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CE - CLINICAL NOTES

Understanding and improving decisions in clinical medicine (I): Reasoning, heuristics, and error

Vincenzo Crupi[1] · Fabrizio Elia[2]

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Introduction

In considering ourselves as agents who think and make decisions, it is natural to rely on a *logic-plus-error* model. According to this view, the human mind is essentially a logical machine providing coherent inferences and choices unless disturbing factors interfere and lead us astray. One key point of this idea is that, in principle, were the sources of error subtracted, logical reasoning would flow undeterred, and mistakes would vanish.

The logic-plus-error model has been strongly influential in medicine. One often presupposes that healthcare professionals, too, would reason according to valid logical rules quite naturally, if only their judgment was not distorted by the effects of sleep deprivation, the reality of emotional stress, the concerns of defensive medicine, or sheer work overload. As to interventions to improve practice, the ensuing policy amounts to a combination of the following: strengthen consequential behavior by training (e.g., teaching some statistics) and institutional control (e.g., enforcing guidelines), and try to lessen the impact of disturbing factors (e.g., by more effective technology and organization).

Clever measures consistent with this view have achieved some significant degree of success. After all, there is little doubt that fatigue, poor planning, and other exogenous causes of burden can indeed hinder accomplishment in a variety of clinical tasks. Despite this, the logic-plus-error view is fundamentally untenable. Research on human cognition indicates that, typically, the *same* kind of mental processes produce a large amount of valid judgments along with patterns of biased reasoning in specific conditions. Such processes are known as *heuristics*, and they are qualitatively different from formal logical principles. In short, the human mind is much more a heuristic, rather than a logical, machine [1, 2].

Heuristics and clinical reasoning

When we read "5 × 10 = ?", we do not really have to retrieve and apply explicitly any rule of arithmetic. The answer—"50"—becomes almost immediately available to our mind, and looks obviously correct. But consider a slightly different kind of problem: if it takes 5 machines 5 min to make 5 widgets, how long would it take 50 machines to make 50 widgets? _____ minutes. Here again, answer "50" quickly comes to mind, with hardly any effort, and most people indeed report it as correct. In this case, though, the response automatically generated turns out to be wrong (it still takes 5 min for 50 machines, too). The tendency to incorrectly respond "50" is a cognitive bias prompted by a form of so-called *availability* heuristic.

This simple example shows in a nutshell what a cognitive bias is, and what is wrong with the logic-plus-error view. A cognitive error does not arise from interference with a logical line of reasoning, but from the spontaneous application of intuitive heuristic processes that are commonly triggered, largely effective, and inherent to the human mind. As a consequence, cognitive errors are

✉ Vincenzo Crupi
vincenzo.crupi@unito.it

Fabrizio Elia
fabrizioelia@libero.it

1 Department of Philosophy and Education, Center for Logic, Language, and Cognition, University of Turin, Turin, Italy

2 High Dependency Unit, San Giovanni Bosco Hospital, Turin, Italy

Table 1 A qualitative schema of the logical relationships between a suspected clinical condition *C* and one possible manifestation of *C*, labeled *M*

Diagnosis and evidence

manifestation *M* of a suspected clinical condition *C*

	M is present	*M* is absent
M is common in *C*	**weak confirmation** of condition *C*	**strong disconfirmation** of condition *C*
M is specific of *C*	**strong confirmation** of condition *C*	**weak disconfirmation** of condition *C*

If *M* is a very common but not very specific manifestation of clinical condition *C* (with, say, $P(M|C) = 95\%$, but $P(\text{not-}M|\text{not-}C) = 70\%$), the presence of *M* (*top left cell*) will only confirm diagnostic hypothesis *C* rather weakly (because the relevant likelihood ratio will be only moderately higher than 1, $P(M|C)/P(M|\text{not-}C) = 95\%/30\% = 19/6$), while the absence of *M* (*top right cell*) will disconfirm *C* more strongly (because the relevant likelihood ratio will be much lower than 1, $P(\text{not-}M|C)/P(\text{not-}M|\text{not-}C) = 5\%/70\% = 1/14$). If, on the other hand, *M* is a very specific but not too common manifestation of *C* (with $P(\text{not-}M|\text{not-}C) = 95\%$, but $P(M|C) = 70\%$), the presence of *M* (*bottom left cell*) will confirm diagnostic hypothesis *C* rather strongly (because the relevant likelihood ratio will be much higher than 1, $P(M|C)/P(M|\text{not-}C) = 70\%/5\% = 14$), while the absence of *M* will only weakly disconfirm *C* (because the relevant likelihood ratio will be only moderately lower than 1, $P(\text{not-}M|C)/P(\text{not-}M|\text{not-}C) = 30\%/95\% = 6/19$). The case of a piece of evidence that is both highly common and highly specific relative to *C* is of course possible, but many clinical data are just not like that. The risk of error is not evenly distributed across different logical combinations. Rather, cognitive science research suggests that clinicians are particularly at risk in situations belonging to the *top left cell* of the table. In fact, several heuristic patterns of reasoning (including the availability heuristic) may lead one to mistakenly read a finding that is common but hardly specific of the current working hypothesis as quite strong a confirmation of that diagnosis, while in fact it is no more than a weak clue. This in turn may be a cause for overconfidence in one's initial diagnosis, and thus failure to detect timely the presence of some other potentially damaging condition

definitely not normally distributed around the correct solution, as other kinds of mistakes (no one fails the widget puzzle by responding "3" or "17", for example). In addition, cognitive errors are not spread evenly over all kinds of tasks and problems. They are, instead, systematic and predictable in specific conditions, much like perceptual illusions.

Heuristics are often a useful guide to accurate judgment, as they typically fit the structure of the environment where a problem arises. When a solution quickly comes to mind, for instance, this is likely because we justifiably feel comfortable with the kind of problem at hand, and we simply "see" what the correct answer is. The very same process can also lead to bias, however, because availability may be strongly affected by variables that are alien to a sound assessment. For a clinician, the availability of a diagnostic hypothesis may bias judgment because of both personal and social contingencies, like an upward fluctuation of recent occurrences or extensive media coverage generating an "availability cascade" [3]. In emergency medicine, the "full moon night myth" is arguably sustained by availability. The evidence fails to show anything unusual in the epidemiology of ED departments on full moon nights [4], but the opposite belief remains popular. That is likely because, knowing in advance that there is a full moon, ED personnel on shift will be more inclined to notice and retain in memory relatively odd events happening that night, while less so inclined on other occasions.

Clinicians may not have heard of the technical definition of heuristics such as availability during professional training, and yet become painfully aware of their potentially unfortunate implications in practice. The initial presentation of a patient can readily suggest one diagnosis as cognitively available at the expense of other plausible and perhaps more serious possibilities. Disregard of such alternatives may then lead the clinician to overlook the low specificity of subsequent findings (precisely because other possible causes of such findings are not explicitly considered), and thus to inflate their confirmatory value for the target hypothesis. This pattern of reasoning departs from the logical principle that strong confirmation of a given diagnosis can only arise from the detection of specific (ideally, pathognomonic) manifestations, not from findings that are just relatively common in instances of that condition (see Table 1). Indeed, the scenario just described is a canonical script for diagnostic error, sometimes subsumed under a variety of further labels, like so-called "confirmation bias", "overconfidence", and "premature closure".

Implications for decisions and error

The traditional medico-legal classification of medical errors as due to incompetence, negligence, or malpractice is of limited value. Not only is it skewed towards judicial preoccupations, it is also consonant with the logic-plus-error view of medical reasoning, as it suggests that error primarily arises from personal defect, thus perpetuating an outdated and noxious "bad apple" approach in attempts to improve practice [5]. Indeed, cognitive errors elude that classification entirely and the logic-plus-error view is starkly at odds with relevant evidence. Many biases of judgment and inconsistent choices emerge in healthcare from the same kind of processes that support effective performance in most situations, namely heuristics.

Once the distinctive, systematic nature of cognitive errors is acknowledged and their causes are revealed, it becomes clear that the risk of biased judgment itself varies in ways that are often predictable. Clinicians are unlikely to misinterpret the implications of a pathognomonic sign, but they may be prone time and again to dismiss the low specificity of an otherwise typical manifestation, perhaps because one familiar or salient diagnostic hypothesis became easily available at the expenses of other explanations (see Table 1). Moreover, the very sensitivity of human intuitive reasoning to minor factors of context and format can suggest active manipulations of the cognitive setting aimed at promoting better decisions, thus disclosing new and specific opportunities for intervention. For all these reasons, understanding and improving decisions in clinical medicine requires completion of a true paradigm change, from the logic-plus-error approach to the cognitive science of clinical reasoning.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Statement of human and animal rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with human and animals performed by any of the authors.

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