Perceiving clinical evidence

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Background This paper demystifies clinical perception by explaining its mechanisms, using insights from neuroscience and evolutionary biology. Clinical diagnosis begins with rapid recognition using our imaging, perceptual (but non-verbal) brain, followed by guided search using our slower, verbal, reasoning brain. Experiential cognition can be (more or less) achieved by integrating these two ways of knowing. Perceptual expertise requires alertness and persistence to ensure clinical accuracy. Each clinician, as a self-aware participant-observer (SAPO) keeping track of what they're thinking ‘as it happens’, can study their perceptual accuracy, pattern matching, interpretation, motivation and judgement.

Keywords Clinical competence /*standards; *perception; diagnostic techniques and procedures /*standards.

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Introduction

With every patient every day, you see, hear, feel and even smell clinical evidence that suggests what’s wrong with them. How accurate is your perception of these signs? To assess and improve your skill, you must understand how your perception works. And you must apply self-aware rigour to deal with the consequences of your perception’s neuropsychological limitations.

Tracing the perceptual sequence

Sink into an armchair, allow your muscles to relax, shut your eyes and just listen. You hear a variety of noises, first those close by and then fainter sounds from further away as your sensitivity increases. You begin to interpret each sound and its origin. You may infer what’s happening.

Repeat the process at your patient’s bedside as you examine the abdomen. Sit comfortably on a bedside chair, relax your shoulders, elbows and wrists as both hands rest on the abdominal wall, and shut your eyes. Focus on what your fingers and hands feel (the tactile and proprioceptive sensory inputs) for a whole minute as you discern the liver edge, the aorta and the pancreas across the aorta.

You’ve just been a self-aware participant-observer (SAPO) of your sensory perception in action. You experienced how your sensitivity rises as other afferent channels (visual and postural) are shut down, and you focus attention on the hearing or feeling inputs with sufficient time to concentrate on the details.

Follow your perception in a patient with shortness of breath and cough. Your training alerts you to evidence that could identify the disease you’re trying to diagnose (say, cardiac malfunction as explanation). You notice something (say, a malar flush). Noticing is unconsciously selective because you’ve perceived that sign before. Listening to the heart sounds, you hear an auditory cue (say, an opening snap and mid-diastolic murmur) that you interpret as a definite clue or physical sign.* From those auditory details, you discriminate what it is from what it isn’t. That is, your perception makes fine, interpretive distinctions from carefully observed sensory data. You may infer the diagnosis (say, mitral stenosis and pulmonary oedema) from those interpretations.

You may even anticipate management and prognosis, and what you feel about that. Has your heart ever sunk, for example, on feeling a hard, irregular prostate on rectal examination of an older man with severe back pain? There you jumped from the sensation at your fingertips to your emotions about prognosis without

* The term ‘cue’ is commonly used in problem solving literature. Etymologically, cue derives from q, an abbreviation of the Latin quando, meaning ‘when’ (to come on stage) and means hint, intimation, a guiding suggestion. In this paper, ‘cue’ indicates a trigger or hint or suggestion that starts a line of thinking. The term ‘clue’ means anything that serves to guide or direct in the solving of a problem, deriving from the Anglo-Saxon clew, meaning a ball of thread, from the legend of Theseus and the Cretan labyrinth. In this paper, ‘clue’ is used for a piece of evidence substantial enough to use as a diagnostic physical sign.
pausing to interpret or infer what’s wrong. This is knowing without thinking.

Your clinical memory stores your intrapersonal affect with your sensory percept and your preparation for action. Your steps in clinical perception included:

• knowing important physical signs and how to detect them;
• being alert and motivated to pick up any evidence;
• noticing cues and clues;
• sensing the details of each cue/clue/sign by focused concentration with sufficient time;
• recognising signs and patterns previously encountered;
• interpreting the pathophysiology of signs and their pattern;
• discriminating these from similar signs and patterns;
• inferring a diagnostic explanation from the interpreted signs, and
• experiencing emotions from the meanings associated with the diagnosis.

What’s the mechanism?

Visual cues run to your occipital retinotopic area, then interact with memory areas in visual working memory until your perceptual neural network recognises that pattern. That sequence takes about half a second, finishing before it registers consciously. How is that so? Because the perceptual memory you have inherited from your reptilian and animal antecedents works very fast.

You are born with neurons that progressively develop connections, a huge associative web of synaptic linkages. Features occurring together create (non-verbal) patterns, following Hebb’s rule that ‘neurons that fire together wire together’. Functional magnetic resonance images (fMRI) of sites lighting up after a stimulus are analogous to the neuronal pattern triggered into activity by your glance at a patient.

Recognition was not diagnostic argumentation by your verbal, numerical, logical, sequential processing (left) brain. Instead, you sensed a case pattern associated in clinical memory by your parallel processing, perceptual, spatial imaging, non-verbal (right) brain. Your imaging brain also captured the context, constructing your episodic (autobiographical or event-structured) memory with all its connotations in both prefrontal cortices and your hippocampus. After that first half-second, conscious reasoning controls the search for the evidence you expect in the case pattern if your diagnostic guess (from your clinical memory) is correct.

This partitioning of two (or more) ways of knowing complicates understanding and teaching of how you diagnose what’s wrong. Your cumulative sensory experiences (with their associated emotions) sit within your private, internal (subjective) clinical memory. There, perception plus case experience construct meaningful patterns that you recognise intuitively (although not always accurately). In contrast, your public clinical reasoning combines pieces of external (objective) evidence logically. Scientific medical knowledge is a verbal construct compiled logically and numerically, using sensory data as evidence. Both contribute to diagnosis, but they communicate awkwardly. This paper emphasises your extraordinarily rich, non-verbal, sensory experience, but also its lack of logical rigour.

Retrieval is faster from organised patterns than from separate physical signs. A name for the pattern (say, thyrotoxicosis) makes retrieval even faster. Clinical memory is case pattern specific, and doesn’t easily generalise across cases or discipline areas! Clinical examination scores, consequently, have low correlations across cases.

Search follows only one possibility at a time, closing an otherwise open problem, because working memory is limited to about five items at a time. This neuropsychological limitation also forces what many call ‘hypothetico-deductive’ search in pursuing only one case pattern. You group (compress or chunk) your findings under conceptual headings (say, cardiac, respiratory) to avoid working memory overflowing. Or you make notes of what you can’t hold in your mind. Eventually, you group the findings under one diagnostic name. The limited capacity of working memory forces you to construct concepts and categories to group all the details under one title. As the number of categories grows, you are obliged to construct classifications.

Key learning points

Your perceptual brain recognises learning patterns before you are consciously aware.

Perception not only notices and recognises, but interprets and infers what is wrong.

What you recognise is stored in your private, non-verbal, perceptual memory until it is described by your verbal, logical brain.

Perceptual expertise demands alertness, thoroughness in examination, careful interpretation and reflection on your thinking as you work.
The left brain’s linear thinking searches categories logically, one at a time, but the perceptual right brain can search laterally across the neural net to other associations, triggering fresh possibilities that ‘spring to mind’. Intuition (our subverbal perceptual memory) may recognise a pattern mismatch (is that really the problem?) but be unable to verbalise what feels wrong. Perception continues to file sensory images automatically in the background during the consultation, linking them to patterns stored in its associative networks.

To integrate these two ways of knowing, the sensory images are described verbally and explained logically in causal explanations of each case. Cognitively, the percept (of sensory evidence) is consciously linked with the concept (of pathophysiological mechanisms). You integrate experience and explanation into the ‘experiential cognition’ of clinical reasoning.

Each case is your ‘unit of work’. Cases represent the framework for building your episodic clinical memory. Case-based knowledge is progressively elaborated by reflection on salient features by reading and case discussion, and by new case variations. Together these create ‘working knowledge’, representing your capabilities for all facets of case management.

What happens in practice?

Some perceptual steps can be taught. Some must be directly experienced. Everyday practice frequently falls short of ideal, however, when alertness or thoroughness are lacking. Exploring each step reveals sources of error, and where to focus in improving perceptual expertise! Return to your role as self-aware participant-observer (SAPO) to glimpse your experiential cognition in action.

(1) Awareness and skills learning

To pick up clinical evidence, you must know what could be there, what it’s like, and how to detect it. Students’ capabilities are frequently sloppy and uncertain, even at graduation. Some are never taught the applied anatomy of where and how to search, or the sensory imagery of feeling each normal organ. Signs may be demonstrated to a group but without ensuring hands-on experience. Many students lack supervised practice or teacher assessment of their skills. High turnover procedural practice in teaching hospitals now limits opportunities to examine patients before their organs are removed. Clinicians who skip over their uncertainty of what they’re sensing model lax examination habits to their students.

None of the clinical teachers observed (by clinical teachers in our Master of Clinical Education programme) had been taught how to teach physical examination. Their explanations and guidance were weak and superficial. None of them had been taught the quiet, focused attention you experienced at the beginning of this paper, with its commitment of adequate time and persistence until certainty was achieved. None of the teachers we studied knew exactly what each student had sensed. Sensory inputs are personal to the student, but their honest reporting on what they sense can identify perceptual gaps.

You can’t be taught ‘the feel of things’. You must experience sensations for yourself (and store them in clinical memory as personal sensory knowledge). Fine-tuning of perceptual sensitivity and its accuracy requires guided practice with feedback. Experimentally, you also perceive without conscious awareness. Incidental learning is continually shaping what you know, whether you think about it consciously or not.

(2) Noticing

What catches your shrewd eye (or ear or nose)? Noticing is never innocent. Something interesting to your perceptual brain crosses your visual (or auditory or olfactory) sensors, focusing you onto the source. Noticing is involuntary.

Personal experience triggers what you notice. Some cue (say, buttons undone to the waist of a swaggering man, or buttons done up to the neck of a withdrawn woman) suggests something noticed before. You look for what else fits your guess. But this ‘quick and dirty’ labelling is rarely tested for accuracy. Verification is not a habitual human trait unless the diagnosis is important (echoing the fast and frugal strategies of our animal brain).

You read body language signals automatically. Evolutionary anthropologists suggest this social intelligence represents the continuance of our prelanguage communication. Neuroscientists have identified sets of ‘mirror’ neurons that respond in unintentional imitation of whoever you’re watching (yawning, wincing when they’re kicked in the crutch), effectively reading the ‘other mind’.

Your perceptual brain notices not only what’s there, but also what shouldn’t be there. General practitioners notice the ingratiating manner and false bonhomie of a drug addict within a few seconds. Perceptual observation continues subliminally every waking moment, but may not intrude into consciousness until it detects a pattern error, such as when a patient’s verbal language is at odds with their body language.
(3) Sensing and recognising

You make sense of what you sense. Recognition matches two patterns – what you’ve found in the patient and what’s stored in your memory.

The evidence available for recognition varies from patient to patient. Clinical data may be faint or incomplete if the disease is early, mild or recovering, or non-specific (allowing more than one explanation), or when physical examination is inadequate, or a case variation doesn’t fit your stereotype exactly. Remarkably, perception’s fuzzy logic recognises salient features that identify faces in a crowd or a cartoon.

Your stored patterns are constructed from the case stereotypes you were taught, the cases you’ve seen, and how well each was understood. Recognition is fuzzy in unfamiliar cases with signs not encountered (or noticed) before. Error rates are higher when case evidence hasn’t been separated into what’s specific and what’s not. Your personal patterns may be vague from lack of experience or lack of critical reflection.

Mismatch between what’s observed and what’s expected may trigger a gut feeling that something’s wrong. That cognitive tension may be expressed physically as tense neck and shoulder muscles. Evolutionary biologists interpret this muscle tension as our animal brain’s preparation for a ‘fight or flight’ response to uncertainty. Clinicians sensitive to this personal biofeedback wisely restart their data collection from the beginning.

Meticulous data collection makes the evidence more exact. As SAPO, you can examine which are the necessary and sufficient pieces of evidence in the patterns you use. When the sensory evidence is specific (with few false positives), recognition is swift and confident (although with the risk of over-confidence with what’s familiar).

(4) Interpreting

Recognition depends on similarity of sensory data and patterns. Interpretation, however, requires explanations of those sensory data, translating what you feel or see or hear or smell into concrete images of abnormality (anatomical, pathological or functional). Interpretation connects similarity with causal explanation within your experiential cognition.

Subjective likelihood can be distorted by primacy (the evidence arriving first), by recency (evidence arriving last, or a case discussed last week), by ready availability (matter taught frequently), or by imaginability (overestimating alarming possibilities).

When signs are vague and patterns incomplete, ambiguity and uncertainty can allow many possible diagnoses. Interpretation must first maximise certainty about the original sensory data, checking whether they were collected carefully enough. Interpretation must never be based on unreliable or haphazard data. Secondly, the accuracy of your personally stored pattern may be testable by introspection or discussion. To track the sources of interpretive mistakes, as SAPO you may need to explore your sensory data, your concepts and inferences, and your motivations.

Under-examination

Failure to take a pap smear may result from forgetting, from underestimating possible pathology, or from discomfort dealing with genitalia. Many have never been taught properly, lack skill, fear error and a missed diagnosis, yet they react by avoidance, not relearning.

Misinterpretation

Jumping to conclusions is rapid and efficient when you’re right, but it risks misinterpretation. Two colleagues saw a 17-year-old girl with vomiting, distension and severe abdominal colic in our Casualty Department. On rectal examination, they felt a pelvic mass of the consistency of bone. She was admitted with a diagnosis of small bowel obstruction from some malignant mass, but half an hour later was transferred to the Women’s Hospital where she delivered a normal baby!

Misinterpretation can be stubbornly persistent. ‘I’ve seen a case like this’ describes a true experience, but not a true interpretation. Misinterpretations aren’t recognised or corrected unless teachers routinely seek students’ explanations.

Over-interpretation

Wide excision of a pigmented mole wrongly interpreted as melanoma may result from any or all of inadequate examination (lack of sensory accuracy), ignorance of discriminatory features (lack of finely tuned knowledge) and concern about under-diagnosis of a potentially serious malady (fear of failure).

Under-interpretation

Giddiness or vomiting from a cerebral tumour may be under-interpreted through lack of diligence in pursuing a complete picture, or from underestimating possible causes, reflecting gaps in case knowledge and absence of alertness and rigour.

Non-interpretation

Lack of energy with loss of libido, appetite and weight from depression may remain uninterpreted because
those separate data are not recognised as a disease pattern. Discomfort with psychological maladies may lead to covert denial or avoidance.

**Pre-interpretation and colleague accuracy**

Referred patients come with a diagnosis that can create a mental ‘set’. You assume the accuracy of investigational colleagues, though most have never correlated each perceptual interpretation with its pathological diagnosis. Ask your radiologist or pathologist to add their personal false negative and false positive rates in that disease to each report based on their perceptual judgement. That’s not a joke! It concerns what is a serious, and as yet untouched, field for evidence-based medicine (EBM) and diagnostic error!

**(5) Discriminating**

Similarity to a previous case triggers recognition, but not everything similar is the same. To discriminate between similar cases you seek evidence of difference. Firstly, check the percept, whether your sensory data are ambiguous or uncertain. Only those clinicians who spend serious time sensing the physical findings are confident about what they see, feel or hear. Fine judgements can be made only on finely collected evidence. These skills are being upstaged by investigations, however, with unintended losses in skilled clinical judgement.31

Secondly, check the concept, how plausibly each sensory finding fits its interpretation, and how their collated pattern matches likely patterns – effectively, differential diagnosis of what it is from what it isn’t. Logically, finding evidence to support or refute a competing diagnosis helps to separate them.

**(6) Inferring**

Recognition of a pattern is not logically equivalent to diagnostic categorisation. Diagnoses are cognitive constructs of evidence from case stories or ‘illness scripts’,32 with underpinning causal mechanisms.33 That requires specific discriminating details to fit an agreed case prototype.

But such nice conceptual distinctions are lost if you jump from perception straight to diagnosis when signs are specific, if a pattern is unambiguous and complete, and if competitors are few. You pass imperceptibly from percept to concept and to categorisation without conscious interpretation or diagnostic inference.29 This seamless integration of personal experience and reasoned explanation reflects successfully packaged experiential cognition.

To fine-tune experiential cognition (and to document expertise), you, as SAPO, must listen to your self-talk, noting what evidence you sought, what weight you gave each piece, and how your judgement operated. Only you can access what you’re thinking as you work out what’s wrong. This ‘little science’ of the individual applies critical thinking to your handling of each unique interaction and context, explicating your diagnostic route, priorities, values and motivations. These case-based findings may not be additive or generalisable, but they describe what happened in your (private) real world!

**(7) Alertness, emotions and motivations**

Sometimes attention wanders; perhaps you’re tired or lazy. Inattention and carelessness frequently cause medical errors, but motivation is rarely an area of clinical study (along with other affective drives that clinical teachers may not understand). Students lose their motivation to learn on the patient when decisions are based on laboratory tests, and examination results are based on ‘the books’. Many doctors don’t examine their patients carefully, or fail to detect what’s there. Emotions and motivations are inextricably stored within perceptual memory. Rectal or vaginal examination may be avoided because of doctor or patient inhibitions or cultural taboos. Questions about sexual practices may remain unasked. After previously missing something, search may be excessive or findings over-interpreted. Undesirable findings may be under-interpreted; perhaps breast cancer is under-diagnosed because the doctor ‘didn’t want to know’. Optimists over-estimate what’s desirable, and pessimists what’s undesirable (often more accurately). Mood affects not only interpersonal politeness, but also judgement and decision-making.34

Clinicians are aware of these biases, but don’t study their impact on clinical accuracy, or teach them. Only you as SAPO can check which blocks and biases are operating in your mind, and in which cases.

**Expertise**

Experts are high-speed recognisers of abnormalities and diagnostic classifiers. They use a personal, organised, perceptual library linked into case-based knowledge.35 Experts jump to conclusions on relatively few but specific findings (like our animal antecedents). Experts ignore irrelevant data; novices examine everything. Experimentally, clinical experts ceased searching after collecting about two thirds of the data available in the case.36 Experts spend little time seeking confirmation,
usually jumping ahead to check the reserve capacity of systems vulnerable to the intended treatment.

Reduced data collection can have ill consequences, however. Surgeons recording an obligatory set of clinical data diagnosed as accurately as computers in early studies of computer-aided diagnosis of appendicitis. However, when the trial was over, their data collection fell off and their lilywhite and perforated appendix rates rose,37 providing an interesting lesson in disciplined examination (and recording) and the benefit of thoroughness.38

Conclusions

Everyday practice bulges with unasked and unanswered questions. Is quick and dirty guessing efficient and effective, or slick and unsafe? Does it indicate mental laziness? Or lack of motivation to ‘leave no stone unturned’? Or shrewd judgement that investigation would waste resources? Or a ‘satisficing’ judgement of ‘that’s enough’ for a sufficiently sound working diagnosis?39 How accurate is intuitive recognition? When are EBM data actually used in ‘thinking on the run’? These questions will remain unanswered until you (perhaps as SAPO) watch how your experiential cognition uses both the brains with which you’re endowed.

Clinical teachers underestimate (and may pejoratively dismiss) the perceptual brain’s huge associative network that is constantly at work compiling sensory experience of case patterns non-verbally. Only when sensory evidence is described can it be communicated. But the limited hardwiring between the two brains is incomplete, and words can never adequately depict what’s happening.

Mapping what each brain can and cannot do clinically is a serious teaching task. One diagnoses by similarity, the other by word pictures and probability. Students can track those differences, thereby gaining insight into their personal learning styles. What and how clinicians teach can then be shaped by how students learn.

Knowing ‘what’s going through your mind’ requires you as SAPO to observe (and document) your ‘stream of consciousness’, noting what you fished out of the stream that affected your judgement and decisions. Clinical teachers who ‘think aloud’ can guide students through their clinical reasoning and motivations.

Scientific and conceptual models have not kept up with the mechanisms that neuroscience is now displaying. Medicine has the education, training and real world opportunities to join the exploration of this ‘last frontier’ of how your brain and mind work.

Clinical diagnosis begins with rapid recognition by your perceptual brain, comparing images from a personal library of sensory patterns, followed by guided search using your slower, sequential reasoning brain. Alertness and persistence in ensuring clinical accuracy are frequently absent, however. Clinician SAPOs can study their accuracy, pattern matching, interpretation, motivation, judgement and the ‘art’ of medicine by keeping track of what they’re thinking (or avoiding) ‘as it happens’.

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References


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