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Editorial

Curious asymmetries. Part 2

Returning to the previous Editorial (*Perception* **33** 639 – 642), in discussing Pierre Curie's Principle that asymmetries cannot be systematically generated from symmetries, I suggested that this is useful for thinking about visual perception, especially illusory distortions and what might cause them. I asked: How can distortion illusions of vision violate Curie's Principle of physics? Do visual distortions give a clue to brain representations?

For perception there must be physical links between perceived objects and the perceiving brain—signals in afferent nerves, somehow evoking utterly different phenomena, such as sensations of consciousness, according to where they stimulate the cortex, as the great physiologist Johannes Müller pointed out in 1838 with his Law of Specific Energies.

Distorted signals could produce local distortions; but there are large-scale, one might say global, distortion illusions, far larger than receptive fields and occurring along repeated small-scale patterns. Though each small-scale pattern is asymmetrical, when repeated along one of these figures the whole figure is symmetrical, as any small region is equivalent to any other. Yet the repeated and so symmetrical pattern gives global asymmetry in well-known distortion illusions. This seems to violate Curie's Principle of physics, and yet occurs in perception. This suggests that brain representations are not simple copies, or pictures, or the isomorphism of Gestalt theories.

I accepted Theophrastus's objections of over two thousand years ago to isomorphism, arguing similarly that, if the visual brain represented objects by similar-shaped brain patterns, or internal pictures, these would not have any explanatory value, as they in turn would need an eye to see them ... generating infinite regress and getting nowhere. Also, if they were shapes like the shapes of seen objects, they must be restricted by Curie's Principle—as what applies to anything will apply to its copy—so they could not allow asymmetrical perceptions from symmetrical objects. Yet this can occur.

Could representation like language, or other digital coding, escape Curie's Principle? Couldn't a symmetrical word represent an asymmetrical object? It can: MUM is symmetrical, but one's mother is not symmetrical fore and aft. Conversely, CIRCLE or SPHERE do not need to be asymmetrical to represent their symmetrical objects. Similarly, there seems no problem for language-like, or digital, asymmetrically shaped brain states to represent symmetrical objects—or for symmetrical states to represent asymmetrical objects—as such brain-symbols would have conventional meanings unrelated to their shapes. This might work for visual representations with lists of characteristics, like Irving Biederman's (1987) geons, characteristic features combined in various ways to represent objects. Biederman's papers show geons as pictures; but of course this does not mean that they are pictures in the brain. They could be digital and so have quite different forms, read as a code for elementary shapes and how they are combined into objects.

There are, I suggested, two possible classes of explanations for global distortion illusions: (i) Some kind of cumulative effect of successive distortions from local asymmetries, cf Fraser (1908) and his 'twisted cord' figures. As these start from asymmetries, they do not violate Curie's Principle. A very different possibility—which does violate the Principle—is: (ii) There might be some kind of modulation from on high, by a digital representation. Just how could this allow asymmetry from symmetry?

This, I suggest, is where the third dimension (Z dimension) comes in. Depth indicated by a repeated and so $X-Y$ symmetrical pattern should introduce Z asymmetry. If one end of a repeated, and so symmetrical, pattern is represented as *further*, there is asymmetry in the third dimension, which could be represented by a language-like digital code.

How is this asymmetry of the Z dimension of depth translated into asymmetry of the $X-Y$ plane? The answer earlier suggested (Gregory 1963) is that the pattern indicating depth sets size scaling, regions represented as further being expanded, to compensate the usual optical shrinking of the retinal image with increasing object distance. The universal expansion with indicated distance in these illusions (though depth is not seen when countered by texture of the picture plane) is, of course, evidence for this notion.

It seems that this was not noticed much earlier, as the illusion figures generally *appear* flat. It turns out that perceived depth is generally countered by texture of the picture plane. When the texture is removed (by drawing the figure with luminous paint, and viewing in darkness with one eye) these figures generally appear quite dramatically in depth, appropriate to their perspective. The distortions disappear when corresponding three-dimensional wire models are viewed with both eyes, or as 3 – D pictures from point-source optics (Gregory and Harris 1975). Some of these are available as anaglyphs (Gregory 1997). Evidently, when the figures are seen in appropriate depth, the Z asymmetry no longer transfers to the $X-Y$ plane. So the initial distortion of the flat figure disappears in favour of the asymmetry of depth in the Z dimension.

We may look now at some well-known distortion illusion figures with these issues in mind. First (Type 1): accumulated local asymmetries; then (Type 2) flat $X-Y$ symmetrical patterns modulated by Z depth asymmetries.

The Café Wall (figure 1) gives asymmetrical distortions of parallel 'mortar lines' from a repeated and so symmetrical pattern of alternating dark and light tiles, with narrow neutral-luminance 'mortar' lines along the rows. These seem to violate Curie's Principle, by appearing as asymmetrical wedges. Gregory and Heard (1979) offered as explanation that the global wedge distortions are produced by successive integration of many local illusory tilts, generated by asymmetries of pairs of the half-overlapping dark – light tiles. (Small-scale tilts are seen with very small tiles.) The supposed cumulative integration of local tilts 'saves' Curie's Principle, as the global wedge asymmetries are produced by small-scale asymmetries. This is a candidate for the first kind of explanation (Type 1): summation of small asymmetries to generate a global asymmetry.

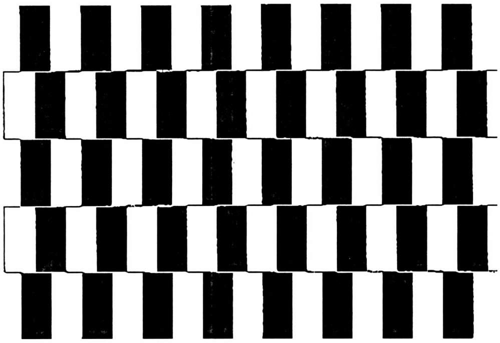

Figure 1. Café Wall illusion. The dark – light 'tiles' form small-scale asymmetries, which add cumulatively to produce the global distortions of the 'mortar' lines.

A candidate for the second possibility (Type 2)—global modulation downwards—is the Zöllner illusion (figure 2). This represents corners, like the Müller-Lyer arrows though more complicated. They are like the treads and risers of a staircase, viewed alternately from each end. By representing depth, it could escape Curie's Principle (though it is outside physics), as it is globally asymmetrical in the Z dimension.

The repeated oblique lines of the Zöllner are like the Müller-Lyer perspective corners, though more complicated, as for the Zöllner there are two 'assumed' viewing positions, alternately for each 'staircase'. (This is a principle of picture seeing that needs further discussion: Where is the observer's assumed place in a picture universe? How many places can he have?) None of this applies to the Café Wall, which does not have depth information.[(1)]

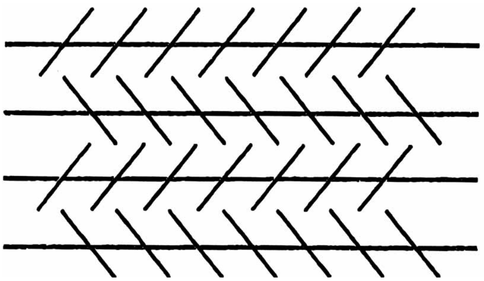

Figure 2. Zöllner tilt illusion. The repeated short tilted lines signal depth, as perspective corners like the risers and treads of a staircase. The depth introduces Z asymmetry into the repeated and so symmetrical $X-Y$ pattern.

It might be thought, as a Type 1 alternative, that the long tilts of the Zöllner (figure 2) are successions of local Poggendorff displacements (figure 3), and so might be Type 1 summation of asymmetries. But it should be noted that the Poggendorff displacements are in the *wrong direction* for producing the tilts of the long lines, as seen by inspecting figures 2 and 3. This favours a Type 2, top–down modulation effect, from Z-dimension asymmetry, in digitally represented depth.

The distortion could not have a retinal origin as it is not affected by rotation of the eye around the line of sight, by tilting the head or by rotating the figure. These distortions remain unchanged when the figure is rotated around the line of sight or head is tilted; though there are exceptions to this. An exception is the Poggendorff illusion (figure 3).

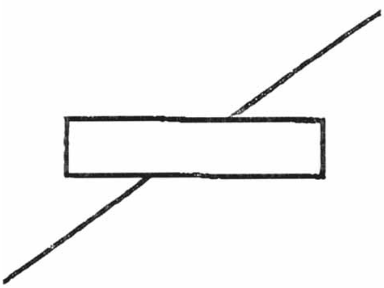

Figure 3. Poggendorff illusion. The long line is displaced across the thick short line or rectangle. This appears to be a very simple Type 2 (perspective) effect. Evidently it is not a unit of the Zöllner, as successive integration goes in the wrong direction.

The displacement of the two halves of the long oblique is reduced when it is horizontal or vertical. When at any other angle, it could be a perspective line, and so might set size scaling with this one-line perspective. This implies that top–down scaling can be set almost as much by assumption of perspective as by rich visual evidence. But as all evidence depends on assumptions, perhaps this is not too surprising.

[(1)] The Café Wall illusory wedges can be seen as perspective convergences, tilting alternate rows of tiles oppositely in depth; then the $X-Y$ distortion is replaced by corresponding Z depth. This exchange can work either way round.

What would Pierre Curie, the physicist, think of extending his Principle from physical to mental space? Perhaps he would not reject psychological explanations, as physicists are expert cognitive beings using symbols to describe and explain the universe: experts in deep symmetries and curious asymmetries.

Richard Gregory

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