Reviewing intuitive decision-making and uncertainty: the implications for medical education

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Context Intuition and uncertainty are inescapable conditions of many instances of clinical decision-making. Under such conditions biases and heuristics may operate, distorting the decision-making process. Physicians and students are generally unaware of these influences.

Purpose To review the extant literature regarding the role of uncertainty and intuition and associated biases on medical decision-making, to highlight the implications this holds for medical education.

Content Using literature identified via *Medline* and *Bioethicsline* searches of the past 3 decades, this paper reviews the sources of uncertainty in clinical practice and the role of intuitive decision-making. A detailed description of associated heuristics and biases is provided, and linked with demonstrable examples from medical decision-making.

Conclusions It is argued that although uncertainty can be reduced, it can never be completely eliminated from decision-making. Therefore most decision-making performed in medicine contains an irreducible intuitive element and is thus vulnerable to these biases and heuristics. Given that few medical curricula overtly address the process of medical decision-making, both medical students and physicians remain vulnerable to these effects on their own (and their patients') decision-making. Insight via education appears the major means in which to avoid distorting decision-making processes.

Keywords Education, medical/*standards; *decision making; professional practice; uncertaintly; prejudice; curriculum.

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Introduction

Many clinical decisions involve the use of intuition.[1] Intuition can be understood as a cognitive 'short-circuiting' where a decision is reached even though the reasons for the decision cannot be easily described. Although intuition is a recognised component of expertise,[2] the exact nature of this relationship is not well understood and has been termed '…the supreme mystery of clinical reasoning…'.[3] It is known that intuitive expertise requires a well organised store of networks and rules which allow efficient access and retrieval of information.[4] These 'personal decision rules' are used by clinicians, particularly in conditions of uncertainty, even though these may not necessarily result in the best performance[5] and are prone to a number of well-recognised biases.[6] This paper reviews current understanding about the relationship between uncertainty and intuition, and the demonstrated effects this relationship has on medical decision-making. The implications of these findings for medical education are discussed, with some suggestions for further research.

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Sources of uncertainty in clinical practice

One of the earliest studies regarding uncertainty and medical education is that of Fox.[7] Although this remains a widely-quoted work, a better conceptualisation (in terms of both breadth and depth) of the sources of uncertainty for physicians is Beresford's[8] who categorises sources of uncertainty into three types: technical, personal and conceptual.

Technical sources of uncertainty are those where there is insufficient information to adequately predict prognosis or the effect of interventions. Many new technologies have not been adequately researched as to

Key learning points

Intuition is an inescapable part of decision-making in medicine and involves personal decision rules of physicians. Intuitive decision-making is more likely to occur particularly under conditions of uncertainty.

Sources of uncertainty in medicine include technical, personal and conceptual. Although technical sources of uncertainty (which relate to uncertainty about medical information) can be reduced and/or eliminated, personal and conceptual sources of uncertainty always remain.

Physicians respond to this persistence of uncertainty in many different ways, including denial, a tendency to uphold medical orthodoxy and a preference for high technology specialties.

Physicians' intuitive decisions made under conditions of uncertainty are also prone to well-documented errors and biases. These errors and biases are often related to the use of heuristics or 'rules of thumb'.

The implications of this evidence need to be integrated within medical curricula in the training of both undergraduate and postgraduate doctors.

the best ways they can be utilised. Another, paradoxical, source of uncertainty lies in the speed of the growth of medical knowledge, which leaves an individual practitioner unsure whether he/she is up-to-date. (Although this could be viewed as a source of personal uncertainty, the technical classification is correct, since the epistemological basis for technical uncertainty differs from that of the other two categories, as discussed below.) Other sources of technical uncertainty include 'natural variability, ignorance about basic physical/biological processes, and lack of confidence in explanatory models'.[9] Technical sources of uncertainty correspond with all those originally described in Fox's work[7] and also correspond with Savulescu's term 'first order uncertainty'.[10]

Personal sources of uncertainty have their origins in the doctor–patient relationship, for example when the patient's wishes are unknown and not able to be solicited. Even if family were available, doubts may remain as to the adequacy of this surrogate decision-making. Another example is uncertainty due to the emotional attachment of the doctor for the patient, leading to a self-perception of the doctor that his/her decision-making may be potentially impaired.[8] An organisational reason why uncertainty may arise is that hospitals are organised around familiarity with techniques, not familiarity with patients.[11]

Conceptual sources of uncertainty arise from an inability to assess differing patient needs competing for the same resources (incommensurability), and the application of general criteria (for example, guidelines) to individual patients.[8] There is also the uncertainty arising from the applicability of past experiences to present-day patients. Another conceptual source of uncertainty is the general, existential uncertainty of the future which is inevitably part of any decision.[12] Conceptual and personal sources of uncertainty are also defined as 'second order or meta-uncertainty':[10] this refers to the uncertainty about how uncertain one is.

What makes Beresford's analysis particularly useful is that it shows that the management of uncertainty is more complicated than the simple provision of more information (a solution which has been suggested by some authors).[13] Further information would merely address the technical or first order sources of uncertainty, and leave untouched sources of meta-uncertainty. Acknowledgement of the broader sources of uncertainty results in acknowledging that a degree of uncertainty is an irreducible element of decision-making. This being the case, understanding of the responses to uncertainty, and the biases engendered by uncertainty, are crucial in reducing undesirable effects on decision-making processes.

Responses to uncertainty

For the most part, people are not consciously aware of how uncertainty is constantly present or deny that it is present. This may be, at least in part, a psychological protective mechanism:

It is a fact of life that human beings find it difficult to maintain a consistent, self-conscious appreciation of the extent to which uncertainty accompanies them on their daily rounds and to integrate that uncertainty with whatever certainties inform their conduct. Physicians are not exempt from this human proclivity.[14]

This denial may be related to the length of time a physician has been practising, as experience increases the likelihood of admitting uncertainty[15] at least to oneself and colleagues, if not to patients.[14]

Why does this denial occur? There are psychological advantages for the physician in that denial replaces uncertainty with certainty, imposes a degree of clarity on what may otherwise be a murky and confusing situation, and may make decision-making easier through this illusion of control and mastery.[16]

It has also been argued that the tendency to uphold medical orthodoxy is also a response to uncertainty, '…that the safest and most comfortable position is to do what others are doing…'.[17] Orthodoxy and the denial of uncertainty may yet be more deeply connected. As Heap *et al*. state, '…power is most insidiously exercised when those who are controlled have their consciousness shaped in such a way that they come to assent voluntarily to their condition'.[18] Douglas, quoting Ludwik Fleck, writes:

> 'The individual within the collective is never, or hardly ever, conscious of the prevailing thought style which almost always exerts an absolutely compulsive force upon his [her] thinking, and with which it is not possible to be at variance.'[19]

It could be argued that it is in a health institution's interest to maintain the denial of uncertainty, as otherwise this challenges the prevailing power structure of that institution. It is in the individual doctor's self-interest to uphold orthodoxy, as this allows a (mostly unconscious) escape from having to face up to uncertainty, as well as engendering a (conscious or unconscious) feeling of security. What this 'mutual benefit society' does not do, is address the needs of the patient for information and participation in decision-making.

On the whole, physicians are reluctant to disclose the inescapable uncertainty of decision-making to patients.[14] This reluctance is often linked to claims that it will cause unnecessary suffering and anxiety in patients and not improve the patients' ability to make decisions. One surgeon has put the problem this way:

> 'All that the doctor can do is to quote objective probabilities modified by his own subjective probabilities which express to some extent the dynamics of his belief systems, and to leave the patient with a final uncertainty about the outcome of treatment. …[it] often leaves the patient asking why is there no precision when there is so much science.'[20]

Katz claims that the underlying reason why these and other reasons (including the elimination of the innate therapeutic or placebo effect of the doctor-patient relationship, an increased likelihood of patients seeking care from 'quacks', and increased utilisation of resources – both financial and time) are proffered by doctors to explain why uncertainty should not be admitted, is that they have their origins in a fear that admissions of physician uncertainty will diminish the ability of doctors to control and maintain power in the decision-making process.[14] This claim is supported by evidence from another study which showed that a retreat into technical matters, and claims that these matters were beyond the understanding of patients, allows doctors to maintain their dominance in the decision-making process.[11]

Katz believes more problems are caused by physicians' defences against uncertainty, than by patients' 'supposed intolerance of medical uncertainties'. He argues that the open recognition and inclusion of uncertainty may well facilitate trust between doctor and patient, more honestly uphold the informed consent procedure, diminish unrealistic expectations on the part of the patient, and reduce the likelihood of litigation. Studies are not available to establish whether Katz or the physicians are correct.

Other responses to uncertainty relate to it being a considerable source of stress for both fully trained physicians and medical students.[7,13] One manifestation of this is the use of grim or black humour. Some of this has entered the literature, an example being 'The House of God', an allegorical tale of the author's experience as a junior doctor in a major American hospital. He describes his first impressions of the medical intensive care unit:

> 'The inside was ultraquiet, ultraclean, ultraunbusy. MUZAK [sic] shirred [sic] the crisp atmosphere as gently as a French chef might shir [sic] a sleepy egg for an early rising guest. …The patients were in their beds, quiet, at peace, at home with all they touched in this calm sea, happy fishes floating, floating. I found myself happily humming along with the MUZAK: 'Some enchanted eee-veniiiinng'….,'[21]

Uncertainty also propels activity – doctors have a '…propensity to resolve uncertainty and ambiguity by action rather than inaction'.[22] Such activity may lead to increased hospital admissions[8] and may be a cause of excessive ordering of tests,[23] although this result has not always been found.[24] Increasing diagnostic uncertainty also leads to a reluctance to withdraw intensive care therapy.[25] (This effect has been found to be independent of the prognosis: '…regardless of the estimate of survival [in ICU], if the physician was not confident in his or her estimate, more resources were used'.)[26]

Other effects associated with uncertainty in decision-making have been found in medical students. An intolerance of uncertainty was associated with a preference for high technology medicine, such as surgery, and a reluctance to look after (and negativity towards) psychiatric, geriatric and chronic pain patients.[27] It also predicted a negative attitude towards hypochondriac, geriatric and chronic pain patients. One author argues that disquiet with uncertainty leads to an inappropriate love of technology in fully trained doctors.[28] The act of

specialisation can help reduce uncertainty in two ways, one valid and one invalid: firstly (and validly), by narrowing the area of required expertise (and thus diminishing the potential for technical uncertainty), and secondly that specialisation engenders notions of the innate superiority of one's speciality over others[29] and thus, invalidly, decreases meta-uncertainty.

Uncertainty has a number of other effects on the decision-making by doctors. Heuristics are especially used under conditions of uncertainty and can give rise to a wide range of errors and biases (see following section). When uncertain, clinicians are more likely to frame their responses about likelihood in broad, 'symbolic descriptions of likelihood', such as 'possibly' or 'probably', rather than use precise percentages.[30] This is despite evidence which shows such broad, 'qualitative' expressions of probability are open to widely divergent interpretation by people (both patients and clinicians) as to their corresponding numerical (percentage) value[31] and creates obvious difficulties for the notion of informed consent.

It has been suggested that peer review, establishing guidelines and seeking consensus are constructive ways of responding to uncertainty. Consensus decision-making '…can help physicians cope with uncertainty by defining the limits of medical knowledge and informing individual practitioners about what is known with reasonable certainty and what is not'.[13] However, these approaches are only likely to affect sources of technical uncertainty. There is also a potential for consensus decision-making to become inefficient and unwieldy. Zussman found this method could lead to a paralysis of decision-making in the intensive care unit.[11] Ultimately each individual decision-maker has to deal with ongoing sources of meta-uncertainty.

Errors and biases in expert intuition

As part of intuitive decision-making, humans have developed heuristics, '…a rule or guideline that is easily applied to make complex tasks more simple'[32] whose purpose is 'serving to discover'.[33] Medical mottoes and clinical proverbs are simple examples of heuristics:

> 'If there is any chance of (the disease), the (procedure) should be performed…[i]f but one patient is saved, the effort is worthwhile…[c]osts should not be considered in decisions about individual patients …[and] [w]hen in doubt, do it.'[17]

A more complex example of a heuristic device is the selection of a 'pivot' – a necessary and sufficient fact – from the plethora of facts available, in making a diagnosis.[34]

In many situations using heuristics may result in accurate predictions and reflect a highly adaptive and efficient response to decision-making in the real world.[35,36] However, the more commonly held view of heuristics is one of more negativity, with heuristics being regarded as sources of biases and errors. Many of these biases have been found to occur in medical decision-making. This discussion describes such heuristics and their associated biases in decision-making using illustrations particularly from the intensive care literature, as an example of how these can infiltrate even the most technologically-oriented areas of medicine. In a seminal paper, Tversky and Kahneman described three heuristics (and their biases) used when making intuitive judgements: representativeness, availability, and adjustment and anchoring.[6]

The representativeness heuristic is an intuitive technique where probabilities are evaluated by the degree to which the given sample matches, or is representative of, a class of samples (or population).[6] Using this heuristic can cause bias in medical decision making several different ways: 1) Physicians can fail to take into account the base rate of events, if the information is presented in terms of probabilities.[37] This is possibly the 'commonest error' in medical decision-making.[3] 2) Physicians can ignore the effect of sample size on the validity of their predictions.[32] 3) Physicians can act under misconceptions of chance including the 'gambler's fallacy' where there is an expectation that a short sequence of events maintains similar qualities to a long sequence.[32] 4) Physicians can be insensitive to the reliability of information, or to the degree to which information allows an accurate judgement to be made and over-weight low-relevance diagnostic information.[37] 5) People's confidence in a prediction is mainly based on the similarity of a sample to a population, making them more confident about a 'good fit'. Physicians' certainty in their decisions increases with the detail of information provided even if that information is irrelevant: such cues can be incorrectly weighted, leading to excessive and unwarranted certainty.[38] 6) Physicians may hold incorrect intuitions about regression towards the mean: for example, improvement during a trial of therapy may be a regression towards the mean (chance variation) and not necessarily imply an increased likelihood that a diagnosis or choice of treatment was correct.[39]

The availability heuristic is an intuitive technique where the perceived probability of an event is influenced by the ease of recollection.[6] More easily recalled events are given a higher probability. More frequent events are often the most easily recalled, but the most easily recalled are not necessarily the most frequent. The

availability heuristic is also associated with predictable biases.

Firstly, biases can occur due to the ease of recalling 'matching' cases: for example, recent events are recalled more easily.[6] The sequence of events in providing physicians with diagnostic information can affect the subsequent diagnosis.[40] Ease of recall is also affected by the 'salience' or prominence related to the emotional strength of a memory with memories associated with strong emotions being recalled more easily.[6] Such a bias can affect perceptions of patient outcome – an emotional salience bias was unintentionally described in an intensive care unit requiring a formal audit to refute it.[41] Another example of the salience bias is the increased probability of radiologists diagnosing a tumour rather than nonmalignant conditions.[37] The importance of the diagnosis, with its associated emotional impact, is thought to increase the frequency of diagnosis.

Secondly, availability biases can occur due to 'the effectiveness of the search net.'[6] The ease of the search gives rise to a bias in thinking it occurs more frequently. For example, in diagnosing bacteraemia, physicians who recalled frequently caring for patients with this diagnosis and who recalled that a high proportion of their patients were currently receiving antibiotics, were more likely to make the diagnosis of bacteraemia than physicians who less frequently cared for bacteraemic patients.[42]

Thirdly, there are biases of the imagination.[6] One example of this is in risk-taking. The ease with which one can imagine the risk increases the predicted likelihood of its occurrence. This may explain why physicians demonstrate a strong aversion to risk when the consequences are serious (for example, death from cancer), an aversion which is even stronger than what they believe their patients would wish.[43] It may be easier for physicians than patients to foresee what would happen in the event of a bad outcome, and hence to make decisions as if there were a higher likelihood of this occurring.

The heuristic device of anchoring and adjustment is used when a series of estimates is required to obtain the final prediction. People usually create a prediction based on the initial information (anchoring) and subsequently modify the result when further information is available (adjustment).[6] Sequential biases can arise in several ways. The final result can be biased towards the initial information, which is given greater weight than later information (simple primacy), or because the initial information causes later information to be distorted in order to support the opinion formed up to that point (configural primacy).[37] Errors can arise from biases in evaluating conjunctive (each event increases the likelihood of the final outcome) and disjunctive (each event decreases the likelihood of the final outcome) events.[6] When considering a series of conjunctive events, the final probability is likely to be overestimated, whereas a series of disjunctive events is often underestimated. This is because the overall probability of a conjunctive event is lower than the probability of the individual events (and vice versa for disjunctive events). The more complex the sequence of events, the more these relationships hold true, even if the probability for the individual events is high (for conjunctive events) or low (for disjunctive events).

In complex systems, such as the human body, the probability of failure can be high simply because of this complexity. Sequential probabilities can also be inaccurately calculated due to an intuitive tendency to add, rather than multiply, the individual event probabilities.[44] Documented clinical examples of sequential biases include data showing that sequential observations did not improve the accuracy of prognosis in ICU death or survival – perhaps demonstrating simple primacy[45,46] – and physicians demonstrating configural primacy by ignoring or eliminating later, discrepant information.[34,37,47] Old practice habits that have not been modified in the light of new information also introduce error into clinical decision-making.[43]

Other biases, apart from those initially described by Tversky and Kahneman, have been shown to occur in medical decision-making. Hindsight bias is the increase in predictive frequency which occurs when a final result becomes known.[26] For example, surgeons given the results of laparotomy (a tortuous aorta) were less likely to diagnose a leaking aortic aneurysm from the case history than surgeons who were unaware of the operative outcome.[32] Physicians demonstrated similar hindsight bias in a hypothetical case of Reiter's syndrome.[48] Apart from implications in decision-making, the authors also commented that such a finding could lead to overconfidence in medical students who were predominantly taught via retrospective case analyses.

There is a bias in avoiding harms arising from acts of commission rather than harms from acts of omission.[49] Several studies have also shown that this bias may account for the reluctance of parents to vaccinate their children, as the perception is that the action of vaccination (commission) is more risky than passive inaction (not vaccinating).[50]

Choices can be altered depending on how information is presented. This is known as a framing effect bias.[6] For example, if information is presented in terms of lives gained, people (including physicians) choose the option with the least risk (risk averse). If, however,

the information is presented in terms of lives lost, the majority will choose the most risky option (risk taking).[51] The framing of statistical information can affect the likelihood of treatment. When physicians were asked to consider treatment for hypertension and hypercholesterolaemia, they were more likely to prescribe treatment when given information about the *relative* change in outcome rates with treatment (24% and 20·3% reduction) than about the *absolute* change in outcome rates (0·4% and 1·5%).[52] The same information was simply being presented in two different ways.

The psychology of the decision-maker can affect his/her decisions. People generally act under optimistic biases.[53] They have an unrealistically positive view of themselves, an exaggerated perception of personal control, and unrealistic optimism.[16] For example, doctors can believe that their own patients do better than other doctors' patients.[32,54] However, the effect is not always consistent. Value bias is a form of 'wishful thinking' where the estimate of the probability of an event is affected by the emotional reaction to the event. For example, physicians estimating the probability of bacteraemia gave lower estimates in high risk patients compared to low risk patients, possibly because they hoped such an event was not happening for patients in whom a bacteraemia carried more severe consequences.[42] Biases due to the emotion of regret can occur by distorting the estimation of probabilities by overestimating probabilities of events associated with higher anticipated levels of regret.[26,55] For example, doctors may knowingly provide futile therapy '…to assuage their own feelings of impotence in the face of death'[56] or in other words, to avoid regret. Regret bias may also explain why people consult their doctors for seemingly trivial complaints.[51] The anticipated level of regret for an unlikely but serious diagnosis motivates patients to seek a consultation even though they may be aware of the low possibility of such an outcome.

Biases in the way information is processed also exists (informational biases). Firstly, evidence which refutes or disconfirms a hypothesis is handled differently from confirmatory evidence. Doctors search harder for evidence that confirms a decision than disconfirmatory information[26] and confirmatory data tends to be overemphasised compared to disconfirmatory data.[38] Disconfirmatory facts are variously dealt with, depending on the consequences of accepting them. Discrepancies which have few consequences tend not to be explored. Discrepancies with more profound consequences, such as causing a complete revision of a hypothesis, may be investigated, but often with the purpose of minimising or eliminating their impact, by finding grounds to reject them or to demonstrate that they are not truly disconfirmatory.[47]

A second information bias is illustrated by Arthur Conan Doyle in a conversation between Inspector Gregory and Sherlock Holmes;

> 'Is there any other point to which you would wish to draw my attention?'
>
> 'To the curious incident of the dog in the night-time.'
>
> 'The dog did nothing in the night-time.'
>
> 'That was the curious incident,' remarked Sherlock Holmes.[57]

Relevant normal findings are difficult for people to take into account.[26] This has been shown to occur in medicine where five significant normal findings were systematically ignored by physicians in the diagnosis of pneumonia.[58] The authors suggest that possible causes include the general human trait of not processing 'absent problems' correctly, the emphasis placed on abnormal findings by patients, physicians' lack of training in the importance of relevant normal findings, and the current system of disease classification which minimises the use of normal findings. Thirdly, unspecified possibilities (i.e. possibilities not specifically mentioned, or overt information provided) tend to be ignored when considering (at least) hypothetical cases.[59]

Finally, there is extensive sociological research which shows the influence of a number of sociocultural biases on clinical decision-making. These biases can arise from characteristics of the patient and/or doctor, the relationship of the doctor with his/her profession, and from the doctor-patient relationship itself.[60] For example, the patient's social class, income, ethnicity, gender and age can influence decision-making, as can the doctor's area of specialisation, personality and age. The doctor is also influenced by how much he/she is motivated by the needs of the patient ('client-dependent') compared to the doctor's need to conform to the speciality ('colleague-dependent'). Much of the evidence for these biases is contradictory and confusing however: for an extensive review of these biases, the reader is directed to Eisenberg's paper and Clark *et al.*[61] as well as a recent study by van Ryn and Burke.[62]

Implications for medical education

There are several implications of this paper for medical education. Firstly, the heuristics and biases described are ubiquitous to all decision-makers and relate to the psychological and neurological ways in which people respond to and process information. They are more

likely to occur in decision-making which is carried out under conditions of uncertainty, which involves the use of intuition. Much – maybe most – of medical decision-making occurs under such conditions: although technical sources of uncertainty may be reduced or even eliminated by close study of scientific fact (evidence-based medicine being an example par excellence), personal and conceptual sources can remain: hence medical decision-making remains prone to these biases. These biases not only affect the decision-making of doctors, they are also potentially present in the decision-making of patients.

Once this is appreciated, the ramifications are large. As the literature shows many clinical examples of a distorted decision-making process are known. Even relatively simple decisions, such as the choice of an antibiotic, can be affected. Not only can these biases affect clinical decisions, they also of importance in ethical decisions. Take, for example, the process of informed consent. If this is taken to mean autonomous choice[63] and that autonomy of thought and will are necessary features of such choice[64] these biases can introduce a subtle coercive element. This is rarely appreciated within the medical ethics literature despite empirical research that demonstrates the potential for such coercion.[65]

What then can be done to improve decision-making? It is a truism that 'knowledge is power' but nevertheless it is true. Education of medical students about the role of uncertainty and these biases can give them insight into their decision-making. For several years I have taught approximately 200 third year medical students per year about these subjects as part of a short course on medical decision-making. In tutoring students, I have observed that whilst they rarely succumb to the 'gambler's fallacy' (this bias has become particularly well known), they reproduce with uncannily identical frequency the errors originally described by Tversky and Kahneman regarding other biases and heuristics. However, once made aware of these possible biases they appear more resistant to these fallacies. They pay particular attention when evidence is presented demonstrating the effects of uncertainty and these biases on the decision-making of otherwise skilled medical specialists: this teaching has rated well in subsequent student surveys.

This is anecdotal evidence, however, that such training does make a difference. It is hoped to formally investigate this by testing future students on their decision-making skills before and after this tuition. Other, far more robust research, shows quite clearly that the decision-making accuracy of students,[66] doctors[67] and lay people[68] can all be greatly improved by providing information not in the traditional manner expressed as probabilities (e.g. 1%), but expressed as 'natural frequencies' (e.g. 10 in 1000). Evidently, the song line 'It ain't what you say, it's the way that you say it' contains a deep heuristic truth! A major effect of providing information in this manner is that it mitigates against the bias of ignoring prior probabilities. However further research is also needed in developing strategies that ameliorate other types of biases and also in exploring the extent these biases affect decision-making in medical ethics. Finally, a 'meta-theoretical' issue needs to be resolved in deciding when and which heuristics are adaptive and useful tools for decision-making, as opposed to being sources of unwanted bias and error. Even while this latter task is being debated, however, the body of evidence justifies, I believe, the incorporation of information and training in this area into medical school curricula.

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