VISION

Knowing where you're going

S. J. Judge

MOTION of an observer creates 'optic flow' of the retinal image, containing information both about the observer's motion (or rather the motion of his eye) and about the three-dimensional structure of the world, as Gibson[1] was the first to emphasize. Although optic flow is purely a matter of geometry, recovering information from it is a non-trivial computational problem (see ref. 2 for a readable introduction). Although there are many theoretical schemes for analysing the phenomenon, it is not clear which computations the brain actually employs. For example, it is disputed[3] whether the brain computes the differential invariants of the optic flow, which in theory provide the information needed. Now, on page 160 of this issue[4], the neurophysiologists Roy and Wurtz report a remarkable new finding which bears on these questions.

The authors have been studying the activity of nerve cells in a zone of the cortex known as MST, once thought to be part of 'association cortex', but now known to be one of several areas specialized for the processing of visual motion signals. Individual MST cells are often direction-selective in their response to visual stimulation: movement in a given direction activates a cell, whereas movement in the opposite direction does not. The novel result is that 40 per cent of the MST cells studied by Roy and Wurtz have a further property: the direction of motion that activates these cells is dependent on whether the stimuli are closer to or further away from the animal than the fixation point (the target at which it is looking). If the cell is activated by stimuli in the foreground moving to the left, stimuli in the background will excite the cell if they move to the right.

Rather than using real three-dimensional targets, Roy and Wurtz simulated the effect of target distance using a stereoscopic display: the stimulus for one eye was projected onto a screen in red, and that for the other eye in green, and red–green goggles were used to separate the two images. This arrangement allowed the binocular disparity (the difference between the angular position of equivalent elements of the stimuli in the two eyes) to be manipulated independently of other changes that would accompany alteration of the distance of real targets.

One circumstance that would generate this pattern of visual stimulation is motion of the observer to one side as he fixates an object, or part of an object, in a scene with objects at different distances. Roy and Wurtz suggest that the disparity-dependent direction-selective (DDDS) cells might be part of a mechanism for inferring the direction of motion of the organism through the environment from its visual consequences. Because the DDDS cells tend to prefer horizontal motion, they could supply information about the sense (leftward or rightward) of the side-to-side component of self-motion. Other cells in MST are already known to respond to the radial expansion that is characteristic of motion in the direction of the line of sight, so one has the beginnings, perhaps, of a coordinate system for analysing self-motion.

One might then ask whether the DDDS cells could provide a signal not only of the sense of self-motion but also its magnitude. Consider an observer moving at velocity v parallel to a plane with disparity d relative to the fixation point, and looking at right angles to the direction of motion (the conditions corresponding to those used in Roy and Wurtz's experiments). Then the angular velocity, m, of motion of the foveal retinal image of features on the plane, is given by $m = vd/I$, where I is the interocular separation. In particular, the ratio m/d is proportional to observer velocity, v, regardless of viewing distance. (This is a consequence of the well-known close geometrical relationship between stereopsis and motion parallax.) So the response of velocity-signalling DDDS cells should be invariant for stimuli with equal m/d, but vary systematically with m/d. From the examples of DDDS cells in Ray and Wurtz's report it is not clear whether this is the case. But it is clear that the two DDDS cells illustrated could only signal self velocity for scenes restricted to disparities less than a degree or so, as the cells' responses saturated at disparities of about one degree, for stimuli of constant m and varying disparity.

There are other circumstances that generate optic flow of the type to which DDDS cells are sensitive — such as the motion of an object, extended in depth, past an observer who is tracking a particular point on the object. Might it be that DDDS cells also play some role in the analysis of optic flow associated with object motion? □

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SYNTHETIC CHEMISTRY

Boron's molecular gymnastics

Keith Smith

BORON has frequently occupied an important position at the forefront of chemical development. For example, diborane (B_2H_6; compound **1**, Fig. 1), which resembles ethane (C_2H_6) in its formula but possesses two fewer electrons, for many years confounded attempts to rationalize its structure in terms of the electronic theory of bonding. The eventual resolution of the conundrum led to an appreciation of multicentre bonding. More recently, polyhedral boron compounds typified by pentaborane(9) (compound **2**, Fig. 2) were instrumental in the emergence of a general theory of cluster species[1,2]. Boron has also provided one of the most widely used reducing agents, sodium borohydride, and a Nobel-prize-winning synthetic reaction, hydroboration[3]. Now, new work in Germany[4] illustrates how the propensity of boron compounds to take part in rearrangement reactions can lead to contortions on a molecular level which on a human level would make the most daring Soviet gymnasts gasp in disbelief.

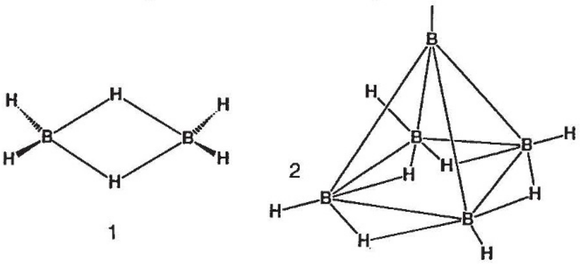

FIG. 1 Diborane (compound **1**) and pentaborane(9) (compound **2**); forerunners in chemical developments.

The work in question concerns reactions of tri-*tert*-butylazadiboriridine (compound **3**, Fig. 2) with carbon monoxide. Peter Paetzold and his collaborators bubbled carbon monoxide through a solution of **3** at low temperature, whereupon crystals of compound **4** separated from the solution in high yield (Fig. 2*a*). The structure of compound **4** was confirmed by its nuclear magnetic resonance and mass spectra, and by X-ray crystallography. It possesses a nearly planar central six-membered ring with two three-membered rings joined in a spirocyclic fashion perpendicular to it.

When the carbon monoxide for the reaction was provided by photodecomposition of iron pentacarbonyl, an even stranger rearrangement took place producing compound **5**,