The neurophysiology of failed visual perceptions: some implications for medical teaching

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ABSTRACT
Failed perceptions of clinical abnormalities may have a neurophysiological explanation including three major covert eye problems and seven major brain-processing problems. Seven suggestions are made in an attempt to minimise their effect. We see in detail much less than we think and there is no substitute for seeing real-life clinical abnormalities.

I see nobody on the road, said Alice.
I only wish I had such eyes, the King remarked in a fretful tone.
To be able to see Nobody! And at that distance too!
Lewis Carroll. Through the Looking Glass

One of the principal duties of a clinician is to detect and identify abnormalities, particularly those that are unusual or unexpected. During 25 years of examining in Final MB and MRCP (UK) I was astounded that many candidates did not perceive unusual or unexpected clinical abnormalities. I presumed such candidates were careless but I now realise that neurophysiological factors operate such that failure to observe abnormalities can almost be considered to be normal.

There are three major problems associated with eye anatomy and physiology, and seven major problems associated with subsequent brain processing of incoming information from the eyes. All 10 problems share 1 fundamental feature: we tend to be unaware of their existence and their extent.

EYE PROBLEM 1
We believe we observe everything within our visual fields as if it were a detailed photograph. In fact we only obtain high definition information about objects whose image falls on the macular area of the retina. A single glance is unlikely to focus the image of an abnormality on the macular areas of the retina (the macula is only 5–7 mm wide and the fovea is 1.5 mm wide) because the wedge of detailed vision is only about 2° (figure 1) and the further away from the macula an image falls, the less detail is collected. Peripheral vision is colourless because there are no cones (the receptors responsible for colour vision) at the periphery of the retina. Worse, even using the macular area of vision, we only see in detail objects on which we focus. Look at the fingernail of your index finger positioned 3 feet in front of your face and then read the footnote.1 To obtain detailed information requires macular vision and focusing on the object of interest. Teaching using two-dimensional images of reality (photographs, pictures in books, or as Powerpoint presentations) does not simulate three-dimensional reality because there is no requirement to change focus continually in order to see the abnormality as would be the case in real life. Thus there is no substitute for observing real-life abnormalities ‘clinical experience.’ This requires time, but time is becoming less available because of working time directives. At consultant appointment I had worked three times the number of hours on call than do current appointees. There is an assumption that increasing academic teaching (that will inevitably occupy a proportion of the hours available for training) will counterbalance the effect of diminished work hours.

EYE PROBLEM 2
The optic nerve is commonly, and wrongly, thought to be a purely sensory nerve. The retina is not just a passive counter of incoming photons. About 10% of the optic nerve fibres travel from the brain to the retina. Exactly what these fibres do is unclear but the brain might be able to actively influence information it collects and processes from the retina as if the retina was a subservient computer peripheral device. This lack of knowledge is possibly of more concern than the other eye problems because we do not know the implications.

EYE PROBLEM 3
The blind spot constitutes about two per cent of the visual field of each eye. This is a small proportion (about 7.5° high and 5.5° wide) but is situated in an area of the retina from which it would be expected that accuracy would be relatively high. Brains hide this flaw by filling in the blind spot with whatever surrounds it1 (look at a sheet of coloured paper with one eye and you see a sheet of coloured paper, not a coloured sheet with a 2% black area). The image of an abnormality is equally likely to be projected onto the macular area, or projected onto the blind spot area. The blind spot in a dominant eye (see Brain problem 2 below) cannot be fully compensated by the overlap of the visual field of the non-dominant eye whose input will, by definition, be accorded lesser significance. Fighter pilots are advised to keep their heads moving to avoid the problem of ‘hidden threats in the blind spot’ of the dominant eye. Collection of

1Can you describe in detail what was in the background around your finger?
information by our eyes is thus compromised and the brain has to try and make sense of the input from the eyes. This may be inevitable: if we were to process all incoming information from the two retinas, then we would have to have a brain bigger than our head.2

Our brain’s ability to make sense of inputs from the eyes is further compromised by the existence of seven major problems with our brain processing.

**BRAIN PROBLEM 1**

*Brains often misinterpret information presented to them.* The large number of optical illusions illustrates the extent of brain misinterpretation. As just one example, on viewing the Necker (so-called) cube (figure 2) most people report that it is a cube that appears to be coming in or out of the paper or alternating between the two. Few brains report the truth—it is not a cube at all. *It is a collection of straight lines on a two dimensional surface.* Of course we all know this, so why do our brains cheerfully tolerate the contradiction? The answer is that our brains have to interpret information from the retina, and interpretation is influenced by previous experience, which inevitably implies a degree of prejudgement. This is standard Bayesian practice in which prior knowledge informs rational inferences. For an in-depth explanation of how brains construct ‘figments of reality’ see Stewart and Cohen.3

**BRAIN PROBLEM 2**

*Occurrences seen by our non-dominant eye may be relatively neglected.* Most people are unaware that they have a dominant eye. To discover your dominant eye, place a finger 18 inches in front of your eyes, look at the background, then close one eye. If your finger appears to jump sideways then you have closed your dominant eye but if your finger does not jump sideways then you have closed your non-dominant eye. By definition abnormalities in the field of vision of the non-dominant eye receive less notice than those of those in the field of vision of the dominant eye.
BRAIN PROBLEM 3

Brains may ignore occurrences that are unusual or unexpected. Such inattention occurs, even when images are received at the area of macular vision. Unusual or unexpected abnormalities are precisely those that clinicians should be registering. Half of MRCP candidates I examined failed to notice that a patient with a facial palsy also had a rodent ulcer on the forehead, presumably because the candidates’ brains knew it was a neurological case. The surprising extent of inattention is demonstrated in one video http://www.youtube.com/watch?v=VG698U2Mvo in which viewers have to count the number of basketball passes that are being made while players are running round a gym. Ideally view this and the following video before reading of the results in the footnote. Further implications are discussed by Chabris and Simons.

BRAIN PROBLEM 4

Brains may ignore substantial changes in a scenario. The surprising extent of such change blindness is demonstrated by a second video http://www.youtube.com/watch?v=voAntzB7EwE in which a card trick is shown and viewers have to try to work out what is happening.

Memory is obviously required to enable a realisation that scenario changes have occurred but brains may insert or delete information from memory, including visual information, if changes are not part of the story clinicians are constructing when dealing with patients. We predict we would notice all such changes but success rates are very low, in effect there is change blindness.

BRAIN PROBLEM 5

Clinical examination often requires multitasking skills. Sadly we often overestimate our brain’s multitasking abilities. It is difficult to observe and correlate two or more simultaneous occurrences but clinicians often attempt to do just this. For example, students are taught to identify right-sided heart murmurs by simultaneously observing that patients are breathing in and the students are taught to identify right-sided heart murmurs by simultaneously observing that patients are breathing in and the murmurs is at its loudest. It is far easier to establish the rhythm of maximum loudness of the murmur with the eyes closed, and then open the eyes to observe whether the patient is breathing in during one of the moments of maximum loudness. A multitask involving simultaneous observations should, if possible, be broken into two separate tasks.

BRAIN PROBLEM 6

Our knowledge of what is normal or abnormal may be less extensive than we think. We often assume familiarity implies knowledge or understanding and assume we have knowledge outwith our areas of specialist expertise. An example, admittedly not visual, but nonetheless illustrating overestimation of knowledge. Familiarity with the specialist knowledge that the incidence of sudden infant death syndrome (SIDS) in families is 1 in 8000 does not equate to a knowing that the chance against 2 SIDS in one family is 1 in 8000×8000=64 million (there is the possibility predisposing genetic factors, certain infections and such like that will lower the chance). Far less does a chance of (<=) 1 in 64 million against SIDS equate to knowing that 2 sudden infant deaths in the same family therefore must have been double murder. This false knowledge was compounded when a whole court full of people were so full of specialist knowledge that they failed to realise the chance against 1 infant murder in one family is probably as small as the chance of 1 SIDS and thus the chance of 2 infant murders would also be likely near 64 million such that it was just as unlikely that 2 sudden infant deaths in one family were double murder, and thus the cause must have been double SIDS. The incidence rates of each were thus irrelevant. It seems that brains with specialist expertise can fail to realise the limits to their expertise and the limits to their less than specialist expertise in other areas!

BRAIN PROBLEM 7

People with low ability, ‘incompetent’, may have brains that protect them by ignoring evidence of their incompetence. Unsurprisingly, they will then take no steps to rectify their incompetence—the Kruger Dunning effect, (‘Incompetent and unaware’) that increases the risk that they will fail to improve defective detection of clinical abnormalities. All examiners will have met confident candidates who fail to see obvious abnormalities although the images of the abnormalities must have impacted upon their retina. Motorists who incompetently pull out in front of easily visible approaching motorbikes often report that they did not see them as if this were an explanation rather than an admission of incompetence. Similarly students often report that they did not see abnormalities.

How can the effect of these 10 covert problems be minimised?

Educators should teach that

1. A cursory ‘single glance’ inspection of a clinical presentation will likely miss abnormalities in areas not seen by the macula. Systematic inspection of areas of interest using macular vision is required with a readiness to welcome abnormalities, particularly if such abnormalities do not fit in with ongoing thought constructions we all use while examining patients.

2. It is important to encourage self-doubt in students and to encourage students to welcome continual feedback to minimise missing of visible abnormalities that clinical practice provides.

Educators should realise that

1. Failure to observe abnormalities is not always blameworthy

2. Detection of clinical abnormalities is a skill that should be learnt by ‘real life three-dimensional clinical experience’, and not just by teaching using two-dimensional non-clinical substitutes.

3. Specialist training will not necessarily help people to detect abnormalities that occur outwith their areas of expertise. People often do not see what they are not expecting.

4. Whenever possible multiple simultaneous or composite tasks should be broken up into sequential single tasks.

5. Trainees should have as much clinical exposure to clinical abnormalities as possible. If working hours are restricted then arrangements should be made so that all trainees can see more real life abnormalities. Each hospital should have a regularly updated list of patients who are willing to have their abnormalities examined as ‘a service to medical training.’
Main messages

▸ Failed perceptions may have a neurological basis and may therefore not represent inattention.
▸ Clinical pictures cannot replace seeing clinical appearances.
▸ There is no substitute to seeing actual patients.

Current research questions

▸ How confident are you that you have seen every word in this paper?
▸ How confident are you that you have understood every word in this paper?
▸ How confident are you that you have seen the 'big picture' in this paper?

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REFERENCES
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