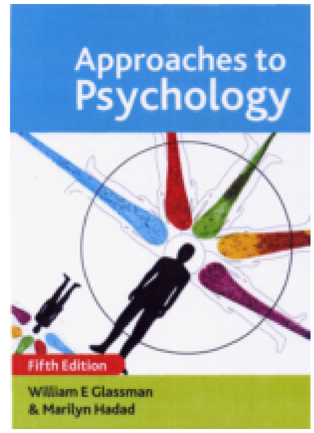
THE BIOLOGICAL APPROACH



Contents

Understanding the Physical Basis of Behaviour

Physiological Foundations of Behaviour

Studying Mind and Brain: The Use of Case Studies

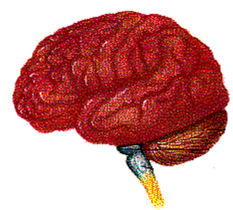
Drugs and Behaviour

Genetics and Behaviour

Applying the Concepts: Sensory Processes

Online Publications Related to the Biological Approach

Understanding the Physical Basis of Behaviour



One of the most perplexing issues in psychology is understanding the relationship between the mind and the brain. We all recognise that we have conscious awareness of our surroundings, and also of ourselves (self-awareness). It is this experience which has normally been described as **the mind**. But what is the basis of the mind? Is it the expression of a non-physical soul, or is it a product of physical processes within our body? Philosophers and scientists have been pondering this question for centuries. Explaining the nature of consciousness (that is, the mind) was regarded by William James (one of the great pioneers of psychology) as the most challenging question for psychology to answer. Today, a hundred years after James made that comment, the challenge still exists.

Physiological Foundations of Behaviour

Underlying questions about mind and brain are a number of basic assumptions. Most physiological researchers today are **materialists**, who see both behaviour and consciousness as simply the product of physiological processes. In essence, the brain *is* the mind. Thus, the task is to identify the structures and processes which produce conscious awareness. Among those who take this approach are James Watson (co-discoverer of DNA) and Dominic Domasio. Both are engaged in research aimed at supporting this view, and their work has drawn public attention. (See references below.)

Arrayed against this stance are a number of opponents, who argue the issue on various grounds. Some physiological researchers have adopted a neo-Cartesian position, arguing that consciousness (and therefore the mind) is not localised in any brain structure, and can therefore not be unequivocally proven to be purely physical in nature. Among these are John Eccles, an eminent British researcher, and the late Wilder Penfield, a pioneering Canadian neurosurgeon. Another approach to the issue comes from those who connect mind to the sense of self. This idea also has Cartesian overtones, since the self is closely associated with the notion of a soul in traditional thought. While many variants exist, the basic argument is that the **self** is a phenomenological construction, which is both in continual flux, and yet experienced as an ongoing identity. In this view, the mind/self may well be a *product* of physiological processes, but it is no more synonymous with the underlying structures than a building is synonymous with its builder. Roger Sperry, a pioneer in the study of hemispheric specialisation, has described consciousness as an **emergent process** of the brain – a product of the whole, whose properties cannot be explained simply by studying the underlying structures.

At present, of course, the debate cannot be resolved; the answer to William James' century-old question continues to elude us.

Resources

Descartes and Dualism

Essay on the continuing impact of Descartes' concept of dualism; appears in *Serendip*, an online journal from Bryn Mawr University which includes topics related to the Biological Approach in many of its essays.

Brain Facts

Illustrated 64-page book (in Adobe PDF), from the Society for Neuroscience; see also Brain Briefings, short articles on a variety of topics, written for a general audience.

The Brain Connection

Interesting website featuring a variety of information related to the brain, including discussions of a variety of topics, interactive demonstrations, and daily news updates on research.

Neuropsychology Central

A website of resources related to the biology of behaviour.

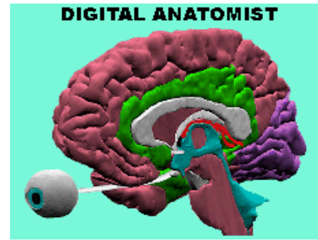
What does Handedness have to do with Brain Lateralisation?

Illustrated discussion that clearly explains the limitations of using handedness to infer underlying patterns of brain specialisation.

Brain Info

A searchable archive of information about parts of the brain, featuring definitions, images, links to research, and more; from the University of Washington.

Digital Anatomist Project



An online interactive anatomy atlas at the Univ. of Washington.

The Whole Brain Atlas

An extensive site featuring an explanation of computerised imaging techniques (e.g., PET, MRI), as well as interactive examples; from Harvard Medical School.

The Personality of the Lowly Neuron--Chapter from *Conversations with Neil's Brain* (1994), by neurophysiologist William Calvin and neurosurgeon George Ojemann (whole text available online).

Studying Mind and Brain: The Use of Case Studies

One of the earliest methods used to explore the workings of the brain was the detailed analysis of clinical patients – typically individuals who had suffered some type of physical trauma. Such **case studies** have often led to remarkable insights. For example, Pierra Broca in 1861 was able to identify an area of the brain involved with speech production (now called "Broca's area") based on studying an individual who for more than thirty years had suffered a fundamental language defect: he could understand spoken language, and could make various sounds, but could not produce coherent speech. Based on his behavioural observations and an anatomic analysis after the patient died, Broca concluded that speech capacity is located in the third convolution of the frontal lobe of the left hemisphere. This represented a dramatic advance in physiological understanding – forming a direct connection between the structure of the brain and behaviour. In addition, Broca saw the broader implications of his analysis, asserting that all behaviour can be associated to some specific mechanism/structure in the brain – a concept called **localisation of function**. Over time, researchers have used case studies to gather further support for this principle. Today, other techniques have provided new ways to study the functions of the brain, but case studies still provide insights, as well as fascinating reading.

The Case of Phineas Gage

One of the best-known clinical cases involved a dramatic injury to an unfortunate railroad worker, Phineas Gage. One day in 1848, he was working on track construction near Cavendish, Vermont. While Gage was placing an explosive charge, a spark of metal against rock set off the charge, sending a long metal tamping rod flying upwards. The rod entered Gage's head just below the left eye, and exited from the top of his skull, somewhat forward of left centre. Remarkably, Gage survived (though he was blinded in his left eye). Even more remarkably, his behaviour changed dramatically. Whereas Gage had previously been likeable and responsible, he became erratic, and given to terrible fits of temper. Sadly, he spent his remaining years wandering around the United States, displaying the hole in his skull and the iron rod which had brought him such grief.

Gage's story has been a source of endless fascination ever since. (His skull, and the iron rod, is still on display in the Harvard Medical School museum.) Given the pathway of the rod through his head, it would seem that the injury extensively damaged the association areas of the left frontal lobe. The behavioural changes, especially in emotionality, have been used as evidence that this region is involved in the expression of emotion. (A view seconded by advocates of **frontal lobotomies** in the 1940s and '50s.)

Resources

The Phineas Gage Page

A website devoted to information on the Phineas Gage case, maintained by Malcolm Macmillan of Deakin University; includes details of the case and discussions of its significance for later brain research.

Drugs and Behaviour

As discussed in the text, psychoactive drugs affect behaviour by affecting neural activity. Drugs may do this in various ways (for example, mimicking a natural neurotransmitter, or altering its normal function and metabolism), and many drugs affect a variety of different types of neurons in various parts of the brain. Consequently, it can be difficult to pinpoint precisely how a drug works. This is one reason new drugs must go through extensive laboratory and clinical testing before they are approved for public use.

The difficulties are further compounded when dealing with illicit drugs, sold on the street. Because there is no mechanism for quality control, users may receive drugs of varying potency and purity – and in some cases, what is sold is not even what it is claimed to be. (For example, a combination of strychnine and milk powder has been sold as "heroin", and various substances have been sold as MDMA or "ecstasy".) Consequently, street drugs pose two concerns: the effects of the drug (including long-term effects) may not be well understood, and the risks associated with taking something whose true content is uncertain. Note that these concerns have nothing to do with moral attitudes towards drug use: they represent practical concerns about the use of illicit psychoactive drugs.

Resources

How Drugs Work

A series of animations produced by PBS to illustrate how various types of drugs affect the nervous system.

Genetics and Behaviour

Earlier this year, researchers announced that the mapping of the **human genome** is nearing completion, at least in preliminary form. In many ways, this represents one of the greatest feats in the history of science: for one thing, our genetic makeup is extraordinarily complex, being composed of some 100,000 genes made up of millions of individual amino acids. At an even deeper level, identifying our genes poses the possibility of understanding what role genetics plays in our behaviour.

The debate between **nativists**, who believe that behaviour is fundamentally innate, and **environmentalists**, who believe our behaviour is shaped by our experiences, goes back to ancient times. (As *Approaches to Psychology* notes, it has been argued that the first known "psychology experiment", in ancient Babylon, was concerned with whether language was innate or learned.) Today, a wide variety of techniques are used to explore the issues of heredity; one of the most recent has been the application of evolutionary theory to try to understand how inherited behaviours may have originated, called **evolutionary psychology**. (Of course, this assumes that behaviour is inherited to begin with!)

Resources

The DNA Files

Website for a PBS Radio series dealing with genetics; includes both original material and many relevant links.

Darwin & Evolution

Articles from special feature in *Natural History* magazine (Nov. 2005) about evolution and the impact of Darwin's theory.

Institute for the Study of Academic Racism

Site at Ferris State University explores ways in which behaviour genetics has sometimes been associated with racism, both in the past and today.

Center for Evolutionary Psychology

Site maintained at University of California, Santa Barbara by Leda Cosmides & John Tooby, two of the founders of evolutionary psychology.

Psychology, Culture, & Evolution

Site maintained by Al Cheyne of the University of Waterloo, containing material on evolutionary psychology as well as various related issues.

Sociobiology Sanitised

A somewhat critical essay from *Science as Culture*, providing an extensive review of the history and recent debates about evolutionary psychology and its "cousin", sociobiology: includes extensive reference list.

Applying the Concepts: Sensory Processes

As noted in Chapter 1, the process of perception starts with stimulation of our senses; our understanding of the world starts with what our senses tell us. Yet how do our senses handle the diverse types of stimuli we experience so that the brain can process the information we receive? While many details are still not fully understood, it is possible to describe the general nature of sensory processing – a process that is both complex and remarkable.

The basic challenge for the nervous system is to translate the information represented by sensory stimuli into neural signals – a process called *transduction*. Each of our senses is designed to respond to different types of stimuli: light for vision, sound waves for hearing, odor molecules for smell, and so on. In order to handle this diversity, each of our five senses uses different types of *receptors*, each specialised to process a different type of stimulus. For example, there are receptors for touch that respond to pressure against the skin, and different receptors that respond primarily to heat or cold. The receptors are the input for *sensory neurons* in the *peripheral nervous system*. Sensory neurons in turn connect to neurons in the *central nervous system* (CNS), forming specialised neural pathways for each of the five senses. This specialisation is both practical and necessary, but it does produce an interesting consequence – in essence, the pathways for each sense are designed to convey information related to that sense mode, *regardless of what triggered the activity*. That is, the sensations we experience depend on the pathway stimulated, not the form of the stimulation. A German researcher named Johannes Müller first noted this in the 1830s, calling it 'the law of specific nerve energies'. Thus, if you close your eyelid and press gently on your eye with your finger, you will see spots of light – the result of the pressure producing randomised activation of receptors rather than light reaching the receptors on your retina. In the end, what we know about the world depends on the characteristics of our senses as much as it does on what is "out there"!

While Müller's law suggests that sometimes our senses can mislead us, in everyday life, sensory processing is remarkably reliable and adaptable. For example, our retina has a complex structure which includes three types of *cone* receptors, maximally sensitive to three different wavelengths (and therefore colors) of light, as well as narrower *rod* receptors which are optimised for functioning in very low levels of light (as in night vision). These receptors are in turn connected to two further layers of cells, called bipolar cells and ganglion cells. The cells within the retina are connected in complex ways that enhance contrast and detection of boundaries; in turn, the axons of the ganglion cells form the *optic nerve*, which relays visual information for further visual processing. (For more information about the eye, and a self-quiz, see the web site maintained by optometrist Ted Montgomery.)

Hearing is mediated by cells in the inner ear which have fine filaments sensitive to mechanical vibration, called *hair cells*. Normally, sound waves (vibration) are transmitted through the air to the tympanic membrane ("ear drum"), then via the bones of the middle ear (which are arranged in way which provides the capacity to amplify or dampen the intensity of the vibrations) to the *cochlea* of the inner ear. The shape of the cochlea, along with the structure of the hair cells, allows different cells to be maximally sensitive to different frequencies – a basic feature of our sense of hearing.

For touch, as noted, receptors of different types are distributed across our body in a non-uniform way – for example, the density of touch receptors is much greater on our fingertips and lips than it is on our back or upper thighs. The sensory nerves for touch are the only sense mode which link to the spinal cord as the entry point to the central nervous system; the pathways for all the other senses go directly from receptors (sensory neurons) to the brain. (In the case of vision, the retina itself is in fact a combination of sense receptors and cells which are properly considered part of the central nervous system.)

Taste and smell are generally grouped together, because of their role as *chemical senses* – that is, they function by detecting the presence of particular molecules, rather than types of energy. They are also related in terms of their importance in relation to our experience of food: much of what we call 'taste' is actually a response to smell. For example, try the following experiment with a friend: In advance, cut a slice of apple and a slice of onion (but don't let the person see them). Blindfold the person, and then ask them to bite the apple, while simultaneously holding the onion close to their nose. Because the texture of the two is similar, the odor of the onion will overwhelm the actual taste of the apple – and your friend is likely to believe you've given them a slice of onion to eat! Beyond such generalities, it turns out that smell and taste are extremely complex; current evidence suggests that there are different types of receptors within each of these senses, and that the pattern of response to different stimuli are the basis of experiencing different smells and odours (somewhat analogous to the way cone receptors are the basis of color vision).

Beyond the receptors, sensory information travels along specialised pathways within the brain. A major relay point for these pathways is the thalamus en route to the cortex. Remarkably, despite the transformation of the sensory signal into a neural signal, and the routing through a series of connections within the CNS, the information which reaches the cortex typically preserves significant detail about the nature, location, and timing of the stimulus. (For example, one can identify where on the body a touch stimulus occurred, the order in which sounds occurred, etc.) In the cortex, as noted in the text, sophisticated processing occurs, in regions whose functions are dedicated to sensory processing. (Primary locations are the occipital lobe for vision, temporal lobe for hearing, parietal lobe for touch, and frontal lobe for some aspects of taste and smell.) In turn, this information is integrated across senses, and with memories of past experiences, to produce our perceptions of the world. Simple, isn't it?!

References

Goldstein, E. B. (2003) *Sensation and Perception*, 6th ed. Pacific Grove, CA: Wadsworth.

Online Journals and Resources Related to the Biological Approach

Behavioural and Brain Sciences

Journal which publishes feature articles along with responses/commentaries; searchable online archive.

Evolutionary Psychology

Online archive for journal; part of Human Nature Review has extensive archive of related material (including reprints of books by Darwin, James, etc.) and links, located here.

The Harvard Brain

Online journal edited by Harvard undergraduates in neurosciences.

Journal of Cognitive Neuroscience

Journal site which has on-line archive of contents and abstracts, with some sample articles

Society for Neuroscience

As of 1 January 1999, the Society began publishing brief papers in an online format; site also provides good links to other related Web resources