

calcium-binding proteins and which is probably shared by the rest of the S100 family. It has been suggested that non-covalently associated dimers of S100 proteins are the functional form inside the cell¹⁰, whereas intercellular forms may function as dimers covalently linked by disulphide bonds. A wide cleft formed upon dimerization may be the binding surface for target proteins, which could be modified further by calcium binding to one or both of the EF hands¹¹. This would be analogous to the changes that occur on the binding surfaces of calmodulin as it goes from the calcium-free state to the calcium-saturated form¹²⁻¹⁴.

The kinase function of twitchin may be temporally distant from the function of the many fibronectin-III-like and immunoglobulin C-like repeats and could be controlled by the expression pattern of S100A1₂. It may be that the kinase activities of twitchin and titin are more important developmentally in muscle formation

and organization than they are in established muscle function. The twitchin phenotype in the nematode *C. elegans* can be rescued by missense mutations involving the myosin head region, suggesting that twitchin interacts with the myosin heads, presumably through its kinase domain. However, twitchin's role in phosphorylating the regulatory light chains of myosin is not obvious because molluscan muscle contraction is thought to be regulated by the direct binding of calcium to myosin heads.

The disparate functions of the giant kinases are more readily examined in the fruitfly *Drosophila melanogaster*, which contains in its muscle cells a titin-like protein, projectin, which has similar structure and functional domains¹⁵. Two projectin mutants were lethal at pre-hatching stages of development, suggesting that the mutant fly embryos lacked the necessary muscle strength for hatching¹⁶. Projectin appeared to help regulate the length of

myosin filaments *in vitro*¹⁷. P-element insertion of mutant genes into fly eggs can replace normal genes and thus tease apart the two proposed functions of organizing muscle and regulating muscle contraction.

Traditionally, worm and fly fishermen are often scornful of one another as the latter consider their fishing style to be more artistic and the former that theirs can catch more. However, versatile fishermen have a tackle-box full of bait for all conditions and know that flies also catch big fish. The S100A1₂/twitchin connection landed by Kemp *et al.* is a big catch for those who angle with worms; fishing with flies may land the rest of the story. □

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VISION

Resolving perceptual ambiguity

Jeremy M. Wolfe

In 1761, M. DuTour placed a prism in front of one eye so that "different objects will be projected on corresponding portions of the two retinas". He goes on to describe what he saw, saying: "If such images could both be simultaneously perceived, a confused picture would be seen... but this was not what was evident to me in the test that I made: sometimes I would see only objects projected in the bare eye, sometimes only those in the eye covered by the prism, and sometimes the object projected in one would seem to intermingle with the objects projected in the other" (ref. 1).

On page 621 of this issue, Logothetis *et al.*², continuing their earlier work^{3,4}, report on a clever experiment that links this classic phenomenon of binocular rivalry to the broader issue of perceptual stability — how we perceive a single interpretation of an ambiguous perceptual world. Like DuTour, they show each eye a different stimulus. Their version of this binocular rivalry experiment shows just how stubbornly the visual system tries to infer a single, coherent interpretation from this biologically implausible input.

Before describing this new result, it is worth providing a bit more detail about the basic phenomenology of binocular rivalry. Consider stimuli like those used by Logothetis *et al.* The left eye sees lines

tilted to the left of vertical and the right eye sees lines tilted to the right. Let us suppose that these are relatively large stimuli (Logothetis *et al.* use stimuli that are 3 degrees of visual angle on a side —

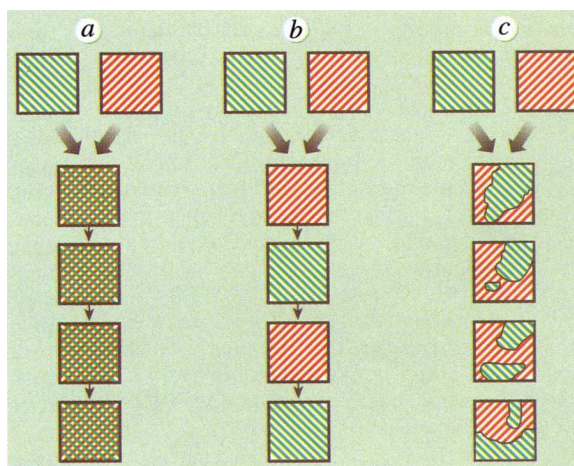


FIG. 1 What happens when the two eyes see two different stimuli? Under most circumstances, the two stimuli do not fuse (a), nor do the two monocular images rival as wholes (b). Rather, we see a continuous struggle between regions dominated by one eye's input and regions dominated by the other (c).

large enough for our purposes). Several possible outcomes are not seen under normal circumstances. As DuTour noted, two distinct monocular patterns do not fuse together (unless you flash the stimuli on and off at the correct rates⁵) (Fig. 1a). Nor is binocular rivalry a competition between the two eyes as a whole. This

would produce exclusive visibility of one or the other monocular stimulus — something that is not normally seen with stimuli larger than 1 square degree (ref. 6) (Fig. 1b).

In most examples of rivalry with large stimuli, what is seen over time looks something like the sequence in Fig. 1c. Each region of the retinal image in one eye seems to fight with the corresponding region in the other eye. However, these interocular battles are not completely local, oblivious to the tide of war elsewhere. Regions expand, contract and vanish in a seemingly systematic fashion. This evolving patchwork probably reflects the actions of two mechanisms: first, an interocular competition for dominance by the left eye or the right eye at each location, and second, a stimulus-specific mechanism that seeks to impose a single perceptual interpretation on the competing stimuli.

In the example shown in Fig. 1, the interocular mechanism would be choosing between the left-eye and right-eye stimuli, whereas the stimulus-specific mechanism would be choosing between left and right oblique gratings. These two choices are perfectly confounded in the usual binocular rivalry situation. Logothetis *et al.* have found a way to unconfound them. This allows us to see the stimulus-specific mechanism building a coherent percept without its being thwarted by the more local, interocular struggles for dominance⁶.

Logothetis and colleagues have taken a number of actions that probably serve to reduce the influence of the interocular

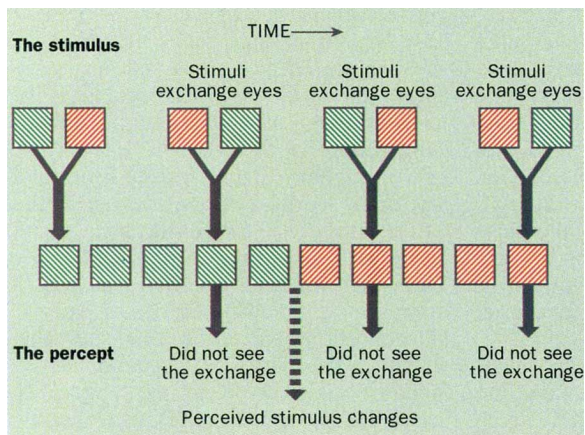


FIG. 2 Logothetis *et al.* present oblique bars to one eye and orthogonally oriented bars to the other. Three times a second, the stimuli exchange eyes. Under the conditions described in the text, observers do not see this exchange. Instead, the visual system tries to hold on to a stable percept, even if the input supporting that perception moves from the left to the right eye.

competition. What they did and saw is illustrated in Fig. 2. They used stimuli similar to those in Fig. 1. They flashed them on and off at 18 Hz to produce a continuous flicker. Their critical manipulation was to exchange the stimuli of the left and right eyes three times a second. Thus, looking with just one eye, you would see a flickering grating repeatedly changing orientation by 90°. Their surprising finding is that this exchange is not seen when both eyes are open.

This is a clear 'win' for the stimulus-specific mechanism. It is managing to preserve the perception of lines of one orientation, even when those lines shift from one eye to the other. If the interocular mechanism were more potent, you would see changes in the currently winning, dominant eye and so you would see the orientations change⁷.

It is not entirely clear why the conditions used by Logothetis *et al.* favour the putative stimulus-specific mechanism. There are ways to eliminate rivalry entirely and produce the plaid pattern of Fig. 1a. Changing from high-contrast bars of black and white to low-contrast bars of very slightly different shades of grey will do it⁸. So will flickering the pattern on and off every fifth second or so⁹. The authors' stimuli are flickering gratings of 20 per cent contrast — not low or slow enough to eliminate rivalry, but perhaps an intermediate state that preferentially disrupts the interocular processes.

There is some evidence to support the idea that local interocular competition has been disrupted. Logothetis and colleagues report whole eye rivalry (Fig. 1b) with their 3 × 3 degree stimuli. Whole eye rivalry usually requires stimuli smaller than about 1 deg, so whole eye rivalry with such a large stimulus suggests reduced local interocular competition. In informal observations in my laboratory,

this dominance of stimulus factors over interocular factors is reduced if either the contrast is raised or the flicker is eliminated. Further parametric work is needed on this point.

If this were merely an illustration of some arcane details of binocular rivalry, it would be of only limited interest. However, its real value lies in its potential to bring under scientific scrutiny the stimulus-specific mechanism described above. Normal visual perception always represents the effort to impose a single interpretation on ambiguous visual input. As a slightly strained example, consider the full stop at the end of this sentence. It

could be a speck of dirt. It could be a small portal into a black void beyond the page. You see it as a full stop because your visual system renders the verdict that a full stop is the most plausible interpretation of that black spot in the image.

Every psychology text contains illustrations of what are called 'ambiguous' or 'reversible' figures — cleverly contrived cases that prevent the visual system from settling on a single interpretation. Examples include the Necker cube and Rubin's face-vase figure. In these cases, one stimulus produces two plausible perceptions. Binocular rivalry allows us to present two arbitrary competing stimuli to the visual system. The demonstration by Logothetis *et al.* enables us to minimize the usual interocular competition. This opens the way for experiments that pit one percept against another in order to uncover the rules that are used to resolve perceptual ambiguity. □

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Inner ferment

THE greenhouse effect is not a purely human invention. The world's cows and termites eat plants, and ferment their saccharides internally to carbon dioxide and the potent greenhouse gas methane. They emit about 300 million tonnes of it into the air each year. And, of course, the plants that evade the cows and termites still die sometime, and similar organisms degrade their saccharides, again to carbon dioxide and methane.

These fermentations proceed through a 'consortium' of many different microbes. The primary gaseous product is hydrogen. This is then seized by the methanogens and combined with carbon dioxide to give methane. For dairy farmers, methane is a pure waste product. They try to reduce it by feeding their cows with 'ionophores' — chelating agents that inhibit the methanogens by seizing the sodium and potassium ions they need for their hydrogen-uptake chemistry.

Curiously enough, we ourselves seem to have solved this problem. We all make hydrogen in our large intestine; even *Escherichia coli* can make hydrogen from saccharides, though some clostridia are better at it. But only a third of us take it on to methane. The rest of us somehow suppress our internal methanogens, and emit hydrogen from our rear ends.

Now some *Streptomyces* moulds put out natural ionophore chelating agents, which kill rival bacteria by stealing their potassium. The methane-free majority among us, says Daedalus, must harbour a bug that makes a similar inhibitor. So DREADCO biochemists are studying the internal flora of volunteers, to identify this organism and the inhibitor it uses. They plan to insert its crucial genes into promising members of the internal flora of cows and termites, and the free-living cellulose-rotting organisms. The new, improved organisms will displace and suppress the methanogens. Some of them may even put the hydrogen to better use — perhaps to make acetate.

When all is ready, DREADCO will release the new genetically engineered organisms into the environment. They will spread rapidly. Every cow and termite in the world will have a mighty internal spasm as the new internal regime takes hold. Thereafter, they won't produce methane, but hydrogen instead.

Environmentalists will agonize over the use of wicked genetic engineering to counter the wicked greenhouse effect. The rest of us will enjoy the benefits. Not only is hydrogen a non-greenhouse gas; it is widely acclaimed as the virtuous, non-polluting fuel of the future. Generated in fermenters and used to power fuel cells, it will be the ultimate renewable source of energy.

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