Comment

Blackawton bees: commentary on Blackawton, P. S. et al.

The creature in figure 1 is a buff-tailed bumble-bee (Bombus terrestris), a member of one of the most abundant bumble-bee species in Europe. It lives underground with its nest mates, often in the abandoned nest of a mouse and, while it spends much of its life foraging within 100–500 m of its nest [1] with occasional excursions further out, buff-tailed bumble-bees transported as far from their nest as 13 km can find their way home.1

This bumble-bee is a social creature, sharing information about food sources with its nest mates by motor displays and chemical signals (pheromones). Its foraging behaviour is an endless series of visits to flowers, typically flowers of a single species as noted long ago: ‘On each expedition the bee does not fly from a flower of one kind to a flower of another, but flies from one violet, say, to another violet, and never meddles with another flower until it has got back to the hive . . . ’ [2, p. 277].

In an elegant book about the economics of the bumble-bee, Bernd Heinrich [3] characterizes flower and bumble-bee as an essentially perfect example of an economic system. Bees and flowers need each other but their ‘interests’ do not always coincide. The bee disperses pollen from the flower, enhancing its rate of reproduction, and the flower provides the bee with its primary source of energy in the form of nectar.

The flower would benefit if it could produce less nectar and more pollen ceteris paribus. But ceteris paribus here implies that the bee would continue to disperse pollen as enthusiastically after what is in effect a cut in wages. Heinrich’s characterization of a bee and a flower as a perfect economic system simply recognizes a brutal fact. The bee has no recourse against a cheating flower other than to vote with its wings and never visit such a flower again. There are no bee–flower contracts and no legal system to enforce them, no police, no politicians and no lawyers. The bumble-bee lives in a libertarian paradise.

But enter the visual system. If the bee is to avoid cheating flowers and their kin, it must be able to discriminate flowers that are less rewarding from those that are more. If one group of flowers mutates to provide less nectar at the cost of pollen, then it is very much in the bee’s interest to be able to detect any subtle differences, chemical or visual between flowers.

generous and flowers mean. The result is selective pressure to improve the bee’s ability to discriminate perceptually so that the bee can favour more generous flowers. The colour and pattern vision of the bumble-bee are the remarkable product of a never-ending economic struggle between two species that need each other very much (see [4]).

The accompanying article is an investigation of the colour and pattern vision of B. terrestris that is remarkable in its origin. The research was conceived, carried out, summarized and written up by a class of 8 to 10 years olds in Devon, England under the light supervision of a teacher and a research scientist. The result is a significant piece of research giving a novel insight in the colour and pattern vision of the bee. Using well-established experimental procedures that were invented by John Lubbock [5] for the study of colour vision in bees and later implemented by a Nobel Prize winner [6], the results provide convincing evidence that bees can transpose between learned colour, pattern and spatial cues when encountering changes in a coloured scene. So far, it has been known that bees can learn and remember more than one colour at any one time [7], use global and local cues in black-white patterns [8] and learn each element in flower-like two-coloured patterns [9]. What is novel in the experiment presented here is that bees learned colour and pattern cues in a spatially complex scene composed of two-coloured local and global patterns. Coloured patterns at small and large spatial scales have been little studied, and hence our knowledge of how colourful patterns and scenes are perceived by insects is still scarce.

The experimental apparatus consisted of a cube with Plexiglas walls, 1 m on each side placed outdoors in a field. Bees could enter the cube through doors on two of the sides and approach a light box placed within the cube. The light box displayed four panels, each a four by four array of coloured lights (see also [10]). At the centre of each light, there was a small rod (feeder) that dispensed sugar water (desirable to the bee) or salt water (aversive to the bee) or nothing. Initially, the bees were allowed to learn that the box contained feeders that dispensed sugar water. In the experiments proper, the spatial patterns of blue and yellow lights contained a clue to which feeders contained sugar water, or with salt, or nothing. If the bee could decipher the cue, it could quickly locate the feeders with sugar water.

The bees were first trained with the outer lights in each 4 × 4 array set to blue, the inner set to yellow or vice versa. The resulting configuration resembled a crude flower. The inner lights had sugar water in their feeders and the outer salt. If bees picked a feeder at random, they would on average encounter sweet as often as savoury. If they always went to blue lights (or only to yellow), they would have the same 50 per cent success rate. If bees could learn the patterns of opposing colours and go to the centre lights of the artificial flowers, they would always encounter sugar water.

After training, the bees were tested with the same patterned array but now with no sugar water or salt water in any feeder. In this way, the experimenters could determine what the bees had learned about visual patterns without any possible contaminating cue.

The experimenter counted where each bee went and tabulated the results. The results demonstrate that bees had learned to use the pattern cue to enhance their probability of success in foraging. Two further tests allowed the experimenters to study how bees would generalize to novel patterns. The result of the first test, which manipulated the colours in the patterns, is surprising. Knowing that bees are capable of defining spatial locations in a patch of food sources with aid of panoramic views [11,12], one would have expected that all the bees would be guided by the spatial rather than pattern cues. Some went for the location, while others did not, which hints to the possibility that the bees can generalize pattern cues in such a situation. In the third test, the whole pattern was strongly disrupted and the most reliable decision would be to trust the spatial cues. However, all bees seem to have generalized the colour cues, distributing their choices across the whole array.

The results indicated that different bees pursued different strategies in a novel situation. Curiously, they seem to be able to extract and flexibly recall different cues from complex scenes, with a remarkable flexibility that easily rivals that of vertebrates. Such ability is extremely useful for shaping adaptive foraging responses in an ever-changing world, with floral communities that can vary drastically over short periods of time or short distances between adjacent habitats.

The experiments are modest in scope but cleverly and correctly designed and carried out with proper controls to avoid possible artefacts. They lack statistical analyses and any discussion of previous experimental work, but they hold their own among experiments carried out by highly trained specialists. The experimenters have asked a scientific question and answered it well.

The tone of the paper is also remarkable. Clearly, these children are tremendously proud of their accomplishments and eager to communicate what they know now that was previously unknown. The perceptual and decisional abilities of insects and other are extraordinarily varied [13,14], shaped as successful responses to environmental challenges. But the same can be said of the children who carried out this research. The resulting article is a remarkable demonstration of how natural scientific reasoning is for us. The insatiable curiosity that characterizes childhood, combined with the skeptical discipline of scientific method, provides a powerful tool that allows us to prosper and grow.

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Figure 1. Bombus terrestris, the buff-tailed bumble-bee.