Evaluation of Physicians' Cognitive Styles

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Background. *Patient outcomes critically depend on accuracy of physicians' judgment, yet little is known about individual differences in cognitive styles that underlie physicians' judgments. The objective of this study was to assess physicians' individual differences in cognitive styles relative to age, experience, and degree and type of training.* ***Methods.*** *Physicians at different levels of training and career completed a web-based survey of 6 scales measuring individual differences in cognitive styles (maximizing v. satisficing, analytical v. intuitive reasoning, need for cognition, intolerance toward ambiguity, objectivism, and cognitive reflection). We measured psychometric properties (Cronbach's α) of scales; relationship of age, experience, degree, and type of training; responses to scales; and accuracy on conditional inference task.* ***Results.*** *The study included 165 trainees and 56 attending physicians (median age 31 years; range 25–69 years). All 6 constructs showed acceptable psychometric properties. Surprisingly, we found significant negative correlation between age and satisficing (r = –0.239; P = 0.017). Maximizing (willingness to engage in alternative search strategy) also decreased with age (r = –0.220; P = 0.047). Number of incorrect inferences negatively correlated with satisficing (r = –0.246; P = 0.014). Disposition to suppress intuitive responses was associated with correct responses on 3 of 4 inferential tasks. Trainees showed a tendency to engage in analytical thinking (r = 0.265; P = 0.025), while attendings displayed inclination toward intuitive-experiential thinking (r = 0.427; P = 0.046). However, trainees performed worse on conditional inference task.* ***Conclusion.*** *Physicians capable of suppressing an immediate intuitive response to questions and those scoring higher on rational thinking made fewer inferential mistakes. We found a negative correlation between age and maximizing: Physicians who were more advanced in their careers were less willing to spend time and effort in an exhaustive search for solutions. However, they appeared to have maintained their "mindware" for effective problem solving.* ***Key words:*** *physicians' cognitive styles; individual differences in decision-making; medical decision-making; dual processing theories.* ***(Med Decis Making 2014;34:627–637)***

Each day, physicians make numerous decisions that have crucial consequences for their patients. Decisions made by physicians are widely recognized as being affected by 3 sets of characteristics: 1) decision features, that is characteristics of the decision itself; 2) situational factors; and 3) individual differences among decision makers.[1] Historically, researchers have focused on studying the first two sets of factors. No study to date has attempted to comprehensively understand individual differences in physicians' cognitive styles. By *cognitive style* we mean a propensity to favor one decision-making or reasoning approach over

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another. Understanding the differences in individual cognitive styles is important for both physicians and patients as it can lead to prescriptive interventions that may improve decision making.

Investigating differences in cognitive styles has been popular in the cognitive sciences for decades and has flourished in higher mental processing research in more recent times.[2]

Numerous constructs for explaining individual differences in decision making have been proposed over the years, and in some cases instruments have been developed to quantify important individual differences. Our review of decision-making literature has led us to consider 6 key constructs on which physician decision makers are likely to show important individual differences. These are 1) maximizing and satisficing, which refer to the amount of effort an individual is willing to expend to determine the absolute best option in a decision[3]; 2) need for cognition, or the degree to which individuals prefer to engage in and derive enjoyment from cognitive activities[4]; 3) intolerance for ambiguity, which refers to an individual's ability to feel comfortable and accept situations where variables, alternatives, or outcomes are poorly defined or unclear[5]; 4) objectivism, or the tendency to seek empirical information under conditions of uncertainty and to attempt to process it in a rational and logical fashion[6]; 5) cognitive reflection, that is, the ability or disposition to resist reporting the response that first comes to mind[7]; and 6) propensity toward intuitive-experiential versus analytical-rational thinking,[8] which can be explained by dual process theories of cognition.[9,10]

Despite some challenges,[11] dual processing theories have increasingly been accepted as a dominant account of cognitive processes that characterize human decision making.[9] One of the central effects highlighted by dual processing theories of reasoning is ''belief bias''—the tendency to evaluate the validity of an argument on the basis of whether one agrees with the contents rather than on whether the conclusion follows logically from the premises.[12–14] The previous studies in samples from the general population showed that high-ability participants (i.e., experts) have more counter-examples accessible to them and are less influenced by belief bias compared with low-ability participants (i.e., trainees-novices).[15] In a medical context, this observation leads to the hypothesis that faculty and attending physicians (''experts'') are expected to perform better on reasoning clinical tasks than are residents and fellows (''trainees-novices''). However, it is not clear that experts and novices rely on the same or different cognitive mechanisms. It is also not clear whether the propensity for using one decision-making style over another (e.g., satisficing v. maximizing, intuitive-experiential v. analytic-deliberative, etc) is affected by the type of training (cognitive-oriented v. procedure-oriented disciplines) or by demographic characteristics such as age and gender. Because such styles are affected by cultural transmission,[16] we would expect them to be sensitive to both expertise and demographic variability.

To address these questions, we assessed the validity of physicians' inferences by measuring cognitive styles and their relationship to accuracy on a conditional inference task. We also sought to understand the extent to which physicians' cognitive styles can be categorized as maximizing versus satisficing or intuitive-experiential versus analytic-deliberative in relation to age, experience, degree (trainee v. attending physicians), and type of training (surgical v. nonsurgical disciplines). Finally, we determined a relationship between these constructs and other constructs of importance to understand individual differences in decision making (such as need for cognition, intolerance for ambiguity, and the disposition to resist reporting the response that first comes to mind).

METHODS

All residents, fellows, and physicians affiliated with the University of South Florida were invited by e-mail to participate in the study. The web-based survey included questions on demographics (i.e., age, level of training, gender, specialty), well-validated scales measuring 6 key constructs on which physician decision makers are likely to show important individual differences, and 4 types of conditional inference (explained below). The complete survey is provided in the online appendix. Because people's problem-solving strategies may rely on an external search,[17] participants were randomly assigned (1:1) to a message informing them that they were allowed versus not allowed to use external resources (Figure 1). The survey was open from 21 February 2013 until 13 May 2013; the survey was closed after 3 reminders were sent to all potential participants, which resulted in the desired sample size approved by the institutional review board (N = 300). The survey was administered using Qualtrics survey software. The study was approved by the University of South Florida Institutional Review Board (No. 9047).

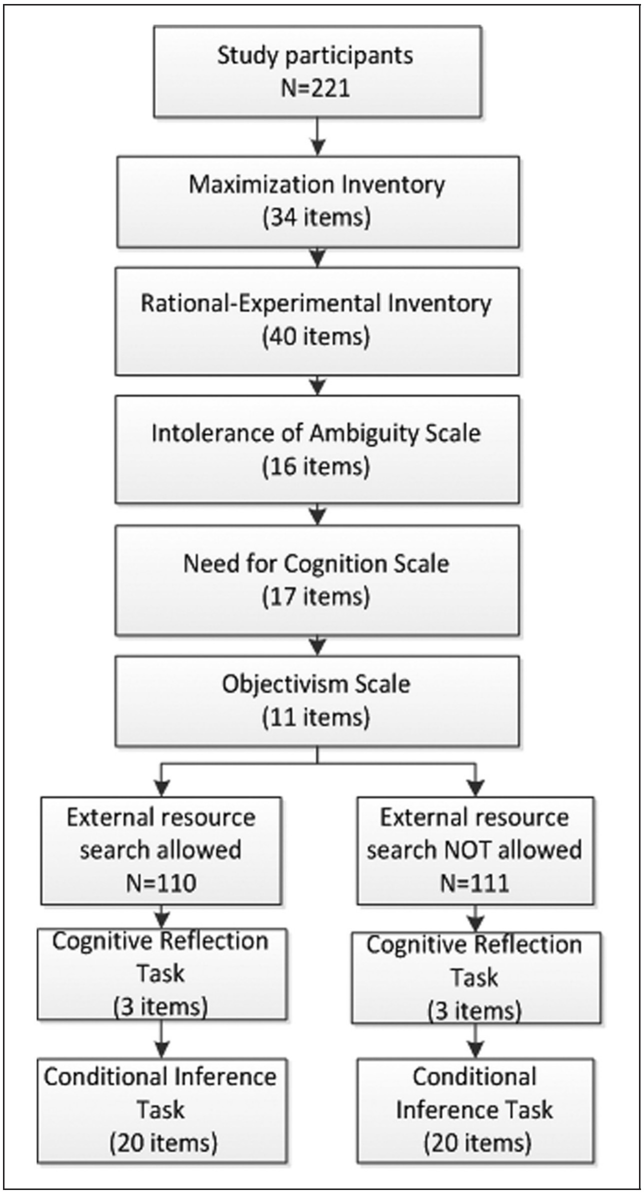

Figure 1 The study design. Because of some evidence that people's problem-solving strategies may rely on the external search, we randomized participants into those who were allowed to use external resources versus those who were not. However, because we found no significant differences in conditional inference between participants with versus without access to external sources, we pooled data from both groups.

Scales to Measure Individual Differences in Cognitive Styles

Maximization Inventory. The Maximization Inventory consists of 3 separate scales.[18] The Alternative Search Scale assesses the tendency to expend resources in exploring all possible opportunities. The Decision Difficulty Scale represents the degree of difficulty experienced when making choices among abundant options. These scales measure maximizing tendency, whereas the Satisficing Scale captures an independent construct. Therefore, maximizing and satisficing are not mutually exclusive; individuals can use both strategies.

Rational-Experiential Inventory. Theories of dual cognition assume 2 distinguishable cognitive styles: rational and intuitive (see also below). The Rational-Experiential Inventory (REI) consists of 2 item subscales and measures intuitive-experiential and analytical-rational thinking based on cognitive-experiential self-theory.[8]

Intolerance of Ambiguity Scale. The Intolerance of Ambiguity Scale (IAS) measures a person's ability to feel comfortable and accept situations in which variables, alternatives, or outcomes are poorly defined, uncertain, or unclear.[5] IAS is particularly applicable to the field of medicine, where individual differences in tolerance of ambiguity are expected to be relevant.

Need for Cognition Scale. The short form of the Need for Cognition Scale contains items that focus on engagement in and enjoyment of cognitive activities.[4] It is a measure of motivated cognition (e.g., information processing, thinking, and judgment).[1] As such, the scale is relevant to individual differences in rational processing.

Objectivism Scale. People differ not only in their cognitive style but also in the kinds of information upon which they base their decisions and beliefs. An objective individual seeks empirical information and attempts to process it in a rational and logical fashion. The Objectivism Scale measures the tendency to base one's judgments and beliefs on empirical information and rational considerations.[6]

Cognitive Reflection Task. The cognitive reflection task (CRT) was designed to test the participants' ability or disposition to suppress intuitive and spontaneous answers in favor of more reflective and deliberative responses.[7] We adapted the CRT using medical contents but preserving the structure of the items to retain fidelity in testing of domain-specific reasoning.

Assessment of Accuracy of Inferences

Belief bias, a central bias studied in dual processing models, is the tendency to be influenced by prior belief when drawing deductive inference regardless of logical validity.[12–14,19] That is, past work has found that people will exhibit belief bias if an argument is *believable*, even if it defies logic.[9,12–15,20] To assess belief bias in medical situations, we used a conditional inference task.[15]

Table 1 presents the conditional inference types and examples of clinical scenarios that we presented in this format. Believability was pretested using a different sample drawn from the same population as the main study. A total of 48 inference problems were derived by crossing believability with the 4 types of inference problems: modus ponens (MP), denial of antecedent (DA), affirmation of the consequent (AC), and modus tollens (MT). These were administered in a random order using Qualtrics survey software. The complete survey instrument is included in the online appendix.

Statistical Analysis

Descriptive statistics were used to summarize the characteristics of the participants. Reliability of the data obtained by the various scales was assessed using Cronbach's coefficient α. To address the hypothesized age/expertise effect (see Discussion), our main analysis consisted of Pearson's correlation statistics to address key questions: 1) a relationship between age and maximizing and satisficing (and other scales used in our study), 2) a relationship between maximizing and satisficing with other scales used to measure cognitive style. Because the level of training is a proxy for expertise, we also analyzed data accordingly (physicians in training v. attending physicians). The level of cognitive skill is also expected to depend on the medical disciplines, as some fields are more procedure oriented (e.g., surgical disciplines) while others are more cognitively oriented (e.g., internal medicine disciplines). It is also expected that gender may affect cognitive styles.[21–23] We therefore analyzed data according to these a priori defined subgroups. The reported *P* values were corrected for multiple comparisons using a Bonferroni adjustment. Chi-square test was used to compare differences in responses between trainees and attendings on the conditional inference task. All analyses were performed using statistical package SPSS and Stata.

RESULTS

An invitation to participate in the study was sent by e-mail to 1023 resident, fellow, and attending physicians. Of the 301 physicians who started the survey, 221 completed all questions. There was no significant difference between those who completed and those who started the survey on the collected variables. The sample consisted of 75% (n = 165) trainees (residents and fellows) and 25% (n = 56) attending physicians. Overall, 120 (54%) were male; females comprised 41% (n = 23) of attending physicians and 47% (n = 78) of physicians in training, respectively. Median age in years was 31 (mean 33.7; range 25–69). There was no difference in age between males (median 31; range 25–69) and females (median 30; range 25–59) (P = 0.336). As expected, attending physicians were older (median 42; range 27–69) than trainees (median 29; range 25–55); ($P < 0.0001$) The participants from surgical disciplines comprised 26% (n = 57) of the sample (see Table 2). A majority of the participants completed the survey in less than 1 hour (median 34 minutes; range 8–249).

The survey flow-diagram is presented in Figure 1. Because there were no significant differences in conditional inference between participants with versus without access to external sources, we present pooled data.

The reliability of the data obtained on all 6 scales is shown in Table 3. For each scale, the values obtained were similar to those reported in studies of nonphysicians. For Maximization Inventory we obtained Cronbach's α of 0.746 for the Satisficing Scale, 0.858 for the Decision Difficulty Scale, and 0.879 for the Alternative Search Scale versus 0.73, 0.85, and 0.83, respectively, reported by Turner and others[18]; for the Rational-Experiential Inventory, Cronbach's α was 0.888 for the Rational Scale and 0.893 for the Experiential Scale versus 0.90 and 0.87, respectively, described by Pacini and Epstein[8]; our Cronbach's α for Need for Cognition Scale was 0.894 versus 0.90 reported by Cacioppo and others[4]; for the Objectivism Scale we obtained Cronbach's α of 0.717 versus 0.83 calculated in the original report.[6]

Cronbach's α remained modest for Intolerance of Ambiguity (0.643) although it was very close to the values observed in the other studies reported in the literature (0.64 and 0.63 calculated by Sobal and DeForge[24]). Similarly, Cronbach's α for Cognitive Reflection Task was 0.599. A recent study found Cronbach's α for expanded CRT of 0.67. However, the authors also cautioned that this scale has only 3 items—too few for testing reliability.[25] Nevertheless, the overall results provided sufficient reassurance that we could continue with the analysis as originally planned and that scales developed in nonmedical fields are applicable to physicians (see also limitations in the Discussion section).

Table 1 The Four Inferences Studied Using the Conditional Inference Model with Examples of Invalid, Believable and Invalid, Unbelievable Clinical Scenarios

Inference	Clinical Scenario Example	Major Premise	Minor Premise	Conclusion	Validity
Modus ponens (MP)	Unbelievable Example Assume the following is true: *If a patient has a high fever, then the patient has malaria.* Given that the following premise is also true: *Ms. Boyle has a high fever.* Is it necessary that: *Ms. Boyle has malaria.* ○ Yes ○ No	If A then B	A	B	Valid
Denial of antecedent (DA)	Believable Example Assume the following is true: *If a patient has pulmonary embolism, then the patient is short of breath.* Given that the following premise is also true: *Mrs. Smith does not have pulmonary embolism.* Is it necessary that: *Mrs. Smith is not short of breath.* ○ Yes ○ No	If A then B	Not A	Not B	Invalid
Affirmation of the consequent (AC)	Believable Example Assume the following is true: *If a patient has pulmonary embolism, then the patient is short of breath.* Given that the following premise is also true: *Mrs. Smith is short of breath.* Is it necessary that: *Mrs. Smith has pulmonary embolism.* ○ Yes ○ No	If A then B	B	A	Invalid
Modus tollens (MT)	Unbelievable Example Assume the following is true: *If a patient has a high fever, then the patient has malaria.* Given that the following premise is also true: *Ms. Boyle does not have malaria.* Is it necessary that: *Ms. Boyle does not have a high fever.* ○ Yes ○ No	If A then B	Not B	Not A	Valid

Note: To evaluate the believability of each statement, we first conducted a pilot study. Forty-one participants rated the probability that each of the 20 statements is true, on a scale of 0%–100%. The 6 statements that received the highest median ratings were classified as *believable* and the 6 statements that received the lowest median were classified as *unbelievable* (see Supplementary material at http://mdm.sagepub.com/supplemental for other examples).

Table 2 Characteristics of Participants (N = 221)

Variable	No. (%)
Training status	
Trainees (resident/fellow)	165 (75)
Faculty (attending)	56 (25)
Gender	
Male	120 (54)
Female	101 (46)
Median age, years (range)	31 (25–69)
Discipline	
Internal medicine	37 (17)
Pediatrics	29 (13)
Surgery	19 (9)
Obstetrics and gynecology	15 (7)
Radiology	15 (7)
Ophthalmology	12 (5)
Psychiatry	12 (5)
Other	82 (37)
Discipline type	
Surgical	57 (26)
Nonsurgical	164 (74)

Table 3 shows correlation analyses between maximizing-satisficing and other measures of cognitive styles. The tendency to engage in analytical thinking correlated positively with satisficing (r = 0.226; P = 0.032) and need for cognition (r = 0.745; P = 0.000). Similarly, objectivism correlated positively with analytic thinking (r = 0.535; P = 0.000), alternative search (r = 0.278; P = 0.0012), and need for cognition (r = 0.358; P = 0.000). Ambiguity intolerance correlated negatively with the need for cognition (r = –0.528; P = 0.000) and analytical thinking (r = –0.346; P = 0.00), which correlated negatively with decision difficulty (r = –0.233; P = 0.021). The latter findings indicate, surprisingly, that when one is faced with a large number of decisions, the higher uncertainty and decision difficulty are associated with reduced application of the rational analytical process. Of note, none of the satisficing-maximizing subscales significantly correlated with the CRT.

Figure 2 shows a correlation between age and maximizing and satisficing. Surprisingly, we found statistically significant negative correlation between age and satisficing (r = –0.239; P = 0.017). As expected, alternative search decreased with age (r = –0.220; P = 0.047) but not with dealing with decision difficulty (r = –0.170; P = 0.53). The Alternative Search Scale showed statistically significant correlation with the Decision Difficulty Scale (r = 0.415; P = 0.000). On other hand, satisficing displayed no statistically significant correlation with alternative search (r = 0.185; P = 0.32) or decision difficulty (r = 0.0421; P = 1.00), findings consistent with the original report of maximizing-satisficing scale used in our study.[18] Age showed no statistically significant correlation with any other scale used in our study for any subgroup analyses.

The subgroup analyses confirmed a positive correlation between analytical thinking and satisficing (r = 0.265; P = 0.025) and negative correlation between analytical thinking and decision difficulty (r = –0.264; P = 0.028) in the trainees; the latter indicates that analytical thinking tends to decrease when one is faced with the larger number of decisions. Interestingly, no such a correlation was observed among attendings; here, we detected a positive correlation between satisficing and intuitive-experiential thinking (r = 0.427; P = 0.0369) but not in the trainees (r = 0.127; P = 1.0). The correlation coefficients were statistically significantly different between the two subgroups (P = 0.038). While we expected a correlation between intuitive-experiential thinking and age, the failure to observe a significant correlation may have been a statistical artifact due to data concentration within relatively a narrow group of the participants. Males showed a positive correlation between alternative search and intolerance toward ambiguity (r = 0.299; P = 0.039), while no such correlation was observed in the females (r = 0.0727; P = 1.00). However, the difference between the two correlation coefficients was not significant (P = 0.084). We also observed a positive correlation between satisficing and alternative search in males (r = 0.416; P = 0.0001) but not in females (r = –0.149; P = 1.0); the difference between two correlation coefficients was highly significant ($P < 0.0001$). Finally, we observed somewhat different patterns of correlation between surgical and nonsurgical disciplines. Surgical participants displayed a positive correlation between analytical thinking and satisficing (r = 0.468; P = 0.009), while the participants from nonsurgical disciplines displayed a positive correlation between alternative search and decision difficulties (r = 0.421; P = 0.000). The correlation coefficients between satisficing and analytical thinking were statistically significantly different (P = 0.029) between surgical versus nonsurgical participants while no such difference was detected between decision difficulty and alternative search (P = 0.826). Both groups showed positive correlation between analytical thinking and need for cognition and objectivism.

CRT score positively correlated with MP inference (r = 0.203; P = 0.0237) and negatively correlated with the fallacious DA (r = –0.192; P = 0.041) and AC (r = –0.306; P = 0.000) inferences but not with MT.

Table 3 Means, Standard Deviations (s), Reliabilities, and Intercorrelations of the Scales Measuring Individual Differences in Cognitive Styles (N = 221)

Scale	Mean	s	1	2	3	4	5	6	7	8	9
1. MI: Decision Difficulty	3.200	0.758	**0.858**								
2. MI: Alternative Search	3.925	0.821	0.415[a]	**0.879**							
3. MI: Satisficing	4.860	0.490	0.042	0.180	**0.746**						
4. REI: Rational	2.980	0.531	–0.233[a]	0.021	0.226[b]	**0.888**					
5. REI: Experiential	2.294	0.577	–0.070	0.105	0.198	0.132	**0.893**				
6. Intolerance of Ambiguity	3.068	0.480	0.198	0.194	–0.216[b]	–0.346[a]	–0.141	**0.643**			
7. Need for Cognition	4.241	0.695	–0.172	0.007	0.154	0.745[a]	0.145	–0.528[a]	**0.894**		
8. Objectivism	2.766	0.492	–0.076	0.279[a]	0.154	0.535[a]	–0.081	–0.020	0.358[a]	**0.717**	
9. Cognitive Reflection Task	1.490	1.003	–0.091	–0.088	0.080	0.104	0.042	–0.115	0.107	0.006	**0.599**

Note: MI = Maximization Inventory; REI = Rational-Experiential Inventory. Boldface numbers are scale reliabilities (Cronbach's α). Scale dimensions (higher numbers indicate more of an attribute): MI: Decision Difficulty (1–6); MI: Alternative Search (1–6); MI: Satisficing (1–6); REI: Rational (0–4); REI: Experiential (0–4); Intolerance of Ambiguity (1–6); Need for Cognition (1–6); Objectivism (1–5); Cognitive Reflection Task (0–3).
a. Correlation is significant at the 0.01 level (2-tailed).
b. Correlation is significant at the 0.05 level (2-tailed).

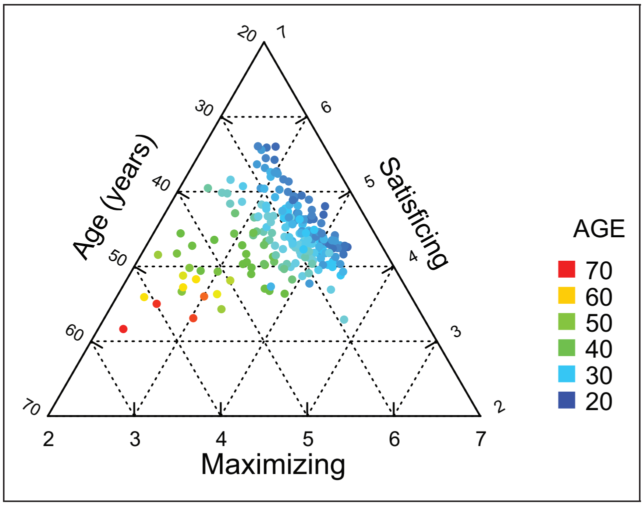

Figure 2 Relationships among age and maximizing and satisficing. As age increased in the physicians sample, problem-solving strategy relied less on satisficing and maximizing (tendency to engage in alternative search to find the optimal solution).

Analytic thinking correlated negatively with the number of incorrect answers on DA (r = –0.232; P = 0.031), while satisficing correlated negatively with the number of incorrect inferences on AC (r = –0.25; P = 0.02), both fallacious. Taken together, the results indicate that those individuals who tend to engage in some form of effortful reasoning (measured as cognitive reflection, satisficing, or rational thinking) score better on conditional inference tasks. Despite the positive correlation of trainees with analytical thinking and attendings with intuitive thinking, trainees performed worse on the conditional inference task, endorsing more fallacious AC inferences (25.4% v. 18.8% agreement, P = 0.0005; Figure 3), indicating that experience is also important in formal inferential process. In the attempt to delineate the effect of age from experience, we regressed AC inferences on both variables, but this resulted in negative suppression.[26] This occurred because in medicine, as in many professions, age and experience are positively correlated across individuals. (see Discussion)

DISCUSSION

We report the first multidimensional assessment of cognitive styles in physicians with a focus on satisficing and maximizing—arguably one of the key cognitive strategies that humans use. The 2 prior studies of analytical styles among physicians used only one of the instruments, the Rational-Experiential Inventory, used in our study.[27,28]

Several immediate implications emerge from our findings. First is the manner in which our results integrate within current theories of human cognition and whether these findings have implications for revising some of the established concepts related to cognitive style and decision making. Second is the implication of our findings for understanding the relationship between experience (age) and formal training. Third is the extent to which certain cognitive styles may lead to better problem solving and decision making (and hence, by extension, to better patient outcomes), suggesting possible educational and prescriptive remedies that may improve the way the physicians make decisions.

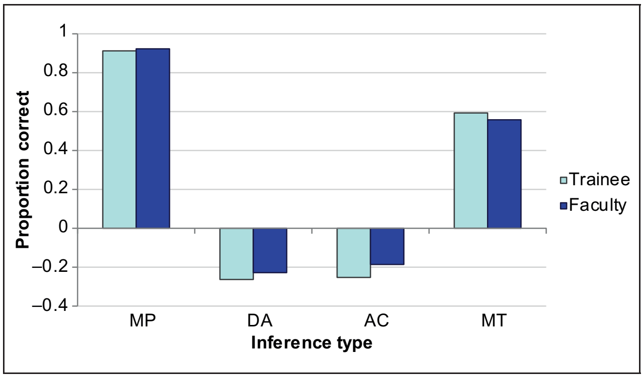

Figure 3 *Assessment of agreement on 4 different conditional inference tasks. Note that trainees performed worse in avoiding inferential error related to fallacy of affirming the consequent (AC), while no differences were seen on other syllogism tasks: MP, modus ponens; MT, modus tollens; DA, fallacy of denying the antecedent. Note that the numbers above the x-axis represent the proportion of the participants answering correctly (MP and MT), while the numbers below the x-axis represent the proportion of participants answering incorrectly (DA and AC).*

To address the first question, we think that our results can be best explained within a framework of dual processing theories. Dual processing theories postulate that cognition is governed by Type 1 processes (which are intuitive, automatic, fast, narrative, experiential, and affect-based) and Type 2 processes (which are analytical, slow, verbal, and deliberative and support formal logical and probabilistic analyses).[2,10,13,29–36] The current view of leading theorists is that humans are ''cognitive misers'' with a tendency to use the least possible effort to engage in problem solving and decision making.[10] Type 1 processes do not require working memory, whereas Type 2 processes rely heavily on working memory.[9] A decision maker's initial, default response to the problem is governed by rapid, autonomous, Type 1 processes, which are generated by series of associations (''what first comes to mind''). However, this initial response may or may not be adaptive to reality. To decouple the real world from imaginary situations, decision makers need the capacity to think hypothetically.[9,10] This is provided by Type 2, higher order reasoning and analytical processes, which can interrupt (override) autonomous Type 1 responses.[9,10] The initiation of the override of Type 1 processes by Type 2 processes is different from the actual algorithm of information processing; it depends on the higher level cognitive dispositional functions of reflective mind, which is related to rationality but is distinct from intelligence.[10]

The response to the task at hand starts with serial associative thoughts of Type 1 process, which tend to focus on the single, most relevant option (''relevance and singularity principle'').[12,13] If the proposed solution does not ''feel right,'' Type 2 processes intervene.[37] This may take a form of satisficing (carried by the algorithmic mind) or a search for the best possible solution (maximizing).[10] Medical education typically relies on heuristics derived from intensive practice of problem solving and decision making using case vignettes (real or hypothetical), which, after many hours of training, become internalized and represent the basis for the actual practice of medicine. In this context, it is important that both Type 1 and Type 2 processing can generate biases or produce normatively correct answers.[9]

From this perspective, satisficing and maximizing represent 2 distinct forms of decision-making strategies.[18] That is, maximizing is not an inverse of satisficing, as traditionally assumed (and incorrectly measured).[38,39] This can then explain a negative correlation with age and maximizing and satisficing: As they advance in their careers, physicians are less willing to spend time and effort in finding an adequate solution to the clinical problem, whether based on an exhaustive search for best possible or good enough solutions. As they age, physicians tend to move from analytical to intuitive-experiential mode of thinking. Surprisingly, and despite the fact that the concept was introduced more than 5 decades ago,[3,40] we could not find any empirical data evaluating age in relation to maximizing-satisficing. The only study that described cognitive styles related to aging did not measure satisficing directly but expressed it as an inverse of maximizing,[41] the concept that was refuted by Turner and others.[18] As shown in Figure 2, age is independently correlated with satisficing and maximizing. The effect of age is indirectly corroborated by findings that trainees rely more on analytical styles while attendings (typically, older physicians) are inclined to use intuitive-experiential cognitive styles. Nevertheless, these unexpected findings raise questions regarding reinterpretation of satisficing as traditionally understood and point to the need for future replications of our results.

Maximizing and satisficing, therefore, represent 2 different problem-solving strategies. Evidence that satisficing constitutes an effective problem-solving strategy is also reflected by the facts that 1) satisficing correlates positively with disposition to think analytically, which, in turn, resulted in fewer incorrect answers on syllogism tasks, and 2) those participants who scored higher on satisficing dimension had fewer incorrect inferences on the fallacy of affirming the consequent task. In general, our results show that the tendency to engage in some form of effortful reasoning (as measured by cognitive reflection, satisficing, or rational thinking) positively predicts performance on conditional inference tasks.

Our study sheds some insights into a complex relationship between clinical experience and the effect of formal training on cognitive performance.[42] Some studies suggest that patients' outcomes may be better when patients are treated by younger physicians, who also tend to perform better on board examinations.[43] This could be due to their inclination to rely on analytical reasoning and adhere to guideline-concordant practice,[28] which is also stressed in the courses on evidence-based medicine (EBM) to which many older physicians have not been exposed. Indeed, our findings indicate that physicians who were more advanced in their careers were less willing to spend time and effort in an exhaustive search for best solutions. This appears to point to the obvious educational prescription: Development of evidence-based resources that are user-friendly, reliable, and immediately accessible may enable all physicians—younger and older alike—access to the information at the time they need it. These educational prescriptions may further need to be customized based on the individual's cognitive style. For example, the physicians who display intuitive-experiential cognitive style (attendings in our study) may prefer a narrative, storytelling (case-based) approach, while those who are inclined toward rational thinking (trainees in our study) may prefer EBM, rule-based education with its emphasis on quantitative evidence and guidelines.

However, the situation between experience and expertise is more complex than this discussion appears to indicate. While formal training and continuing medical education are undoubtedly important, so is experience.[44] Because it takes a long time—at least 10 years or 10,000 hours[45]—to acquire important skills, it is typical that older individuals will possess required skills for optimal practice of medicine. Experts' judgments are particularly accurate in the environment that is sufficiently regular to be predictable and following sufficient opportunities to learn these regularities.[30,44] These characteristics are typical of the practice of medicine. Expertise provides individuals with the necessary ''mindware.''[10] The concept of mindware can explain why older doctors fared better on at least of one formal inferential task despite the fact that the trainees showed a tendency for analytical thinking. It is not enough to be motivated to engage in analytic thinking—one must also have the necessary cognitive tools. Lack of required tools, or existing inappropriate cognitive tools, can lead to erroneous responses even with analytic reasoning. We surmise that being in a training situation motivates trainees to engage in analytic thinking, but, as their training is not yet complete, they have not yet acquired all the necessary cognitive tools to generate normatively correct responses. They think harder but less effectively. This, too, underlines the importance of training and experience to sound medical decision making. Nevertheless, age probably has an independent effect on cognitive styles that is unrelated to acquiring expertise; aside from the possibility of cognitive decline associated with aging, older physicians tend to experience a large decrease in their theoretical knowledge base[43] and may need to develop compensatory mechanisms that tap into their subject expertise.[42] As demonstrated in our study, these mechanisms appear to serve them rather well, helping them to maintain their mindware for effective problem solving. Unfortunately, in our attempt to delineate the effect of age from experience in the conditional inference task, we detected a spurious effect of negative suppression in regression analysis.[26] This occurred because in medicine, as in many professions, age and experience are positively correlated across individuals. This makes it difficult to isolate the unique influence of one (or the other) variable on some third variable (see Beckstead[26] for details). Thus, while we found reliable and systematic differences among physicians as a function of both their age and years of experience, we are not able to make a statement about the relative importance of the cumulative experiences specific to the practice of medicine, and the general biosocial process of aging, as determinants of these differences.

The main limitation of our study is that it was done at a single institution. However, we believe that the overall results are likely generalizable to all U.S. physicians because the composition of physicians at the University of South Florida is similar to what would be expected around the United States. Nevertheless, we cannot rule out the possibility of self-selection of faculty versus trainees, which may have generated an analytical sample producing a potential artifact in our statistical analysis. This possibility can only be confirmed or refuted by future studies aiming to reproduce our research results. In addition, our study represents a cross-sectional look at a point in time of a dynamic phenomenon of the downstream effects of the selection and education of physicians. That is, a proportion of physicians with given expertise and training level may differ if another snapshot in time is taken. This may explain, for example, why we had few family practice physicians. Nevertheless, we had a wide representation of physicians across the specialties that use similar reasoning skills as family practitioners (e.g., internal medicine, pediatrics, psychiatry, etc), providing sufficient generalizability of our findings. In addition, the results agree well with the findings from the general population, alleviating potential concerns of self-selection.[15]

We also assume that better decision making leads to better patient outcomes, but we have not actually measured the outcomes. Nevertheless, this is an acceptable normative position to take, as previous studies showed that physicians' reactions to ambiguity affect physicians' resource use and practice patterns.[36,46–48] In fact, it is quite likely that cognitive processes play one of the key roles in the wide variation in contemporary medical practice,[49] much of which results in inappropriate diagnostic and treatment decisions. It is estimated that more than 30% of medical interventions are currently not appropriately applied.[50] This implies that many of the features we measured in this study may be immutable. However, it is possible to train people to face uncertainty[36] and to ''stop and reflect,'' which may increase their capacity to resist acting on ''what first comes to mind.''[30,35,51] This may improve accuracy in inferences and, in turn, lead to better patient outcomes.[35]

FUTURE RESEARCH

Our study lends itself to straightforward extension of this line of research to at least 2 settings: 1) evaluation of cognitive styles of physicians in actual practice and 2) education of medical doctors. For example, it would be interesting to correlate the cognitive scale scores with the patterns of diagnostic testing and treatment prescribing. This would provide direct empirical evidence regarding potential causes of over- and undertesting and over- and undertreatment—a significant public policy question, as discussed above. Similarly, it would be interesting to test whether adaptation of educational practice to cognitive styles improves trainees' knowledge. For example, it would be possible to conduct a randomized trial attempting to answer whether physicians with a tendency toward intuitive-experiential cognitive style score better on medical knowledge tests when the material is presented in a narrative versus algorithmic, rule-based approach. A number of similar proposals can emerge from our current results along the lines highlighted here. In addition, other researchers may find it useful to use our approach, as the appendix provides a ready-to-use protocol, saving time and effort in identifying the most suitable instruments to test the constructs presented in this paper.

In conclusion, we present the first multidimensional study of cognitive styles of physicians, which calls for reinterpretation of some of our prevailing views on human cognition while highlighting additional implications for medical practice and training. Our study also supports dual processing theories underpinning physicians' decision making, which should be taken into account in the ways we train doctors and deliver continuing medical education.

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