Images of mind in brain

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Vision is continuous creation of meaning from images. The images are the retinal pictures in the eyes. To say that visual perception continuously creates meaning is saying that experience is richer than the eye's images, yet poorer than physical reality. It is richer as the brain generates the vivid sensations of colour, sound and much more; yet poorer as so little of the physical world is signalled by the narrow channels of the senses, and much is hidden that we seem to see. Creation of edges and surfaces that 'should' be there, in surprising gaps, is beautifully demonstrated by the Italian psychologist Gaetano Kanizsa's pictures, such as figure 1.

Some images seem to have immediate impact — such as shocking scenes of violence — but all images need to be interpreted to have significance. In normal perception, this interpretation is fast and effortless without awareness in consciousness; so the immensely complicated processes of inferring the rich world of objects from limited information, as signalled by the senses, is not generally appreciated.

The indirectness of perception is still resisted by philosophers who hope to base truth on sensory premises. Illusions are embarrassing for Direct Realists, but are highly significant phenomena for brain scientists who investigate active processes of perception, to continuously create hypotheses of what is out there.

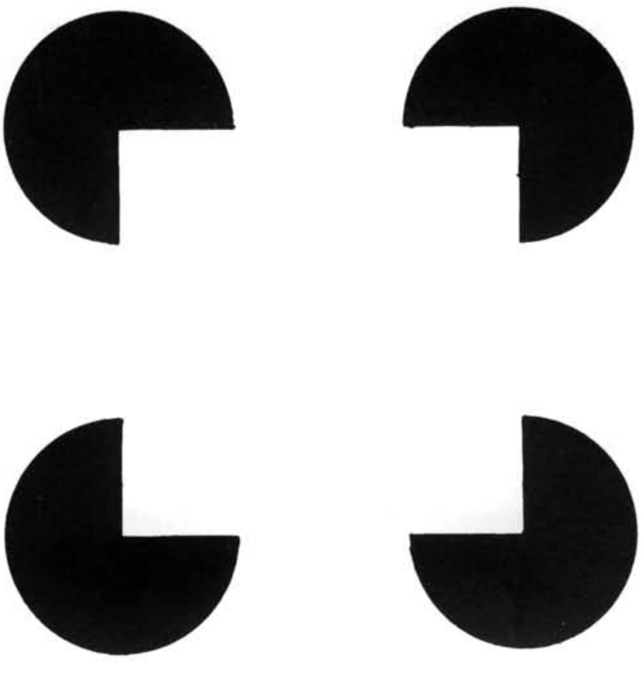

Figure 1. *Illusory surfaces*. The white square does not exist physically, but is created by eye and brain, 'explaining' the gaps.

Much as for hypotheses of science, Perceptual Hypotheses, which are our most immediate reality, depend on knowledge. We see a table as something to support things, and as made of hard scratchable inflammable wood we have learned about from years of interactive experiments. A *picture* of a table calls up this object-knowledge so it looks almost real — yet pictures are very odd. Although they call up our hard-earned knowledge of objects, such as tables, we do not try to eat off a picture of a table in a picture. When we look at a familiar object we interact with it by appreciating its potential uses or functions. Its picture calls up the knowledge of functions; but at the same time we are warned, by noting that it is merely a picture, not to expect anything materially useful from it (except, of course, if we sell it for money!).

Engineers are expert at reading functions of machines from pictures and from special kinds of diagrams. When we look at a machine, such as a bicycle, as we understand it we seem to *see* quite literally the functions of its various parts. But the fact that some special understanding is needed shows that this cannot be immediate or free from inference from background knowledge. And even very simple machines with all the working parts exposed to view can be surprising. In fact very few people can draw bicycles from memory. One has to kind of reinvent them to draw them, as evidenced in drawings such as the one shown in figure 2, by a bicycle-riding student.

Most of us have inadequate knowledge for seeing even simple functions in somewhat unfamiliar machines. What happens to this balance when a weight is moved out along one of its arms (figure 3a) ? Does it go *down* — as seems obvious for figure 3b? No — the answer is, *nothing* happens! We may discover this by experiment, or we may deduce it from the fact that the weights travel the same vertical distance, however far they are out along the arms. In 3b, though not in 3a — as the arms remain horizontal as they move up or down. As these weights travel the same distance up or down, wherever they are along the arms, the same work is done, (for work equals the mass times the distance travelled, against gravity) so though surprising, it remains balanced. It is surprising while we expect it to behave like the more familiar scales (or see-saw) of figure 3a, or when we fail to 'see' what is going on conceptually by understanding its dynamic principles.

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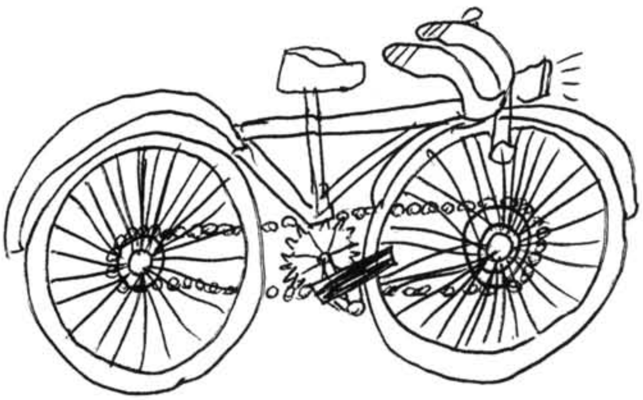


Figure 2. *Drawing of a bicycle.* Although drawn by a University student who rides a bicycle everyday, this is mechanically impossible! How could the front wheels steer? (This is quite typical.)

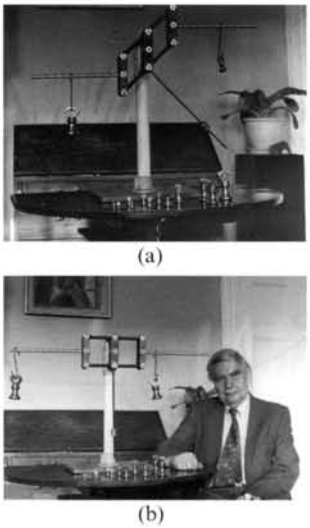
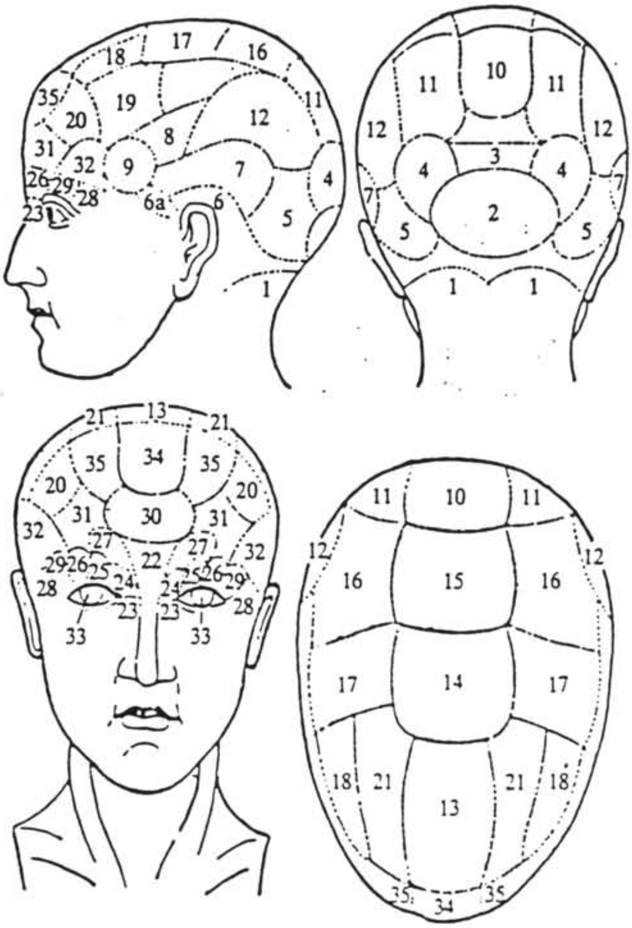


Figure 3. *Enigma Scales.* Few people can 'read' how the simple Enigma (a) works or what it does.

Is it possible to *see* what is going on, in functional terms, without general conceptual understanding? Can simple *looking* give us the necessary understanding to see significances in images? A present and very important example is images of brain functions as shown by fMRI (magnetic resonance imaging). Wonderfully, these can show which regions of a human brain are especially active while we think, or we feel emotion, or imagine or see things around us. The question is: Is it possible to see or 'read' functions of the brain in these images?

As is well known, the German neurologist Franz Joseph Gall (1758–1828), while working as a physician in Vienna, related regions of the brain to particular mental attributes by noting bumps of the skull (figure 4). Thus a bump might 'mean' superior musical ability, or love of home, or self-esteem, wit, or language and so on. There were 32 bumps of brain associated



The regions identified as personality organs, according to the classification of Gall, with additions by Spurzheim and Combe, were:

1. Amativeness
2. Philoprogenitiveness
3. Concentrativeness
4. Adhesiveness
5. Combativeness
6. Destructiveness
6a. Alimentiveness
7. Secretiveness
8. Acquisitiveness
9. Constructiveness
10. Self-esteem
11. Love of approbation
12. Cautiousness
13. Benevolence
14. Veneration
15. Conscientiousness
16. Firmness
17. Hope
18. Wonder
19. Ideality
20. Wit
21. Imitation
22. Individuality
23. Form
24. Size
25. Weight
26. Colour
27. Locality
28. Number
29. Order
30. Eventuality
31. Time
32. Tune
33. Language
34. Comparison
35. Causality

Figure 4. *Galls's brain-mind regions.* Phrenologists 'read' bumps as localised mental functions. This we now see as misleading, as concepts have changed. Cliché Bibliothèque nationale de France

with aspects of mind. The very idea that brain could be so closely identified with mind, and with human propensities and abilities, was shocking at that time and it remains a challenge to comprehend now.

Phrenology, for this is what Gall founded with his bumps, implied that parts of our natures are effectively localized in specific regions of the cerebral cortex. Is this plausible? Or is it better to say that almost all the cortex is used for everything — but when some parts are more developed, or more efficient than the average, the whole thing works in specifically different ways? This is a very different account from saying that particular regions are responsible for corresponding psychological attributes.

Looking at phrenology now, it is clear that surface bumps do not correspond closely to corresponding brain enlargements from the average. Much more profound is that it is hard to believe that, for example, specific mental abilities are related at all simply to particular regions of the brain. This is indeed the 'phrenological fallacy' — that particular psychological characteristics or abilities are represented in brain regions with corresponding functions. Thus, there would not be particular regions that give intelligence, if intelligence results from many different (individually unintelligent) processes. This now seems far more likely — though what these processes are that give intelligence remain to be discovered. For this we need to know how intelligence or whatever works. In short, to identify functions we need to understand what the functions are that create intelligence, or speech, or emotions or seeing, or whatever, so we need to know how the brain works.

The new brain imaging techniques are wonderful, opening the way to immense understanding. But much as Galileo found in the seventeenth century — that it was hard to interpret what was in the heavens, with the first telescopes — it is generally hard to see something new in images.

This is especially difficult with interacting functions. To those of us who have played about with electronics, it seems inconceivable that complicated outputs can be given by simple unitary processes. Many processes are needed for the speech and music of a radio (even more for television's pictures) and the internal processes are quite different from what we hear or see. Vision, for example, calls upon a wealth of knowledge built up from years of interactive experience of things around us. Surely this implies distributed functions, with many kinds of brain contributions — many bumps! And typically electronic systems have processes going on inside that are not represented in their 'behaviour' (such as oscillators in radios which are not seen or heard), which must be mysterious if the principles of their circuits are not understood. Does not the same apply to the brain — and, thus, for seeing brain images?

As children we learn to see by hands-on experiments, and this is true for science itself. Thus science and children take things to pieces to discover what the parts do. I suggested such an analogy from electronics to brain functions a long time ago (Gregory, 1961):

> To remove a part of a machine … is not in general to remove a necessary condition for some feature of the output. If a part is removed from a complex machine, we do not in general find that simple elements or units are now missing from the output. [Also], the functional processes taking place in the components … are generally quite different from anything in the output. Thus we do not see the spark in a car engine in its output — we see wheels turning and the car moving: no spark. If a component is removed almost anything may happen: a radio may emit piercing whistles or deep growls, a television may produce curious patterns… To understand the reason for these 'behavioural' changes we must know at least the basic principles of radio, or television, or car engines, or whatever it is… Of course, if we already know about radio, or engines, then these abnormal manifestations may well lead to correct diagnosis of the fault: the difficulty is to reverse the procedure.

Rather like David Marr (1981), I had a discussion of kinds, or levels, of representations of function (figure 5): *Blueprints* (anatomical drawings of components; *Circuit diagrams* (physiological accounts of component functions); *Block diagrams* (of organization of the system).

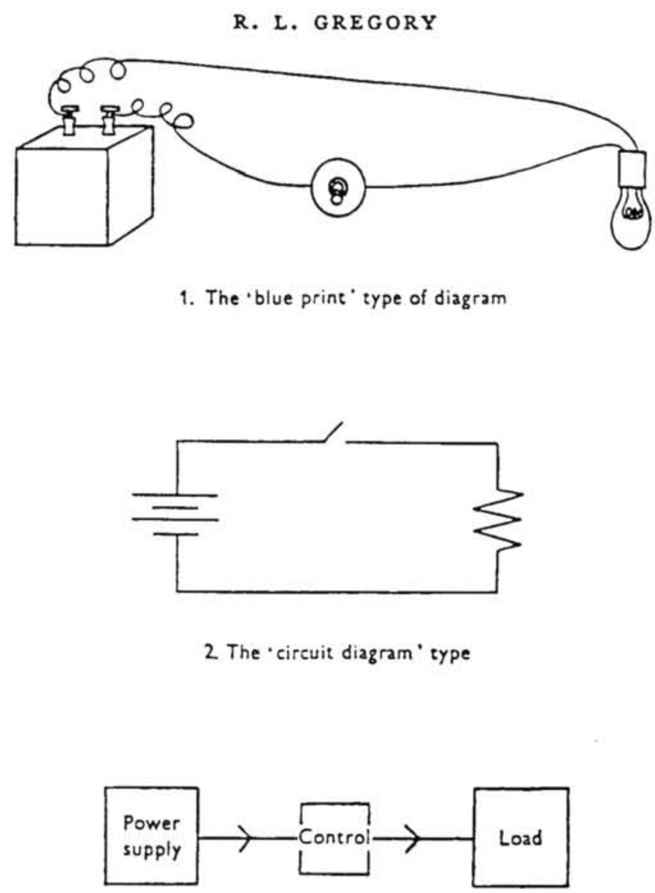


Figure 5. *Images for three levels of function (In Gregory 1961).* Described in the text. Cliché Bibliothèque nationale de France

So we should, in some systems, be able to map projection areas and delimit pathways, and this is a good deal. Analogy with familiar physical systems strongly suggests that to go further these studies should be used to test rival hypotheses of brain function, rather than attempt to isolate functional regions.

The problem becomes acute for highly interactive systems, so:

> … the removal of any of several widely spaced resistors may cause a radio set to emit howls, but it does not follow that howls are immediately associated with these resistors, or indeed that the casual relation is anything but the most indirect. In particular, we should not say that the function of the resistors in a normal circuit is to inhibit howling. Neurophysiologists, when faced with comparable situations, have postulated 'suppressor regions'.

Now that we have nuclear magnetic resonance (fNMR) for locating local activities, it seems worth asking whether these kinds of difficulties, if accepted, apply to reading brain scans. For if these difficulties do indeed apply, there is a danger of the wonderful new techniques reviving the old naive phrenology.

The more there are interactive loops in the brain, the harder the problem becomes for seeing what the images mean. As there are rich 'downwards' connections to the primary visual area V1 from the cortex, it does not follow that when V1 is active it is originating the activity from the eyes. Just as for crime and punishment it is hard and may be impossible to recognize key individuals as originators when many are involved.

Images can represent various conceptual levels of understanding. This is indeed the wonderful power of symbols. But they are generally seen or read in terms of what is already understood or known. Perhaps only the symbols of mathematics can generate new concepts, and the interactive procedures of fractals do generate new perceptions. Reading causes of mind in brain images surely requires theoretical understanding that we must win from experiments of many kinds. Then we might see our minds, in images of physical functions of the brain, perhaps even to discover and see the basis of consciousness. These images will only be meaningful from deep conceptual understanding of brain and mind.

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