Visual perception, cognition, and error in dermatologic diagnosis: Diagnosis and error

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Learning objectives
After completing this learning activity, participants should be able to recognize how cognitive principles can explain medical errors of visual perception and identify exercises that can improve visual recognition.

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Diagnostic error in dermatology is a large practice gap that has received little attention. Diagnosis in dermatology relies heavily on a heuristic approach that is responsible for our perception of clinical findings. To improve our diagnostic accuracy, a better understanding of the strengths and limitations of heuristics (cognitive shortcuts) used in dermatology is essential. Numerous methods have been proposed to improve diagnostic accuracy, including brain training, reducing cognitive load, and getting feedback and second opinions. Becoming comfortable with the uncertainty intrinsic to medicine is essential. Ultimately, the practice of metacognition, or thinking about how we think, can offer corrective insights to improve accuracy in diagnosis. (J Am Acad Dermatol 2019;81:1237-45.)

Key words: cognitive error; diagnostic error; heuristic; metacognition; patient safety; visual intelligence.

In the fields of dermatology and dermatopathology, cognition and perception are at times inseparable. In part 1[1] of this 2-part series, the specific principles that inform visual perception, as well as the pitfalls of visual perception, such as gestalt and inattentional blindness, were discussed. In part 2 of this report, we focus on the cognitive heuristics used in dermatology, along with their

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respective utilities and pitfalls. Attention will then be given to methods for prevention and correction of errors that derive from the use of these heuristics.

HOW WE ERR: WHY THIS SUBJECT?

Numerous sources (autopsy data, studies utilizing standardized patients, systematic reviews, and the Institute of Medicine second report) substantiate an overall diagnostic error rate in medicine of 10%-15%.[2] The staggering magnitude of this is brought to light when compared with errors in aviation (1 in 11 million chance of dying in an air traffic accident).[3] The consensus in medicine is that diagnostic error rates remain unacceptably high.[4] More than 75% of diagnostic errors are cognitive in nature, a direct result of flawed thinking processes.[4] Of the 4 types of cognitive error (faulty knowledge [gaps or inexperience], faulty information gathering, faulty processing [pattern recognition, misinterpretation of data and cognitive biases], or faulty verification), knowledge gaps account for a minority of errors, whereas processing errors make up the majority.[4,5]

Of note, pathology and radiology report lower error rates (~5%).[6] Pathology, radiology, and dermatology share in common a primary emphasis on visual data; in other specialties, language (auditory), kinesthetic, or computational data are primarily used. The lower error rates in specialties in which visual recognition is primarily used might be due to their predominant focus on 1 perceptual modality with less chance of processing error.

Little is known about error rates in dermatologic diagnosis.[7] In a recent pilot study involving the use of biopsies as the diagnostic gold standard, an overall 20% discrepancy rate was noted between clinical and histologic diagnoses.[8] In contrast, in a survey distributed to dermatologists, physicians reported that the majority (85%) of errors happened once a year or less, with most (86%) resulting in no patient harm.[9] The disconnect between the results of these 2 studies (discordance of clinical and histopathologic diagnoses of 1 out of 5 biopsies and diagnostic error of once per annum) should give dermatologists pause. Diagnostic error quite possibly presents the largest practice gap in dermatology today and receives little attention. To address these issues and contradictions and further improve the rates of accurate dermatologic diagnosis, a better understanding of how we process information in this context is critical.

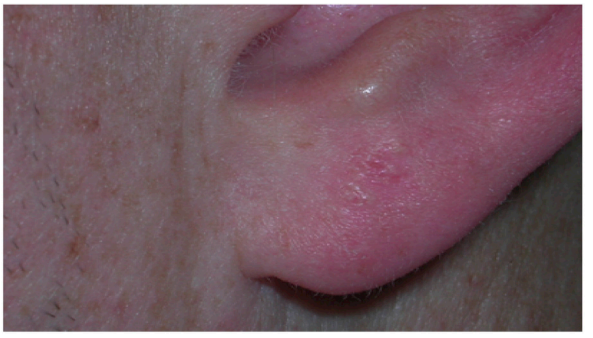

Fig 1. This lesion on the earlobe of a sun-damaged older individual can deceive the viewer diagnostically (gut diagnosis of basal cell carcinoma). Features of the primary lesion (yellow papules) are helpful for identifying this lesion as nevus sebaceous of Jadassohn.

DID I SEE IT (AS COMPLETELY AS POSSIBLE)?

Dermatologic heuristics

As was reviewed in part 1,[1] visual recognition is an intuitive System 1 function that is instinctive and not processed in a logical analytical System 2 manner. Dermatology has specific heuristics (cognitive shortcuts) for diagnosis, including primary lesion, shape, location, distribution, pattern, color, and context.[10,11] Use of these heuristics hones the dermatologist's approach, ultimately increasing the speed and accuracy of the diagnosis of skin disease.[10-13] With skill and experience, a visual diagnosis can be made without conscious awareness in as rapid as 200 ms.[14,15] Yet, these same heuristics contain pitfalls, which will be clarified in this report.

A reliable heuristic in dermatology is the primary lesion (Fig 1). Focus on the primary lesion enables the dermatologist to remove contextual biases created by distribution and location heuristics, which sometimes mislead us diagnostically. However, exclusive focus on the primary lesion can be of limited value in the evaluation of diagnoses where contextual information is essential, such as location in erosive pustular dermatosis of the scalp. In addition, diagnoses made on the basis of the primary lesion can be impossible without comparison with nonlesional skin (eg, morphea or vilitigo).

Other important heuristics in dermatology include shape or pattern, distribution, and color. The mid-18th century cutting portraits of silhouette outlines provides an example of how shape alone can simplify recognition. This technique has been popularized in dermatopathology atlases.[16] For example, a featureless silhouette outline of adnexal tumors often enables rapid low-magnification

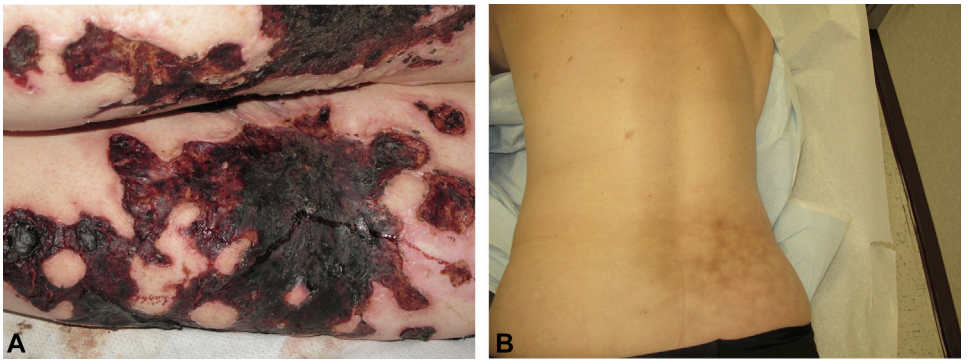

Fig 2. The retiform shape shared by these 2 lesions is a consequence of involvement of the same size and pattern (medium venous plexus) affected by inflammation and clot from repeated and progressive levamisole vasculopathy of the thighs (**A**) and a burn from a heating pad (erythema ab igne) on the right waist (**B**).

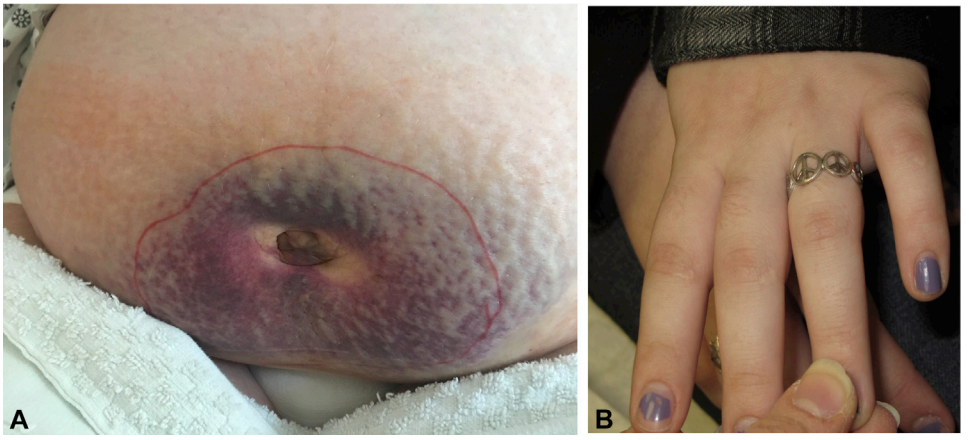

Fig 3. **A**, The periumbilical location of Cullen sign is informative for intraabdominal bleeding secondary to Cesarean section. **B**, Idiopathic scars on the knuckle narrow down diagnostic possibilities for this child to include the rare diagnosis of erythropoietic protoporphyria. (**A**, Photo shared by Dr Rex Ugorgi.)

pattern recognition and diagnosis. In dermatology, this silhouette approach is also useful, for example, when determining the etiology for contact dermatitis or a retiform skin pattern suggesting vascular occlusion (Fig 2, *A* and *B*). In addition to pattern, the location heuristic enables more rapid diagnosis; for example, the periumbilical location of a new purpuric rash immediately brings to mind Cullen sign (Fig 3, *A*). The location heuristic can be essential—the diagnostic key—for particular diseases and skin findings, such as vulvar melanosis, Gottron papules, or the origin of knuckle scars in a child with erythropoietic protoporphyria (Fig 3, *B*). Also, color can serve as the primary diagnostic heuristic, as when distinguishing mucosal sarcoid from Kaposi sarcoma in the mouth (Fig 4, *A* and *B*).

Heuristics can work in opposition. For example, pattern can be more important than the location on the body (Fig 5). Generally, the availability heuristic serves us well, considering that common things are common—hoofbeats mean horses rather than zebras. In Fig 6, *A*, the location and availability heuristics are at war; basal cell carcinoma, a common tumor, is unusually located on the areola. Diagnosis comes easier when heuristics are in harmony; for example, in Fig 6, *B*, the location and availability heuristics point the diagnosis in the same direction (Paget disease is common on the nipple).

The heuristics of context and semantics

Context, a framing heuristic, is an essential cue for gestalt diagnosis and is also considered one of

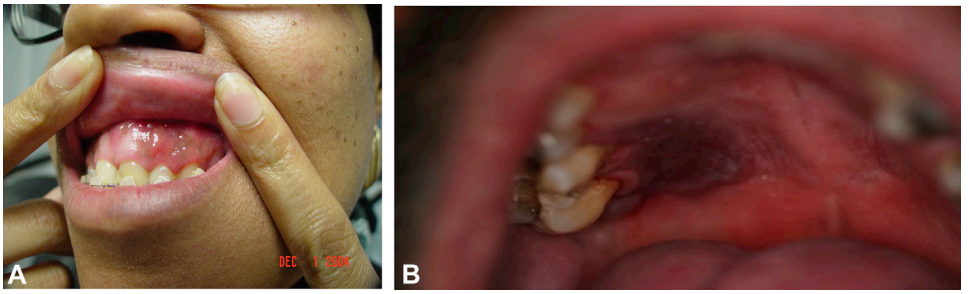

Fig 4. The apple currant jelly color of mucosal sarcoid on the gums (**A**) is distinct from the violaceous color of Kaposi sarcoma on the oral hard palate (**B**).

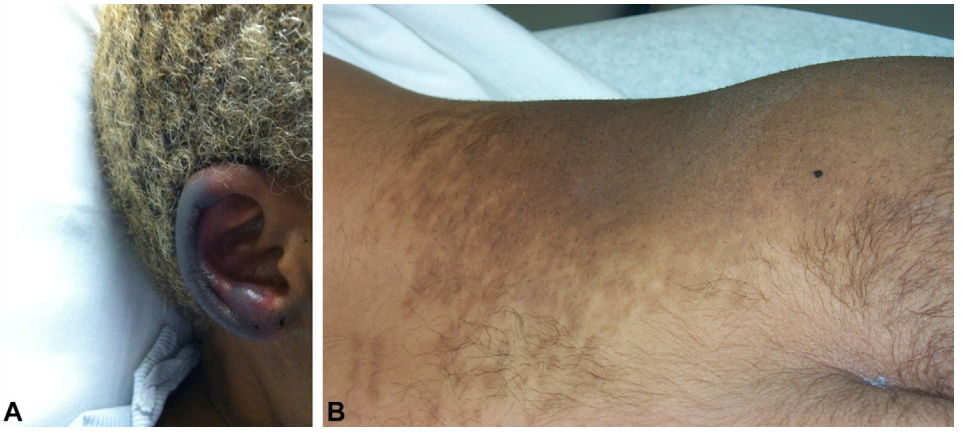

Fig 5. **A**, Purpura at the location of the ear is highly significant in the diagnosis of levamisole-mediated vasculopathy. **B**, The location heuristic (flank rather than the more common site of shoulder and back) is less helpful here than the pattern heuristic (hyperpigmentation with a scalloped edge and hypertrichosis) in identifying a Becker nevus on the hip and buttock area.

the most potentially biasing heuristics. Context can be informational (comorbidities, history of medical procedures, culture or sport activities, medications taken) or visible and can be so informative that it is almost pathognomonic (Fig 7, *A* and *B*).

Verbalization and the use of semantic qualifiers in the description of clinical skin findings can improve diagnosis.[17] Successful diagnosticians have been shown to use twice as many semantic qualifiers as the physicians who were diagnostically incorrect.[18] Using this method requires the existence of descriptive terminology that is both specific and universally understood in the field of dermatology. When adjective descriptors paint a clear image to the listener (eg, grouped vesicles on an erythematous base reflexively suggests the diagnosis of herpes), such use of semantic qualifiers could be diagnostic. However, semantic classification can limit our perspective. Semantics are also only as good as our understanding. For example, nomenclature of melanocytic lesions is not uniform, resulting in much diagnostic disagreement.[19] Likewise, some adjectives (eg, mottled, variegate) lack clear definitions and distinctions, interfering with clarity.[19]

METHODS TO REDUCE DIAGNOSTIC ERROR IN DERMATOLOGY

Brain training

Focus given to skills specific to dermatology can increase diagnostic accuracy. Any effort to increase visual observational skills, even on subjects unrelated to dermatology, can increase diagnostic acumen. The study of art to improve observational skills has been used to train police officers and physicians alike.[14,20-24] Strikingly, just a 15-minute session of observing a painting can significantly increase radiology residents' detection of radiographic abnormalities.[25]

Interleaving, the practice of alternating between related concepts (eg, multiplication and division) within the same learning session, increases learning capacity.[26] Medical students' diagnostic accuracy in interpretation of electrocardiograms

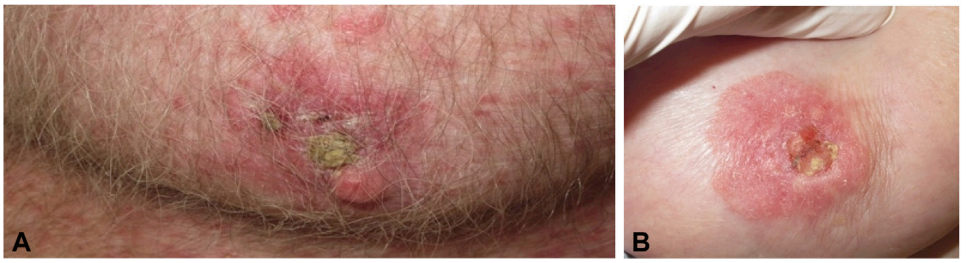

Fig 6. **A**, Erosive basal cell carcinoma involving the areola. Sparing of the nipple itself—which can easily be overlooked—is an important clue mitigating against Paget disease of the nipple. **B**, Erosive Paget disease of the nipple.

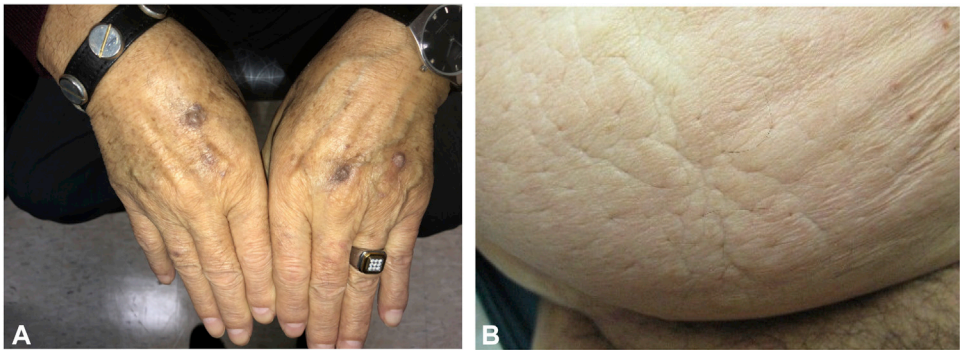

Fig 7. **A**, Eruptive keratoacanthomas on the dorsum of the hands of a cancer patient on sorafenib (tyrosine kinase inhibitor) known to induce these cancers on sun-damaged skin. This example demonstrates the need for contextual information in achieving the correct diagnosis. **B**, Likewise, the context of abdominal obesity enables the diagnosis of lipodermatosclerosis of the pannus secondary to venous circulatory compromise. (**B**, Photo provided by Dr Carl Leichter.)

was significantly improved with such contrastive practice (ie, studying examples from different categories of cardiac disease rather than 1 category alone).[27] This finding has implications for dermatologic education, as students are likely to learn best when examples of disease are contrasted with other diseases with dissimilar appearance, as in atlases.

Beyond the visual, a better understanding of statistics can help avoid common mistakes, such as base rate neglect (the prior probability of a disease occurrence) (Fig 8).

Reducing cognitive load

Human minds are constrained by a limited capacity for information retrieval and processing. The growth of available information has been exceeded only by the expansion of noise.[28] Excess data can overwhelm our minds just as bandwidth constraints can overwhelm communication systems.[29] The more data we have, the more likely we are to drown in it. Cognitive load can be reduced with the use of algorithms, evidence-based protocols, practice guidelines, decision support, and making time for a diagnostic timeout (time to give the case appropriate consideration, whether in the clinic or after hours). Computer-generated differentials or aids built into the electronic medical record or included in pathology reports can lighten cognitive strain.[30] The algorithmic assessment tool Laboratory Risk Indicator for Necrotizing Fasciitis generates scores that correlate highly with accurate diagnosis for the typically difficult-to-diagnosis necrotizing fasciitis.[31] Applications, such as Mohs Surgery Appropriate Use Criteria (American Academy of Dermatology Association, Des Plaines, IL), that aid in the treatment selection for nonmelanoma skin cancer can be very useful.[32] The use of VisualDx for the diagnosis of cellulitis has been proven helpful diagnostically and might help mitigate the >100,000 incorrect admissions per year for diagnoses of cellulitis.[33]

Checklists, although often viewed as crutches for a feeble mind, have repeatedly been shown to

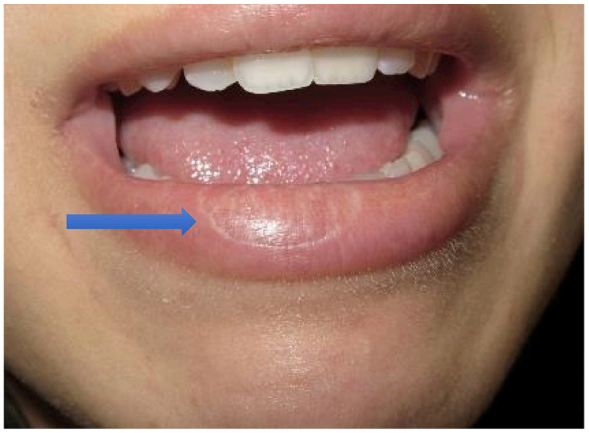

Fig 8. The initial misdiagnosis of this lip lesion as cornoid lamella of porokeratosis is an example of base rate neglect. Ignoring statistical information (rarity of porokeratosis on the lip) in favor of irrelevant information (circular lesion with a raised rim) resulted in overlooking the much more probable and correct diagnosis of lichen planus with an unusual pattern of Wickham striae.

improve performance.[34] Checklists can help us avert our judgement flaws but need to be short and to the point.[35] Vital signs, invented by nurses in the 1960s, are probably the earliest universally accepted checklist, although not referred to as such.[35] A caveat is that although checklists can be useful in simple, clearly understood situations, they are not appropriate for complex situations involving ambiguous data.[36]

Ultimately, modern artificial intelligence tools are predicted to become a part of the norm, as adjuncts in dermatologic diagnostics, decreasing cognitive load and the need for biopsies.[37]

Importance of feedback

Getting frequent feedback can help us correctly calibrate our efforts and help avoid attitudinal overconfidence and complacency. Reviewing our clinical differential diagnoses with biopsy results is an example of a relatively simple way to receive feedback over time on our initial impressions.

Unrealistic expectations from physicians of themselves and their diagnostic accuracy have contributed to a culture of silence around error.[38] Getting a second opinion has been shown to improve accuracy and patient care for pathology diagnoses and has become mandated in many laboratories to improve diagnostic accuracy and patient care.[39-42] For melanocytic lesions, most pathologists (78%) perceived that second opinions increased accuracy and protected against malpractice (62%).[43]

Table I. Ten metacognitive suggestions to reduce diagnostic error

No.	Suggestion
1	Verbalize physical findings
2	Verbalize the differential diagnosis
3	Name and describe the heuristic or cognitive trap involved and how it is affecting clinical reasoning
4	Get feedback and second opinions
5	Reduce cognitive loads using protocols, mnemonics, brain training, and diagnostic decision support tools
6	Increase mindfulness and focus, decrease distractions, and use diagnostic timeouts and good stress management
7	Strive to nurture humility, avoid complacency, and avoid cognitive and attitudinal overconfidence
8	Diagnoses are hypotheses: openly acknowledge, discuss, and embrace uncertainty and incomplete puzzles
9	Become aware of when all the diagnostic pieces don't fit; respond by broadening your search rather than by ignoring part of the data or forcing conformity of data to one's theory; avoid zebra retreat (avoiding diagnosing rare diseases)
10	Metacognitive approaches: think about the thought process and where it might be wrong, *errando discimus* (learn from one's errors), embrace error to avoid it

Reducing discomfort with uncertainty

Data shows that doctors have difficulty recognizing or remembering errors they make (due to survivorship bias, the tendency to remember only the successes or winners), with the most dramatic or positive instances selectively recalled.[44] We desire predictability and perfection in diagnosis. Paradoxically, hardwired processes in our brains that lead us toward diagnostic inaccuracy cannot be removed, and some degree of uncertainty and error cannot be avoided.[45] Hence, in its essence, while medicine involves the reduction of uncertainty, we can rarely be certain.[46] Reframing the definition of diagnosis to reflect reality comes down to this: diagnosis is an evolving hypothesis that is based on assumptions and interpretations of findings. Medicine is much less evidence-based than we believe, and we understand less about disease than we presume.[47] Most of what we observe in life is like a puzzle with missing pieces.[48] Despite the intellectual and emotional discomforts involved,

only by acknowledging our many diagnostic blind spots (as "we can be blind to the obvious and also be blind to our blindness"[49]) can we begin to reduce error in our field. Through accepting our limitations (and ignorance at times), avoiding complacency and overconfidence, and nurturing humility vis a vis the diagnostic process, we will be able to better serve our patients.[50]

Metacognition

Diagnoses are made by experts using significant tacit knowledge and an intuitive, nonanalytical unconscious intelligence.[51-53] The use of heuristics enables rapid decision making under conditions of uncertainty but represents a tradeoff between speed and accuracy, in which speed might lead to bias and error.[49,52] About 40% of our cognitive work directed toward the diagnostic process involves heuristics.[54] This unwitnessed and almost never recorded covert source of cognitive error constitutes a blind spot.[55] Metacognition, or thinking about how we think, can reduce the errors produced by the use of heuristics. As choice architects in diagnostic decision making, having a conscious approach to the diagnostic problem (Table I) can be key to arriving at the correct diagnosis and avoiding diagnostic error (Part 1, Table II).[1,34,56]

Using metacognitive techniques and training can help to avoid diagnostic traps created by the indiscriminate use of heuristics. Training the mind with cognitive debiasing or forcing strategies might help to anticipate and possibly avoid such traps.[57] When information acquired from heuristics is mistaken for analytical data, an illusion of knowledge can be created where in fact little or limited information exists. It is important to apply heuristics only in forming diagnostic hypotheses, not for confirmation of the same when the diagnosis is in doubt.

The most common cause of diagnostic error is failure to even consider the right diagnosis. We can invoke metacognitive techniques by asking what doesn't fit, what else can it be, and what the traps are here, all while not dismissing gut feelings.[58] The more complex a case and the more pieces do not fit, the more essential it becomes to have a comprehensive differential diagnosis. Diagnosing zebras (or diagnosing rare diseases) is the result of having a comprehensive differential diagnosis. Like swimming against the current, diagnosis is difficult and takes experience, effort, and exposure. Zebra retreat, a bias based on our aversion to making these uncomfortable diagnoses, is a source of diagnostic error that can be avoided. Prospective hindsight (consciously expanding the differential diagnosis after a diagnosis has been made) enables for re-evaluation and interpretation of findings and helps prevent premature closure.

CONCLUSION

Diagnosis is still an individual art made up of habits and personal judgements rather than an evidence-based science.[59] For much of what we do, there is no established best practice for initial diagnostic investigation. We are taught in rational problem solving, to look before we leap, and analyze before we act, but this practice is far from our strategy in navigating daily life and the world of dermatologic diagnosis.[51] Although there is a certain mistrust of quick decision making, the question is not if we can trust our gut feelings but when and how we should. In this article, numerous suggestions have been made to improve diagnosis (Table I), but few have proof of efficacy. Still, it seems reasonable to infer that with the habitual use of both our heuristic thinking and metacognitive correction and redirection, improving diagnostic accuracy and decreasing medical error is possible.

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