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Putting the brain in the mind: Promoting an appreciation of the biological basis to understanding human behavior

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Abstract

A surprising number of students in psychology, behavioral science, and related social science classes fail to appreciate the importance of biological mechanisms to understanding behavior. To help teachers promote this understanding, this paper outlines six sources of evidence. These are (a) phylogenetic, (b) genetic/developmental, (c) clinical, (d) experimental, (e) brain recordings, and (f) experiential. The evidence can be easily understood from common knowledge or personal experience and can be incorporated into an introductory-level lecture. It is concluded that the successful study of human behavior requires the student to appreciate the biological basis of the discipline.

Introduction

In my experience in teaching about human behavior to psychology, behavioral science, and related social science college students, a surprising number of them are puzzled, uncertain, or unaware of why understanding the biological basis to behavior is so important. These feelings can have a knock on effect in reducing their motivation to learn about topics like brain anatomy, neurophysiology, hormones, and genetics. There is also the danger that students will not fully appreciate the significance of neuroscience – the modern day blending of the biological and psychological sciences. To motivate students and implant in them the first seeds of knowledge, I have had success in using six sources of evidence for the biological basis of behavior. The link between each source of evidence and its relevance to behavior is so obvious that it can be appreciated even in an introductory level class. These six sources of evidence are described here to provide a reference from which teachers can apply in their behavioral science class.

A quote

It is useful to preface the six sources of evidence with some words from Bertrand Russell, the brilliant mathematician, scientist, and philosopher. He said:

> The important point is, that the difference between mind and brain is not a difference in quality, but a difference in arrangement. It is like the difference between arranging people in geographical order or in alphabetical order, both of which are done in the Post Office directory......The ancient question of the dependence of mind on brain, or brain on mind, is thus reduced to linguistic convenience. In cases where we know more about the brain it will be convenient

> to regard the mind as dependent, but in cases where were know more about the mind it will be convenient to regard the brain as dependent. In either case, the substantial facts are the same, and the difference is only as to the degree of our knowledge. pg. 289.

What is Bertrand Russell's point here? He is arguing that there may in fact be no distinction between the mind and brain. By implication, any scientific explanation for the mind will ultimately be based on the physical characteristics of our brain. That is, thinking, perceiving, remembering, desiring, and feelings are all brain functions. Our claim that they are all part of the mind is merely one of linguistic convenience. Psychological science is a field in which students apply the scientific method and the tools of induction and deduction to examine behavior. The question that we must encourage our enquiring student to ask is "What is the basis of behavior?"

The Evidence

The basis of behavior is the biological processes of the brain. Some evidence in support of this claim can be detailed and complex. For instance, there is more dendrite branching of the precentral brain area in the left hemisphere than there is in the right hemisphere (Toga and Thompson 2003). This fact is not commonly thought of by teachers (or students) as supporting the dominance of the left hemisphere for language and, by consequence, supporting the link between biological processes and behavior. Fortunately, it is not necessary to look too hard. There are six plain sources of evidence that can be easily understood from common knowledge by the typical student. These evidences are phylogenetic, genetic/developmental, clinical, experimental, brain recordings, and experiential.

Phylogenetic

The phylogenetic argument is grounded in evolution. The argument states that there is a positive relationship between brain complexity and the cognitive abilities of the species (Greenberg and Haraway 1998). As we sample different species we observe that those which have the largest and most complex brains tend to have the greatest cognitive capabilities.

Rats are perhaps the most commonly studied animals by behavioral scientists. Rats have a moderately complex brain and are capable of many feats of learning and memory. The dog brain is more complex still and dogs were used by Ivan Pavlov in his experiments on classical conditioning. As we would expect from the phylogenetic argument, the cognitive abilities of dogs surpass those of the rat. Moving along we encounter the brains of monkeys. The remarkable machine in the skulls of monkeys is capable of highly complex learning tasks that rats and dogs could only dream of. It is also capable of a wider range of communicative abilities, emotional responses, motor movements, and sexual responses.

The monkey brain is truly amazing, yet some would say that even this pales into insignificance when you consider the human brain. It is no wonder that psychologists take great pride in studying the human brain, perhaps the last unconquered frontier on earth. It is not necessary to list the many cognitive abilities that we posses. That this surpasses all other brains on this planet goes without saying. Yet, this is only possible because our behavior is determined by the many billions of neurons and the interconnections between these neurons.

Genetic/Developmental

The second source of evidence for the biological basis to behavior derives from the study of genetics and development. The abilities of the brain will emerge with maturation and failure of the brain to mature correctly will adversely affect cognitive development.

There are some instances in which development does not occur normally for genetic reasons. One example is the inherited metabolic disorder called phenylketonuria (pronounced as *fen ul kee ta new re a*) or PKU. PKU is characterized by the lack of an enzyme which converts phenylalanine into tyrosine. Without this enzyme, phenylalanine accumulates in the body in interferes with myelination of the brain. Myelin is a protective covering around the axons of neurons and allows them to communicate quickly and efficiently. If untreated, PKU results in severe intellectual retardation. This would not occur if there was no biological basis to behavior.

A similar argument applies when children develop normally. Take the acquisition of language. Language is acquired only after the child reaches about 18 months of age. This is not due to some mystical process, but it is due to myelination. The myelin which covers the axons of neurons does not develop in the language areas of the brain until a child reaches that age of 18 to 24 months (Pujol et al. 2006). Before this time any neural communication between the neurons in the brains language areas become scrambled and no meaningful output can be produced. However, once myelination has been completed, children can begin to acquire language.

Clinical

Clinical psychology abounds with examples of how biology influences behavior. Brain damage from accidents (Pineas Guage is one such famous example), disease (e.g., stroke), toxic or infectious sources, or from poor nutrition will result in predictable and often irreversible loss of mental functions (Pinel 2000). Damage to the hippocampal formation makes a person unable to remember new things. Damage to the cerebellum will make a person's movements jerky, erratic, and uncoordinated. In language production, damage to Wernicke's area makes a persons speech full of function words but devoid of content words to result in speech that is meaningless. If another part of the brain important for language, called Broca's area, is damaged a very different disruption to speech occurs. In such cases, a person will produce speech that is not fluent and contains few words, short sentences, and many pauses. The list of clinical examples could go on. However, all of these effects demonstrate that behavior is dependent on the correct functioning of our brains.

Experimental

Clinical cases show the effects of naturally occurring disruptions of the brain. Much more specific effects have been seen in experiments in which areas of the brain are destroyed on purpose through lesions. Lesions can be permanent or temporary. Experiments can affect brain function by not only lesions, but also electrical stimulation or the administration of drugs. All of these methods have consistently shown that cognitive operations are related to biochemical and anatomical changes in the brain. For instance, electrical stimulation of the medial area of the primary motor cortex results in movement, albeit jerky, of the arm or fingers. In biochemical studies, injections of testosterone will increase aggression in laboratory animals. Finally, anatomical changes in the brain are correlated with predictable effects on behavior. One of the many examples is that the biological clock of animals can be disrupted when a small structure called the suprachiasmatic nucleus is damaged.

Brain recordings

To see brain in action through brain recordings is fascinating to students. Yet, it becomes even more intriguing when they realized that brain activity is correlated with mental processes. The brain can be observed through recordings of electricity generated by neurons by measuring brain ways (the electroencephalogram). Brain waves show a predictable pattern, measured by the frequency of the waves, during mental states such as being relaxed. Moreover, the features of the brain waves will be different when compared to when a person is watching television or reading a book. The pattern is also different depending on whether the person is experiencing a negative emotion or a positive one.

A graphically more meaningful way to look at brain activity is through brain imaging. This uses techniques referred to as CT scans, *f*MRI scans, and PET scans. Using the PET scan, it has been shown that when a person is asked to perform language tasks, specific areas of the brain are activated. These areas correspond to Broca's area, Wernicke's area, and the posterior language association area (Pinel 2000). *f*MRI scans have been done in which a person is asked to imagine that they are playing a game of tennis. When they do this, areas of the supplementary motor area, which is a part of the brain that helps control movement, become activated (Owen et al. 2008). If it were not for the biological basis to psychology, it would not be possible to see how brain activity relates directly to mental processes and behavior.

Experiential

The final area of evidence supporting a physiological basis to behavior is one that will be familiar to many students. From personal experience, people have been exposed to effects of numerous natural and synthetic substances that interact chemically with the neurons of the brain. If this was not the case, if neural modifiers were unable to affect things such as our emotions and consciousness, then nicotine, alcohol, caffeine, LSD, cocaine, and marijuana would have no recreational value at all. The underlying biochemical mechanisms for how these drugs influence our behavior are now being understood. For instance, the addictive drug nicotine works by acting as an acetylcholine agonist by stimulating nicotinic achetylcholine receptors (Levin et al., 2006).

Other drugs produce experiential effects that are far more beneficial to society. One such group of drugs includes the anesthetics which allow people to become unconscious and eliminate pain sensations. Without anesthetics, major surgery would be impossible. Many psychological disorders may also be treated through the use of medications. A commonly known medication in the treatment of anxiety is Valium. The effectiveness of anesthetics and medication would not be possible without the biological basis to behavior.

Conclusion

The implications that an increased appreciation for the biological basis of behavior will have for the student can be many. Students who have been presented with this evidence in either written form or through a lecture have reported to be encouraged to learn more about basic biological processes, particularly those relevant to psychology, such as anatomy, physiology, genetics, and pharmacology. Students also seem to develop a deeper understanding within other areas of psychology. For example, when a student studies a topic in clinical psychology, they are primed to learn about the biological basis and pharmacological treatment approaches to psychological disorders.

To conclude, this paper has presented some easily understood and interesting pieces of evidence that support the biological basis of behavior. Based on the phylogenetic, genetic/developmental, clinical, experimental, brain recording, and experiential evidence, there are good reasons to suppose that the working of the "mind" is dependent on the biological processes of our nervous system. With that being said, we may return to the quote by Bertrand Russell that was presented at the start. He noted that the distinction between the body and mind had its origins in theological rather than scientific thinking. Teachers who make use of the evidence presented here will need to keep this in mind to properly frame the discussion around scientific issues. It can be left to the student themselves to decide what theological implications it might have.

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