
Editorial

Curious asymmetries. Part 1

Pierre Curie (1859–1906) had the creative curiosity of a great physicist. Distinguished for his discovery of piezoelectricity, now the heart of quartz crystal watches beating more regularly than Galileo's pendulum, he is known more reconditely for Curie's Principle of symmetries and asymmetries. His lasting fame is ensured from transmuting, by marriage, Marie Skłodowska into Madame Curie—discoverer, with Pierre's help, of the most curious of all the elements, radium. Pierre was professor of physics at the Sorbonne, his Chair going to Marie, when he died from an accident with a cart carrying military uniforms.

Curie's Principle, may be stated: *Symmetry cannot produce systematic asymmetry*. Asymmetry can occur once-off. Thus a stone will break a window in a jagged irregular pattern, but, when repeated, the pattern will vary and on average will be symmetrical. Yet, and this is what I will discuss, some symmetrical illusion figures show asymmetrical distortions. Can illusions of perception flout such a basic principle of physics?

The most familiar, though curiously seldom recognised, visual challenge to Curie's Principle is mirror-reflection—mirrors reversing right–left but not up–down. As a plane mirror is symmetrical, right–left and up–down, this appears to violate Curie's Principle and so looks impossible. It looks impossible until it is realised that the object (including oneself) is rotated around its vertical axis (which is usual because of gravity) from direct view, to face the mirror. Another principle of physics is that the rotation can only be around one axis at a time. When around the vertical axis, it gives right–left reversal; but when around the horizontal axis, it gives up–down and not the usual right–left 'mirror' reversal. So, against appearances, Curie's Principle is not challenged by mirror-reflection. Mirror reversal is neither an optical nor a perceptual phenomenon. I have discussed this in Editorials (Gregory 1993a, 1993b, 2001) and elsewhere.

What of visual distortions? Can distortion-illusions of symmetrical figures violate Curie's Principle? It is a question of importance: that what applies in physics may not apply in perception, as perceptions are essentially separate from the physical world, and so may break physical restraints, even though this is beyond possibilities of behaviour. The notion of brains violating principles of physics is, however, curious, as we think of brains and eyes, and the rest of the nervous system, as physical machines. Yet we see the Penrose Triangle as physically impossible (even when made as a three-dimensional object viewed from a special position), and we see the fictional Kanizsa Triangle, which has no physical existence, as though it appears as physically real. Visual distortions are further examples of appearances departing from realities of the physical world; but can visual departures violate physics as deeply as Curie's Principle?

If perceptions were 'pictures in the brain' or isomorphic models, we would need to ask how *they* could have properties of illusion, especially how they could exist while flouting Curie's Principle. But, although there are still temptations to think of the brain as representing shapes with similarly shaped brain structures, the essential error was pointed out over two thousand years ago. More recently the Gestalt psychologists ran into trouble with their *isomorphism*, especially their account of the Phi phenomenon of apparent motion. They argued that, because (illusory) movement is seen, something corresponding must be moving in the brain. Hence moving isomorphic brain fields. Yet this kind of explanation was effectively shot down over two thousands years ago by Theophrastus (c. 372–286 BC), when he criticised Empedocles's 'direct' account of

perception with essentially isomorphism, though his example was hearing:⁽¹⁾

“It is strange of him [Empedocles] to imagine that he has really explained how creatures hear, when he has ascribed the process to internal sounds and assumed that the ear produces a sound within, like a bell. By means of this internal sound we might hear sounds without, but how should we hear this internal sound itself? The old problem would still confront us.”

Though, as noted by Theophrastus long ago, the notion of isomorphism gives only the semblance of explanation, and generates confusions and paradoxes, it has been held tenaciously ever since, even by recent scientists of top distinction, including heroes of physiology. Thus, the axioms of physiological psychology, proposed by the father of modern physiology, G E Müller, in 1896, posited cortical activities similar to perceptions. Müller is quoted, with comments, by the historian of experimental psychology E G Boring (1929/1950, page 679). Müller wrote: “To an equality, similarity or difference in the constitutions of the sensations ... there corresponds an equality, similarity or difference in the constitution of the psychophysical [brain] process, and conversely”. Boring points out that this isomorphic account was shared by the good and the great. Müller found support for this view from Lotze (1852), Fechner (1860), Mach (1865), and Hering (1878). Boring cogently comments: “... yet there is no logic that compels its acceptance”. (For these references see Boring 1950.)

It is interesting to see how many, and how distinguished, were adherents of isomorphism, at any rate until recently with lessons from computers. No doubt, isomorphism gets its plausibility by seductive analogy with the similarity of a drawing’s shapes to what it represents. But, of course, the drawing has an eye and brain to see it, with no need or temptation for a regress of further eyes and brains. (And, for the ear, no regress of internal sounds and inner, inner ears.) Computer descriptions are very different from ‘pictures in the brain’, which need another eye and brain—then another—and another—driving a regress without end, making isomorphism worse than useless. Boring continues with an example from hearing (though Theophrastus is not mentioned):

“Recently it has been suggested that low pitches may vary with the frequency of the impulses in the acoustic nerve, that high pitches may depend on the particular nerve fibre stimulated most, and that the series of pitches may nevertheless appear continuous to introspection. That would be a discontinuity yielding a continuity and would contradict Müller’s axioms; yet there is no reason why a discontinuity should not be symbolized by a continuity. We do the opposite with the integers and in the decimal system when we add a new digit in passing from 99 to 100.”

The seductive drawing-of-pictures analogy has initial plausibility for shapes; but it is at once physiologically absurd to suppose that colours are represented by regions of brain similarly coloured (bits of green brain for seeing grass, of blue brain for seeing sky), and it is implausible for moving shapes, and unnecessary and paradoxical for stationary shapes. Language gives a clue to the way out: the word RED, though printed in black, means red; and the word MOVEMENT, though static, suggests shifts of position through space in time. This extends to mechanical representations of movement: the hand of the car speedometer rests unchanged on say 60 mph, telling the driver to watch out as he is moving.

However, when we think of perceptions as brain *descriptions*, separation from the object world presents no special problem, as all descriptions are necessarily separate from what they describe. Illusions as mistaken descriptions have no problem as departures from the object world; though ‘direct’ theories, and isomorphic brain copies, do suffer death by conceptual conflicts.

⁽¹⁾Theophrastus, “On the Senses”, translated, in G M Stratton 1917, *Theophrastus and the Greek Physiological Psychology before Aristotle* (London: Allen and Unwin) page 35. (Yes, this is the G M Stratton of reversing-goggles fame.)

Can the brain's perceptual hypotheses, of what may be out there, violate basic physics such as Curie's Principle? Most, if not all of us, believe that the brain responsible for perception is a machine, but what kind of machine? Could it be so special that the laws and principles of physics that hold for the rest of the known universe do not fully apply to brains? How could brains be so curiously special? There are special states of matter—as in the centre of stars, and the Sun—where principles of normal physics do not apply. It is well known that Lord Kelvin put Darwin off his stroke, by saying that Evolution had only some 12 million years to run, as the Sun, being like a coal fire, would lose its heat by then. It turned out that the Sun has very different physics—the physics of radioactivity, initiated by Marie Curie, with Pierre's help. The brain is, of course, utterly unlike the centre of a star, but it does have uniquely complicated structures. Does its intricate complexity confer the brain with special powers placing it outside normal physics? If so, are its special powers and freedom from restraints of normal physics unique to brains? Candidate for other beyond-physics machines are, of course, computers. Computers can also produce and handle physical impossibilities, and many kinds of distortions. This is because the machine incorporates software working with symbols—meaning: objects *standing for* other things. These 'other things' may include abstractions, that can never be sensed. Here we may follow the American philosopher Dan Dennett (1991) in saying that the mind is a virtual machine, living within and depending upon the hardware computer. It is a technological ghost; yet breathes with the life of the mind, conferring intelligence, and even consciousness.

The notion of the brain working with internal models of reality was suggested by the Cambridge psychologist Kenneth Craik (1943), though his brain models were (as he wrote before the impact of electronic computers) essentially mechanical copies of external realities. So Theophrastus's objection to isomorphism would apply to Craikian internal models. Having shapes corresponding to the shapes of things they represent, they could not escape Curie's Principle, to generate asymmetries from symmetries.

The question now becomes: Can software virtual reality of the mind be free of Pierre Curie's Principle, that symmetries cannot produce systematic asymmetries? The virtual reality must be different from real reality, to escape physical restraints of the possible; but how different, and in what ways different? For object perception, can computer or brain descriptions by lists of characteristics, such as Irving Biederman's *geon* unit shapes (Biederman 1987), allow exceptions to Curie's Principle? Is this indeed a key to the nature of mind, freeing imagination and perception from limitations of physics?

For Curie's Principle—that asymmetries cannot be systematically generated from symmetries—for perception, we may look at illusory distortions. Can they violate the Principle? Does rejection of isomorphism (which was cogently challenged over two thousand years ago by Theophrastus, and was a headache for the Gestalt psychologists) allow perceptual asymmetries from symmetrical objects? We see this in some well-known illusion figures, so we can look for empirical evidence, and perhaps use Curie's Principle, as a challenge and a guide for explaining distortion illusions.

The stumbling block of isomorphism is not hard to avoid, as pictures are not the only kinds of representations, as indeed language shows. A script consisting of symmetrical letters might describe an asymmetrical object, as shapes of letters are only significant by arbitrary conventions, and could have any shape. Thus the words CIRCLE or SPHERE do not need to be symmetrical to evoke mental images of symmetrically shaped objects. Similarly, there seems no problem in imagining or seeing asymmetries with symmetrical brain states if they could code or represent asymmetries, whatever their symmetry.

For perception, there must be some physical links between perceived objects and the perceiving brain. We know from physiology that these links are neural signals, in afferent nerves from stimulated receptors, somehow evoking utterly different phenomena,

such as sensations of consciousness, according to where they stimulate the cortex—as Müller pointed out with his law of specific energies, in 1838.

Sensory signals start from the physics of stimuli; so surely these, at least, must obey Curie's Principle. For stimuli are in the domain of physics, and 'normal' physics reigns before the signals are decoded into perceptions. The sensory receptors (especially the retinal receptors) sample stimuli, and serve as transducers to convert them into neural signals on a roughly point-to-point basis. So—homing in on phenomena of visual distortions—only local distortions seem possible, with no opportunity for violations of Curie's Principle here. Yet some illusions that apparently flout Curie's Principle, such as the Café Wall and the Zöllner figures, are large-scale, one might say global, distortions, far larger than information from individual receptive fields. What is interesting here is that the global distortions occur along axes of symmetry of repeated small-scale patterns, which are identical across the figures, and yet give large-scale global asymmetries.

How might neural signals be globally distorted? Global distortion of vision can occur with astigmatism; but the distortion here is before the retinal signals, and affects practically all patterns equally. Can neural signals themselves be globally distorted? Physical distortions of the retina, as by detachment, can produce large-scale distortions; but these are not exactly neural, and again all patterns are equally affected. Wired-in interactive effects across distant receptors might produce large-scale effects, such as graded changes of sensitivity, as for the retina's gradual loss of acuity and colour responses outwards from the fovea. These might appear asymmetrical (especially perhaps with glaucoma), but, unlike the Café Wall and the Zöllner illusions, these distortions will be by reference to the *eyes*, not to the figures or objects being seen. If the head is tilted, the distortions will rotate correspondingly on the display. But, with a few interesting exceptions, the illusion-distortions are unchanged for the figure when the head is tilted (that is, when the eyes are rotated around the axis of vision). Also, unlike these perceptual illusions, astigmatism presents no challenges to Curie's Principle, as there *is* asymmetry of the optics of the eye. This is entirely different from the problem set by repeated small-scale patterns (black and white tiles and tilted cross lines, respectively) of the Café Wall and the Zöllner illusion figures, as they are symmetrical along the axes of perceived asymmetry, remaining so for any orientation, and so do seem to flout Curie's Principle.

There are two possible explanations: (i) There might be some kind of cumulative effect of successive distortions from local asymmetries. This would not violate Curie's Principle, as the global distortion would arise from asymmetry—from many local asymmetries—though the figure is globally symmetrical by its small-scale repeated patterns, so that any region may be substituted with any other. Or, a very different possibility: (ii) There might be some kind of modulation of neural signals from on high—'top-down'—from a higher-level global reading of the pattern. This would be reading some kind of asymmetry from symmetry by the virtual reality of the mind, by non-isomorphic brain processes. Which of the symmetrical illusion figures giving asymmetrical distortions fall into which kind of explanation, local or global, is the 6.5×10^4 question.

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