Heuristic reasoning and cognitive biases: Are they hindrances to judgments and decision making in orthodontics?

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Studies show that our brains use 2 modes of reasoning: heuristic (intuitive, automatic, implicit processing) and analytic (deliberate, rule-based, explicit processing). The use of intuition often dominates problem solving when innovative, creative thinking is required. Under conditions of uncertainty, we default to an even greater reliance on the heuristic processing. In health care settings and other such environments of increased importance, this mode becomes problematic. Since choice heuristics are quickly constructed from fragments of memory, they are often biased by prior evaluations of and preferences for the alternatives being considered. Therefore, a rigorous and systematic decision process notwithstanding, clinical judgments under uncertainty are often flawed by a number of unwitting biases. Clinical orthodontics is as vulnerable to this fundamental failing in the decision-making process as any other health care discipline. Several of the more common cognitive biases relevant to clinical orthodontics are discussed in this article. By raising awareness of these sources of cognitive errors in our clinical decision making, our intent was to equip the clinician to take corrective action to avoid them. Our secondary goal was to expose this important area of empirical research and encourage those with expertise in the cognitive sciences to explore, through further research, the possible relevance and impact of cognitive heuristics and biases on the accuracy of orthodontic judgments and decision making. (Am J Orthod Dentofacial Orthop 2011;139:297-304)

In an age of evidence-based dentistry, how do we select the treatment that we do in clinical orthodontics? On what evidence, if any, do we rely when making clinical recommendations? In spite of our considerable success over the past century, there is still much we do not know about the care we provide. Examples of such areas of uncertainty include the orthopedic response to growth modification, long-term treatment stability, and the degree to which genetics and environment influence facial growth. In spite of these and other areas where evidence is incomplete or nonexistent, we march forward in clinical orthodontics, relying on personal experience, popular opinions, and whatever data exist, both good and bad. Orthodontists face uncertainty daily when deciding on an optimal course of treatment. Questions such as these arise. Should I recommend extractions? Which teeth should I extract? Should I recommend intervention in this growing person now or later? When is the optimum time for starting treatment? If surgery is the best treatment option to meet the occlusofacial goals for the patient, what are reasonable alternatives if the patient rejects this option? When sorting through multiple treatment options, do subjective facial goals trump more objective concerns for periodontal health and stability? Making such decisions can be a source of anxiety, disappointment, fear, and concern for many ethical, caring practitioners who truly desire the best treatment outcomes for their patients.

In any clinical science, acquired diagnostic information might be flawed through systematic or organizational problems.[1] The literature in both medicine and orthodontics is replete with examples of flawed procedures that reduce the accuracy of clinical data and can lead to diagnostic failures.[2-21] Studies also show that diagnostic errors occur when the objective data are incomplete because of simple oversight or a failure to perceive the need for relevant information.[22-24] Even when diagnostic information is accurate, the data can be inappropriately interpreted because of deficiencies

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in knowledge or understanding of the empirical scientific literature.[6,13,22,25-36]

Graber et al[22] published a noteworthy study analyzing the causes of medical errors. They analyzed 100 cases of diagnostic errors over a 5-year period in 3 academic medical centers. Errors, retrospectively classified into 3 categories, occurred with the following frequencies: (1) system-related (technical or organizational failures) occurred in 65 of the 100 cases, (2) no fault (unusual presentation or patient-related, such as deception or poor cooperation) in 44 cases, and (3) cognitive (faulty knowledge, data gathering, or synthesis) in 65 cases. Further assessment showed that cognitive errors were most commonly related to premature closure (the tendency to stop considering other possibilities after reaching a diagnosis). Although the reasons for premature closure were multi-faceted (eg, sloppiness, taking inappropriate shortcuts), the data indicated that clinicians were simply biased toward a single explanation, causing them to overlook other possibilities and thus fail to gather relevant data. Interestingly, Graber et al concluded that cognitive errors (processing biases) were more common than errors caused by gaps in knowledge. That study broke new ground by isolating different types of medical errors and identifying the underlying causative mechanisms. Disentangling the complex processes that lead to diagnostic errors opens the door for developing more effective strategies for intervention.[37-41]

The phenomenon of premature closure identified in the study of Graber et al[22] provides additional insight regarding the combined influence of the "anchoring and adjustment" heuristic and the "confirmation" bias: the clinician quickly forms an initial impression (an anchor) and adjusts this tentative judgment until a diagnosis is finalized. When the search for information begins after determining the anchor, reasoning takes place in a backward fashion from hypothesized diagnosis to supporting data. Studies show that this strategy biases the clinician's attention on the information that confirms the initial clinical impression; this can result in disregarding data that are important but inconsistent with the preliminary diagnosis.[23,42]

Reducing errors in orthodontic diagnosis and clinical judgment has been a topic of much discussion and research over the past several decades, especially in developing refined, multi-dimensional diagnostic and treatment planning protocols.[43-54] Although some interest in the psychology of decision making can be found in the orthodontic literature to date, our literature search failed to find studies or reviews concerning cognitive biases (and the failed processes that underlie them) and their possible roles in causing errors in judgment and decision making in the everyday practice of clinical orthodontics.[55,56]

The aims of this article were to summarize findings from the literature concerning the impact of cognitive biases in medical decision making and to show the possible relevance of these findings in clinical decision making in orthodontics.[57-60] By highlighting possible examples of such flawed decision making strategies in clinical orthodontics, we hope to familiarize our practicing colleagues with these potential sources of error and, in so doing, to help better equip all of us in ways to avoid them. Finally, it was our intent to inspire future domain-specific study and research in the constraints of flawed decision-making strategies and biases in clinical orthodontics, especially under conditions of complexity and uncertainty.

WHAT IS COGNITIVE BIAS?

Cognitive biases are tendencies commonly used to acquire and process information by filtering it through one's own beliefs and experiences.[61] They are flaws in judgment, which studies have shown are caused by memory, social attribution, and statistical errors.[25] Humans develop cognitive biases for many reasons; however, they are frequently the result of a system of heuristic processes (problem-solving strategies) that help the brain to process information quickly. Although heuristics are indeed helpful in problem solving, under conditions of complexity and uncertainty, they are known to produce systematic errors in judgment.[59,62] Numerous cognitive biases have been identified and shown to be relevant in many health care settings.[23,24,27,62-76] Specific strategies for heuristic reasoning and associated errors in thinking that are reviewed here have been truncated to those that seem most relevant, in our opinions, to the medical sciences, including orthodontics.

It is important to distinguish cognitive biases from other forms of bias, such as cultural bias, organizational bias, or bias that results from one's own self-interest. In other words, a cognitive bias does not result from any emotional or intellectual predisposition toward a certain judgment but, rather, from mental procedures for processing information.[77] When psychological experiments show a bias, this does not mean that every judgment by every person will be biased. It means that, in any group of people, there will be bias to a greater or lesser degree in most judgments made by most of the group. On the basis of this kind of experimental evidence, one can only generalize about the tendencies of groups of people and not make statements about how any specific person will make judgments and render decisions. Psychological studies in this field used test subjects from many disciplines, including physicians, stock market analysts, horse-race handicappers, chess masters, research

directors, and professional psychologists. This research extends the pioneering work of Kahneman et al.[78] In most cases, the mental tasks performed in these experiments were realistic and domain specific; that is, they are comparable with judgments that specialists in these fields are normally required to make.[77] Although specialists in orthodontics have not been studied, we are thus persuaded that the findings from medicine and nursing most likely apply to the cognitive processes used by orthodontists.

DUAL PROCESS THEORIES OF COGNITION

Recent studies in cognitive psychology suggest that our brains use 2 distinct and neurologically differentiated systems of understanding.[25,79-82] System 1, the heuristic, is automatic, intuitive, parallel, and fast; system 2, the analytic, is rule-based, serial, and slow—ie, consciously deliberate. The theory that seems to be emerging in understanding the functional relationships posits that system 1, through a collection of an indeterminate number of subsystem manipulations, delivers judgments to the conscious mind, where the conscious reasoning processes of system 2 take over to produce its own judgments. System 2 provides the capacity to abstract and decontextualize information. It applies rules and protocols in accordance with explicitly codified instructions, making use of central working memory. Importantly, this system copes efficiently with only 1 task at a time (bounded rationality).[25,64,69,79,81-87]

Studies in the medical domain have raised questions as to whether the intuitive and tacit processing of system 1 and the analytical and scientific processing of system 2 are equal partners in producing correct judgments. Research in the nursing literature suggests that nurses rely on both systems equally in real-world decision making.[70,72,88] However, cognitive psychologists have generally thought that system 2 takes epistemological precedence over system 1, overriding or inhibiting its responses by default and serving in a supervisory capacity by monitoring and correcting the intuitive judgments.[81,89] Other studies have demonstrated that the intuitive processes in system 1 will be predominant when dealing with complex and ill-structured tasks that often confront clinicians' decision making, when information is often lacking and probabilities are unknown.[90,91] Studies are ongoing to better understand and explain the functional relationships of forming judgments and decision making and to validate whether the dual-process theory truly accounts for the complexities of human thinking operations.[37,92] But, for now, we concluded that the dual-process theory holds promise in helping to explain judgment biases and errors that predictably occur in human reasoning and provides a helpful model for the study of decision making under uncertainty in orthodontics.

THE HEURISTICS AND BIASES TRADITION

As mentioned previously, the identification of the relationship between cognitive heuristics and bias under uncertainty began with the research program by Kahneman et al.[78,93,94] (In 2002, Daniel Kahneman won the Nobel Prize in economics for his work in prospect theory, a theory that explains how people evaluate potential losses and gains under risk).[78,95] Over the past 4 decades, intense research has been ongoing to explain not only the psychological mechanisms for reasoning, formulation of judgments, and decision making, but also in more recent years to study the neural functions of the brain during these processes.[96-101] The literature consistently shows that people use a subsystem of intuitive mental routines to cope with the complexity inherent in most decisions. These simplifying heuristic mechanisms, although prone to bias and errors, are nonetheless essential in directing our judgment and in most situations will serve us well.[102] The problem that people face is that errors in judgment easily go unchecked (system 2). Again, intuitive reasoning (system 1) relies on experiential, tacit knowledge undergirded by heuristic rules to streamline judgments. However, since not all information is considered in this mental process, heuristics can lead to predictable errors in judgment.

Numerous heuristics and their potential for biasing judgments in health care settings have been extensively cataloged.[59] We have selected several biases and judgment traps that seem relevant to the clinical judgments and decision making in orthodontics to illustrate how each bias theoretically could play out in clinical orthodontics. Each bias (observed behavior) and underlying heuristic (mental construct) is illustrated with real-life scenarios or clinical applications.

REPRESENTATIVENESS

People assess the likelihood of an event by the similarity of the occurrence of the event to their stereotypes of similar occurrences. This might, in some cases, be useful as a good first-cut approximation, but it becomes problematic when this heuristic is taken as accurate, complete, and sufficient when there is better information with which to make a more accurate judgment.

A clinical application is the extraction vs nonextraction issue. Because of a certain facial pattern and how it fits or does not fit a provider's idea of how a face should look, a decision is made not to extract even when there is better information (eg, degree of crowding, position and

inclination of incisors, periodontal architecture, and so on). In such a case, the provider decides that "this is a nonextraction face," and everything else, including subsequent and arguably more significant diagnostic evidence, becomes secondary.

THE COMMISSION BIAS

Providers tend to favor action rather than inaction. Commission bias is more likely to occur in someone who is overconfident; it reflects the urge to "do something." Pressures from colleagues or the patient can augment commission bias and lead to a commitment to action even when related evidence or practice guidelines show that inaction is the best course.

A clinical application is the 1-phase vs 2-phase treatment of Class II patients. The movement toward early treatment of Class II patients by "growing mandibles" via growth modification began in the 1970s. Phase 1 treatment continued to grow in popularity over the next several decades. When the results of various clinical trials funded by the National Institutes of Health on early treatment cast doubt on the relative efficacy and effectiveness of such treatment, many orthodontists refused to accept the validity of that research.[103-106] We ignored the evidence, even though it represented the finest studies available to clinical orthodontists. We assumed that the authors of the trials did not know how to properly manage the functional appliances used in the studies, or that the significant variations of subject responses obfuscated the outcomes, or that mean data do not speak to the treatment of individual patients. There are many reasons to explain such illogical behavior, but a large part of the explanation arises from the biases we as providers bring to the table. For some of us, our desire to do something outweighed the evidence that suggested that a Class II malocclusion can be corrected later and in less time. Certainly, immediate treatment can benefit patients psychologically and, perhaps, better protect them from early trauma. However, in the absence of such concerns, it is now accepted that the cost-benefit ratio does not justify routine 2-phase treatment for most patients with Class II malocclusions.

Considering the complexity and controversy surrounding early treatment in particular, it is possible that no 1 heuristic or bias adequately explains our reluctance to accept this reality. A commission bias prompts us to do something, even if it is not necessarily the correct decision. A visceral bias introduces our emotions into the equation and allows positive (or negative) feelings toward our patients to replace or, at least, influence the desired objectivity necessary for good decision making. To both of these common judgment traps, add the possible and subtle influence of a value bias, which is the tendency for people to favor what they hope will happen rather than what they believe will happen. Then one can better understand our collective tendency to practice and promote early correction of Class II malocclusions in spite of mounting and compelling evidence to the contrary.

THE OVERCONFIDENCE BIAS

Overconfidence has been identified as a common judgmental pattern and demonstrated in a wide variety of settings. People often tend to be overly confident about the infallibility of their judgments and the accuracy of their estimations. The consequences can range from annoyance to severe repercussions. Although confidence in our abilities and judgments is necessary for achievement in life, overconfidence about the accuracy of predictions results in setting too narrow a range of possibilities and overlooking probable outcomes. However, tests and disciplines can be built into our thought processes to uncover errors in thinking before they become errors in judgment.

As a clinical application, good examples of this judgment trap can be found at the podiums of many of our national meetings. A clinician with a good original idea is sharing his experience of his new appliance or treatment on a large screen in front of many practitioners. Although not random, his before-and-after case reports are favorable and indeed demonstrate a biologic plausibility for the success of his new treatment. But the second and equally important criterion that must be met for a theory to become reality is for the new idea to withstand the rigors of the scientific method. Without such testing, even the best idea remains opinion and conjecture, even when held and delivered by the most charismatic and earnest person. The fact that almost everything in orthodontics works at least some of the time does not even occur to the speaker. Instead, an air of infallibility and overconfidence sets in, and the need for testing is replaced by the need to get the word out about the extraordinary appliance or therapy, and a promise that "the data are on the way" is quickly composed. A corporate sponsorship increases credibility, and the goal shifts from seeking truth about a potentially better treatment to satisfying the shareholders of the sponsoring corporation.

ANCHORING AND ADJUSTMENT HEURISTIC AND THE CONFIRMATION BIAS

Anchoring is the tendency to perceptually lock onto salient features in the patient's initial presentation too early in the diagnostic process and fail to adjust this initial impression in the light of later information. This

disposition can be compounded severely by the confirmation bias, which is the tendency to support a diagnosis rather than to look for disconfirming evidence to refute it, even though the latter is often more persuasive and definitive.

The following is a clinical application. As we observed from the findings of the study of Graber et al,[22] described briefly earlier, the effect of cognitive bias is to lead to premature closure, which accounts for a significant number of missed diagnoses.[28,107] Orthodontists might be predisposed to these errors, especially when making complex decisions under the stress of managing high volumes of patients, as typical of contemporary clinical practices.

Here is a scenario that might apply. A 9-year old girl comes for an evaluation of a possible overbite problem. The chair-side examination shows a full-step Class II molar relationship, a 5-mm overjet, a deep anterior overbite, and moderate anterior crowding. Her profile is moderately convex, but her lips are competent in repose. Her mother reports that her daughter "looks just like I did at her age," but, in her case, an orthodontist had advised delaying orthodontic treatment until her deciduous molars became loose. The mother states that she was treated at age 12 (all her deciduous molars were exfoliated). Four premolars were removed. She wore braces for about 2.5 years and remembers having to wear rubber bands for a long time. Now she wonders whether the decision to remove permanent teeth was really necessary. She recently read that treatment of bite problems should begin earlier to take advantage of jaw growth, and so she is seeking advice for her daughter. At this point in the conversation, an office assistant reminds the orthodontist that he is running behind schedule; several patients are waiting, one of whom needs the removal of a Herbst appliance. There is at least 1 emergency, and another patient is ready for the initial placement of full appliances. Having noted that the patient has no profile concerns or functional problems, the orthodontist, pointing to recent studies, assures the mother that it is okay to delay treatment until her daughter's growth spurt begins and tells the assistant to schedule the patient in about a year for a follow-up evaluation to assess maturation and determine the timing for diagnostic records. The patient returns at age 11 for the follow-up evaluation and full records. She reports that menses began over a year ago. Additional data show that her skeletal maturity is 13 years. The cephalometric analysis shows a significant mandibular size deficiency, which is being masked by mandibular overclosure. Realizing the true severity of the patient's malocclusion, the orthodontist now regrets not having made the diagnosis 18 months previously.

From the vantage point of hindsight, this anecdote points to several flaws in judgment. The busy orthodontist anchored initial impressions on the relatively mild clinical profile presentation during the first examination and, under the press of other demands, failed to pursue other vital information regarding the patient's developmental status and family history. The orthodontist adjusted and confirmed his cursory impression by focusing on the child's lack of concern to confirm his opinion with the conclusion that she could be well treated at the onset of puberty around 11 years of age. Anchoring and confirmation bias led to premature closure (system 1) that, ironically, was based on a sound scientific rationale (system 2), a scenario that shows the psychology behind a flawed judgment and a missed diagnosis.

CONCLUSIONS

Cognitive psychology is the science that examines how people reason, formulate judgments, and make decisions. The literature in this field is vast, and so the primary focus of our overview has been to target studies of decision making in health care settings. The volume of applied studies in various medical fields is extensive. The literature shows that many errors in diagnostic thinking are attributable to heuristic reasoning, whereby clinicians use mental shortcuts to maximize making efficient judgments when circumstances are complex and uncertain. We should first acknowledge that heuristic reasoning in many circumstances is typically accurate and produces desired results with a minimum of delay, cost, and anxiety. However, the research also shows an important caveat: certain heuristic strategies lead to flawed judgments from misleading intuitions. Unfortunately and surprisingly, our search produced no findings of comparable research in orthodontics. Since there are many obvious parallels in the patterns of diagnostic reasoning between physicians, nurses, and orthodontists, there is probable cause to believe that orthodontists are also susceptible to similar cognitive errors when making judgments and decisions under complexity and uncertainty. We hope that the scenarios provided here will help lend credence to our hypothesis and encourage future research efforts. Our overall goal is to encourage our colleagues in orthodontics to be open to the possibility that such errors can occur in clinical decision making, to help better understand how these mistakes typically are made and to take corrective action to avoid them.

We recognize that this is an ongoing and difficult process for all of us. We operate from an understanding that, although the willingness to analyze our thinking processes can be humbling and even make us vulnerable, in the end we are better clinicians and care providers for the effort. So, we invite you to give us your responses,

thoughts, and suggestions that can help us to implement strategies and educational models to improve our decision-making acumen and identify appropriate questions for future research.

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