

■ Review Article

Probability or Reasoning: Current Thinking and Realistic Strategies for Improved Medical Decisions

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A prescriptive model approach in decision making could help achieve better diagnostic accuracy in clinical practice through methods that are less reliant on probabilistic assessments. Various prescriptive measures aimed at regulating factors that influence heuristics and clinical reasoning could support clinical decision-making process. Clinicians could avoid time-consuming decision-making methods that require probabilistic calculations. Intuitively, they could rely on heuristics to obtain an accurate diagnosis in a given clinical setting. An extensive literature review of cognitive psychology and medical decision-making theory was performed to illustrate how heuristics could be effectively utilized in daily practice. Since physicians often rely on heuristics in realistic situations, probabilistic estimation might not be a useful tool in everyday clinical practice. Improvements in the descriptive model of decision making (heuristics) may allow for greater diagnostic accuracy.

Keywords: Heuristics; Decision Making; Evidence-Based Medicine, Bias; Problem Solving

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INTRODUCTION

Decision making in the medical profession remains a science that is inseparable from the undercurrent of uncertainty. In a recent study examining diagnostic errors in medicine, a significant proportion of diagnostic errors was attributed to the cognitive processes of the doctor.¹⁾ Advancements in cognitive sciences play a major role in decreasing human-prone medical errors.²⁾ Hence, there has been extensive research in the field of cognitive psychology to palliate uncertainty and reduce diagnostic errors made by clinicians.

By quantifying the elements of uncertainty, the normative Bayesian model of probability remains an important technique to increase precision in clinical decision making.³⁾ However, an underlying mismatch exists between the utility and practicality of this model in real-world situations.⁴⁾ Individuals incorporate little probabilistic information to account for decision making in highly naturalistic environments.⁵⁾

The purpose of this review is manifold. Primarily, this review serves as an accessible compendium of the latest theories in medical decision making for all health professionals, especially those working in the field of primary care and emergency medicine. Secondly, the article offers techniques that help improve diagnostic accuracy based on recent evidence. This article also allows health organizations and individual physicians to re-examine the possibility of implementing corrective measures in their institution based on the emerging paradigms in medical decision making and clinical reasoning. More importantly, the article draws attention to the relevance of a less probabilistic, and perhaps more practical approach by using elements of clinical reasoning, naturalistic decision making (NDM), script activation, and dual process theory when solving daily medical problems.

MEDICAL DECISION MAKING UNDER UNCERTAINTY

In general, there are three major approaches to the concept of thinking under uncertainty—the normative, descriptive, and prescriptive models.⁶⁾ The normative, or rational model proposes the best possible way of achieving a particular goal or rational decision. This model is synonymous to the subjective expected utility framework, which utilizes Bayes' theorem as a standard to compare actual human decision making via mathematical equations,⁴⁾ and forms the foundation of evidence-based medical practice.

Contrary to this belief, expert physicians seldom rely on probabilistic models and often use diagnostic reasoning processes to aid in hypothesis refinement.⁷⁾ In a primary care setting, decisions must be made within a stipulated amount of time with very scarce information obtained from patients. Therefore, physicians rely primarily on heuristics (a simplification of diagnostic reasoning) because they are convenient and frequently correct although they do not reflect base rates.⁷⁾ The greater the uncertainty in the analysis of a medical scenario, the greater the tendency of physicians to turn to diagnostic intuition rather than probabilistic models to guide their decision analysis.⁸⁾

On the other hand, the descriptive model approach describes how people normally think.⁶⁾ Early proponents of this framework had reservations about the notion of making optimal choices through calculations. Contradictions to subjective utility maximization were soon discovered (for example, the Allais paradox, bounded rationality, and Prospect theory), which only serve to indicate that real-life decisions often differ from what is proposed by the principles of the normative model.^{6,9,10)} Physicians utilize a variant of the descriptive model, known as heuristics or rule of thumb, as a shortcut to simplify complexity of data analysis gathered during consultation.¹¹⁾ According to classical decision-making theory, the efficacy of medical heuristics is often plagued by the existence of various judgment errors, called biases.¹¹⁾ While the explanation and function of biases are beyond the scope of this article, discussions on biases are readily available in many books or literature reviews.^{3,11)} Crucial to the discussion, however, is the evidence from a problem-solving perspective that challenges the conventional preconception of biases as being a faulty decision-making mechanism.⁴⁾ Results of several studies designed using problem-solving techniques suggest that clinical experts seem to use heuristics to generate accurate diagnostic hypotheses in several disciplines in medicine, despite being prone to biases.¹²⁻¹⁴⁾

CONTEXT: CONCEPTUAL FRAMEWORK FOR A PRESCRIPTIVE MODEL

The prescriptive model of decision making defines the rules on how one ought to think, or how a person should adopt a better decision, if not the best decision.⁶⁾ The prescriptive model is a corrective design or an intervention that influences actual thinking, bringing it into closer agreement with the normative model.⁶⁾ In medicine, the prescriptive model represents (1) useful heuristics that have been widely tested through experience in a relevant field of practice, or (2) the process of being aware of the many biases that coexist in any diagnostic decision analysis.

The conceptual framework below outlines the premise of this article. A discussion of the impact of specific components of the prescriptive framework and how this framework functions in a realistic clinical environment will be dealt with in the subsequent sections of this article (Figure 1).

NATURALISTIC DECISION-MAKING STRATEGIES AND THE COMPENSATORY MODEL

Scant research effort has been mobilized towards investigating the effects of stress on medical decision making. Research coverage in this field has been limited to assessing the effects of sleep deprivation.¹⁵⁾ Sleep deprivation seems to negatively impact physician cognition and medical performance.¹⁶⁾ However, these research designs were not specifically constructed to explore medical errors secondary to stress. Despite the lack of direct evidence of the effect of stress on medical decision making, researchers began designing theories (such as the

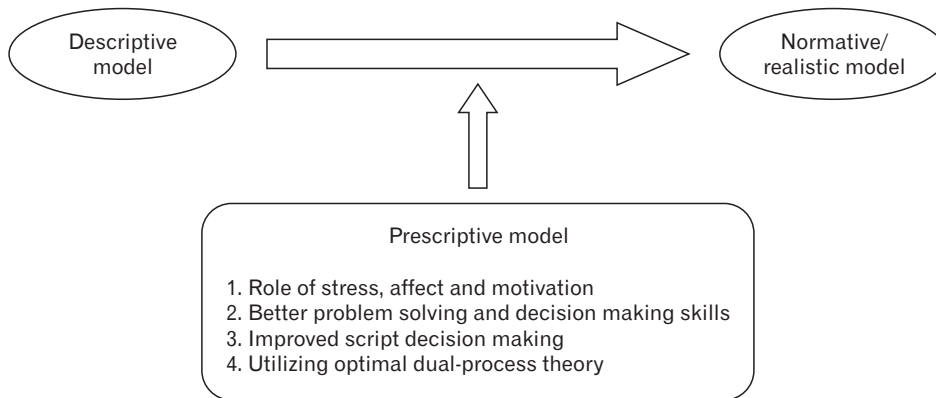


Figure 1. Conceptual framework for a prescriptive model of medical decision making.

NDM theory) that would serve to fill the gap in knowledge.¹⁷⁾

NDM theory revolves around the idea of gauging apparent changes in the cognition of individuals working in environments that integrate many factors, such as limited time, high stakes, vague goals, and unstable situations.¹⁷⁾ Studies involving NDM concepts appear to demonstrate that in stressful situations, fire commanders¹⁸⁾ and nurses in emergency telephone triage settings¹⁹⁾ rely on recognition-primed decision making.^{4,17)} This concept is similar to script activation, which is the automatic retrieval of a script from a vast repertoire of previous exposure to or experience with earlier cases, and is largely non-analytical.^{20,21)} The accuracy of these decisions is remarkably higher in experts with greater experience in the field than in novices.¹⁹⁾ This evidence seems to show that experts make decisions based on previous exemplars in the form of mental scripts that support decision heuristics.⁴⁾

High-stakes decision making produces high levels of perceived stress that distorts the way one thinks.²²⁾ Under situational pressure, individuals rely more on non-compensatory methods of thinking inclined towards the use of heuristics (a category-based inferential technique). This situation arises because there is an increase in cognitive load and limited processing time.^{23,24)} The compensatory model (an attribute-based technique closely resembling the normative model) pursues detailed processing of individual pieces of information that could only be undertaken when there is little time constraint or less cognitive load on the individual.²⁵⁾ Similarly, cues arising from emotions and changes in affect could alter decisions that have major outcomes.^{26,27)} These deviations from the normative model are referred to as 'affect heuristics'.²⁶⁾ They are a reactive response to risk without taking into account any probabilistic measure.²²⁾ Therefore 'affect heuristics' are largely pertinent to primary care physicians who work in a very demanding environment where the absence of judicious life-saving decisions can have catastrophic outcomes for patients.

Little emphasis has been made on bridging the gap between motivational aspects of cognition and the medical decision-making process despite significant scientific contributions in both fields. In an experiment to determine the role of positive affect amongst physicians, it was found that physicians who have been induced to acquire positive affect had greater diagnostic problem-solving skills.²⁸⁾ Anchoring bias

in decision making is significantly less common in physicians with positive affect.²⁹⁾ The cognitive evaluation theory of motivation posits that the primary components of intrinsic motivation (autonomy, competency, and relatedness) are paramount to an individual's psychological needs.³⁰⁾ Hence, interventions designed to improve positive affect through intrinsic motivation could allow physicians to make better decisions in complex situations.³¹⁾

STRATEGIES FOR BETTER PROBLEM-SOLVING AND DECISION-MAKING SKILLS IN CLINICAL REASONING

1. The Role of Hypothesis Refinement

In clinical reasoning, two main approaches underpin the fundamentals of diagnostic thinking in medicine: problem-solving strategies and standard decision-making analysis.³²⁾ Evaluations based on the concepts of problem-solving strategies show that expert physicians not only generate quicker hypotheses but also form diagnostic plans with greater efficacy than novices.^{11,33)} Also, the mechanics of problem-solving in medicine suggest that it is necessary for hypotheses formation to undergo certain crucial steps before a diagnosis is deemed valid.⁷⁾ These steps include hypotheses generation, hypotheses refinement, data verification, and finally, a working diagnosis.⁷⁾ Flaws in any of these steps could lead to a faulty provisional diagnosis.

The implications of these theories are best described in the form of a routine clinical example. It is known that experts are better than novices at identifying salient findings that might provide a more holistic view of a case.¹¹⁾ In other words, experts are better at hypothesis refinement, by using memories as diagnostic criteria when assessing a particular case. This is evidenced in domain-specific disciplines, where a simple set of clinical tests and historical data may be sufficient to correctly identify a disease.³⁴⁾ Furthermore, conditions that cannot be easily detected by biological markers will naturally require the act of eliciting a specific set of information pertaining to clinical symptoms and disease progression to enhance hypotheses refinement.³⁵⁾

2. Choosing Heuristics over the Standard Decision-Making Strategy

As discussed earlier, the traditional decision-making strategy requires strict compliance with the normative model (Bayes' theorem). Contrary to this rule, most physicians still make revisions to their diagnostic opinion through heuristics.¹¹⁾

Recent studies suggest that in situations of uncertainty as seen in medicine, the role of medical decision-making theory in daily practice may be negligible.³⁶⁾ It is thought that, in medical decisions, mathematical calculations may not be crucial to the evidence-based model.³⁷⁾ Therefore, heuristics seem to be inescapable and indispensable tool in the realm of medicine, despite their evident disadvantages.

The evidence stated above suggests that the construction of a simple, easy-to-recall heuristics could be crucial to decision making in medicine. For example, by using a fast-and-frugal tree shortcut, patients with angina have been screened with perhaps better accuracy than by applying a probabilistic model.³⁸⁾ Similarly, in the evaluation of the decision to commence macrolide treatment for community-acquired pneumonia in children, the fast-and-frugal method correctly identified 72% of high-risk cases.³⁹⁾ Thus, simple heuristics may have some value in making therapeutic decisions without relying on more expensive methods of analysis.³⁹⁾

IMPROVED SCRIPT DECISION MAKING

1. Scripts as a Non-Probabilistic Alternative in Decision Making

Scripts seem to be a departure from the probabilistic model of evidence-based practice. Scripts describe how physicians routinely gather information from patients' complaints and recognize a familiar pattern of a particular illness. Scripts influence physicians by guiding them to formulate treatment plans without much deliberation on probabilities or utility.¹⁵⁾ Therefore, it is widely believed that diagnostic reasoning is highly dependent on decision scripts.⁴⁰⁾

Decision scripts allow physicians to rely on reasoning skills to arrive at a proper clinical diagnosis, even if there are no prototypical or suitable instances available.⁴⁰⁾ When presented with clinical vignettes, the treatment choice or perceived treatment benefit chosen by critical care physicians had little to do with prognostic probabilities.^{15,41)} Instead, physicians seem to rely on decision scripts to help steer them towards making a correct decision.^{15,41)} This action requires script activation, a phenomenon that occurs almost effortlessly in a non-analytical manner and is based on pattern recognition or instances from previous clinical experience.^{20,21)} One study argues that the accuracy of these decision scripts could be augmented by learning a script through exposure to analytic aids.^{15,38)} Through this intervention, it was found that diagnostic aids were no longer required when dealing with real-time clinical situations.^{15,38)}

2. Recall Advantage through Scripts

A clinical decision can be rendered faulty if one focuses solely memo-

rizating a specific script containing clinical features of a disease entity. The untenable structure of memory fails to retain such information over the course of time or with increasing case difficulty.⁴²⁾ However, memory can be improved by emphasizing the mastery of knowledge in basic sciences. It was found that clinical accuracy did not diminish profoundly with time in subjects who utilized basic sciences to find coherence in a set of clinical features, in contrast to subjects who utilized epidemiological probabilities to reach the same conclusion.⁴³⁾

Decision scripts are also influenced by exemplar models of categorization retrieved from past experience of discernible environmental cues.⁴⁴⁾ However, depending on the way they are acquired, exemplars can have contrasting effects in a clinical setting. In visually oriented clinical domains, for example, prior exposure to examples of cases could enhance clinical diagnostic skills.⁴⁵⁾ Conversely, in another study using less memorable details such as electrocardiograms and historical data, diagnostic accuracy was reduced when family medicine residents chose to rely on a previous case scenario that bore a close resemblance to the clinical case at hand.⁴⁶⁾

3. Relevance of Scripts in Decision Making

Results of these experiments consolidate the view that physicians and medical students might benefit from a more guided exposure to real case scenarios through structured training programs. These programs could foster better decision scripts and greater diagnostic accuracy. It would also be equally advisable to raise awareness amongst clinicians and students on how decision scripts could skew clinical reasoning if not utilized judiciously in certain circumstances. Unverified non-analytical decision scripts might lead to the problem of premature closure, a common diagnostic error.¹⁾ Experienced clinicians were found to be more susceptible to this error since they assign more weight to their initial diagnosis compared to their less experienced counterparts.⁴⁷⁾ Prevention of these errors could be achieved in part by paying attention to analytical reasoning and criteria of validity (coherence, adequacy, and parsimony) in the final steps of the diagnostic verification process.⁷⁾

PUTTING DUAL PROCESS THEORY INTO ACTION

1. Dual Process Theory and Heuristics

Dual process theory suggests that heuristics are an inevitable aspect of the art of decision making. Contrary to being labeled as a potential precursor of biases, heuristics have been recently considered a fairly reasonable attempt at mental reasoning before analytical processing is activated.⁴⁸⁾ It is assumed that the analytical system regulates heuristics (non-analytical judgments) by acting as a gateway that selectively endorses these intuitive decisions.⁴⁹⁾ Heuristics make use of prior knowledge in pattern recognition and forming selective representations, which are later conveyed for analytic processing if required.⁴⁸⁾ Thus, heuristics behave as default options that might or might not be inhibited by the analytical phase.⁴⁸⁾

2. Application of Dual Process Theory via Pattern Recognition and Hypothetico-Deductive Techniques

In the field of medicine, pattern recognition and hypothetico-deductive techniques employed in clinical reasoning are consistent with the aspects of dual process theory.⁵⁰⁾ Firstly, the intuitive system of dual process theory is represented by pattern recognition.^{20,51)} Both experts and novice physicians display greater clinical success when they engage in pattern recognition strategies to guide their diagnostic reasoning.⁵²⁾ Secondly, hypothetico-deductive techniques are comparable to the analytical system⁵⁰⁾ that spring into action when the intuition system fails to provide a convincing diagnostic hypothesis.⁵¹⁾ In tandem with this stance, physicians often explore other avenues in decision making such as forward reasoning or exploration of biomedical research for better clues to a possible diagnosis.³²⁾

Although mostly described in a dichotomous manner, there is growing evidence of the potential benefits that could be derived from the application of both analytical and non-analytical strategies in clinical practice.⁵³⁾ Several papers have alluded to the relevance of this theory in the field of general practice and emergency medicine.⁵⁴⁻⁵⁶⁾ Accurate diagnostic closure, a component of analytical processing, was found to be exemplified in the way general practitioners respond to complicated non-critical clinical cases in daily practice.⁵⁵⁾ However, in instances involving urgent or high-stakes decision making, general practitioners intuitively searched for markers of severe illness using red flags derived from personal experience.⁵⁵⁾ Hence, both the analytical and non-analytical components of the dual process system are dynamic and can be used flexibly depending on the nature of the situation at hand.

3. Improving the Intuitive Process through Debiasing

In order to allow effective compilation of information within the intuitive system 1 of dual process theory, the physician needs to identify accurate mental representations for fast recall. The integrity of heuristics relies on intricate cognitive processes. The mental representations, which do not contain faulty information nor excluding any critical information, would then be conveyed for further analysis under system 2.⁴⁸⁾

Hence, it is possible to implement a strategy to reduce biases which could, in turn, improve diagnostic accuracy. This technique is formally known as 'debiasing'. 'Debiasing' allows for better judgments to be made without reference to probability estimation.^{50,57)} The view on the effectiveness of this approach has so far been mixed.⁵⁸⁾ However, it has been argued that cognitive forcing strategies could be used to promote awareness in physicians and thus counter common cognitive pitfalls that could lead to biases.⁵⁹⁾ This step could be achieved by encouraging physicians to consider alternatives to a clinical problem by constantly checking if other probable entities could account for the information gathered during a consultation.⁶⁰⁾ Biases could also be reduced by decreasing cognitive overload on working memory by using cognitive aids such as mnemonics, algorithms, or clinical practice guidelines.⁶⁰⁾

4. Improving the Analytical Process through Metacognition

The ability of system 2 to monitor the activities of system 1 needs to be kept in a strict balance. The response of cognition is influenced by various determinants and these have the potential to disrupt the performance of system 2.^{61,62)} These factors, which are numerous, include the affective state of the physician, past experience, ambient conditions, fatigue/sleep debt, and the characteristics of patients.⁶²⁾

Metacognition is seen as a possible strategy to attenuate this problem. Metacognition is simply defined as thinking about one's own thinking.⁶³⁾ By heightening metacognition, physicians would be able to adopt a reflective approach to making clinical decisions so that biases may be reduced.⁶²⁾ In a realistic and highly demanding field such as medicine, physicians could be taught to step back for a moment from a clinical scenario to examine their thoughts and affective processes.⁶²⁾ Despite its promising outlook, there has been a constant debate on how metacognition could improve diagnostic efficacy. Currently, metacognition remains an avenue worth exploring but requires further validation through future clinical application and feedback.⁵⁸⁾ In a more recent study designed to explore this premise, metacognition was seen to enhance quick and accurate reasoning skills during later consultations.⁶⁴⁾

CONCLUSION

In the rapidly evolving realm of medical decision making, there should be some reflection on how pre-existing research could contribute to current beliefs on diagnostic accuracy. Although this article had been critical of the role of evidence-based medicine in routine clinical practice, this should not translate into a total abandonment of this valid methodology. Instead, a pluralistic view should be adopted so that medical decisions can be maintained at an equilibrium between practicality and efficiency.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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