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Jeffrey Evan Florman
Maine Medical Center

Et al.

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APPLICATION OF BEST PRACTICES

A Primer on Cognitive Errors Illustrated through the Lens of a Neurosurgical Practice

Jeffrey Florman MD,[1] Lisa Almeder MD,[2] Robert L. Trowbridge MD[2]

[1]Department of Surgery, Maine Medical Center, Portland, ME, [2]Department of Medicine, Maine Medical Center, Portland, ME

Problem Statement: Diagnostic error is often attributed to cognitive errors, including biased thinking patterns, rather than knowledge or data limitations. Education on cognitive bias deserves review in all spheres of practice.

Background: The cognitive biases of practitioners create an inherent fallibility in recognizing and treating medical conditions. Awareness of these cognitive errors is valuable for mitigating risk of diagnostic error. Cognitive error substantially impacts the management of neurosurgically relevant disease. Remarkably, broad differential diagnoses often accompany neurologic symptoms. Both focal and non-focal symptoms contribute to diagnostic inertia that can lead to errors. Further, initial diagnostic direction can be inaccurate in the involved biological system, anatomic localization, and the pathologic process. This inaccuracy can delay diagnosis and lead to severe consequences. We present clinically relevant vignettes of neurosurgical cases that illustrate the major types of unconscious cognitive errors in medicine, as well as strategies to mitigate cognitive error.

Application: Awareness of the types of cognitive errors and debiasing strategies is valuable for avoiding faulty estimates of disease likelihood, overlooking all relevant possibilities, and mitigating errors in critical thinking. Recognizing that all clinicians are vulnerable to cognitive error is of foundational importance in the strategies to reduce biases. These errors in medicine can be addressed by strategically working to reduce bias and increase discipline in clinical reasoning.

Keywords: cognitive error, diagnostic error, cognitive bias, neurosurgery

PROBLEM STATEMENT

Error in medicine, like entropy, is inevitable. The human mind is inherently fallible. It has evolved to function efficiently by relying heavily on incomplete evidence and depending on mental shortcuts (heuristics) to make decisions. Heuristics, although efficient and often helpful, may fail. Thus, we continue to risk experiencing the limitations of processes in clinical decision-making.

Most medical judgments and actions appear appropriate, rational, and sometimes even easy at the time, but our cognitive machinery limits our ability to completely avoid unconscious errors of reasoning. As evidenced by diagnostic error in particular, cognitive errors contribute substantially to patient harm and yet are often unrecognized.[5] Thus, practitioners must use a steady, reflective, and skilled approach to counter these forces and avoid error. Although these phenomena have received increased attention over the past decade, most of the literature has centered on emergency and adult medicine. While there has been little discussion or application of these issues to the surgical specialties, including neurosurgery, there is nothing to suggest that such disciplines are not equally subject to biases and erroneous thinking.

Correspondence: Jeffrey Florman, MD
MMP Neurosurgery and Spine
49 Spring Street
Scarborough, ME 04074
flormj@mmc.org

BACKGROUND

The “dual process model” is a useful construct to help understand the mental modes by which we perform and what processes may underlie some of our cognitive failures. This problem- solving and decision-making theory provides a scheme of processing by which we (1) make acute judgments in an automatic, intuitive, and unconscious fashion, and (2) facilitate reasoned choices using a slower, logical and more analytic conscious mode.[1,2] The former is a mainstay of decision-making: it acts quickly and intuitively, and its strength is in its efficient and effortless manner. The latter is a slow and effortful process that provides deliberate reasoning. Both processes are at the mercy of the data presented, but inherent cognitive biases further threaten to corrupt their conclusions. Clinical reasoning is influenced by the patient and the environment, including the time-pressures of clinical practice. Thus, studying cognitive bias could be valuable for improving the process.[1,3,4]

Although the exact contribution of specific cognitive biases to errors is often unclear, their etiology likely goes beyond a knowledge deficit and represents a "failure of judgment." Yet, most efforts in medical education do not focus on instruction in clinical reasoning, critical thinking, and metacognitive skills.[4,6] To date, most efforts to improve cognitive errors have centered in internal medicine and emergency medicine, even though surgical specialties are equally at risk. Here, we use a neurosurgical perspective to evaluate how cognitive bias impacts medical error.

Neurosurgical practice is distinguished by an exposure to a diverse patient population, caregivers across many specialties, demands on physical and cognitive practice, and an extraordinary spectrum of pathology, gravity, acuity, and risk. These factors provide a valuable, and perhaps unique, perspective from which to view error. Clinical neurosurgery is not unique in its demands for shrewdness, but it unmasks the gamut of common cognitive biases. While recognizing that a knowledge deficit can simultaneously contribute to error, we use neurosurgical cases to describe common types of bias and explore debiasing strategies. See Table 1 for common types of biases.

COMMON TYPES OF COGNITIVE BIAS ILLUSTRATED WITH VIGNETTES

1. Premature closure and search satisficing

Case

A 55-year-old female with a history of breast cancer presents to her primary care physician with several weeks of pain in the bilateral buttocks extending to the posterior thighs. The results of the exam are benign, except for slight hesitation during muscle testing. Her doctor clinically diagnoses a lumbar disc herniation, recommends anti-inflammatory medications, and refers her to physical therapy. Table 2 describes the differential diagnosis for sciatica. After the pain persists, she undergoes magnetic resonance imaging (MRI), which reveals sacral metastasis.

Bias illustrated

Premature closure refers to the tendency to settle on a diagnosis and cease all diagnostic efforts before that diagnosis has been reasonably established. It is often driven by intolerance of uncertainty, the desire of clinicians and patients to have an explanation, and perceived time pressures. Premature closure is closely related to search satisficing, or the tendency to cease diagnostic efforts after some form of explanation is found, even if that explanation is not good (i.e., the explanation "suffices"). Colloquially, premature closure is often described as "when the diagnosis is made, the thinking stops."[7] In this case, imaging is needed to definitively diagnose the herniated disc and rule out malignancy, but the clinician "called off the search" before adequately considering a significant aspect of the patient's presentation (the history of breast cancer).

2. Framing bias and diagnostic momentum

Case

A neurosurgeon evaluates an elderly man for one week of painless foot drop in the setting of chronic back problems and a history of L5S1 spondylolisthesis. The results of an MRI reveals no change from previous scans showing "significant but stable L5 nerve root compression that would be concordant with foot drop." The patient undergoes uneventful lumbar fusion surgery. However, the weakness ascends over the following weeks to involve the more diffuse lower extremity. Additional workup demonstrates a parasagittal brain tumor compressing the motor cortex.

Bias illustrated

Framing bias describes how diagnostic thinking is affected by the context the clinician is exposed to or constructs in evaluating the patient. This bias may be the result of patient actions, such as the patient who attributes a new symptom to a chronic problem and suggests this attribution to the clinician. It may also be due to clinician actions, such as the physician who strongly suggests a diagnosis when referring a patient to a consultant, thus influencing

Table 1. Common Cognitive Biases

Bias	**Description**
1. Premature Closure	Clinician settles on diagnosis before the data necessary to establish a diagnosis is available
2. Framing Bias	Patient’s pre-existing condition or other clinicians' impression over-influences thinking
3. Confirmation Bias	Clinician only orders tests or interventions that are likely to affirm favored diagnosis
4. Availability Bias	Clinician arrives at a diagnosis by the ease with which it comes to mind
5. Affective Bias	Clinicians emotional state or relationship with patient influences diagnostic reasoning

Table 2. Differential Diagnosis for Sciatica.

spinal infection
spondylolisthesis
spinal fracture
facet arthropathy
intraspinal tumor (eg, metastasis, schwannoma)
extraspinal tumor (eg, sciatic nerve tumor)
piriformis syndrome
muscle spasm
peripheral nerve entrapment (eg, superior cluneal nerve, carpal tunnel)
extremity joint pathology (eg, trauma, infection, arthritis)
neuritis (eg, diabetic neuropathy, plexopathy)
peripheral vascular ischemia
venous thrombosis
malingering

the consultant's thinking. A clinician's perception of risk or severity of illness may also influence their thinking. The term "diagnostic momentum" reflects a common form of framing bias in which an upstream provider suggests a diagnosis and subsequent clinicians accept this diagnosis without skepticism, adequate verification, or further investigation. In this case, the patient was "framed" as having nerve impingement secondary to the known L5S1 spondylolisthesis, despite the new clinical findings in the setting of stable radiographic results. The painless presentation is widely known as atypical for lumbar radiculopathy. The presence of the "known" disease likely influences the cognitive processes of the evaluating clinician.

3. Confirmation bias and anchoring

Case
An adult patient with a history of opioid use disorder presents to the emergency room with escalating postoperative pain 2 weeks after lumbar discectomy. The results of the exam reveal that the patient looks uncomfortable but has no fever, an unremarkable incision, and no neurologic deficit. After discussion with the neurosurgeon, the pain is attributed to inadequate opioid dosing. The patient is discharged with an increased opioid prescription, but he returns 1 day later septic with pus expressing from the surgical wound.

Bias illustrated
Anchoring refers to the tendency to latch on to one or more prominent or salient features of a patient presentation and establish a diagnosis without adequate verification. This bias may be particularly prevalent with laboratory or imaging findings given that they appear more definitive and less nebulous than historical findings. Anchoring is closely related to confirmation bias, in which a clinician only pursues testing that is likely to affirm their diagnostic impression. In this case, the evaluating clinicians likely anchored on the known opioid dependency with concomitant low pain-tolerance, opioid-induced hyperalgesia, or pain medication-seeking behavior. A more thorough approach to ruling out infection might have been pursued in the absence of the opioid abuse disorder.

4. Availability bias

Case
A 12-year-old presents with 1 week of mild headache, nausea, and intermittent vomiting to her pediatrician. The results of their exam are benign, although tandem gait is not tested. The patient and family are reassured that the symptoms are likely from flu and prescribed over-the-counter symptomatic treatment with instructions to return if symptoms worsen. Over the following days, the child becomes increasingly lethargic and imbalanced, leading to brain imaging that revealed a large posterior fossa tumor with hydrocephalus.

Bias illustrated
Availability bias refers to the tendency to prioritize diagnoses by the ease with which they come to mind. It is often a helpful heuristic that underlies much appropriate clinical thought. However, availability may cause problems when diagnoses that are most "available" because of common, recent, or memorable experiences rise to the top, even when they are not the most likely. A clinician may strongly consider a recently missed diagnosis in a subsequent patient on the basis of availability, even if there is little to support it. In this case, a complete neurologic exam should have included tandem gait testing, which might have exposed a relevant deficit. This case demonstrates the "double-edged sword" of availability: when correct, availability is a useful heuristic; when wrong, it's a faulty bias.

5. Affective bias

Case
A clinician sees a coworker's significant other, who is also a friend with known alcohol use disorder, in a consultation for mid-back pain and mild abdominal pain. Reassurance is given and physical therapy is ordered following a spine MRI with normal results. Progressive back pain and abdominal pain with subsequent emesis lead to a laboratory diagnosis of acute pancreatitis.

Bias illustrated
Affective bias occurs when a clinician's own mood or their feelings toward a patient impacts their diagnostic reasoning. Although many clinicians would like to view themselves as dispassionate scientists who are immune to emotions when approaching diagnosis, all clinicians react emotionally to (and have emotions about) their situations and other individuals. In this case, the clinician's closeness to the patient may have led to hesitation in considering a diagnosis related to alcohol use disorder. The absence of emotion may have led to an objective evaluation and broader

differential diagnosis, including pancreatitis in the setting of back and abdominal pain in a patient with alcohol use disorder.

APPLICATIONS/RECOMMENDATIONS

Debiasing strategies

Devising effective educational programs to counteract or even detect cognitive bias and errors has proven challenging.[2,8,9] Clinical reasoning is largely subconscious. Even expert clinicians well-versed in the mechanics of clinical reasoning may struggle to describe their thought processes or identify factors that influence their conclusions. Furthermore, hindsight bias may corrupt the analysis of cases and skew observations. For example, the same clinical thought process may be seen as based in beneficial heuristics when the outcome was favorable but as skewed by biases when the outcome was unfavorable. Given the obscurity of clinical thought, it is not surprising that there are a lack of established intellectual tools and strategies for debiasing. Yet, there is increasing literature on debiasing strategies and how they may be incorporated into clinical practice.

Key steps in improving diagnostic reliability include the incorporation of medical education curriculum designed to develop explicit clinical reasoning abilities and raise awareness of the fallibility of clinical reasoning and cognitive bias. Tools for the medical educator have been designed to assess and facilitate formative feedback on clinical reasoning. There is also an increasing emphasis on clinical reasoning at the undergraduate and graduate medical education levels.[6] Yet, to be successful, programs to improve cognitive performance must also reach practicing physicians, many of whom trained in an era when admitting fallibility and imperfection was frowned upon or counter to the culture. Debiasing requires explicit effort and begins with humility as a tool for acknowledging uncertainty, combating overconfidence, and introducing a spirit of heightened curiosity and wonder into practice. While true mastery should be the goal, it may not be obtainable. Instead, students and teachers of clinical reasoning should strive for the well-calibrated mind.[3,10]

Debiasing strategies may take multiple forms that fall into three categories: cognitive, motivational, and technological. Cognitive strategies are designed to improve clinician thought processes, motivational hold clinicians accountable for their efforts, and technological leverage technology-based interventions to improve cognition) (Table 3).8 Many debiasing strategies pertinent to the individual clinician fall into the cognitive category. Most simply, the individual practitioner needs to develop metacognitive abilities to assess their own mental state and its potentially negative influence on reasoning abilities.

Part of self-assessment to maintain performance should also include attentiveness to levels of fatigue, sleep deprivation, stress, and cognitive load.[1] Cognitive load represents the attention needed to complete a cognitive task and the extraneous factors placed on the brain by the environment in which decisions are made. The lack of awareness or ability to modulate cognitive load is increasingly recognized as a major cause of cognitive error. Inattention to cognitive load could increase the likelihood of premature closure, framing bias, anchoring, and availability bias. For example, as described in the first case vignette with the patient with sciatica, a clinician might prematurely accept a diagnosis as sufficient for closure of a workup, in part, because of fatigue. Similarly, cognitive load could have contributed to the availability bias demonstrated in the fourth vignette with the 12 year old whose nausea and headache was misdiagnosed as the flu.

Although one's ability to recognize their own biases is debated, there should be little controversy that being able to recognize the propensity for bias in one's colleagues could improve clinical reasoning. For example, in the fifth vignette, imagine that another clinician without relationship to the patient observed the interaction between the patient and clinician. A lack of emotional connection to the patient might have immediately exposed the affective bias. Overall, an algorithmic approach to avoiding bias relies on three steps: being aware of of bias, learning to detect it, and giving motivation to correct it with sustained alternate strategies.[10] Three specific actions which may minimize preventable errors in cognitive processing include: increasing knowledge, improving deliberate consideration in decision-making, and seeking help from other people or tools.[5]

Pragmatic efforts to mitigate bias often focus on decoupling rapid intuitive processing from slower and more deliberate decision-making.[1,4] For

Table 3. Examples of Debiasing Strategies

Motivational	Cognitive		Technological
Ensure feedback on decisions	Develop awareness of cognitive fallibility	Self-assess levels of fatigue and stress	Computerized systems to support clinical decisions
Clarify team member roles and accountability	Acknowledge and embrace uncertainty	Acknowledge team dynamics	Embedded diagnostic algorithms
Reduce task complexity and ambiguity	Incorporate deliberate consideration in decision-making	Seek help from coworkers	Differential diagnosis generators
	Use “diagnostic time-outs”	Assess affective component of physician-patient relationship	
	Seek and discuss disconfirming and conflicting evidence	Address knowledge gaps	

example, “forcing functions” are interruptions that induce consideration of alternative possibilities, which ideally entail clinicians do 4 things: 1. step back from the immediate problem, 2.decrease reliance on memory, 3. gather additional information, 4. apply metacognitive steps, or otherwise constrain their responses.[13] Meaningful techniques expand the view during the diagnostic process or encourage reflection. These techniques include making checklists, using algorithms, and using technologically based interventions, such as diagnostic decision-support systems and differential diagnosis generators. Adopting a practice of slowing down and performing diagnostic “time-outs” involves simply pausing to consider if the intuitive diagnosis is validated by a more deliberate effort.[4,8,14,15] The practice of time-outs can involve pausing to ask what the worst-case scenario might be, whether there is anything not concordant with the working diagnosis, or if there could be multiple processes at play. Practical tools can be adopted to resist susceptibility to cognitive bias, which can be supported by enlisting others as partners in the diagnostic process.[4] In addition, clarifying accountability is a valuable workplace strategy. By explicitly assigning roles, care team members may become better partners in recognizing and avoiding bias.

Improving the reflective abilities of the individual clinician, however, is unlikely to have a significant impact, unless clinical teams can impact and achieve improvements in the practice environment and workflows to deliver care. A learning environment is an important companion, especially when embedded in a culture that prioritizes safety, civility, and respect. Interventions can help to establish a safe culture, including team training, executive and interdisciplinary rounding, and comprehensive safety programs.[11] Academic or extended care team models must consider complex dynamics to mitigate biased thinking, such as student, resident, and advanced practitioners erroneously initiating, failing to challenge, or perpetuating errors. Further, promoting an environment that alleviates or minimizes time-pressures, interruptions, and distractions could decrease the likelihood of cognitive error. Awareness of cognitive load may similarly help with “right-sizing” the clinical load.[12] Together, optimizing clinician and institutional ethos can help to expose cognitive bias and reduce errors.[4,8]

CONCLUSION

The practice of medicine is an indefatigable dynamic between the altruistic determinations of smart, hard-working, and knowledgeable people and the elusiveness of diagnosing and treating disease.

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This process requires a special mix of knowledge, judgment, and humanistic skills that are necessary, but not sufficient, to avoid errors. Understanding cognitive bias provides a construct and vocabulary to explain how thinking can go wrong despite sound knowledge and evolved algorithms. Reasoning abilities expand from the exercise and practice of "meta thinking," which involves monitoring and regulating thought by reflecting on, analyzing, and critiquing ones' own reasoning. Metacognition is reasoning while deliberately engaging in and examining available data. It invokes the power of the slower logical system in the dual process model. The value of the effort required to reflect and analyze beyond using speedy shortcuts, such as heuristics, is amplified by practice and debiasing tools. In other words, making mistakes in medicine is inevitable and can be resisted by knowledge of cognitive error, tools to combat it, and a culture that is understanding and supportive.

Conflicts of Interest: None

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