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BMJ Christmas Piece

Brainy Mind

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We have all been struck by the spooky question: Is *your* sensation of green like *my* green? For how can we compare sensations - *qualia* as philosophers call them - of colours, tastes or sounds? Our 'green' qualia may be different (and in cases such as colour anomalies must be different) though we both call grass green and may assume we see the same.

WHERE DO SENSATIONS COME FROM?

The primary question is whether the brain *receives* or *makes* sensations. When we look at grass: is the sensation of green picked up by the eyes, from light reflected from the grass, or are the sensation, the qualia of green, created in our brains? It is now as certain as anything - as Sir Isaac Newton appreciated three centuries ago - that light itself has no colour. Light evokes colour in suitable eyes and brains, which is very different. And violins have no sounds without ears and brains to create sound qualia. Recently the brain scientist Semir Zeki, working in London, has located colour-creating cells in the brain (in the visual area of the striate cortex V4). Although hearing research is less advanced, the auditory cortex is also yielding its secrets.

One can imagine a bunch of simple-minded Robots getting on fine without any awareness of qualia; but surely they wouldn't spend hours looking at pictures, or listening to Beethoven. This is just how the Behaviourist psychologists a few years ago described *us* - as lacking consciousness, or qualia of red or pain, or the sound of violins. Why an audience without music qualia would sit through a symphony was hardly questioned and certainly not answered. Now, psychology has abandoned the Behaviourism of J.B. Watson and B.F. Skinner, who tried to make psychology appear more scientific and less spooky by denying

consciousness. The situation is reversed so that physicists, especially Roger Penrose, are asking how the physical world can have consciousness. And the brain is very generally seen as a physical system obeying physical laws. Consciousness is a hot scientific topic, and books on how the brain does it appear just about every week, Philosophers such as Daniel Dennett, Paul and Patricia Churchland, as well Francis Crick , discuss from the basis of detailed knowledge of neurophysiology and brain anatomy how the mind can be brainy.

It remains mysterious how physical stimuli affecting the physical brain give us, and presumably at least the 'higher' animals, the consciousness of qualia. If qualia affect the nervous system, how can chemistry and physiology give adequate explanations of behaviour and of how the brain works? Yet why should consciousness have developed through Evolution if it is useless?

The key notion of cognitive psychology, since the collapse of behaviourism, is that we build *brain-descriptions* of the world of objects, which give perception and intelligent behaviour. Perceptions are not regarded as internal pictures or sounds, but rather as language-like descriptions coded, we suppose, by brain structures of what may be out there. We carry in our heads predictive hypotheses of the external world of objects, and of ourselves. These brain-based hypotheses of perception are our most immediate reality. But they involve many stages of physiological signalling and complicated cognitive computing, so experience is but indirectly related to external reality.

From patterns of stimulation at the eyes and ears and the other organs of senses, including touch, we *project* sensations of consciousness into the external world. Although this is a startling thought, the experience of projecting afferent reality from the eyes is familiar in visual after-images. Try looking at a bright light, then at a surface such as wall. One sees the pattern that is 'photographed' on the retina from the flash, as outside the eye - as lying on the wall. The more distant the surface, the larger it appears, though of course the retinal photograph is unchanged. This startling notion that perception is projecting brain-hypotheses outwards into the physical world - endowing the world with colour and sound and meaning - has surprising implications, and it is still not the way most of us think of ourselves.

SOME TRUTHS FROM ILLUSIONS

Paradoxically, such truths of perception are revealed most clearly through illusions. Quite simple figures or objects can be ambiguous - spontaneously changing into other orientations or other objects, even

though there are no changes of the images in the eyes. This is evidence of changes of the brain's *hypotheses* of what are out there. Just as for clinical or scientific hypotheses, there may be many interpretations of the available evidence, and background knowledge is very important though it is not always appropriate. An example of the misleading power of inappropriate knowledge is a hollow mask (Figure 1).

Fig. 1

Changes of brain-hypotheses change the meaning of perceptions, and may even change sensations. This was realised in the nineteenth century by the Austrian physicist Ernst Mach. Figure 2 shows an ambiguous corner which 'flips' in and out in depth. When the flipping corner is *in*,the grey region may look considerably lighter than when it sticks *out*. It looks lighter when seen as a shadow, rather than as a mark on the surface. For shadows are normally minimized, as they are not objects for behaviour. (This little experiment works well with a shadow on a folded menu at a boring dinner!)

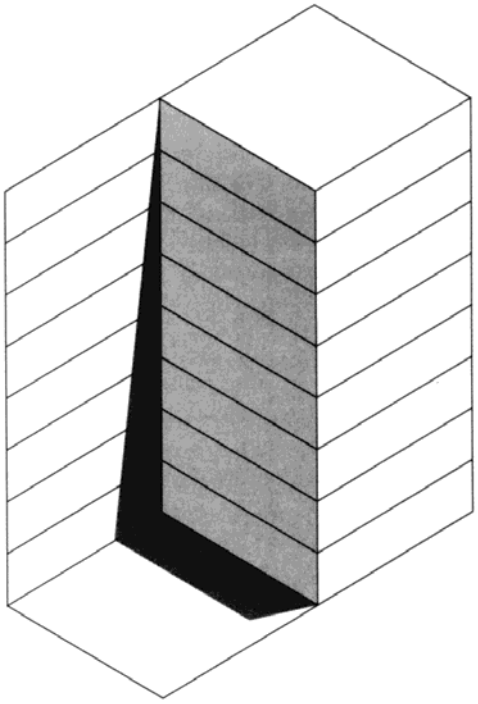

Figure 2

The recorded sound of an audience clapping is quite different when interpreted as being rain, or as frying bacon. This can be experienced with a tape recorder in the garden on a dull day, or in the kitchen. It is interesting to repeat words or musical phrases on a tape loop: after several repetitions they seem to change into other words or phrases. Though seeing and hearing and touch *seem* simple and direct, they are not. They are fallible inferences, based on knowledge and assumptions which may not be appropriate to the situation.

It might be useful to suggest a plan of the cognitive visual system. It is useful to distinguish between: *'Top-down'* knowledge from the past; *'Bottom-up'* sensory signals from the present; and general rules, such as for perspective, which we may say are introduced *'Side-ways'* (Figure 3).

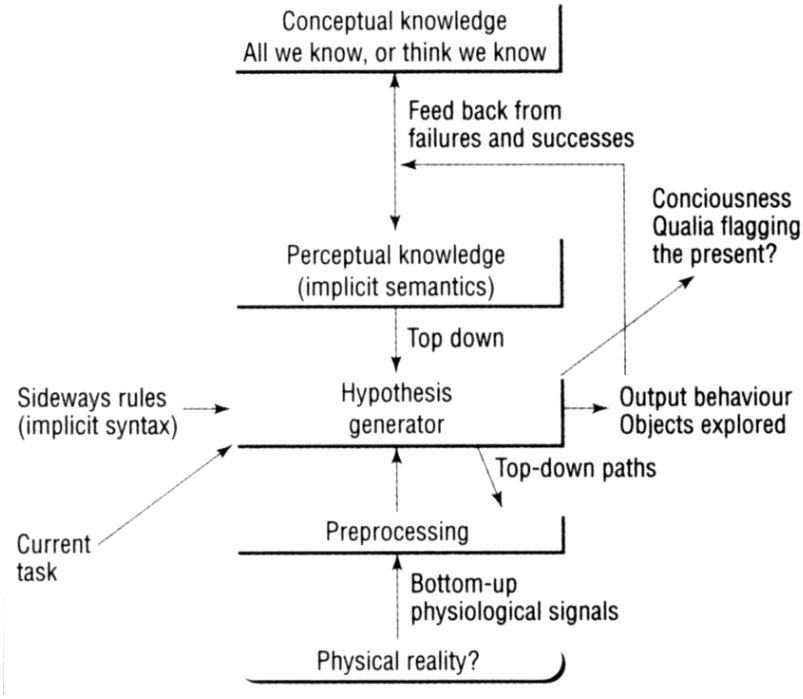

Fig. 3

Such a major contribution of stored knowledge to perception is consistent with the recently-discovered richness of down-going pathways in brain anatomy. Some 80% of fibres to the Lateral Geniculate Nucleus (LGN) relay station come *downwards* from the cortex, and only about 20% from the retinas (Sillito 1995). Although the plan of visual processing of Figure 3 is not an anatomical diagram, it is consistent with brain anatomy as currently appreciated.

FLAGGING THE PRESENT WITH QUALIA.

We might hazard a guess as to what qualia do. As perception depends on rich brain-stored knowledge from the *past,* there must be a problem for identifying the *present moment* from past memories, and also from anticipations running into the future. The present is signalled by real-time stimuli from the senses; but as perceptions are ninety percent or more stored knowledge, the present moment needs to be identified, for behaviour to be appropriate to what is happening out there now. Crossing the road, it is most important that the traffic light seen as red, is red *now,* and not a past remembered red light. This importance of the present is seldom recognised as important by psychologists, though it is discussed by Nicholas Humphrey in *A History of the Mind* (1992).

Do try this most-simple-of-all experiments. Try looking intensely at some distinctively coloured object, such as a red tie. Then close the eyes and *imagine* the tie. Surely the vivid qualia are suddenly far dimmer in imagination. To reverse the experiment, imagine the object, then open the eyes and look at it. The qualia of the visual *now* are startlingly vivid

by comparison with the memory. So perhaps what qualia do is *flag the present* so that we do not get confused with remembered past or anticipated future.

EXCEPTIONAL CASES

At least one exceptional person, free of drugs or schizophrenia has been described as confusing memories with present reality. This is the remarkable case of Mr S described by the Russian neuro-psychologist Alexander Luria (Luria 1968). At times in his strange life, S was a professional 'memory man'. His vast memory and extremely vivid imagination became confused with real-time reality to the point of danger. It may be suggestive that he experienced unusually rich synaesthesia (Luria 1968). Confusions of memory with present reality could be dangerous for him, as he would confuse imagined with real traffic lights, and as he said: "I'd look at a clock and for a long while continue to see the hands fixed just as they were, and not realise time had passed . . . . that's why I'm often late."

There are some commonly experienced failures of sparating the present from memory. An after-image from a bright flash give qualia lasting even minutes following the flash. But afferent signals continue after this stimulus (gradual break down of photo-pigment molecules) so, as for normal perception, there is a *present* afferent input but giving qualia from past stimuli.

Vivid qualia unrelated to present sensory signals seem to be experienced in dreams. In sleep, the present moment has no special significance, for behaviour is not related to external events. When sensory inputs are cut off, or ignored, the system may become abnormal. This occurs in isolation situations when sensory stimulation is absent over many hours. And in hallucinogenic drug-induced states, and in schizophrenia, vivid qualia are experienced with no sensory input; but similar brain activity seems to be present. (Kosslyn et al 1995, Silbersweig et al 1995, Posner and Raichle 1994).

It is reported that in drug-induced states time may seem to stop. In *Doors of Perception* (1954) Aldous Huxley describes changes of consciousness experienced with mescaline. One ceases to be interested in action, becoming a passive observer ('the will suffers a profound change for the worse'), though ability to 'think straight' is little if at all reduced. So he became almost 'a Not-self'. Most suggestive, 'Visual impressions are greatly intensified', while 'interest in space is diminished and interest in time falls almost to zero'. Huxley stresses that colours are immeasurably enhanced in vividness, ordinary objects appearing self-

luminous, with the inner fire of jewels, while time essentially stops, becoming: 'an indefinite duration or alternatively a perpetual present'. Under mescaline and other hallucinogens there are enhanced sensations - super *qualia* - and the *present* is emphasised with corresponding little flow of time.

Although normally memories lack visual or other qualia, there can be surprisingly vivid sensations in remembered *emotions* , as when an embarrassing situation is recalled years later. William James, with the Danish physician Carl Lange (James 1890), suggested that emotions have a basis in autonomic changes of the body. The James-Lange theory of the emotions is that the body responds, for example to a situation of danger, by preparation for action and these autonomic physiological changes are sensed as emotions, of fear or rage or whatever. For guilt there is a marked autonomic change with visible blushing. Darwin (1872) suggested that blushing is a social signal, warning other's that this individual is not to be trusted. It is perfectly possible to blush at the memory, or thought, of the guilt-making deed - and to experience qualia of guilt years after the event - presumably because there are present afferent inputs from memory-evoked autonomic bodily changes.

This notion that normally qualia flag the present, does not begin to explain how qualia are produced by brain processes; though much has been discovered recently, especially for vision (Zeki, 1995; Crick 1994). Which brain regions are involved should change with changes of cognitive processing, to be charted dynamically with local changes of blood flow recorded by fNMR brain imaging. These new techniques of brain research are promising deeper understanding of how physiological functions are related to cognitive processing, and to consciousness, but much remains mysterious.

This flagging-the-present notion has implications for consciousness in other animals. As perception got more intelligent through Evolution, it drew away from direct control by stimuli, as it depended increasingly on hypotheses of what might be out there. So identifying what is out there *now* must have become an increasing problem with development of cognitive brain function. This is bound to be a problem with future robots whe (as we may suppose) they will access vast memory stores for intelligent behaviour. Will they have to develop qualia - or will there be some other solution for avoiding confusion from the past?

Intelligence cannot be tied to the sensed present. So here there is a balancing act. What is needed for imagination and intelligence is what pushes the mind to distance present reality. It is a speculation that qualia

normally flag the present. But, as the tortoise said, "I can't take a step forward without sticking my neck out."

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