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Do bees like Van Gogh's *Sunflowers*?

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Abstract

Flower colours have evolved over 100 million years to address the colour vision of their bee pollinators. In a much more rapid process, cultural (and horticultural) evolution has produced images of flowers that stimulate aesthetic responses in human observers. The colour vision and analysis of visual patterns differ in several respects between humans and bees. Here, a behavioural ecologist and an installation artist present bumblebees with reproductions of paintings highly appreciated in Western society, such as Van Gogh's *Sunflowers*. We use this unconventional approach in the hope to raise awareness for between-species differences in visual perception, and to provoke thinking about the implications of biology in human aesthetics and the relationship between object representation and its biological connotations.

Keywords: Bumblebee; Colour preference; Colour vision; Primate; SciArt

"And other eyes than ours
Were made to look on flowers…"
Christina Rossetti 1830–1894 (From the poem: *To what purpose this waste*)

"That not for man is made
all colour, light and shade…"
Edmund Gosse 1849–1928 (From the poem: *The farm*)

1. Introduction

The "Colour and Design" symposium of the Linnean Society, that gave rise to this special volume was numerically dominated by two distinct sets of participants—engineers/physicists and artists. Yet, colour is neither purely physics nor a domain of the arts: it is, to a large extent, biology. The coloured world we see is not the real or the physical world—instead, the colours we perceive are filtered through the specific sense organs that we have acquired in evolutionary history [1,2]. Colour vision systems differ widely between different animal species, and the reason is that different aspects of the coloured world are biologically relevant for different species. Our goal was to raise appreciation of this fact in an audience not specifically trained in the biology of vision.

The insight that flowers (and their colours) have not been created solely to please us humans dates back to the 18th century. The history of that discovery is a healthy lesson for those who think that science in the earlier days was less riddled by competition and strife. The idea that flowers are in fact sex organs, designed to attract the services of pollinators, is commonly attributed to Sprengel 1793 [3], who entitled his book "The uncovered mystery of nature…". When Goethe heard of Sprengel's progress with that book, he competed to publish his own botanical work [4]. Goethe [5] won the race, publishing his book in 1790. His work had a strongly different focus, and what Goethe offers on flower colouration (e.g., that floral colours are caused by

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the contaminating influence of male seed in the petals) shows he would have done better to leave the field to Sprengel. However, Sprengel himself was little more innocent: more than 30 years before him, Kölreuters [6] noted that "… anyone who had made these observations, would have much earlier discovered them [the causes of pollination in the activities of insects], and would have … *removed the curtain from this mystery of nature*"—which shows that Sprengel did not only borrow a key idea from Kölreuters, but that in fact the very title of Sprengel's volume stems in part from Kölreuters' original wording.

Flower colours are clearly important signals to bees, since flowers provide bees with nectar and pollen. But how do insect pollinators see colours? In 1874, Lord Rayleigh [7] pointed out that 'The assumed attractiveness of bright colours to insects would appear to involve the supposition that the colour vision of insects is approximately the same as our own. Surely this is a good deal to take for granted'. Lord Rayleigh was right: in 1924, Kühn [8] discovered that bees see ultraviolet light (Fig. 1), and in subsequent decades a wealth of information has been collected on how bees process colour information. Bees (including the familiar bumblebees and honeybees) have three colour receptor types, with maximum sensitivities near 340 nm (UV receptors), 440 nm (blue receptors) and 530 nm (green receptors); see [9], and references therein. Brightness, a parameter so fundamental to our own visual experience, has a relatively minor role in bee colour discrimination [10]. But bees use a single colour receptor, the green receptor, for detection of flowers from a longer distance [11]. How the information from the colour receptors is processed in the bee brain is still controversial, but it is certain that at least two colour opponent processes are involved, which compare responses from different colour receptor types [12,13]. Bee colour vision is optimal to code for floral colours [14].

Old world primates, including humans, have three colour receptor types whose spectral sensitivities peak at around 430 nm (blue receptors), 530 nm (green receptors) and 565 nm (so called red receptors, even though their peak sensitivity corresponds to yellow) [15]. The light sensitive pigment of human photoreceptors have some sensitivity to UV light, but such radiation never reaches the retina because it is absorbed by the lens [16]. C. Monet (1840–1926), an avid painter of flowers, had the lens removed from his right eye in 1923 due to cataract, and would therefore have been able to see UV patterns of flowers.

It is thought that the mammalian ancestors of primates had only blue and green receptors, and that the red receptor is an adaptation to frugivory [17,18]. Flowers do not play a major role in the diet of humans and other primates; the biological significance of human attraction to flowers is discussed later. It is clear from the above, however, that there will be both differences in perception and in meaning for human and bee observers

Fig. 1. A flower of *Iris pseudacorus* photographed in the visible (left) and in the ultraviolet (centre panel). The centre of the flower is strongly UV absorbing and appears as black, whereas the periphery reflects UV light. Right panel: a bumblebee worker probes the boundary between the two areas with her antennae. Photos by Prof. K. Lunau, with permission.