II. An introduction to behavior for neuroscientists

Neuroscientists whose academic background is primarily in physical science, anatomy, biochemistry, genetics, physiology, pharmacology, etc., are likely to feel somewhat bewildered when they consider the function of the brain in general terms. It will seem obvious that the normal functioning of the brain is responsible for all aspects of human conduct and mental capacity but how can one make any progress in understanding this whole area? Psychology, considered as an academic field, is not taken seriously by many scientists: it appears to be widely regarded as consisting largely of equal parts of trivia and nonsense. The inevitable result for many scientists is an unquestioning acceptance of commonsense views of the mind and human behavior. However, when the origin of these commonsense views is examined, it becomes apparent that they are derived, not from any form of scientific investigation, but from the speculations of ancient Greek philosophers, especially Aristotle and Plato (see Chapter I, The mind and the explanation of behavior). This is not reassuring. Considering the success rate of the ancient philosophers in physics, chemistry, physiology, etc., why should we trust their judgment in the field of the mind and human behavior?

One of the great benefits of studying history, especially the history of science, is that we become aware that highly intelligent people in past centuries accepted beliefs that we now know to be completely false. This prompts the thought that some of the things we believe today will also be regarded as nonsense by our descendants. Is it possible that today's conventional opinions about the mind and human behavior will, at some point in the future, appear to have much the same validity and authority as is now granted to alchemy, astrology, and Ptolemaic astronomy?

Let us attempt to think through the problem of behavior and the mind very carefully. First of all, possession of the power of movement is one of the most striking characteristics of animals. Among the multicellular organisms, individual plants and fungi remain rooted in one spot throughout life. If local conditions became unfavorable, they must adapt as best they can, relying on genetic and physiological defences. Although these reactions are ordinarily very slow, it is most impressive that higher plants can coordinate the activities of a variety of different tissues hormonally by means of auxins, cytokinins, and gibberellins without having anything resembling animal nervous tissue.

In contrast to plants, animals (except a few sessile forms such as sponges or barnacles), when confronted with unfavourable conditions, can move away relatively quickly in the hope of finding something better. Since mere random motor activity may make things worse rather than better, there has evidently been a strong selection pressure favoring the development of sensory organs and nervous centers to guide and control motor activity.

It is conventional to refer to motor activity in a general sense by the term "behavior". This includes primarily posture and movement. Thus, holding the head up against gravity, sitting up, standing, walking, speaking, etc., are common components of human waking behavior; lying down with eyes closed and with a relaxation of postural tone are common aspects of sleep behavior. At times there have been attempts to distinguish between "behavior" and "physiological reactions" such as shivering or simple somatomotor reflexes. Such distinctions seem to me to be purely arbitrary and based on an implicit assumption that some motor patterns are the result of psychic or mental activity but others are not. It is simpler to assume that all motor activity is the result of physiological activities and to refer to the entire class of motoric and postural activities as "behavior." Whether autonomic activities should also be considered to be behavior is a matter of taste. Is blushing a behavior? What about piloerection or sweating in response to social stresses?

Systematic study of behavior developed in the late nineteenth and early twentieth centuries in three geographic regions: (a) the Sechenov-Pavlov school of reflexology in Russia; (b) the ethology-animal behavior school of Heinroth, Lorenz, and Tinbergen in Western Europe; and (c) the behaviorist school of Thorndike, Jennings, Watson and Skinner in America. In addition, studies of reflex activity, especially by Sherrington in England and Magnus in the Netherlands provided an essential foundation for our understanding of the physiological basis of simple behaviors.[1] Two essential assumptions underlay all of these varied endeavors: (1) motor activity should be recorded and observed in objective terms, avoiding all subjective psychological interpretations; and (2) all behavior is due to the physical and chemical activity of sense organs, neurons and muscles. Interpretations of behavior that depended on the activities of a non-material mind or psyche were ruled inadmissible.[2] It is widely assumed in this field that what requires explanation is behavior itself rather than some mental process that may be hypothesized to underlie behavior.

An important concept in modern studies in the science of animal behavior that coalesced out of the work of the pioneers in the field is that the varied behaviors displayed by an animal have evolved under the influence of natural selection. Therefore, even infrequent and seemingly trivial aspects of behavior are likely to have a real biological function and are well worth the attention of serious investigators. For example, Niko Tinbergen devoted a not inconsiderable research effort to determining why black-headed gulls carry empty egg shells away from the nest shortly after the chicks have hatched.[3] This is a behavior that may occupy no more than a few seconds per year. Nonetheless, it has an adaptive role in the life of black-headed gulls and must have a definite neural basis.

What this means for neuroscience is that all aspects of behavior must be studied, including not only behaviors of obvious importance such as feeding or reproductive behavior, but also behaviors whose contribution to adaptation may not be immediately obvious. One can think of this as a three-stage process. First, careful observation of spontaneous behavior is required to determine what animals do in terms of the actual postures and movements that are displayed. Second, controlling factors such as current stimulus input, levels of nutrients, electrolytes, or hormones, body temperature and past experience should be identified. Third, the role of different brain regions, different types of central neurons and different neurotransmitters or intracellular signals should be identified using various neuroanatomical, electrophysiological, neurochemical, neuropharmacological, and brain imaging techniques. In all such work, it is essential that a broad spectrum of behavior should be investigated, including all aspects of feeding, reproductive behavior, social and parental behavior, avoidance of natural dangers (including predators), body grooming, sleep, and shelter-seeking behaviors (which play a major role in temperature regulation). When dealing with human subjects, in particular, the "social behavior" category is a very large topic indeed, encompassing language, gestures and facial expression.

Disentangling behavior from the psyche. Although it is today a common belief that scientific progress is dependent largely or entirely on the development of new technologies, a modest degree of acquaintance with the history of science reveals that possession of appropriate concepts and theories is of even greater importance. It is quite possible to spend years making accurate detailed measurements of things that are subsequently understood to be of no consequence whatever. The medieval and early modern alchemists possessed an impressive array of chemical techniques including solution, calcination, sublimation, fusion, crystallization, distillation and fermentation but made only slow and accidental advances in chemistry because their efforts were directed towards the discovery of the philosopher's stone (to transmute base metals into gold) and the elixir of life (to confer immortality).[4]

I think that advances in understanding the function of the brain have been similarly impeded by continued adherence to an ancient and inappropriate set of concepts. It is of great importance to make a clear distinction between behavior and hypothetical mental processes offered as explanations for behavior. Thus, speaking is a behavior; the cognitive processes that may be invoked to account for the speech are not behavior. Scratching one's head is also a behavior but a sensation of itchiness in the scalp is not. The essential distinction here is that "behavior" is a physical event that can be observed externally or detected by a recording device of some sort. Subjective states, by their very nature, cannot be detected by an external observer.

These distinctions are fundamental to any general approach to the function of the brain. If one thinks that the overall aim is to account for behavior then one must first make a catalogue of the behaviors a given species displays and then begin an analysis of central nervous control of those behaviors.

In contrast to this, a mentalistic approach suggests that the only behavior patterns that are worthy of serious study are those that can be assumed to be indicative of the activity of some mental process such as attention, cognition, emotion, or memory. It is assumed that we already have a good knowledge of the nature of these processes: therefore we can devise behavioral tests to measure them on an *a priori* basis. For example, such tests as delayed match to sample or delayed non-match to sample were widely adopted because they seemed to provide rather pure tests of memory which was conceived of as a mental process distinct from sensation, perception, attention, motivation and motor processes.[5] The difficulties and lack of real progress associated with this approach have been discussed in more detail elsewhere[6] (also see Chapter I).

The conventional theory of the brain as the organ of the psyche or mind offers us the comforting illusion that we already understand the big picture. We know how the brain/mind works because Plato, Aristotle and Descartes analyzed it for us long ago. If we abandon this, we become acutely aware of the enormity of our own ignorance. We must begin almost at the beginning, carefully analyzing brain activity in relation to behavior, tentatively feeling our way and building on our successes. My own conviction that this is the only possible way of making advances in the brain-behavior field is based, not merely on arguments of a semi-philosophical nature, but also on more than four decades of experience on the relations between behavior and the electrophysiological activity of the hippocampus, the neocortex, and the pyriform cortex. During the course of this work it became ever more apparent that brain field potential activity and the related unitary activity are not organized in terms of conventional psychological concepts but are, rather, closely related to various sensori-motor processes.[7] Mentalistic approaches to the brain-behavior field discourage the discovery of the relations between brain activity and sensori-motor processes because they: (1) encourage the belief that the details of behavior are trivial and unworthy of serious scientific study; and (2) encourage investigators to ask inappropriate questions. Neuroscientists who are interested in the overall function of the central nervous system should acquaint themselves with the study of behavior in both human and non-human animals and should learn to recognise the nature and present day influences of ancient philosophical theories concerning the psyche.

Notes

1. Short histories of the study of animal behavior have been provided by: Lorenz, K.Z. (1981). *The foundations of ethology*, New, York: Springer-Verlag, and by: Ratliff, F. (1962). Some interrelations among physics, physiology and psychology in the study of vision. In: S. Koch (ed.) *Psychology: A study of a science. Study II. Empirical substructure and relations with other sciences vol. 4: Biologically oriented fields: Their place in psychology and biological science*. New York: McGraw-Hill, 417–482. A collection of landmark papers in the history of animal behavior has been provided by: Houck, L.D., and Drickamer, L.C. (editors) *Foundations of animal behavior*, Chicago: University of Chicago Press, 1996. Useful summaries of classical reflex physiology and its relation to behavior include: Denny-Brown, D. (1939). *Selected writings of Sir Charles Sherrington*, Oxford, U.K.: Oxford University Press; Fukuda, T. (1984). *Statokinetic reflexes in equilibrium and movement*, Tokyo: University of Tokyo Press; and Fulton, J.F. (1949). *Physiology of the nervous system*, 3rded. New York: Oxford University Press.
   An excellent modern introduction to the behavior of the laboratory rat that is relevant to neuroscience is: Whishaw, I.Q., and Kolb, B. (editors) *The behavior of the laboratory rat: a handbook with tests*. Oxford: Oxford University Press, 2005. A very general discussion of recent developments in the Thorndike-Watson-Skinner approach to behavior has been provided by: Staddon, J. (2001). *The new behaviorism: mind, mechanism and society*, Philadelphia: Psychology Press.
2. It is interesting that Sherrington, who allowed no trace of mentalistic interpretations in his studies of reflexes, was nonetheless a dualist and believed that higher level perceptual and motor processes involved something beyond anatomy and physiology.
3. Tinbergen, N. (1972). *The animal in its world, vol. 1, Field studies*. London: George Allen and Unwin Ltd., pp. 250–294. It appears that gulls remove egg shells from the vicinity of the nest soon after hatching because the white interior of the empty shell attracts predators.
4. Holmyard, E.J. (1990). *Alchemy*. New York: Dover Publications (first published, 1957).
5. Vidyasagar, T.R. (1993). Assessment of brain electrical activity in relation to memory and complex behaviour, in *Methods in Neurosciences*, vol. 14, *Paradigms for the Study of Behavior* (Conn, P.M. ed.) Academic Press, San Diego, pp. 407–431.
   In delayed matching tests, three food wells (i.e. large holes drilled in a thick piece of plank or plastic) are placed just outside the bars of a cage containing a monkey. As the monkey watches, a food item is placed in the center well, covered by a distinctive item such as a beer can, and the animal is allowed to retrieve the food. An opaque screen is then lowered and the beer can (for example) is placed over one of the outside food wells and a novel object, such as an empty bottle, is placed over the other outside food well (either the right or the left one in random sequence). After a variable delay, the monkey is allowed to choose one of the objects. In the delayed match-to-sample version of this test the food item would be located under the beer can in this example while in the delayed non-match-to-sample version of the test the food would be located under the bottle. Thus, in everyday language, we can say that the monkey is required to remember the original demonstration item (many different items are used) and to make a choice based on that memory.

6. Vanderwolf, C.H. and Cain, D.P. (1994). The behavioral neurobiology of learning and memory: a conceptual reorientation. *Brain Research Reviews*, *19*: 264-297. Also see: Vanderwolf, C.H., and Leung, L.-W.S. (1998). The relation of brain electrical activity to behavior. In: A.A. Boulton, G.B. Baker, and A.N. Bateson (eds.) *Neuromethods*, *vol. 32*, *In vivo neuromethods*, Totowa, New Jersey, pp. 325–357.
7. Vanderwolf, C.H. (2003). *An odyssey through the brain, behavior, and the mind*. Boston: Kluwer Academic Publishers.

Springer
http://www.springer.com/978-0-387-34229-0

The Evolving Brain
The Mind and the Neural Control of Behavior
Vanderwolf, C.H.
2007, IX, 104 p., Hardcover
ISBN: 978-0-387-34229-0