to interpret the signs and symptoms at every turn *in a new light* and *compare and contrast* plausible alternative diagnoses. Third, this possibly strengthens associations between a particular disease and its concomitant signs and symptoms and increases knowledge of features that differentiate between look-alike diseases. This would explain why deliberate reflection increases students' ability to recognise these diseases when they encounter them in the future,[28] and help physicians avoid biases.[26] Research on disease knowledge among physicians has indicated that the better problem solvers in a particular domain have more extensive and more specific illness scripts for that domain.[41] This increased differentiation between look-alike cases might also account for the fact that students not only were better in diagnosing diseases for which they were trained but also on diseases for which they were not trained but that were adjacent to the ones trained for, the issue of transfer.[28] The latter findings led some to assume that training in using deliberate reflection changes the way in which the problem solver approaches future problems.[42] The diagnostician might as a result deal with such problems in a more analytical way. There is however as yet no evidence that this is actually the case. In addition, studies trying to teach general reasoning strategies in the domain of medicine have met with very limited success.[16] More research is needed here.

These possible explanations have in common that they require physicians to possess the relevant knowledge to resolve a particular problem in order to benefit from deliberate reflection. If the approach works by fostering identification of diagnostically relevant information and retrieval of appropriate knowledge, then deliberate reflection will not help when this knowledge is not available to be retrieved. As a consequence, it only helps when the problem presents a sufficient level of difficulty for the problem solver. This is a basic idea in the reflection literature and has been reaffirmed in the studies on

deliberate reflection. When clinical cases display common diseases with rather typical presentations and when misleading cues are not present, clinicians do not gain from reflection.[17] Deliberate reflection is only effective when the difficulty level of a diagnostic problem is optimal in view of the knowledge level of the problem solver. If the problem solver lacks knowledge to deal with a problem, deliberate reflection may even lead him or her astray. This is exemplified in a study in which students and residents diagnosed easy and difficult problems ("easy" for the residents as defined by prior research).[18] While the residents profited from deliberate reflection while dealing with the difficult problems, the students were actually hurt by the deliberate reflection approach. And while residents did not profit from it while engaging with the "easy" problems, the students benefited from deliberate reflection. The impact of deliberate reflection depends on the level of difficulty of a problem that in its turn depends on the level of expertise of the problem-solver.

3.2 | Comparison with other methods

In a number of studies an attempt was made to induce reflective reasoning while processing a case. Students were for instance instructed to consider all clinically relevant findings in a case before reaching a diagnosis.[43,44] And Arzy et al.[45] warned physicians to watch out for potentially misleading information in a case. These instructions to be more analytical did not help; in some cases performance even deteriorated. It seems that *taking a second look* is a precondition for instructions to be successful; a tentative diagnostic hypothesis, attained with whatever means (intuitively or more analytically) needs to be produced *first*, before any reparative actions can be taken through instruction. Features of a case should be interpreted in the light of a particular hypothesis rather than lead to a hypothesis. More important perhaps is scrutinising findings *in a stepwise approach*. Some of the more successful interventions focusing on reflection, as delineated in Appendix S1, deconstruct a case step-by-step in search of a better diagnosis. This seems particularly the case for the use of checklists, for deliberate reflection, and for self-explanation.

Other studies focused on the process rather than the contents of clinical reasoning. They are driven by the belief that diagnostic error is the result of sloppy reasoning or because doctors fall prey of bias. Workshops were evaluated in which students were taught the iterative hypothetico-deductive process involving hypothesis generation and testing.[46–48] Others attempted the teaching of metacognitive skills in identifying cognitive biases, such as search satisficing or availability bias, in one's own thinking, so called cognitive forcing strategies.[49,50] Effects on diagnostic performance of such interventions aimed at improving the reasoning processes or increasing awareness of the pitfalls of diagnostic thinking were however largely absent. Similarly, while checklists that aim at supporting the diagnosis by improving physicians' reasoning process have shown little effect, content-focused checklists appear to help.[51,52] These findings are not surprising in view of the fact that specific disease knowledge and clinical experience as such paramount determinants of diagnostic expertise, that attempts to improve clinical reasoning that do not focus on improving the knowledge base of physicians or students are bound to fail. Content overshadows process. See for more extensive overviews of attempts to improve clinical reasoning in students and physicians.[3,7,53]

3.3 | Unresolved issues

In a study involving almost 400 clinicians from emergency and internal medicine departments, Ilgen et al.[54] presented their participants with a number of vignettes and, in the deliberate reflection condition, asked their participants to list the three most likely diagnoses for these cases. Subsequently, they were asked to write down, for each diagnosis, features that support the particular diagnosis, and features that do not explain the diagnosis. They failed to find evidence in favour of this version of the deliberate reflection approach. Mamede and Schmidt[55] retorted that the deliberate reflection procedure requires that diagnostic hypotheses emerge sequentially in a bottom-up fashion while dealing with findings that may or may not support one's own initial diagnosis. Illgens et al's study required participants to produce competing diagnostic hypotheses *first*, in a top-down approach, much in the way a differential diagnosis is produced. In this approach, hypotheses are not triggered by the confrontation with (possibly contradicting) evidence. Such procedure leaves little room for new and unexpected ideas to emerge from the further interaction with the findings in the case. However, there is clearly a need for research into the effects of variations in instructions on how to process a clinical case.

A second unresolved issue is how much guidance is helpful in learning to diagnose clinical cases. Cognitive load theory suggests that learning to solve problems in a particular domain is facilitated by providing worked examples of the problems in the learning phase. In an experiment in which the effect of unguided deliberate reflection was compared with a condition in which the diagnostic hypotheses to reflect upon were provided ("cued reflection") and a condition in which the deliberate reflection table was already filled in by an expert, the effect of the latter two on the diagnosis of new cases was significantly higher than that of the former.[31] Because additional instructional support was also considered to require less effort, one may assume that during unguided reflection and because of perhaps not always successful search in memory, ideas were generated that were not directly relevant to the task at hand. However, it remains to be seen whether this more extensive processing might not be more useful in the longer run or on cases adjacent to the cases studied.

A third issue concerns the finding that if one requires participants to process a case a second time, improvements in diagnosis equal the effects of a deliberate reflection procedure.[56] This suggests that there may be alternatives to the quite time-consuming deliberate reflection procedure.

Finally, deliberate reflection was only applied in studies using vignettes that contain *all* information necessary for an accurate diagnosis. Studies have indicated that such vignettes have high predictive validity.[57,58] Nonetheless, it remains to be seen how useful deliberate

reflection is in cases as encountered in clinical practice where the physician, based on a presenting complaint, has to collect relevant findings rather than be presented with them. In clinical practice physicians would also need to determine whether the problem at hand is "difficult enough" to benefit from deliberate reflection. Studies have suggested that physicians' self-monitoring of their performance give them insight on the correctness of their solution to the problem at hand.[59,60] This might help in triggering reflection when needed.

Summing up, a substantial body of empirical evidence exists that deliberate reflection increases physicians' diagnostic performance, particularly for difficult diagnoses. Deliberate reflection has also proved helpful to improve students' diagnostic learning and to facilitate learning of new scientific information. Translating this body of research into recommendations for employing deliberate reflection in regular clinical practice depends on further examining the crucial aspects we addressed above. Things are different, however, regarding deliberate reflection in education. Here, recommendations for practice can be made. For example, teachers can provide students with a relevant case to be solved through deliberate reflection immediately before exposure to related knowledge (e.g., before a lecture or small group learning). The existing evidence also supports the offer of structured exercises with clinical cases in which students engage in deliberate reflection to diagnose cases of lookalike diseases. Teachers have good basis to expect that these exercises would foster learning and help develop their students' diagnostic performance.

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Silvia Mamede provided substantial contribution to the conception of the work, the acquisition, analysis and interpretation of data for the work, drafting the manuscript and revising it critically for important intellectual content, gave final approval of the version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy of integrity of any part of the work are appropriately investigated and resolved. Henk Schmidt provided substantial contribution to the conception of the work, the acquisition, analysis and interpretation of data for the work, drafting the manuscript and revising it critically for important intellectual content, gave final approval of the version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy of integrity of any part of the work are appropriately investigated and resolved.

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ENDNOTE

* Search terms: TS = (reflection OR (reflective practice)) AND SO = ((Academic Medicine) OR (Advances in Health Sciences Education) OR (Medical Education) OR (Medical Teacher) OR (Advances in Physiology Education) OR (Teaching and Learning in Medicine)).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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