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Review article

Cognitive diagnostic error in internal medicine

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ABSTRACT

Medical error poses an important healthcare burden and a challenge for physicians and policy makers worldwide. Diagnostic error accounts for a substantial fraction of all medical mistakes. Most diagnostic errors have been associated with flaws in clinical reasoning. Empirical evidence on the cognitive mechanisms underlying such flaws and effectiveness of strategies to counteract them is scarce. Recent experimental studies, reviewed in this article, have increased our understanding of the relationship between cognitive factors and diagnostic mistakes. These studies have explored the role of cognitive biases, such as confirmation and availability bias, in diagnostic mistakes. They have suggested that confirmation bias and availability bias may indeed cause diagnostic errors. The latter bias seems to be associated with non-analytical reasoning, and was neutralized by analytical, or reflective, reasoning. Although non-analytical reasoning is a hallmark of clinical expertise, reflective reasoning was shown to improve diagnoses when cases are complex. Research on cognitive diagnostic mistakes remains a quite novel line of investigation. Follow-up studies that shine more light on the cognitive roots of, and cure for, diagnostic errors are needed.

1. Introduction

Since a little over a decade, cognitive diagnostic errors, i.e., diagnostic mistakes resulting from flaws in physicians' clinical reasoning processes, have caught the attention of researchers and policy-makers, and the topic has been pursued in several position papers [1–3]. Nonetheless, little empirical evidence supporting a relationship between these cognitive factors and medical error exists. In this paper, we will review the evidence on this theme.

2. Medical error

After the landmark Institute of Medicine (IOM) report "To Err is Human" on patient safety issues was published [4], medical errors have been a subject of lively debate [5,6]. The IOM report, which evaluates medical errors in the United States, estimates that up to 98,000 Americans die annually as a result of those mistakes [7,8]. This figure surpasses the annual number of deaths due to motor vehicle accidents and Alzheimer's disease [9], and medication errors alone cause more deaths than workplace injuries [10]. Moreover, medical errors resulting in injury are costly. A rough estimation showed that those mistakes cost the American society between $17 billion and $29 billion annually [11]. Although most descriptive studies on medical error have been conducted in the US, the problem is not exclusive to the American healthcare system. On the contrary, medical error is universal, with frequencies and consequences worldwide similar to the US [12–16].

Besides treatment-errors (e.g., medication errors, surgery-related errors), which comprise the majority of all mistakes, faults related to the diagnostic process are considered to contribute substantially to total medical error. Elstein estimates the rate of diagnostic error in clinical medicine in the order of 15% [17], and his view is supported by findings from autopsy-studies, which indicate that such errors occur in approximately 10–15% of cases [18,19]. This rate is highest in internal medicine and emergency medicine [7,8,20]. The susceptibility for diagnostic mistakes in these specialties is believed to be related to domain-specific requirements, such as complex decision making in contexts of high uncertainty [21]. That is, in internal medicine a diagnostic decision is frequently a complex endeavor, because the spectrum of problems is much larger than in other specialties. In addition, a medical diagnosis requires explaining and interpreting findings in the context of each individual patient. Furthermore, normal variations in test results pose challenges to the diagnostic process. For instance, the value of serum creatinine, is influenced, among others, by body mass, age and pregnancy [22]. The same value, then, could be considered as normal, borderline, or abnormal, depending on other aspects of the patient. Finally, adding up to uncertainty, clinical decisions, especially in acute internal medicine, are often made under time pressure, which, for example, may impair thorough data-gathering, or are affected by other disturbances, such as telephone calls, which may divert attention from a patient.

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3. Cognitive diagnostic error

In one of the few retrospective studies exploring the etiology of diagnostic errors, Graber et al. provide highly informative data [23]. Their study describes 100 cases of diagnostic error in internal medicine identified retrospectively from five academic medical centers over a 5-year period. They found diagnostic errors usually resulted from multiple causes and typically involved both system-related and cognitive factors. System-related mistakes, for instance, due to technical failure, equipment problems and organizational flaws, were found to contribute to errors in 65% of cases. However, faults in individual physicians' cognitive processes contributed to an even greater proportion of mistakes (74%). These so-called cognitive diagnostic errors may be caused by inadequate knowledge, faulty data gathering, inaccurate clinical reasoning and erroneous verification of diagnostic hypotheses [24]. For example, a physician may focus on or overweigh clinical findings that are in line with a (incorrect) diagnostic hypothesis he has in mind, which could increase the chance of accepting this diagnosis. Several position papers have stressed the potential effect of cognitive errors on medical diagnosis [1–3], and observational studies have provided indirect evidence that faults in physicians' cognitive processes may in fact be involved in the majority of missed or delayed diagnoses [23,25]. Such studies have indicated that faulty reasoning, more than knowledge gaps, may be the most frequent cause of cognitive errors.

The mechanisms underlying faulty clinical reasoning are, however, still subject of discussion [26]. Research on medical expertise, which describes how clinicians make judgments in clinical encounters with patients, suggests that clinicians' reasoning may be susceptible to bias [27–29]. This research has shown that clinicians generate hypotheses early in the clinical encounter, mainly through pattern recognition: similarities in clinical characteristics between the current and previously seen patients quickly bring one or a few diagnostic hypotheses to the physician's mind, which are subsequently used to guide the search for additional information. This so-called non-analytical mode of reasoning, which tends to be a largely automatic, and therefore relatively effortless, process, is the dominant reasoning mode when clinicians deal with routine problems [29]. As it occurs largely without conscious control, generation of hypotheses based on pattern-recognition could be influenced by multiple factors that remain unnoticed, making physicians more prone to bias and, consequently, to errors [1,2]. Experimental studies establishing a relationship between physicians' clinical reasoning and diagnostic error are, however, scarce.

4. Reasoning modes and diagnostic error

Within the literature on clinical reasoning a debate is on-going whether a particular diagnostic reasoning mode would predispose physicians' to make cognitive diagnostic errors [26,30]. Some authors believe that excessive reliance on non-analytical reasoning may lead to errors [1,3], which could have been avoided if a strategy consisting of analytical and non-analytical reasoning would have been used [31,32]. In addition, there is experimental evidence that diagnostic accuracy on complex clinical problems may improve if physicians engage in analytical, reflective reasoning [33,34]. Analytical reasoning is rule-based and systematic, and therefore costs more time and effort than non-analytical reasoning, which is based on holistic pattern-recognition rather than on intensive deliberation. The two modes of reasoning are the representatives of System 1 and System 2 within the so-called dual processing theories of thinking that have been studied extensively in the psychology literature on judgment and decision making [35–37]. Dual-processing theories, with non-analytical reasoning referred to as System 1 and analytical reasoning as System 2, have recently become a widely used theoretical framework also in research on clinical reasoning [32,38].

The anatomical and physiological co-existence of two distinct reasoning systems is supported by experimental findings. For instance, an event-related fMRI-study showed that non-analytical thinking is associated with ventral medial prefrontal cortex activity and analytical thinking is reflected by activity in the right inferior prefrontal cortex [39]. Likewise, physiological evidence of the dual process model of reasoning has been presented based on the assumption that analytical reasoning requires more primary fuel (glucose) for brain processes, than non-analytical reasoning. In their study, Masicampo and Baumeister show how blood glucose interacts with the reliance on non-analytical reasoning [40].

The two modes of reasoning are simultaneously possible for clinicians, and research has shown case ambiguity (i.e., a case that is consistent with the typical pattern of a disease but also includes features consistent with alternative diagnoses) to be a determinant of reasoning strategy: more ambiguous clinical cases are associated with a shift from non-analytical to analytical approaches in clinical reasoning [41]. It is, however, unclear whether errors in medical diagnosis are associated with either analytical or non-analytical reasoning, although new evidence is emerging [30]. In addition, certain specific cognitive tendencies, such as the inclination towards confirmation, might, regardless of the interplay of reasoning modes, lead to diagnostic errors.

5. Confirmatory tendencies in reasoning

Physicians' inclination towards confirmation of hypotheses is often pointed out as an important cause of cognitive diagnostic errors [1,2]. In psychological research, this tendency has been studied for several decades [42,43]. If errors are made because data are gathered or interpreted to confirm a hypothesis rather than refute it, confirmation bias may be pointed out as the cause [42]. This bias is considered one of the primary causes of error in the literature on reasoning [44] and, since the phenomenon was first demonstrated, its influence has been shown in several settings, such as judicial reasoning, forensic science, and gambling [45–47].

6. Confirmatory tendencies in clinical reasoning

In the medical domain, research on physicians' confirmatory tendencies used, until recently, mainly visual stimuli, and focused on the influence of diagnostic suggestions on the quality of diagnostic decisions [48,49]. This research showed that medical students and physicians could be biased towards a correct diagnosis or a plausible alternative diagnosis, by having them first evaluate the plausibility of either the correct or the alternative diagnosis. In one study [49], medical students and residents were shown photographs of patients accompanied by a case history that was supportive of a subsequently presented diagnostic suggestion. This diagnostic suggestion was either the correct or a plausible alternative diagnosis. Next, participants were asked to rate the likelihood of the suggested diagnosis. Results showed that participants who were first exposed to the correct diagnosis accurately decided that this diagnosis was indeed correct in 77.2% of the cases. When they were suggested the incorrect diagnosis, they erroneously decided that this one was correct in 65.8% of the cases. Results further showed that participants' difficulty with rejecting incorrect diagnoses probably arose because their identification and interpretation of clinical features was influenced by the suggested diagnosis [48,49]. For example, in one scenario, participants misinterpreted tanned skin as jaundice more often when biased toward liver cancer (which is frequently associated with jaundice) than when biased toward stomach cancer (which is less frequently associated with jaundice), despite the patient's white sclerae (which indicated that there definitely was no jaundice, since jaundiced skin is by definition accompanied by jaundiced sclera).

7. The interdependence of clinical feature identification and diagnosis

A main goal for internists involved in the training of residents and students is the prevention of mistakes in clinical reasoning of their apprentices. As a result, they often recommend students to gather all information before making a diagnosis. This complete gathering of information, including the meticulous listing of the patient's presenting features, is believed to reduce the chances of premature closure [1]. However, as the abovementioned studies point out, the detection of clinical features may not be a clear-cut process [48,49]. In fact, some authors believe clinical features to be anything but independent cues that are processed and used as pieces of evidence in order to arrive at a diagnosis [48–50]. Instead, they argue that features are extracted and interpreted in light of the diagnoses that the physician has in mind.

For instance, research that used radiographs to study clinical decision making has shown that tentative diagnoses can increase diagnostic accuracy by drawing attention to features that might otherwise be missed [51]. In another study using chest radiographs, prior clinical histories for ambiguous cases of bronchiolitis affected not only the diagnoses but also the identification of the presence of particular clinical features [50]. Likewise, a study using ECGs showed that a biasing history influenced both diagnostic accuracy and the identification of features [52]. In this study, a suggestive history prior to evaluating the ECGs guided internal medicine residents towards the diagnosis suggested by the history. Additionally, when a history supportive of the correct diagnosis was suggested, residents mentioned more features compatible with this diagnosis and fewer features compatible with the plausible alternative diagnosis. In contrast, when a history supportive of a plausible alternative diagnosis was given, residents were more likely to leave out features compatible with the correct diagnosis, and report more features that were compatible with both the correct and alternative diagnoses. Similar results have been found in studies using photographs of patients [48,49]. A consistent finding in the aforementioned studies was, therefore, that physicians do not objectively, impartially identify and interpret features in a clinical case; instead, perception and interpretation are influenced by a hypothesis that is held in mind. This tendency to identify and interpret clinical features in light of a suggested diagnosis may lead to diagnostic errors through susceptibility to confirmation bias.

The previous studies showed that diagnostic decisions may be influenced by diagnostic suggestions, and that the tendency to confirm a suggestion may be caused by a reinterpretation or misidentification of clinical features. In these studies, however, the evaluation of the suggested diagnosis was preceded by a biased (i.e., supportive) case history, which is likely to have led to participants' difficulties with rejecting incorrect diagnoses. In fact, because different case histories accompanied the same photograph, in these studies, the cases *themselves* can be viewed upon as being different.

In addition, those studies used highly visual materials, such as pictures of patients, which may be more affected by interpretation. That is, visual images are probably more powerful in opening space for noticing features that would probably not be expressed in a written case description. For instance, a tanned skin shown in a patient's picture could be misinterpreted as jaundice, if a wrong diagnosis of liver carcinoma is suggested. But in a written case, the “tanned skin” would not be mentioned, rather either the sclerae would be described or nothing would be said. Therefore, the results of previous studies [48–52] can hardly be generalized to other types of medical stimuli, such as internal medicine cases. Recently, several studies investigated whether such confirmatory tendencies also occur when physicians evaluate suggested diagnoses on *written* clinical internal medicine cases [53–55]. These studies brought a relevant contribution, since doctors are known to rely on case histories [48], and internal medicine is often implicated as being affected by diagnostic error [7,8,20]. One study was conducted with 24 internal medicine residents who evaluated diagnostic suggestions on six written cases. The cases were the same and were presented in the same order for all residents, but the diagnostic suggestions that preceded them differed: half of the residents first evaluated a correct suggested diagnosis, the other half an incorrect suggested diagnosis, after which the correctness of the suggested diagnoses alternated. Results showed that participants' diagnostic score on the three cases with a correct suggested diagnosis was significantly higher than that on the three cases with an incorrect suggested diagnosis suggesting, meaning that internists in-training indeed found it easier to accept correct diagnoses than to reject incorrect diagnoses [53]. Another recent experiment indicated that the tendency to accept a diagnostic suggestion for written cases may be mediated by a search that draws out features preferentially in favor of the suggested diagnosis, which could lead to diagnostic errors [55]. In summary, these studies showed that internal medicine residents also tended to accept diagnostic suggestions on *written* clinical cases and provide additional data that biased reasoning might indeed influence diagnostic decision making.

8. The effect of the ease of information-retrieval from memory

Besides confirmatory tendencies, other potential cognitive pitfalls exist. For example, if information from an unlinked source influences medical diagnosis and causes a diagnostic mistake, the physician has fallen prey to a cognitive error called availability bias [1]. Psychological research has shown cognitive biases, such as the availability bias, are often evoked by the use of heuristics, which are defined as mental shortcuts that we tend to use to make daily decisions, mostly through intuitive, largely unconscious judgments [36,37]. Heuristics are invoked, largely unconsciously, by physicians to accelerate the decision-making process in clinical practice [2,3,56]. Heuristics tend to be helpful in most situations, but they may also lead to biased decisions [57].

The availability heuristic leads people to assess the likelihood or probability of an event by the ease with which instances can be retrieved from memory [57,58]. As Nobel-prize winners Tversky and Kahneman pointed out, this heuristic is generally rather useful, as events that occur more frequently are easier to recall or imagine than less frequent ones [57]. However, the ease with which instances come to one's mind is also influenced by other issues, such as someone's own recent experiences. Consequently, the use of this heuristic may generate an *availability bias*, resulting in errors of judgment.

In psychology, several demonstrations of this bias are given. An illustration comes from an experiment that is described in a seminal paper by Tversky and Kahneman [58]. The authors present a study in which participants heard a list of names of both sexes. Next, they were asked to judge whether the list contained more names of men or women. Different groups of participants listened to different lists. In some of the lists the men were more famous than the women, and in others the women were more famous than the men. In each of the lists, the subjects erroneously judged that the sex that had the more famous individuals was the more numerous. This indicates that such frequency judgments are mediated by availability, since famous names are generally easier recalled than not so well-known names.

Such biased reasoning may have substantial consequences. This is illustrated by an effect of the September 11 terrorist attacks, that may be attributed to availability bias: people's diminished enthusiasm to fly because of dread risk [59]. Dread risk is defined as people's inclination towards avoiding circumstances in which many people could die simultaneously, while being relatively unmoved by risky situations in which deaths are less condensed. Ironically, avoiding the dread risk of flying after the September 11 attacks may have led to an elevated number of traffic fatalities. In the three months after the 9/11 attacks, the number of fatal traffic accidents was intensely elevated relative to baseline rates from other years during the same period, apparently because people decided to avoid air travel due to fear for a repetition

of the September 11 tragedy. This illustrates that the availability bias might have caused numerous indirect fatalities due to the influence of this dramatic event on people's judgment and decisions.

9. Availability bias and clinical reasoning

The medical literature names the availability bias as a main contributor to errors of judgment in diagnosis, despite the scarcity of empirical evidence encountered in this literature [1–3,60–62]. There have been a few correlational studies suggesting the occurrence of bias [63], but experimental evidence of a causal relationship between availability bias and diagnostic mistakes was, until recently, missing. In the first empirical study that focused on availability bias in clinical reasoning [64], it was investigated whether recent experiences with patients bias physicians' reasoning, and thereby could lead to errors. In addition, the potential of a cognitive protective strategy, reflective reasoning (i.e., analytical reasoning), to reduce such errors was assessed. In this experiment with 18 first-year and 18 second-year internal medicine residents, participants were confronted with 6 clinical cases and subsequently diagnosed, through non-analytical reasoning, 8 different cases; 4 cases had different diagnoses but findings similar to some of the previous cases. These 4 cases were subsequently solved through reflective reasoning. All cases were based on real patients with a confirmed diagnosis. Results showed that availability bias only occurred for the second-year residents; they obtained significantly lower scores on the cases similar to those previously encountered. Furthermore, it was found that reflection improved the diagnostic scores compared to those obtained on the same cases through non-analytical reasoning. This study provided the first demonstration that availability bias may occur in medical diagnosis as a consequence of recent experiences with similar problems. In addition, it showed that flaws in reasoning processes rather than knowledge tend to underlie diagnostic errors, which can be repaired by a more reflective reasoning approach. Rather than protecting against bias, increased experience seemed to make residents more prone to bias.

10. Strategies to make physicians less prone to cognitive diagnostic error

Equally scarce as proof for cognitive bias' potential to cause diagnostic errors is empirical evidence in support of strategies aimed at making physicians less susceptible to bias. The medical literature has raised attention for “debiasing strategies” and metacognitive training as a method to reduce error and improve diagnostic decision making [1,21]. For example, enthused by parallels between the fields of medicine and aviation [65], it is suggested that enhancing situational awareness (i.e., a shared understanding of “what's going on” and “what is likely to happen next”) might reduce diagnostic errors [66]. Others believe that stimulating physicians' awareness of possible biases under conditions of non-analytical reasoning would make them less vulnerable to errors [1]. However, it is easier to find discussion papers advocating such strategies as a means to counteract bias than experimental evidence that they actually *do*.

A few experimental studies have suggested that reflective reasoning may be able to counteract bias [33,34,64]. These studies have employed a structured procedure, developed based on research on reflective practice in medicine [67], to guide physicians' reflection upon the to-be-diagnosed case. The procedure compels physicians to critically analyze their initial reasoning, by searching for disconfirmatory as well as confirmatory evidences of initial diagnostic hypotheses and analyzing alternative diagnoses, before making a final diagnostic decision [33,34,64]. In two experimental studies [33,34], where deliberate reflection upon the to-be-diagnosed cases was operationalized in this way, internal medicine residents diagnosed simple and complex written clinical cases, either through pattern recognition (non-analytical reasoning) or reflective (analytical) reasoning. The results indicated that structured reflection increases diagnostic accuracy on complex cases for internal medicine residents. When residents were subjected to a prior task that induced availability bias before solving a set of cases [64], deliberate reflection was shown to counteract the bias associated with non-analytical, improving diagnostic accuracy. These studies have set rationale for the hypothesis that reflection may decrease the chances of diagnostic error and to counteract bias, providing evidence in support of an optimal model of clinical reasoning that integrates non-analytical and reflective reasoning.

11. Perspectives

The studies reviewed in this paper reflect a relatively novel line of investigation in research on clinical reasoning. Although years ago many position papers were published on the subject of cognitive diagnostic error, experimental evidence, and therefore the possibility to make causal inferences, was scarce. The experimental studies described in this review provide evidence supportive of a role for cognitive factors as causes of diagnostic mistakes. Nevertheless, many aspects remain to be addressed in this domain. One line that might be explored in future research addresses the potential of generalizability that can be assigned to studies on clinical decision making, which results have been obtained in laboratory conditions. More ecologically valid scenarios with standardized patients involved will extend the findings from controlled experiments that have been conducted. However, it might be highlighted that the tasks and manipulations that have been used in the studies reviewed in this article come close to actual medical decision making: solving clinical problems after receiving diagnostic suggestions or having recent experiences with similar cases.

Furthermore, limited experience with diagnostic reflection as a remedy for cognitive errors warrants cautiousness regarding the generalizability of findings from these studies. Replication studies are needed and are being planned. Although the relationship between experience and reasoning modes has been established [27–29], the finding that more experienced physicians were subject to bias might seem counterintuitive and warrants further study [64]. Because, if experience alone does not protect physicians from cognitive bias, what should be done? An interesting option might be to explore whether or not the teaching of reflective reasoning is possible. Previous studies on the effect of reflection on diagnostic performance have employed a structured procedure to guide reflection upon clinical cases, which has been shown to improve diagnostic accuracy at least when problems are complex. Although effective as an experimental design, a so highly structured procedure is probably not used so often in real life even by reflective practitioners. It is worthwhile to explore whether other forms of reflection, less structured and conducted with less guidance, would also lead to better diagnoses in complex problems. Finally, other biases, many of which are well described for the medical domain [12], should be explored and their possible mechanisms of action should be disentangled in order to allow for the design of strategies to strengthen physicians' defenses against cognitive errors.

Learning points

- Diagnostic errors are common in internal medicine.
- Flaws in physicians' reasoning have been shown to contribute to most diagnostic errors.
- The sources of flaws in diagnostic reasoning are still under investigation.
- Cognitive biases, such as availability and confirmation biases, can cause diagnostic errors.
- Reflective reasoning may counteract bias and seems to improve diagnostic accuracy in complex cases.

Conflict of interests

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