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Recognition and prevention of cognitive biases and judgment errors in diagnostics and dental therapy

Introduction: Cognitive biases affect perception, memory, thinking and judgment. Mostly, they are the result of heuristics, i.e. mental shortcuts accelerating the decision-making process. In medicine, several biases can be recognized in both patients and practitioners such as choosing between treatment options and making errors in diagnostics and therapy, respectively.

Methods: In order to synthesize this review, the literature in psychology and medicine was analyzed for the purpose of elucidating various biases and describing their relevance in dental practice.

Results: Several cognitive biases were found to be relevant for diagnostics, decision making, treatment and practice management: the tailored framing of the communication content changes the perception of risks and influences the placebo and nocebo effects. The status quo bias may explain why patients tend to avoid undergoing reasonable treatment due to loss aversion. Affect heuristics shows the dependence of decision making on current emotions, which are rarely beneficial for the patient. Both the confirmation bias and attribution error affect diagnostics; facts supporting the initial diagnosis are given preferential consideration and the symptoms of patients who are perceived as difficult characters may be ignored or conveniently classified as psycho-somatic. The anchoring effect demonstrates why initial information has a disproportionate influence on the diagnosis. The overconfidence bias results in the practitioner's distorted self-perception, which can result in errors in diagnostics and therapy. Priming can direct the patient's perception towards a more positive outcome. The peak-end rule states that the recollection of a treatment is mainly influenced by the most aversive and final stimulus. The hindsight and outcome biases illustrate the tendency to remember a past experience in a distorted manner after events occur, thus underlining the importance of detailed patient records. The perception of the dentist's competence depends not only on dental skills, but due to the halo and nocebo effects, also on the environment, circumstances and style of communication.

Discussion and conclusion: Cognitive biases affect both patients and dentists and this leads to errors in diagnostics, decision making and treatment. Dentists can try to use debiasing strategies in order to reduce those effects. Visual images such as pie charts and bar graphs help to reduce the effects of framing, especially in patients who are not mathematically inclined. The strategic use of cognitive biases by practitioners can be used to direct patients' perceptions towards more positive treatment experiences.

Keywords: biases; heuristics; psychology; diagnostics; decision making; treatment; practice management

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1. Introduction

For centuries, a general consensus existed that humans are rational beings who make deliberate and utility-maximizing decisions. Yet, over time, it has become increasingly clear that various influences affect the decision-making process.

Biases are universally detectable cognitive distortions in perceiving, remembering, thinking, and judging. They usually arise due to the use of heuristics, i.e. mental shortcuts that accelerate decision-making processes through unconscious judgments [19]. Also, in medicine, diverse biases exist. These affect both patients when they weigh treatment options, as well as, physicians who can make diagnostic and therapeutic errors [38].

The aim of the article is to describe some of the systematic errors which are particularly relevant for dental practitioners with regard to diagnostics, the interaction between dentist and patient, therapeutic decisions, but also for dental practice management. This is intended to enable dental practitioners to better reflect on and control their behavior as well as to understand patient actions more thoroughly. In addition, specific strategies may help to reduce the effects of practitioners' cognitive biases (debiasing).

2. Diagnosis, therapeutic decision and treatment

At the start of every dental treatment, the anamnesis as well as the extraoral and intraoral findings are collected. This is followed by the diagnosis, the presentation of treatment options, informed decision making and potential treatment. The inherent cognitive biases in this process are explained below.

2.1 Framing

The concept of "framing" refers to the specific framework in which the content in communication is conveyed, as the form of presentation influences the reaction to the content [44]. A well-known study of the phenomenon of different reactions to a situation, which is the same in terms of content, but presented differently in terms of communication, includes the example of a fictitious illness formulated by Tversky and Kahnemann [44]. In the study, 600 people were told that they might have been infected during the outbreak of a disease and then asked to evaluate programs for dealing with the disease: by applying Program A, 200 people would be safely saved, while Program B would save all 600 people with a probability of 1/3 and nobody with a probability of 2/3. Although both programs had the same expected value of survivors, 72 % preferred program A, the risk-avoiding alternative. Other participants received the following alternatives: by applying program C, 400 people would die, while the application of program D corresponded to a 1/3 probability that nobody would die and a 2/3 probability that 600 people would die. Only 22 % of the participants chose program C in spite of the fact that its content contains the same risk-avoiding scenario as program A.

People thus prefer a risk-avoiding option in the case of a potential gain, but make riskier decisions when losses are anticipated. Accordingly, the way a therapy is presented will lead to different decisions depending on whether the option is in the context of a gain or loss. A systematic review showed that patients are 1.5 times more likely to choose a riskier treatment alternative if the expected outcome is presented as a survival rate rather than a death rate [27]. Framing can also enhance the placebo effect and weaken the nocebo effect [12]. Yet, not only patients are affected by framing: physicians likewise interpret data, such as drug efficacy, differently depending on how the data is presented [33].

If the findings pertaining to framing are applied in dentistry, there is the presumption that patients will evaluate the possibility of tooth preservation more positively when it is framed as a gain. This includes, for example, the phrasing that 9 out of 10 teeth will be saved by root canal treatment. When framing a loss, such as the possibility that one tooth out of 10 teeth will not be saved, the judgment is expected to be less positive.

2.2 Denominator neglect

The way probabilities are presented also influences the decision. Subjects had the choice between an urn containing 10 balls, one of which was red, and another urn containing 100 balls, 8 of which were red [29]. The study participants were then asked to select the urn from which they would like to draw a ball, knowing that a prize would be offered for drawing a red ball. Although the first urn should have rationally been preferred, 30–40 % of the study participants chose the second urn because of the higher nominal numerator value. They neglected the influence of the denominator. Applied to dentistry, this means that patients evaluate therapeutic outcomes more positively if, for the same probability, the representation with a larger numerator is selected, e.g. 90 out of 100 teeth instead of 9 out of 10.

A variation of this phenomenon is evident in another study in which the same probabilities led to different estimates due to different representations: forensic psychologists and psychiatrists were asked to decide whether a patient could be discharged from a hospital. The probability of committing a violent crime within 6 months after discharge was estimated at 10 % for similar patients. Other participants were told that, from 100 similar patients, 10 would commit a violent crime within 6 months of discharge. Despite equal probabilities, only 21 % of psychologists and psychiatrists were against discharge in the first presentation, compared with 41 % in the second, nearly twice as many [41]. This means that a higher probability of occurrence is assigned to absolute frequencies than to percentages when they represent the same value.

Conversely, when numbers are compared directly, a relative description such as a 100 % increase has a more dramatic effect than an absolute comparison involving an increase from one to two cases per 1000 patients. The representation of results in absolute numbers is thus considered to be the format least influenced by bias [33].

2.3 Status quo bias

It is not uncommon for therapeutic proposals to be prepared for patients and discussed with them, but ultimately not be carried out. Causes for this include the fear of treatment [16], on the one hand, and financial aspects, on the other hand [14]. However, even patients for whom these factors do not apply sometimes wait until the onset of complaints. The reason for this may be the "status quo bias," i.e., the preference to maintain the current condition. If an existing status quo alternative exists, it is chosen disproportionately often [37]. In dentistry, this implies that patients tend to want to avoid treatment in order to maintain the current condition, especially if there are no acute complaints.

One of the explanations for the status quo bias is "loss aversion". This describes the tendency to avoid losses if there is an equal chance of a gain [21]. Some studies suggest that losses are perceived twice as negatively as gains of the same magnitude [22].

Despite today's massively changed living environment compared to earlier developmental times, one conceivable explanatory approach is of an evolutionary nature: if the loss of a unit of food might have been fatal, the gain of an additional unit yielded little advantage in relation to it. In connection to dentistry, this effect means that, in the absence of complaints, the risk-benefit ratio of treatment is shifted in the direction of the risk of possibly experiencing pain after treatment. The above-mentioned factors can then result in the status quo bias of tending to avoid treatment.

2.4 Affect heuristics

Affect heuristics describes how people generally tend to make decisions depending on their current, prevailing emotional state. Like the status quo bias, it can influence patients' treatment decisions. If the feelings towards a situation are positive, the risks are assessed as being lower and the potential benefits as being higher. On the other hand, if negative feelings predominate, the assessment is reversed [6].

Current emotional states can influence treatment decisions in dentistry. The "fight-or-flight" reaction is particularly pronounced in anxious patients. As originally described by Walter Bradfort Cannon [4], the body automatically reacts with fight, flight or freeze in moments of fear. In these conditions, it is more difficult for a patient to make rational decisions. In relation to elective treatments, it has been shown that anxiety leads to the rejection of certain dental treatments [24]. Thus, the practitioner should be aware of the patient's emotional state. This awareness can occur intuitively or through the acquisition of additional knowledge for analyzing facial expressions [5], body language, voice, etc.; it represents a demanding and central task of the dentist.

2.5 Confirmation bias

The confirmation bias describes the tendency of people to interpret, select, and favor information in ways that fit their own expectations [30]. Attempts to revise these assumptions are rarely made. This is because maintaining two opposing opinions at the same time creates cognitive dissonance, which can lead to mental stress or even physical discomfort [11]. In diagnostics, this mental bias can ensure that, once practitioners are convinced of the correctness of a diagnosis, they will selectively search for facts supporting the respective theory.

2.6 Attribution error

The attribution error states that the reason for complaints is searched for in a patient's personality traits, and consequently, symptoms may be overlooked. This is particularly true if dealing with the patient is strenuous due to their personality type, and the causes of the symptoms of discomfort are unclear [9]. Mentally taking a step back in order to objectively check if the correct diagnosis has actually been made or a premature ending to the diagnostic process is being aimed for is worthwhile.

2.7 Illusion of truth

Patients do not generally know whether the information presented by the dentist is factually correct. Hence, they rely on the trust placed in their practitioner. Whether a true statement is judged as being true or false depends on various factors which can be influenced to some extent.

The frequency with which a piece of information is perceived tends to determine whether it is believed to be correct or false. In one study, different statements were presented at two-week intervals for a total of three times and it was assumed that the subjects did not know the correct answers. The content that was repeated all three times was assigned a higher degree of truthfulness [15]. Thus, it is advantageous for the success of the practice when consistent communication with the patient is used by all employees.

"Processing fluency" also contributes to the assessment of a statement. Information that is conveyed using clearly legible lettering and color is easier to process mentally. Consequently, a higher degree of truthfulness is attributed to it [34]. The same applies to the use of language: content has a more credible effect when it is presented with words that are easy to understand [32]. When conveying information to the patient, the practitioner should attempt to make it as comprehensible and discernable as possible by using, for example, medical decision aids such as decision boards [23].

2.8 Anchoring effect

In a study, Tversky and Kahneman manipulated a wheel of fortune so that it could only stop on the numbers 10 and 65. After spinning the wheel, the subjects were asked how high they thought the share of African states in the United Nations was. Mean estimates were 25 % in the group that had been shown the number 10 on the wheel of fortune, and 45 % in the other group [43]. A number that is completely independent of the outcome therefore significantly influences estimates and serves as an anchor to which further mental steps are attached.

The anchoring effect is also present in medicine, for instance in diagnostics, where it ensures that the first piece of information mentioned influences the subsequent analysis, and

it can thus lead to an incorrect result [38]. If a physician has made a tentative diagnosis, for example, it serves as an anchor that influences the next physician's diagnosis [18].

2.9 Overconfidence Bias

The overconfidence bias describes the fact that most people perceive themselves and their abilities as above average [25]. The overconfidence bias can also lead to incorrect diagnostic outcomes, as already established diagnoses are no longer questioned [2]. Especially beginners overestimate their abilities in the profession [8]. Together with framing, the overconfidence bias is one of the most common cognitive biases among physicians and it may be the cause of treatment errors [38].

2.10 Priming

The priming effect states that input from a particular stimulus influences the processing of subsequent afferent input. This has to do with the fact that implicit memory content is activated for the most part unconsciously by the first stimulus [28]. For example, if one reads the word "eat", one will subsequently complete the word fragment "so_p" as "soup" rather than "soap". The contrary would probably be the case if the word "wash" is read before [31].

In an investigation in which patients were shown a list of mentally, or physically, threatening as well as neutral and positive words prior to root canal treatment or extraction, it turned out that anxious patients remembered significantly more threatening words than those who were not anxious [3]. Dentists should be aware of the fact that certain words increase anxiety, and that anxiety in turn can also affect the perception of aversive stimuli. By intentionally applying this knowledge, patients' perceptions can be steered in a positive direction through the use of words that are not associated with pain or anxiety.

2.11 Negativity dominance and the peak-end rule

Negativity dominance states that when positive and negative stimuli are of equal magnitude, negative stimuli have a greater impact on the psychological well-being [36]. Therefore, the methodical avoidance of aversive stimuli in dental treatment should generally be pursued.

A distinction is also made between what patients feel during treatment and what they remember after it, where the latter is decisive for the final assessment. In a study assessing pain during colonoscopy – performed with no narcotics and amnestic drugs at that time – patients were asked once per minute about the pain they felt at a particular moment and the pain intensity was plotted against time [35]. The scale of pain intensity ranged from "pain-free" (grade 0) to "unbearable pain" (grade 10). Subsequently, the patients were asked to provide an overall retrospective assessment of the pain they had experienced during treatment. Theoretically, the results should have correlated with the area under the curve of the recordings, but this was not true. The grading was well predicted by the pain intensity at the peak and at the end (peak-end rule), while the duration of the unpleasant sensations was neglected.

Relating to dentistry, this means: if the goal is to ensure that the patient remembers the treatment as being the least unpleasant as possible, the dentist must first try to keep the peak of aversive stimuli as low as possible during the entire treatment period. On the other hand, the treatment session should be planned to end positively, for example, through the use of empathetic communication or by performing the final treatment steps in a particularly gentle manner.

2.12 Hindsight and outcome biases

The human brain's ability to reconstruct past beliefs after a change of opinion is inadequate [20]. This leads people to assess previous events as having been more predictable than they actually were before they occurred, which is then referred to as hindsight bias.

The outcome bias refers to the assessment of the quality of decision making based on the influence of currently known outcomes. Actions which may have seemed thoroughly thought out at the time of the decision may now be considered negligent under the impression of events occurring differently than expected. Therefore, in the legal evaluation of medical negligence, the hindsight and outcome biases play a role because both pose a risk to the realistic judgment of a situation that occurred in the past [17].

In dental practice, the dentist should be aware of the effects of the aforementioned cognitive biases. The need for accurate records of all findings and procedures is particularly clear in cases where dentists are required to prove exactly how they arrived at certain therapeutic steps in the event of an accusation by the patient, thus avoiding the negative consequences of the hindsight and outcome biases.

3. Practice management

There are also some biases and misconceptions when it comes to practice management and dealing with employees; knowledge of them can potentially improve success and employee satisfaction.

3.1 Fundamental attribution error

Attribution is the process of assigning causes to behaviors. External attribution is characterized by seeking reasons not related to the self, but rather, to the difficulty of the task or the influence of other people. Internal attribution refers to searching for causes related to the self, e.g. individual abilities, personality, or motivation. The fundamental attribution error states that strange behavior is mostly explained by the traits of the respective person. In contrast, attribution varies when self-performance is assessed: in the case of negative events, the influence of the situation is more likely to be emphasized, whereas in cases of positive events, mainly dispositional factors of the person are seen as the cause of success [13]. Practitioners should be aware of this bias in order to achieve satisfactory communication with their staff. If a mistake is made, knowing that the situation and not necessarily the lack of skills or lack of motivation is potentially decisive; this allows the practitioner to solve problems more empathically.

Bias	To be considered in practice	Example
Affect heuristics	Establishing an emotionally positive setting	e.g. "take a deep breath in and out" vs. "you do not need to be afraid"
Anchoring effect	In diagnostics, ensuring that the initial information does not disproportionately influence the subsequent analysis	e.g. patient: "my family dentist has said that the tooth can no longer be preserved"
Attribution error	In case of unclear complaints, do not search prematurely for a diagnosis based on the patient's personality structure	e.g. in cases where patients are receiving psychological therapy, do not directly assume that the causes for the complaints are psychosomatic
Availability bias	Question diagnoses so that recently acquired knowledge regarding a possibly rare disease does not influence the current diagnosis through its mental presence	e.g. considering the possibility of bone metastasis of a carcinoma for apical ostitis
Confirmation bias	Diagnostics: do not only search for facts that confirm the initial assumption	e.g. suspicion of "symptomatic apical periodontitis" after positive percussion test. Nevertheless, consider and check other diagnoses (e.g. sinusitis maxillaris)
Denominator neglect	A higher numerator increases the perceived probability	e.g. "90 out of 100 teeth are retained by treatment" vs. "9 out of 10 teeth are retained by treatment"
	Absolute frequencies increase the perceived probability	e.g. "90 out of 100 teeth are preserved by treatment" vs. "90 % of teeth are preserved by treatment"
Framing	Present treatment options using positive framing	e.g. "9 out of 10 teeth are preserved by treatment" vs. "One out of 10 teeth cannot be preserved"
Fundamental attribution error	Being aware of dispositional and situational influences on oneself as well as on others	e.g. in patients with a small mouth opening, do not directly assume that a lack of willpower might be the cause
Halo and horn effect	Factors not related to the dental performance per se also influence the patient's judgment	e.g. paying attention to friendliness, cleanliness, etc.
Hindsight and outcome biases	Complete recording of the findings and treatment procedures	e.g. clarification of the treatment procedure and recording the participatory decision making of the patient
Illusory truth effect	All employees consistently communicate the same information to the patient	e.g. regular team meetings in order to discuss and coordinate communication with patients
	Patient information clearly legible (color, font), use of easily understandable words	e.g. written information for patients should be easy to understand
Loss aversion	Might lead to the avoidance of treatment, especially when no pain is present	e.g. patient has no complaints. Thus, no subjective gain is likely achieved through treatment, but only a potential loss of freedom from pain
Overconfidence bias	Critically scrutinize own diagnoses and performance	e.g. discussing cases with colleagues
Peak-end rule	Minimize the magnitude of aversive stimuli during treatment and end the treatment procedure on a positive note	e.g. performing the final treatment steps in a gentle manner, concluding discussion should take place in a positive atmosphere and at eye level with patients
Priming	Using positive words to describe the treatment	e.g. treatment of children: "We'll put the tooth to sleep now" instead of "There is a sting now"
Status quo bias	Might lead to the patient's avoidance of treatment due to the tendency to want to maintain the current condition	e.g. patient no longer comes for treatment after the therapy has been proposed

Table 1 Overview of the above-mentioned biases listed in alphabetical order and their significance in dental practice
(Tab. 1: O. Rehder)

3.2 Perceived competence of the dentist

The patient's image of the dentist's competence is not only determined by dental skills. The "halo effect" states that the positive impression of a person, company or brand in a certain area has a favorable effect on its judgment in another unrelated area [1]. The opposite of this is the so-called "horn effect" [40], in which a negative factor influences the judgment in areas that are not actually associated with it. If these findings are transferred to dentistry, it can be assumed that both the halo and horn effects unconsciously influence the judgment of the dentist's competence. This is because factors such as friendliness, attractiveness and equipment of the practice, all of which do not correlate with the actual quality of treatment, have an effect on the formation of the patient's opinion.

The individual's own prediction about how a task will be accomplished has an influence on perceived competence as well: in one study, participants were presented with a task and were required to make a prediction about the outcome that would be attained before beginning to solving it. After the results were evaluated, the observers assessed the competence of the participants. Not only did the actual outcome matter, but also the prediction: participants were evaluated positively if good self-assessments were followed by congruent performance, or if the quality of the latter remained unknown; conversely, participants with negative self-assessments were evaluated adversely even if their assessment was accurate [39]. Practitioners should therefore be aware of the fact that their own prognosis about the treatment has an impact on the perception of their competence, especially since patients cannot ultimately judge the actual quality of the treatment. In this regard, practitioners should not create unrealistic hopes, but should show confidence which is justified.

4. Summary and prospects

Cognitive biases and the associated misjudgments can affect both patients and physicians. The aim of this review article is to explain a selection of systematic errors which appear to be particularly relevant with regard to diagnostics, the interaction between dentist and patient, treatment decisions and practice management. An all-encompassing presentation of all biases affecting dentistry is beyond the scope of this review article. For this reason, this article has focused on the most important biases and it presents an overview of this information (Table 1).

Various studies indicate that practitioners' errors in diagnosis and therapy can be possibly attributed to cognitive bias [38]. However, the decisions of patients may also be modified by the effects of framing, denominator neglect, status quo bias, anchoring effect, and confirmation bias.

There is also the possibility of using mental biases for the therapeutic advantage of patients: through priming, it is conceivable to channel patients' perceptions in a favorable direction, for example, by using words with positive connotations so that the current experience is not dominated by ideas with negative connotations. Understanding the peak-end rule may put the dentist in the position to prevent situations where the patient experiences severe discomfort and to end the treatment session on a pleasant note, thereby positively influencing the patient's recollection of the treatment.

Knowledge of the hindsight and outcome biases illustrates the need for having good patient records. In cases of negative treatment outcomes, it then becomes possible to comprehend how decisions and treatment procedures were made. In this regard, the records serve as a basis for positive communication with the patient while also providing reassurance should legal disputes ever arise.

Moreover, by knowing about the effects mentioned above, the practitioner becomes aware that it is not exclusively the dental performance per se that determines the practice's success, but, for example, that the halo and horn effects and own prognoses influence the patient's judgment to a certain extent.

Studies aiming to reduce the negative influences of mental biases have shown that it is not possible to eliminate patients' biases by simply pointing out their existence, and then asking the patients to avoid being influenced by them [7]. Accordingly, visual representations in the form of pie charts and bar graphs can help to reduce the effects of framing. It is noteworthy to mention that patients with low mathematical competence benefit more from such visual images than patients with good skills in this domain [10].

The "debiasing" approach can be used in order to minimize the influence of biases on physicians' diagnoses and decisions. This includes the questioning of the initial diagnosis by seeking evidence that rejects and confirms it, before making a final diagnosis [26]. Moreover, the use of checklists can reduce the influence of overconfidence, the anchoring effect, and framing [38].

Mental biases are probably ubiquitous in medicine. However, their true influence on treatment errors and outcomes has not been conclusively examined so far due to the insufficient number of studies [38]. Nonetheless, in the best interest of patients, it makes sense to use these findings in order to give patients the opportunity to make better decisions for themselves and to provide a more positive treatment from a psychological point of view.

Conflict of interest

The author declares that there is no conflict of interest as defined by the guidelines of the International Committee of Medical Journal Editors.

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