

The Biological Role of Consciousness

Horace Barlow

Horace Barlow has been actively involved with the physiology and psychology of perception for forty years. He was guided on this path by E. D. Adrian, who showed where neurophysiological research was leading, and William Rushton, who showed that research might be enjoyable as well as informative. He has worked on the frog's retina (discovering lateral inhibition and 'fly-detectors'), the rabbit retina (directional selectivity), cat retina (responses to single photons) and cat cortex (disparity selectivity). He has also been interested in the physical and biological factors that limit sensation and perception, such as photon fluctuations, the dynamic range of nerve fibres as signal channels, and their large though limited ability to interconnect with each other.

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What is the selective advantage conferred on the human race, or any other species, by consciousness? Is it just an epiphenomenon of our brain mechanisms – the whine of the neural gears, the clicking of the neural circuitry? Or can one identify a more important role for it in the survival and future of our species? Like many others, I feel intuitively certain that consciousness is of paramount importance, and it therefore becomes an intriguing task to search for and try to define this role.

The answer I shall put forward is that consciousness links the individual to the community within which he lives, a link that is crucial to all that is human. Normal perception, learning and memory are thought to be involved – nothing paranormal – but the individual's need for consciousness and its impossibility without social experience means that consciousness itself is what forces an individual to interact with the community. This interaction occurs in both directions, for one's consciousness is much concerned with other individuals, while past experience with other individuals has much influence on the content of each individual's consciousness.

This idea places consciousness in the border regions between the individual and the community; this is quite different from the border between dualism and identity theories that Jeffrey Gray has been concerned with,^{1,2} but the two ideas are complementary, not conflicting, and if it is correct that consciousness haunts the intersection of these two boundaries we shall have made good progress in delimiting the types of

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nervous activity with which it is concerned. But let me start by explaining the converging paths which have brought me to this viewpoint; in a sense these are digressions, but I hope they will move you gradually towards my way of looking at the problem.

Consciousness and Single Units

I started thinking about consciousness because of my interest in the role of single nerve cells in sensation and perception.^{3,4} Briefly, one can find neurons in sensory centres and pathways that show discriminative powers not unlike those of an intact human being. You find cells in the rabbit retina that respond when things move up but not down, and we can tell if things are moving up or down (see figure 24.1). Likewise you find cells that discriminate between different velocities of movement, and between stereoscopic disparities, and colours, and the various categories of cutaneous sensation. More recently cells have been found in the monkey cortex that respond to human faces,⁶ and appear to be able to discriminate between the faces of particular individuals.⁷ Such cells have much of the discriminative capacity of our own sensations, and when you come across these facts you are bound to say to yourself, 'Well, I know that when I discriminate between red and green this is accompanied by a conscious sensation. When this single nerve cell shows the same sort of

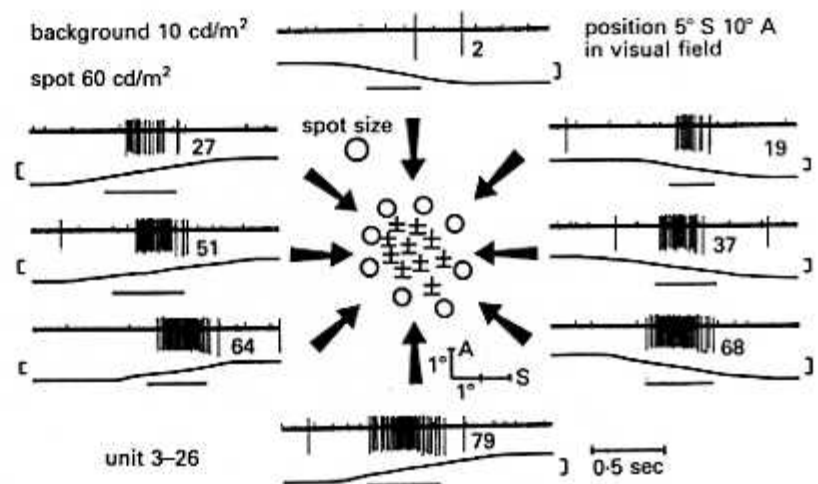


Figure 24.1 Example of pattern discrimination at the cellular level. This ganglion cell in the rabbit's retina gave a vigorous burst of impulses (lowest record) when a spot of light moved upwards through the appropriate part of the visual field, very few when it moved downwards (highest record). Other directions gave intermediate responses (records at the side). The receptive field was first mapped with a stationary spot turned on and off, and this region is represented in the centre of the figure by the \pm symbols, indicating that a brief response occurs at on (+) and off (-); no responses occurred outside the ring of O's. Then a spot was moved through the receptive field in the direction of the arrows, and the records at the bases of the arrows obtained. Here the vertical lines are action potentials or impulses, which are the messages signalled to the brain, with the numbers of impulses (from 2 to 79) indicated. The lower trace in each record shows the movement of the spot of light (from Barlow, Hill and Levick, 1964).⁵

discriminative capacity, am I to suppose that it is actually having some kind of rudimentary sensory experience? Although there may be some people who think that a primitive form of sensation occurs in a single cell, that doesn't make sense to me, and I cannot accept it.

I think this is a problem of levels of analysis: if one cannot find the explanation for consciousness at the level of single cells one has the choice of looking at a lower level or at a higher level. The lower, more analytic, level does not seem promising to me, for transmitter substances and receptor molecules are surely even further from consciousness than single neurons. Going one step in the other direction, to nerve nets and groups of neurons, does not seem to introduce any very interesting new possibilities, but the picture changes dramatically if you consider whole brains, for then types of behaviour occur that result from one brain interacting with another. This seems to me the level at which one must look for a better understanding of consciousness, and especially of its biological role.

Conscious Thought and Social Understanding

The second digression is to compare my position with that of Nick Humphrey. Even though we had never previously talked to each other on the subject, we found that we had rather similar views when we gave talks at a conference in Cambridge about seven years ago,^{8,9} for we agreed that consciousness is closely connected with the social behaviour of animals; however, I think I have carried this initial insight to its logical conclusion and shall try to clarify my viewpoint by comparing it with Nick's better-known position.¹⁰

He points out that knowledge of the working of one's own mind can be very important in social behaviour; one understands the motivation and causes of the behaviour of others by analogy with one's introspective knowledge of the motivation and causes of one's own behaviour. While fully agreeing that the survival value of consciousness derives from its influence on social problems and their solutions, I think he has much too much confidence in the validity of the knowledge gained by introspection about the working of one's own mind. I do not think it gives accurate knowledge of the causes and motivation even of one's own behaviour, let alone that of others. Introspection only leads one to *think* one understands the reasons for one's actions, and the limitations of this partial knowledge are crucial. Furthermore, his view does not emphasize the influence of social experience, particularly early experience, on the nature of an individual's consciousness. This experience may control the quality, depth and validity of an individual's introspection, thus making consciousness a joint product of the individual and his social environment.

Of course this is to some extent simply an echo of Freud, but once it is admitted that introspection is fallible, one must look at the errors it leads to, as well as the advantages it confers, when considering its survival value. Some may find this cynical, but there are other sources of knowledge than introspection, and in this post-Freudian, post-Marxist age it seems to me a much sounder viewpoint. My mistrust of introspection is also the basis of my last digression.

Biological Roles are not Introspectively Obvious

The third and most important pathway to my viewpoint arises from a difficulty in the direct introspective attack on the question. A few analogies will show how deceptive such an approach can be.

First consider pain: introspection tells us that pain is unpleasant and that pain-producing objects and situations are to be avoided, but it does not tell us that pain preserves our lives and limbs. The fact that this is indeed the case becomes abundantly clear when one encounters unfortunate individuals who lack a sense of pain, for they suffer repeated and potentially dangerous minor injuries from burns or abrasions that others reflexly avoid. Furthermore when they have received a minor injury, they lack the automatic reactions that rest and protect the injured part, allowing it to recover.

The important point to realize is that direct introspection about pain does not lead one to appreciate its value and it is instructive to see how to circumvent this difficulty. Instead of contemplating pain directly, ask the question 'What is the principal action associated with the sensation of pain?' I think one would answer, either by introspection or by observing others, that it leads to withdrawal from painful objects or situations, and avoidance of these in the future. From there it is of course a small step to understand the survival value of a system of nerve fibres that can only cause unpleasantness, and to see the benefits derived from them.

Now take another example – falling in love. Poetry books are full of introspections on this subject, and as before they somehow miss the point we are interested in. On the other hand, asking what principal action is associated with falling in love makes it obvious that the propagation of the species and future survival of the human race are at stake. The poets are unintentionally instructive on the devious fallibility of introspection, for they avoid emphasizing the fertility and motherliness of the person concerned and dwell on very different qualities.

EXPERIENCE	INTROSPECTIVE MESSAGE	SURVIVAL VALUE
Pain	Unpleasant and to be avoided	Minimizes injuries
Love	Desire for lifelong attachment, feelings of unbounded admiration, etc.	Propagation of the human species
Redness	Attribute of a physical object	Ability to communicate about this attribute

Introspection on our experiences does not directly tell us their survival value (more on redness at pp. 369–72)

I think this brief consideration of pain and love has shown how hopelessly misleading it can be to try and draw conclusions about the

biological survival value of a subjective experience by direct introspection. That doesn't mean to say that one should ignore one's introspections altogether, for when the misleading aspects are pointed out we may be able to say, 'Well yes, perhaps this does make sense.' But the survival value of a subjective experience is certainly not the first thing revealed to introspection, and it helps to look at the principal associated actions which it brings about in yourself and other people.

This could be pursued further by talking about hunger or thirst, and I shall return to the sensation of redness later, but it is time to leave these digressions and attack consciousness itself, applying the lessons learnt in these preliminary skirmishes with pain and love.

No longer mourn for me when I am dead
 Than you shall hear the surly sullen bell
 Give warning to the world that I am fled
 From this vile world, with vilest worms to dwell:
 Nay, if you read this line, remember not
 The hand that writ it; for I love you so,
 That I in your sweet thoughts would be forgot,
 If thinking on me then should make you woe.
 O, if, I say, you look upon this verse
 When I perhaps compounded am with clay,
 Do not so much as my poor name rehearse;
 But let your love even with my life decay;
 Lest the wise world should look into your moan,
 And mock you with me after I am gone.

Figure 24.2 Sonnet no. 71 by Shakespeare.

Conscious and Unconscious Neural Activities

If our consciousness is limited, what is it limited to? Upon what types or classes of neural activity can we obtain an introspective viewpoint? At first one is inclined to think that, without consciousness, all mental life would cease, but it is certainly not true that all neurally mediated behaviour would cease. Consciousness is therefore associated with the working of only part of the brain, and we want to find what part this is.

We have seen that one path to the answer may be to look at the principal actions that are associated with it, and also of course at those that can occur without it. It would also be illuminating if one could find pathologies of consciousness analogous to the absence of the sense of pain, or colour blindness, for then one might be able to point to the direct consequences of its absence or faulty functioning. Let us start by trying to decide what parts of the working of the brain are accessible to consciousness and what parts are not.

I think everybody will accept that there are many things one's brain does for one that are not associated with consciousness. For instance, I walk towards my front door or my car, and I find my hand in my pocket getting out the key. That part of my brain is actually rather stupid because it usually gets out the wrong key, but one must give it credit for doing a quite complicated action without any conscious thought passing through one's mind. I am sure everyone can think of many equivalent neural computations that their brain performs without their awareness: picking footfalls on a mountain path, many aspects of driving a car or returning a

shot at tennis, brushing one's teeth or putting on one's clothes, for example. Maybe these are consciously initiated, and maybe when first performed one has to pay conscious attention, but in normal life one's brain does many complex operations for one without the breath of consciousness. What then is the general characteristic of those brain operations that *do* accompany consciousness?

The answer I would give is that they are concerned with social interactions, and especially with the preparation and execution of communications with other individuals. Of course this mainly means communication with other humans, though I wouldn't want to deny consciousness to the person who is talking to his dog. Somebody might object that all forms of neural activity must be brought about in the same way, by nerve impulses, synaptic potentials and so on, so that it is inadmissible to suppose that some forms of activity are accompanied by consciousness, others not. An analogy may make clear why this objection is invalid. Consider speech and sound: again it might be said that both are transmitted by the vibration of air molecules, hence one cannot attribute an important property to the one and not the other. But speech is not *just* the vibration of air molecules; speech sounds form only a very small subset of all vibrations of air molecules, and when talking about speech it is that sub-set we are interested in, not the general question of how sound is transmitted to the listener. In the same way, it is quite reasonable to say that the nervous activity associated with consciousness is only a small part of all the activity of the brain, namely the part which is concerned with communications with other individuals; that is the important aspect of conscious activity, not the fact that it is mediated in the same way as most other operations of the brain.

Now, of course it is true that you can have mutual communication between two individuals without consciousness. If we recognize that unconscious communication is possible, we are not forced to say that bees, for example, are conscious even though they certainly communicate with one another very freely and effectively. But one can also have consciousness without concurrent communication with another individual, and this needs more careful consideration.

If I'm shut in a room by myself I don't become unconscious, so that the relationship between consciousness and communication isn't simple and immediate; consciousness continues when communication is cut off. But I would claim that whenever one is conscious, even in one's deepest introspections, one is in a sense addressing some other individual. Are others aware of an audience when they are thinking to themselves? I could often name the individual or individuals to whom my thoughts are addressed, but I don't know how universal this is. Even when the audience cannot be specified, I believe it is reasonable to insist on the importance, for all conscious thought, of some internal model of one or more other human minds.

As Kenneth Craik argued, our brains are adept at modelling the environment,¹¹ and the characteristics of other individuals must be among the most important candidates for such modelling. If you have doubts about the importance of human models in introspection, ask yourself what language your thoughts are couched in, and from whom you

learnt that language. For me at least it makes sense to suppose that the dawn of an infant's consciousness comes with its early communication with its parents, and that ever afterwards the image or model of the communicatee is a partner in conscious experience.

The importance of interaction and communication for one's consciousness will probably be challenged, so my first task is to make the idea acceptable to common sense. I shall try to do this in two ways: first, see whether these ideas fit in with common usage; and second, find whether they are plausible when we introspect about them.

Common Usage of 'Conscious'

I have chosen three rather different examples to show that communication is an important part of consciousness, as this term is commonly applied. If someone says 'he's unconscious', to test this you would immediately try to establish reciprocal communication with the individual concerned, and if you failed you would be likely to agree that he was unconscious. This would be so even if, for example, the person was sleep-walking and showed many indications of being in a normal state. In such a case you might go up and tap him on the shoulder, and if you didn't get sensible responses you might say, 'Well, he appeared at first to be conscious, but he is not responding to me and his consciousness must at least be impaired.'

Another example indicates what seems to be a very different usage of the word 'conscious'. In a train coming back from London once, I heard two football fans talking about a third person whom they both knew; they were saying, 'he's not even conscious.' It turned out that what they meant was that this third party didn't support the same team; so it seems that they were imputing unconsciousness simply because they couldn't communicate on this one issue.

Conscious (kɒnʃɪəs), *a.* [f. L. *consci-us* knowing something with others, knowing in oneself, privy to, conscious + -ous. L. *consci-us* f. *con-* together + *sci-* knowing, as in *scire* to know: cf. *nescius* unknowing, *praescius* foreknowing. There is no such word in F., which uses *conscient* in some of the senses (as did also Bacon); but It. has *conscio* privy, accessory, guilty, from 16th c.]

†1. Knowing, or sharing the knowledge of anything, together with another; privy to anything with another. *Obs.* [With quot. 1651, cf. L. *alicui alicujus rei conscius*.]

1651 HOBBS *Leviath.* 1. vii. 31 Where two, or more men, know of one and the same fact, they are said to be Conscious of it one to another. 1664 SOUTH *Serm.* (1823) 1. 394 Nothing is to be concealed from the other self. To be a friend and to be conscious are terms equivalent.

2. *fig.* Attributed to inanimate things as privy to, sharing in, or witnesses of human actions or secrets. Chiefly *poet.*

(The earliest recorded use—the word being one of those ridiculed by Ben Johnson. Frequent in the Latin poets: with 1667, cf. Ovid 'quorum non conscia solast'.)

Figure 24.3 The Oxford English Dictionary's definition of conscious agrees that shared knowledge, implying communication, is an important aspect of consciousness (reproduced courtesy of Oxford English Dictionary, Oxford University Press).

Now let's just take a third example. I made a conscious decision this morning to miss my dentist appointment. And what I mean by that is that I didn't accidentally miss it; I went through a stage when I could have told you, or the dentist, that I was going to miss it. So what the word 'conscious' adds to the meaning of the above sentence is the fact that I was in a position to communicate my decision to another person.

In all these three examples, which are really quite diverse, it is the ability to communicate that is the crucial test of consciousness, so I wonder if anyone can think of a good example of the proper use of 'conscious' which would disprove this statement: the person who is said to be conscious is in a position to communicate, and the person who is said to be unconscious is not. In common usage, communication or the ability to communicate appears to be a crucially important aspect of consciousness.

Introspective Acceptability

Does this attempt to delimit the types of neural activity that are involved in consciousness seem plausible introspectively? As I've mentioned, there are pitfalls here, but no idea about consciousness is likely to survive unless it can at least be reconciled with our introspections on the subject.

Many people will point out that although one's conscious thoughts are largely composed of words and language, they are not exclusively composed of them. I'm sure musicians can consciously think in terms of musical phrases and harmonics, but music is after all a form of communication, so that objection is answered. I'm also told that if a champion skier is to have any chance of winning he must, just before he starts a race, rehearse in his mind exactly how he will take every gate. Well, at first those don't seem to be communications that pass through his mind, but I wonder if the skier is not actually rehearsing messages from (or to) his trainer, rather than rehearsing the motor actions he will perform. In any case these two examples are unusual, and the prevalence of language in consciousness will probably be conceded.

Even with my more elaborate conscious thoughts I can often make myself aware of an audience whom I am addressing; this is important because I would have different thoughts if the audience were different. Perhaps many of you would agree that, when you are thinking in a particular mode, this is sometimes because you have in your mind a particular person or audience. If you accept this, then you have admitted that consciousness is not a property of a single brain, but also involves the representations in that brain of others. This is particularly important for those introspections about one's beliefs and actions that, as Nicholas Humphrey points out,¹⁰ help one to understand other people, for it means these others are having a reciprocal action on one's own thoughts. Thus conscious introspection is not just a simple aid to social behaviour, but is itself moulded and formed by social experience.

I find that this comparatively small change in how I think of consciousness makes an important difference, and now that it has been incorporated in my thoughts, it is not only acceptable but also attractive to realize that consciousness is not all my own brain's work, but is partly caused by those with whom I communicate.

Autism – Life Without Consciousness?

Can one point to pathological conditions of consciousness, analogous to the lack of a sensory system subserving pain, or to congenital colour blindness? It was suggested before that childhood autism, whose pathogenic symptom is the failure to develop normal social relationships, might represent such a condition,⁹ and recent experimental¹² and theoretical¹³ studies add some plausibility to this. Baron-Cohen, Leslie and Frith found that 16 out of 20 autistic children failed a test that required them to understand that another being could hold a false belief because it had incomplete information;¹² a group of normal children of mental ages matched to the autistic group passed the test without difficulty, as did a group with Down's syndrome similarly matched. Thus the autistic children were unable to do a simple version of precisely the task that Humphrey said consciousness facilitated – understanding the causes of another individual's actions and beliefs. As I have emphasized, our own introspective knowledge is incomplete, but autistic children appear to lack even our limited conceptualization of mental states and their origins.

One wonders if some impairment of the mechanism and range of consciousness might not be the cause of ill-defined 'psychopathic personalities', habitual criminals, and others whose principal problem lies in their relationship with other individuals and society. This may amount to no more than saying 'they do not think like us', but it may also draw attention to the aspect that is different, namely the capacity to introspect on one's own mental state and recognize the existence of similar mental states in others.

It is also interesting to speculate about an individual whose introspection could extend far beyond the limits restricting those of the majority. Such an individual would have access to superior understanding of the causes of his own and also of his friends' beliefs and actions: he or she would make a good playwright or novelist, but would we regard such an individual as unusually understanding and sympathetic, or as cold, calculating and unsocial? Greater introspective power, like any other improved mental faculty, could clearly be advantageous to the individual, but it might be disruptive to the group and species. How much then does social morality depend, not on the validity of our introspections, but on each individual's introspection having limitations and errors similar to those of others in the community?

Raw Consciousness

Consciousness of course means many things. So far I have talked mainly about the aspect that decides one's future actions in the light of introspection on one's own mental state and that of others. Because so little is known of the underlying physiology and psychology of these processes, there is little temptation to think about them in over-simple, over-mechanistic terms; but this is not true of supposedly more elementary forms of consciousness such as 'raw' redness, which some would



Figure 24.4 Jane Austen (1775–1817), another super-conscious person. Did she have introspective powers that exceeded normal bounds and limits, thus giving her superior knowledge of the causes of people's beliefs and actions (Mary Evans Picture Library).

hold to be just our brains' direct response to a stimulus in the external world. The rather complete physiological and psychological knowledge we possess of such peripheral sensory processes seems at first to support this notion, for it might be thought to imply that there is no room for communication and interaction in generating the experience. I do not think this view is correct because current knowledge does not explain how sensory experiences acquire their labels, and for a number of other reasons.

First, we often *do* want to communicate about sensations like redness, and I claim this is why they form part of the content of our consciousness. We want to be able to say, 'That strawberry is red enough to pick and eat', or 'The red sunset forecasts good weather'; no one can deny this need to communicate about our immediate sensations. Furthermore the influence of language, and hence necessarily of social experience, upon the raw sensations themselves is greater than one normally admits. Consider a colour-blind individual who completely lacks one of the three types of cone photoreceptor possessed by those with normal colour vision (that is,