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The Colour Currency of Nature

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Mankind as a species has little reason to boast about his sensory capacities. A dog's sense of smell, a bat's hearing, a hawk's visual acuity are all superior to our own. But in one respect we may justifiably be vain: our ability to see colours is a match for any other animal. In this respect we have, in fact, surprisingly few rivals. Among mammals, only our nearest relatives, the monkeys and apes, share our ability – all others are nearly or completely colour-blind. In the animal kingdom as a whole, colour vision occurs only in some fishes, reptiles, insects and birds.

No one reading this book can doubt mankind's good fortune. The world seen in monochrome would be altogether a drearier, less attractive place to live in. But Nature did not grant colour vision to human beings and other animals simply to indulge their aesthetic sensibilities. The ability to see colour can only have evolved because it contributes to biological survival.

The question of how colour vision has evolved is – or should be – an important issue for psychologists (and for designers). If we were to understand how the seeing of natural colour has in the distant past contributed to our ancestors' lives we might be better placed to appreciate what colour in 'artificial' situations means to us today. Yet this is not in fact an issue which has been much explored. Indeed, few psychologists, for all their obsession with the physiological mechanism of colour vision, have asked what to an evolutionary biologist must seem the obvious question: where – and why – does colour occur in nature?

It may seem odd to tack 'why?' on to the question 'where?' But the question why is crucial, for the evolution of colour vision is intimately linked to the evolution of colour on the surface of the Earth. It may go without saying that in a world without colour, animals would have no use for colour vision; but it does need saying that in a world without animals possessing colour vision there would in fact be very little colour. The variegated colours which characterize the Earth's surface (and make the Earth perhaps the most colourful planet of the universe) are in the main organic colours, carried by the tissues of plants and animals – and most of these life-born colours have been designed in the course of evolution to be seen.

There are, of course, exceptions. Before life evolved, the drab landscape of the Earth may have been relieved occasionally by, say, a volcanic fire, a rainbow, a sunset, perhaps some tinted crystals on the ground. And before colour vision evolved, some living tissues were already 'fortuitously' coloured – blood was red, foliage green, although the redness of haemoglobin and the greenness of chlorophyll are wholly incidental to their biochemical roles. But the most striking colours of nature, those of flowers and fruits, the plumage of birds, the gaudy fishes of a coral reef, are all 'deliberate' evolutionary creations which have been selected to act as visual signals carrying messages to those who have the eyes to see them. The pigments which impart visible colour to the petals of a dandelion or a robin's breast are there for no other purpose.

We may presume that colour vision has not evolved to see the rare colours of inorganic nature, since rainbows and sunsets have no importance to survival. Nor is it likely to have evolved to see simply the greenness of grass or the redness of raw flesh, since those animals which feed chiefly on grass or on flesh are colour-blind. It can and almost surely has evolved alongside signal colouration to enable animals to detect and interpret nature's colour-coded messages.

The messages conveyed by signal colouration are of many kinds. Sometimes the message is simple: 'come here' addressed to an ally (the colour of a flower serving to attract a pollinating insect, the colour of a fruit to attract a seed-dispersing bird), or 'keep away' addressed to an enemy (the colour of a stinging insect or a poisonous toadstool serving to deter a potential predator). Sometimes the message is more complex, as when colour is used for communication in a social context in courtship or aggressive encounters (a peacock displaying his fan, a monkey flashing his coloured genitalia). Whatever the level of the message, signal colours commonly have three functions: they catch attention, they transmit information, and they directly affect the emotions of the viewer – an orange arouses appetite in a monkey, a yellow wasp fear in a fly-catcher, the red lips of a young woman passion in a man.

Primates came on the scene relatively late in evolutionary history, and the surface of the Earth must already have been given much

of its colour through the interaction of plants, insects, reptiles and birds. The early tree-dwelling primates moved in on an ecological niche previously occupied by birds: they picked the same fruits, caught the same insects, and they were in danger of being harmed by the same stings and the same poisons. To compete effectively with birds, primates needed to evolve colour vision of the same order. It is for that reason, I suspect, that the trichromatic colour vision of most primates (including humans) is in fact so similar to that, say, of a pigeon (although, as it happens, the selectivity of the three types of colour receptor is achieved by quite different physiological mechanisms in primates and birds). Once primates had joined the colour vision club, however, they too must have played their part in the progressive evolution of natural colour, influencing through selection the colours both of themselves and of other plants and animals.

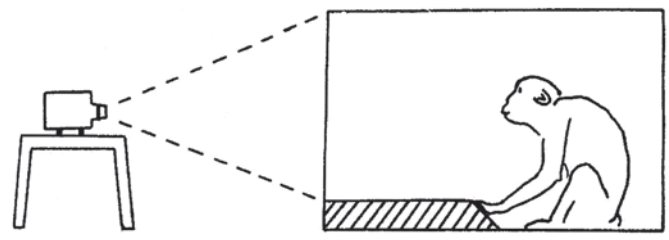
Then, not far back in history, the emergence of *homo sapiens* marked a turning point in the use of colour. For human beings hit on a new and unique skill – the ability to apply colour in places where it did not grow. Most probably they first used artificial colour to adorn their own bodies, painting their skins, investing themselves with jewels and feathers, dressing in coloured clothes. But in time they went further and began to apply colour to objects around them, especially to things which they themselves had made … until the use of colour became eventually almost a trademark of the human species.

In the early stages, humans probably continued the natural tradition of using colour primarily for its signal function, to indicate maybe status or value. And to some extent this tradition has continued to the present day, as testified, for instance, in the use we make of colour in ceremonial dress, traffic signals, political emblems, or the rosettes awarded to horses at a show. But at the same time the advent of modern technology has brought with it a debasement of the colour currency. Today almost every object that rolls off the factory production line, from motor cars to pencils, is given a distinctive colour – and for the most part these colours are meaningless. As I look around the room I'm working in, man-made colour shouts back at me from every surface: books, cushions, a rug on the floor, a coffee cup, a box of staples – bright blues, reds, yellows, greens. There is as much colour here as in any tropical forest. Yet whilst almost every colour in the forest would be meaningful, here in my study almost nothing is. Colour anarchy has taken over.

The indiscriminate use of colour has no doubt dulled modern humans' biological response to it. From the first moment that a baby is given a string of multi-coloured – but otherwise identical – beads to play with, she is unwittingly being taught to ignore colour as a signal. Yet I do not believe that our long involvement with colour as a signal in the course of evolution can be quite forgotten. Even though the modern use of colour may frequently be arbitrary, humans' response to it surely continues to show traces of their evolutionary heritage. So people persist in seeking meaning from colour even where no meaning is intended, they find colour attention-catching, they expect colour to carry information and to some extent at least they tend to be emotionally aroused.

The most striking illustration of human beings' deep evolutionary involvement with colour is the significance that people still attach to the colour red. I was first alerted to the peculiar psychological importance of red by some experiments not on humans but on rhesus monkeys.[1] For some years I had been studying the visual preferences of monkeys, using the apparatus shown here (Figure 1.1).

The monkey sits in a dark testing chamber with a screen at one end onto which one of two alternative slides can be projected. The monkey controls the presentation of the slides by pressing a button, each press producing one or the other slide in strict alternation: thus when he likes what he sees he must hold the button down, when he wants a change he must release and press again. I examined 'colour preference' in this situation by letting the monkeys choose between two plain fields of coloured light. All the monkeys that were tested showed strong and consistent preferences. When given a choice between, for instance, red and blue,



1.1 Rhesus monkey in testing chamber.

they tended to spend three or four times as long with the blue as the red. Overall, the rank order of colours in order of preference was blue, green, yellow, orange, red. When each of the colours was separately paired with a 'neutral' white field, red and orange stood out as strongly aversive, blue and green as mildly attractive. Direct observation of the monkeys in the testing situation indicated that they were considerably upset by the red light. When I deliberately added to their stress by playing loud and unpleasant background noise throughout the test, the aversion to red light became even more extreme. Further experiments showed that they were reacting to the red light exactly as if it was inducing fear.[2]

This aversion to red light is not unique to rhesus monkeys. The same thing has been found with baboons and also, more surprisingly, with pigeons. But what about humans? Experiments on colour preference in humans have given results which appear at first sight to be at odds with those in other primates. When people are asked to rank colours according to how much they 'like' them, red often comes high if not top of the list, although there is a wide variation between individuals depending among other things on personality, age, sex and culture. However, I am inclined to give little weight to such findings for two reasons. First, as Tom Porter has emphasized, the choice of a 'favourite' colour may be heavily biased by changes in fashion; indeed, when Porter tested people from social backgrounds where fashion probably has relatively little influence – African children, on the one hand, the residents of an Oxford old people's home, on the other – he found that both groups ranked colours in much the same way as did my monkeys, consistently preferring the blue end of the spectrum to the red.[3] Second, and more important, there is a methodological problem with most of the preference experiments, for the question 'Which do you like best?' is really much too simple a question to ask of a human subject: people may say they 'like' a colour for a host of different reasons depending both on the context in which they imagine the colour occurring and on how they construe the term 'like'. It would be manifestly foolish to ask people the abstract question 'Do you like better to be excited or to be soothed?', and it may perhaps be equally foolish to ask 'Do you like red more than blue?' To discover the significance of colours to human beings we must look to rather more specific studies.

I shall briefly list some of the particular evidence which demonstrates how, in a variety of contexts, red seems to have a very special significance for humans:

1 Large fields of red light induce physiological symptoms of emotional arousal – changes in heart rate, skin resistance and the electrical activity of the brain.[4]
2 In patients suffering from certain pathological disorders, for instance, cerebellar palsy, these physiological effects become exaggerated – in cerebellar patients red light may cause intolerable distress, exacerbating the disorders of posture and movement, lowering pain thresholds and causing a general disruption of thought and skilled behaviour.[5]
3 When the affective value of colours is measured by a technique, the 'semantic differential', which is far subtler than a simple preference test, people rate red as a 'heavy', 'powerful', 'active', 'hot' colour.[6]
4 When the 'apparent weight' of colours is measured directly by asking people to find the balance point between two discs of colour, red is consistently judged to be the heaviest.[7]
5 In the evolution of human languages, red is without exception the first colour word to enter the vocabulary – in a study of 96 languages, Berlin and Kay found 30 in which the only colour word (apart from black and white) was red.[8]
6 In the development of a child's language, red again usually comes first, and when adults are asked simply to reel off colour words as fast as they can, they show a very strong tendency to start with red.[9]
7 When colour vision is impaired by central brain lesions, red vision is most resistant to loss and quickest to recover.[10]

These disparate facts all point the same way, to the conclusion that humans as a species find red both a uniquely impressive colour and at times a uniquely disturbing one. Why should it be so? What special place does the colour red have in nature's scheme of colour signals?

The explanation of red's psychological impact must surely be that red is by far the most common colour signal in nature. There are two good reasons why red should be chosen to send signals. First, by virtue of the contrast it provides, red stands out peculiarly well against a background of green foliage or blue sky. Second, red happens to be the colour most readily available to animals for colouring their bodies because, by pure chance, it is the colour of blood. So an animal can create an effective signal simply by bringing to the surface of its body the pigment already flowing through its arteries: witness the cock's comb, the red bottom of a monkey in heat, the blush of a woman's cheek.

The reason why red should be in certain situations so disturbing is more obscure. If red was always used as a warning signal, there would be no problem. But it is not, it is used as often to attract as to repel. My guess is that its potential to disturb lies in this very ambiguity as a signal colour. Red toadstools, red ladybirds, red poppies are dangerous to eat, but red tomatoes, red strawberries, red apples are good. The open red mouth of an aggressive monkey is threatening, but the red bottom of a sexually receptive female is appealing. The flushed cheeks of a man or woman may indicate anger, but they may equally indicate pleasure. Thus the colour red, of itself, can do no more than alert the viewer, preparing him to receive a potentially important message; the content of the message can be interpreted only when the context of the redness is defined. When red occurs in an unfamiliar context, it becomes therefore a highly risky colour. The viewer is thrown into conflict as to what to do. All his instincts tell him to do something, but he has no means of knowing what that something ought to be. No wonder that my monkeys, confronted by a bright red screen, became tense and panicky: the screen shouts at them 'This is important', but without a framework for interpretation they are unable to assess what the import is.[11] And no wonder that human subjects in the artificial, contextless situation of a psychological laboratory may react in a similar way. A West African tribe, the Ndembu, state the dilemma explicitly, 'red acts both for good and evil'.[12] It all depends.

I have tried to show how an evolutionary approach can help throw light on human beings' response to colour. Whether this approach can be helpful to the practice of design remains an open question. In many areas of our lives we already overrule and nullify our natural tendencies. But I believe we should try to be 'conservationists' as much on behalf of ourselves as we are learning to be on behalf of other species, and that we should try where possible to make our style of life conform to the style to which our ancestors were biologically adapted. Designers, who are now more than anyone responsible for colouring our world, have a choice before them. They can continue to devalue colour by using it in an arbitrary, non-natural way, or they can recognize and build on humans' biological predisposition to treat colour as a signal. If they choose the latter, bolder course they might do well to study how colour is used in nature. Nature has, after all, been in the business of design for over a hundred million years.[13]

Notes

Introduction

1 Batchelor, D. (2000) *Chromophobia*, London: Reaktion Books.

Part 1: Why and How We See Colour

Chapter 1: The Colour Currency of Nature

1 Humphrey, N.K. (1972) 'Interest and pleasure: two determinants of a monkey's visual preferences', *Perception*, 1: 395–416.
2 Humphrey, N.K. and Keeble, G. (1974) 'The reactions of monkeys to "fearsome" pictures', *Nature*, 500–2.
3 Porter, T. (1973) 'An investigation into colour preferences', *Designer*, September: 12–14.
4 Gerard, R.M., quoted by J.M. Fitch (1968) 'The control of the luminous environment', *Scientific American*, 219: 190.
5 Goldstein, K. (1942) 'Some experimental observations concerning the influence of colors on the function of the organism', *Occupational Therapy,* 21: 147; Halpern, L. (1956) 'Additional contributions to the sensorimotor induction syndrome in unilateral disequilibrium with special reference to the effect of colors', *Journal of Nervous and Mental Diseases*, 123: 334.
6 Wright, B. and Rainwater, L. (1962) 'The meanings of color', *Journal of General Psychology*, 67: 88–9.
7 Pinkerton, E. and Humphrey, N.K. (1974) 'The apparent heaviness of colours', *Nature*, 250: 164–65.
8 Berlin, B. and Kay, P. (1969) *Basic Color Terms*, Los Angeles: University of Los Angeles Press.
9 Brown, W.P. (1972) 'Studies of word listing', *Irish Journal of Psychology*, 3: 117–59.
10 Goldstein, op. cit.
11 Humphrey, N.K. and Keeble, G. (1978) 'Effects of red light and loud noise on the rate at which monkeys sample their sensory environment', *Perception*, 7: 343.
12 Turner, V. (1966) 'Colour classification in Ndembu ritual', in M. Banton (ed.) *Anthropological Approaches to the Study of Religion*, London: Tavistock.
13 Humphrey, N.K. (2006) *Seeing Red: A Study of Consciousness*, Cambridge, MA: Harvard University Press.

Chapter 2: Seeing Colours

1 Gregory, R.L. (2005) *Eye and Brain: The Psychology of Seeing*, Oxford: Oxford University Press.
2 Newton, I. (1704) *Opticks*, London: Smith & Walford.
3 Young, T. (1807) *A Course of Lectures in Natural Philosophy*, London: Johnson.
4 Helmholtz, H. von (1856) *Handbuch der physiologischen Optik*, Leipzig: Voss.
5 Munsell, A.H. (1905) *A Color Notation*, Boston: Ellis.
6 Ostwald, W. (1916) *Die Farbenfibel*, Leipzig: Unesma.
7 Ladd-Franklin, C. (1929) *Color and Color Theories*, New York: Harcourt Brace.
8 Hering, E. (1878) *Zur Lehre vom Lichtsinne*, Vienna: Gerold.
9 Rushton, W.A.H. (1962) *Visual Pigments in Man*, Springfield, IL: Thomas.
10 Purves, D. and Lotto, R.B. (2003) *Why We See What We Do*, Sunderland, MA: Sinauer Associates.
11 Ibid.
12 Land, E. (1977) 'The retinex theory of colour vision', *Scientific American*, 237: 108–28.
13 Gregory, op. cit., p. 121.

Chapter 3: The Dynamics of Colour

1 Glancey, J. (2000) 'Do architects have a future?', the *Guardian*, 26 June.
2 Manley Hopkins, G. (2006) *Collected Works of Gerard Manley Hopkins*, vol. IV, Oxford: Oxford University Press.
3 Berlyne, D. (1971) *Architecture and Psycho-biology*, New York: Appleton Century Crofts.
4 Lawton, G. (1974) 'A brain of two halves', *New Scientist*, 22 Sept., p. 38.
5 Lewin, R. (1974) 'The brain's other half', *New Scientist*, 6 June.
6 Jung-Beeman, M., Bowman, E. and Kunios, J. (2004) *Biology Today*, April.
7 Chomsky, N. (1972) *Language and Mind*, New York, Harcourt, Bruce, Jovanovich.
8 Lumsden, C.J. and Wilson, E.O. (1982) *Genes, Mind and Culture*, Cambridge, MA: Harvard University Press, p. 89.
9 Smith, P.F. (2003) *The Dynamics of Delight*, London: Routledge.
10 Porter, T. and Mikellides, B. (1976) *Colour for Architecture*, London: Studio Vista, p. 99.