Visual perception, cognition, and error in dermatologic diagnosis: Key cognitive principles

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Learning objectives
After completing this learning activity, participants should be able to describe cognitive concepts important in recognition of dermatologic diseases and recognize cognitive concepts that can lead to diagnostic errors.

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Dermatologic diagnosis relies on vision primarily and auditory and verbal input secondarily. Accurate dermatologic diagnosis is predicated on seeing and perceiving a skin finding, categorizing and naming the finding correctly, and comparing the visual data and data obtained from the totality of the clinical encounter (ie, from other sensory modalities) with one's working mental database of dermatologic diagnoses. The baseline assumption—which is false—is that a dermatologist is an expert at each of the aforementioned steps and transitions sequentially between them seamlessly in an error-free fashion. Each of these steps has inherent challenges, and the transitions between steps can also be problematic. In part 1 of this 2-part report, we describe the pitfalls associated with visual recognition. In part 2, we discuss cognitive heuristics as they relate to the dermatologic diagnostic process and prevention of diagnostic error. (J Am Acad Dermatol 2019;81:1227-34.)

Key words: cognition; dermatologic diagnosis; error; gestalt; heuristic; inattentional blindness; metacognition; visual diagnosis; visual perception; visual recognition.

The practice of medicine is typically learned as an apprenticeship, with years devoted to intense learning during medical school, residency, and beyond; however, the exact factors involved in becoming an expert physician are unclear.[1] Experience and practice, real or simulated,[2] is

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Table I. Key concepts and definitions

Concept	Definition
Visual perception	Interpretation of what is seen visually after processing of visual stimuli by the brain; affected by key factors, including perceptual filters, gestalt, and inattentional blindness
Gestalt	Overall assessment (the whole that might be more than the individual parts); important elements of figure–ground separation include part versus whole, proximity versus similarity, and color
Inattentional blindness	Inability to perceive an object that crosses the visual field, usually because attention is directed elsewhere
Bias	Systematic error that recurs predictably in particular circumstances
Heuristic[7]	A rule of thumb; a simple procedure that helps find adequate, though often imperfect, answers to difficult questions[7]; might be derived from a bias
System 1[7]	Gut assessment (characterized by only 1 answer, no doubt), fast thinking, automatic, intuitive, habit-based, involves pattern recognition; examples: expert thought, heuristic thought, automatic mental activities like perception (gestalt) and memory, driving a car
System 2[7]	Calculated assessment (characterized by possible doubt and uncertainty); slow thinking, analytical, reflective, systematic, deliberate, effortful, involves decontextualization

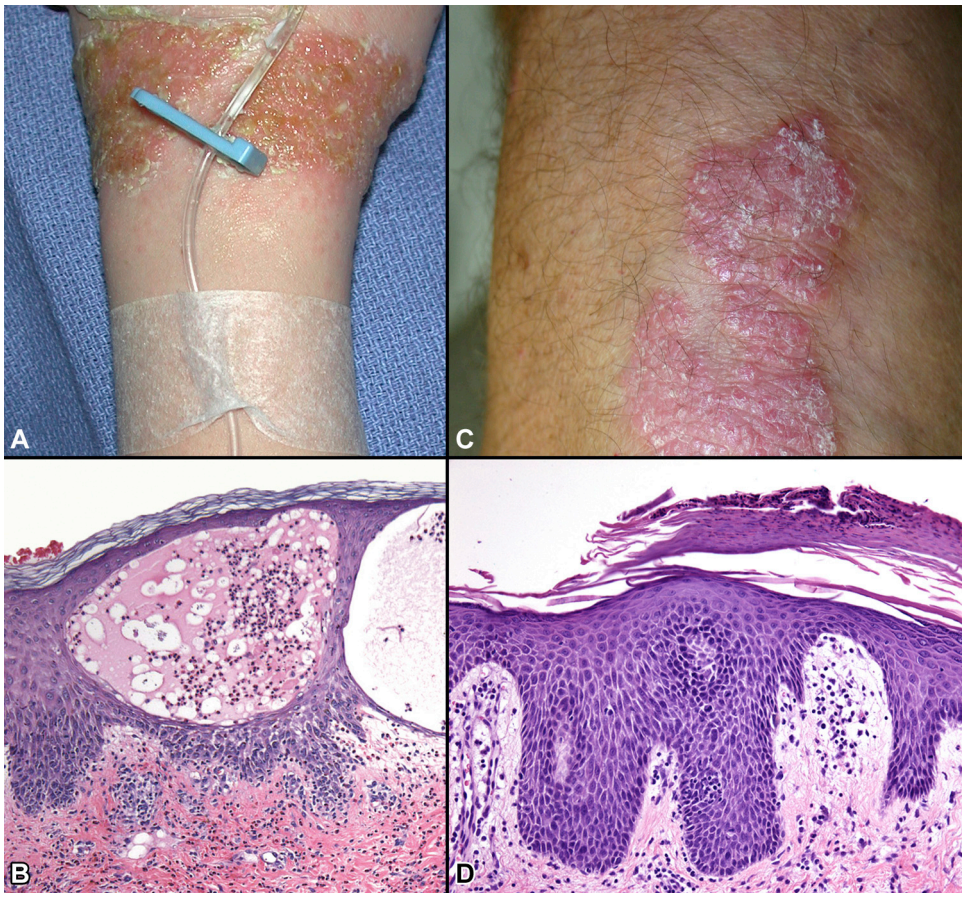

Fig 1. Gestalt pattern recognition. Eczematous and papulosquamous are 2 major patterns of dermatologic disease. **A** and **B**, Allergic contact dermatitis is a classic acute eczematous pattern with vesiculation of the epidermis. **C** and **D**, Psoriasis is the prototypical papulosquamous disorder with erythematous plaques and adherent scale. Many physicians with little dermatology training might perceive only a rash on the arm. (**B** and **D**, Hematoxylin-eosin stain; original magnification: ×20.) (**A** and **C**, Courtesy of the Yale Dermatology Residents' Collection.)

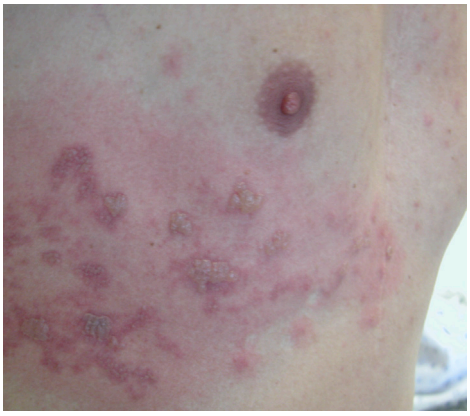

Fig 2. Part versus whole, example 1. Herpes zoster. In this photograph of the trunk, most of the body is not pictured, but a sense of unilateral, dermatomal restriction is perceived. This perception is a cognitive illusion that is based on the morphology of the clustered vesicles placed within a dermatomal pattern. Dermatologists with extensive experience can appreciate that although the rest of the exam could certainly confirm unilateral restriction, similar lesions could be present more widely. In the latter situation, disseminated zoster and an immunocompromised state would be in the clinical differential diagnosis. (Photo courtesy of the Yale Dermatology Residents' Collection.)

necessary, and Malcolm Gladwell says in his book *Outliers: The Story of Success* that it takes 10,000 hours (5 hours/day over 6 years) of deliberate practice for true expertise to develop.[3-5] Perception and cognition are intimately related and, at times, inseparable in visual fields like dermatology and dermatopathology.[6] Deliberate practice in dermatology is augmented by knowledge of specific cognitive principles that affect visual perception.[6] Visual perception is complex and yet simple; we can often easily classify an animal as a dog rather than a cat, despite the fact that there is no pathognomonic reason for such gestalt classification.[6] Gestalt, in which the whole (ie, dog) might be more than the sum of its parts (ie, 4 legs, 2 ears, tail), is key to visual perception and quick classification. In this article, we will review visual perception and related cognitive concepts, which underlie dermatologic diagnosis.

KEY CONCEPTS

Visual perception is a product of the brain and might be less or more than what is actually seen, when seeing is defined as the objects in the visual field (Table I).[7] Important experiments in cognitive psychology have demonstrated time and time again that we have a limited capacity to perceive all that is around us. Our perceptual filters lead to an overall gestalt and also inattentional blindness.

PERCEPTUAL FILTERS

Our perceptual filters limit what we perceive, leading to bias. There are many biases in medicine; 2 examples are confirmation bias and search-satisfying bias.[8] Confirmation bias is the result of the tendency to look for supportive evidence and the failure to perceive findings that would refute our bias; a concerted search for pertinent negatives is helpful to avoid such bias. Search-satisfying bias is due to the common predisposition to stop a search once something is found.[8] In addition to biases important in decision-making, personal bias, inherent within us all, refers to how we are influenced by our own experiences, including our geographic location, education, likes and dislikes, mood, and information from others.[9] Notably, our own biases might be the same or different from those of others around us.[9] Biases are prevalent because they often help us think and can be useful as a mental shortcut or heuristic. For example, a fungating, localized mass is more likely to be blastomycosis in Ohio but coccidioidomycosis in California; these biases, that are based on geographic location, are practical. Heuristics that are particularly relevant to diagnosis and diagnostic error are further covered in Part 2.[10]

GESTALT

Gestalt is a psychologic term that means unified whole, and gestalt recognition refers to an immediate, involuntary recognition of pattern. Although the mechanisms behind gestalt recognition are complex and incompletely understood, such visual matching by pattern is an efficient way to learn to recognize different dermatologic diseases (Fig 1).[11,12]

Gestalt is an example of rapid, effortless processing of large amounts of information by the brain, so-called System 1 thought.[7] Principles of perception that lead to gestalt include qualitative elements, such as part versus whole, proximity and similarity, and the organization of such elements into the figure and background.[13] System 1 thought is at play when a dermatologist makes a diagnosis from the doorway or the dermatopathologist has instant pattern recognition of a slide at low magnification. Gestalt can be further confirmed or denied by System 2 thought, which is slower processing, the type of thinking we typically use when we multiply 71 by 13.[7]

Expert dermatologists and dermatopathologists first use System 1; processing by System 2 can be bolstered with mnemonics, algorithms, checklists,

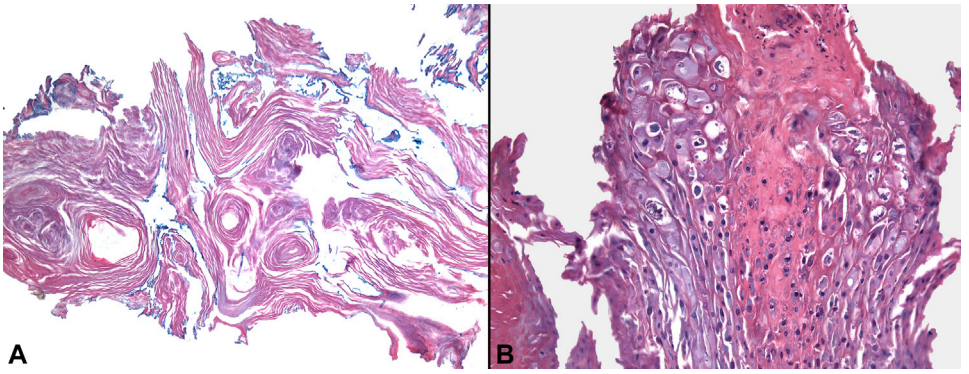

Fig 3. Part versus whole, example 2. **A**, Seborrheic keratosis. The stratum corneum above a seborrheic keratosis has characteristically whorled keratin. **B**, Myrmecial wart. This photomicrograph of mostly stratum corneum has rounded parakeratosis, papillomatosis, and foci with viral inclusions.

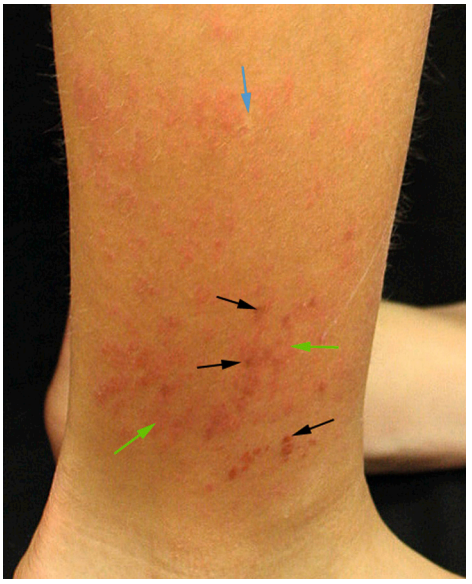

Fig 4. Grouping, example 1. Goltz syndrome (focal dermal hypoplasia). This close-up view of the ankle shows part of a linear streak that extended down the entire leg. There are hypopigmented foci (*blue arrow*), telangiectasia (*green arrows*), and hyperpigmented macules (*black arrows*); the presence of these 3 different morphologies is characteristic of Goltz syndrome. Soft yellow papules (herniations of fat) and atrophy are also typical but not evident here. (Photo courtesy of Richard Antaya, MD.)

and lists of differential diagnoses for a given category of disease.

Part versus whole

While our brains can fail to perceive vast amounts of information, the brain also has the ability to fill in missing information. Although making assumptions can be to our detriment, in general, this practice helps us navigate the world. For example, we can read words that are missing letters or incorrectly

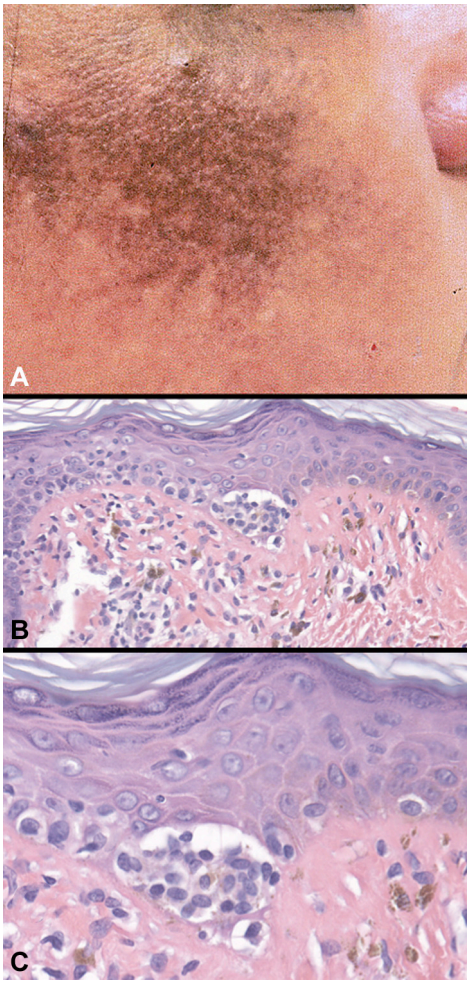

Fig 5. Grouping, example 2. Pseudomelanocytic nests of a lichenoid process. The patient had bilaterally symmetric lesions over the cheeks; divorced from the clinical presentation, the microscopic findings could be misinterpreted as melanoma in situ. (**B** and **C**, Hematoxylin-eosin stain; original magnifications: **B**, ×10; **C**, ×40.) (**A**, Photo courtesy of Jeffrey Alter, MD.)

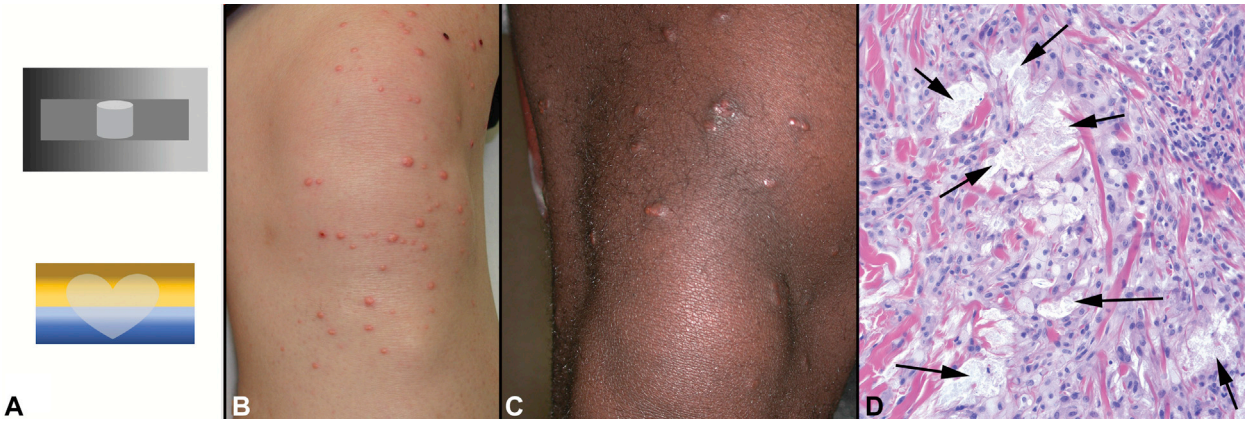

Fig 6. Color perception. **A**, Around the cylinder, the inner gray horizontal bar is all 1 color. The heart is all the same color but appears to be 2 different shades, depending on the background color (more yellow superiorly and more blue inferiorly). **B-D**, Eruptive xanthomas. The yellow-pink tinge to the papules on the knee is more apparent in lighter skin (**B**) than darker skin (**C**). **D**, The similar light-blue color (*arrows*) aids the perception that the material (lipid) is all the same, despite being spatially dispersed. (**D**, Hematoxylin-eosin stain; original magnification: ×20.) (**B** and **C**, Photos courtesy of the Yale Dermatology Residents' Collection.)

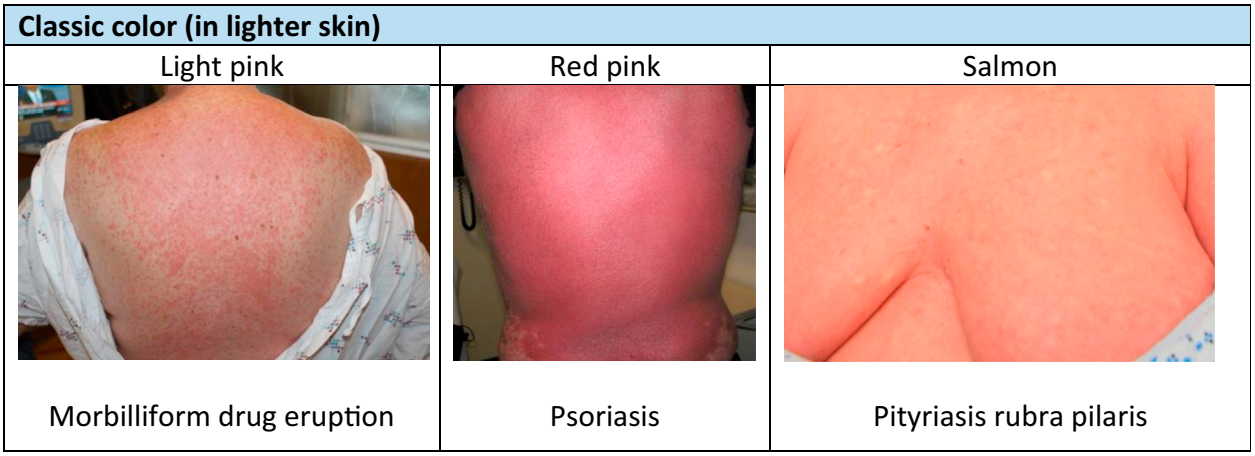

Fig 7. Subtle differences in erythema in lighter skin.

spelled because our brains can correct for the missing information.[9] Likewise, in dermatology, clustered vesicles aid the perception of unilateral distribution, despite incomplete information (Fig 2). While by no means ideal, experienced dermatopathologists can sometimes make a diagnosis on the stratum corneum alone (Fig 3), without the majority of the epidermis.

Proximity versus similarity

The brain is trained to group things. For example, objects that are closer or similar tend to be grouped together.[13] A tendency to group by similarity (eg, primary lesion morphology[14]) is obvious with a quick glance at any major textbook of dermatology and dermatopathology. Grouping by proximity can be a useful heuristic for rapid clinical diagnosis in many cases, common and rare, but can also lead to error in both a clinical skin examination and analysis of a microscopic slide. Grouped vesicles is a classic clinical example (Fig 2) that immediately brings to mind the category of herpetiform processes. The cognitive tendency to group is also helpful for different morphologies; for example, in Goltz syndrome, telangiectasia, flesh-colored papules, pigmented macules, and hypopigmented lesions are diagnostically unified by their location within a common streak (Fig 4).

In dermatopathology, many disorders are defined by proximity of similar structures or cells; examples

Fig 8. Figure-ground separation, example 1. The staircase disappears as you move down from the upper level. Untitled drawing by Morton Livingston Schamberg (1881-1918) drawn circa 1916, graphite on paper. Purchase of Bertram F. and Susie Brummer Foundation Inc, and gifted in 1968 to public domain. (Image courtesy of the Metropolitan Museum of Art of New York.)

include pyogenic granuloma and sarcoidosis. In contrast, for lichenoid processes, we now recognize that clustering of cells within a nest (Fig 5) does not mean that the cells are all of 1 type of cell, ie, melanocytic; immunohistochemical staining suggests that there is a mix of keratinocytes, inflammatory cells, and possibly melanocytes.

Color

Uniform color imparts connectedness and plays a large part in the brain's perception of figure, parts, and similarity.[13] In addition, color perception is affected by surrounding colors; a color can be perceived as a different shade when placed next to another color (Fig 6).[15] This phenomenon has well-known effects in dermatology; for example, skin lesion color can differ by skin type. Once skin color is accounted for, particular lesions and rashes do have characteristic colors. The eye can be trained to perceive even subtle differences in erythema, which can vary from light pink to orange to dusky red (Fig 7).

Figure–ground separation

Ultimately, gestalt separates key information from the background, ie, the figure in the foreground from the less important background.[13] Many artists have played with this visual tendency, including artists such as M.C. Escher and Salvador Dali (Fig 8). Training enables dermatologists and dermatopathologists to quickly recognize the figure (eg, primary lesions) versus background (unaffected skin). On occasion, as seen with dyspigmentation, ascertaining the true figure (ie, hypopigmentation vs hyperpigmentation; Fig 9) can be difficult with physical examination alone. When using microscopic slides, initial classification as neoplastic or nonneoplastic is generally immediate, with the recognition of the tumor or the inflammation, respectively, as the figure. Incorrect assignment of figure versus ground can result in diagnostic error (Fig 10).[16]

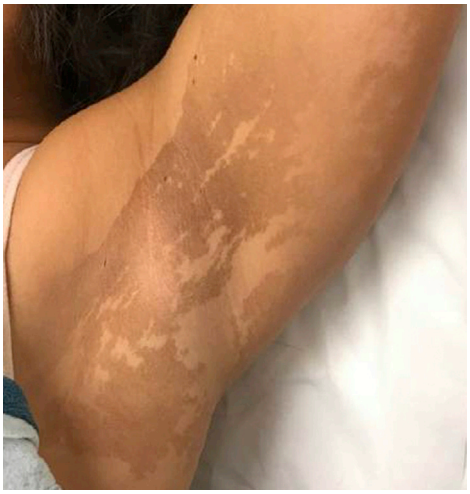

Fig 9. Figure–ground separation, example 2. Axillary dyspigmentation in pigmentary mosaicism. Occasionally, it can be difficult to ascertain if lesional skin is hypopigmented or hyperpigmented. (Photo courtesy of Richard Antaya, MD.)

INATTENTIONAL BLINDNESS

Inattentional blindness (also known as perceptual blindness, familiarity blindness, change blindness) is the term given to the inability to see certain things that are in plain sight, given filtering by the brain. In a classical cognitive psychology experiment, ~50% of people missed a concurrent significant event (ie, a gorilla passing through players playing basketball) when concentrating on another task (ie, counting basketball passes).[17]

In a study of fully trained radiologists who were instructed to scan computed tomographic images for abnormalities, 83% of seasoned radiologists did not notate the presence of a black gorilla in the scans.[18]

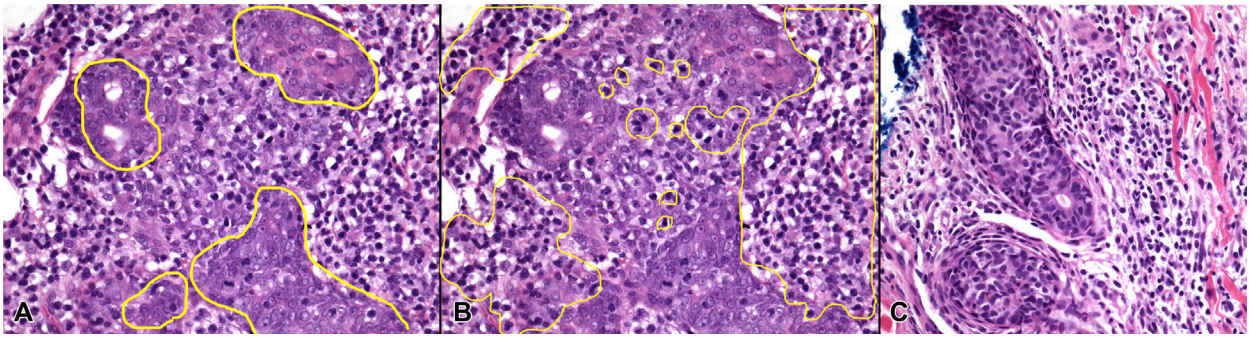

Fig 10. Figure–ground separation, example 3. Syringotropic mycosis fungoides. **A**, In the patient's initial biopsy, eccrine gland and duct hyperplasia was extreme, and the eccrine structures were initially perceived as the figure with a background of inflammatory cells. **B**, Ultimately, syringotropic mycosis fungoides was diagnosed. **C**, Another biopsy from the same patient showed enlarged eccrine units with surrounding lymphocytes. (**A-C**, Hematoxylin-eosin stain; original magnification: ×40.)

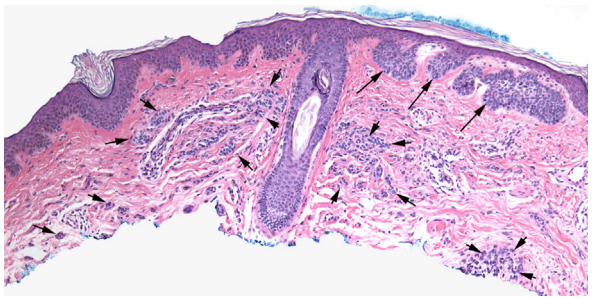

Fig 11. Inattentional blindness. Superficial basal cell carcinoma (*long arrows*) and intradermal melanocytic nevus (*short arrows*). Because having 2 different diagnoses in a small biopsy specimen is relatively uncommon, one or the other could potentially be overlooked.

Although such inattentional blindness would not have altered the diagnosis, being sanguine is difficult when ~4 of 5 experienced radiologists—expert observers—failed to discern an object that blatantly had no place in a radiologic image. This failure, however, is an expected, normal consequence of visual perception, as the brain does not perceive much of what it sees; eye tracking movements did indeed indicate that the radiologists in the previous study did look directly at the large gorilla.[18] While seeing can be defined as what crosses our line of vision, perceiving is the heuristic processing and interpretation of what we see. We see much more than we perceive. We often, without being aware of it, are directed by our brain to overlook the unexpected, the unfamiliar, the camouflaged, and the abhorrent; this phenomenon is critical for our brains to be efficient on an evolutionary basis.[9] Although recognizing what we ourselves have overlooked in a moment of time is difficult, noting the inattentional blindness of others is easier. For example, in teledermatology or skin examinations presented by others, we might be able to point out important findings that others have not perceived. Microscopy is more amenable to documenting one's own inattentional blindness, as slides are static over time, and if we come to suddenly notice something on a second or third look, we know that it was always there. Stopping observing once we have a diagnosis is easy, but making sure to look at the patient or slide entirety is important (Fig 11). Taking the time to use system 2 thought proactively and consciously and mentally asking "Could this be anything else? Am I missing anything else? Have I looked everywhere?" is useful.

SUMMARY

Visual recognition in dermatology and dermatopathology is often instantaneous. For those new (or newer) to dermatology and in the case of unusual patterns, knowledge of largely subconscious cognitive heuristics (Table II) helps increase visual intelligence, with the ultimate goal being accurate diagnosis. Conscious evaluation of pertinent positives and negatives for a given diagnosis, reassessing for what we might have missed, and taking the time to do so or ask others are necessary for deliberate practice and the development of greater expertise. Part 2 of this 2-part review will address heuristics in greater detail.[10]

Table II. Thought processes in dermatology and dermatopathology

System	Thought process			
1	Gestalt (instant recognition leading to a diagnosis)			
2	Conscious checklist →	2x (from the door) or 40x (up close) →	Dermatology heuristics: overall distribution on the body, overall pattern, tumor versus infectious or inflammatory, unilesional versus multilesional, color, configuration, primary lesion, secondary characteristics	Dermatopathology heuristics: location (eg, epidermal, dermal, subcutaneous), neoplastic versus nonneoplastic, inflammatory pattern (eg, spongiotic, lichenoid, perivascular), benign versus malignant tumor, cell type (cytology), mitoses, inclusion bodies

With greater experience, consciously evaluating a checklist is not necessary for correct diagnosis. Notably, the heuristics in this table are only examples that might not apply to every lesion or rash; the listed order does not reflect importance as different heuristics are more useful for particular diagnoses (see Part 2).[10]

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