

Bell, Magendie, and the Proposals to Restrict the Use of Animals in Neurobehavioral Research

C. R. GALLISTEL *University of Pennsylvania*

ABSTRACT: *The discovery by Magendie of the sensory and motor functions of the dorsal and ventral roots of the spinal nerves provides an illuminating case study of the scientific and ethical considerations that arise when one contemplates restricting neurobehavioral research on animals because of the suffering it causes them. Such restrictions reduce the number of worthless experiments only at the cost of reducing the number of worthwhile experiments—experiments that shed new light on the sources of behavior and provide the knowledge that enables us to alleviate human suffering. Therefore, one should urge the abandonment of animal research in part or in toto only if one believes that the moral value attached to the avoidance of animal suffering is greater than the moral value attached to the enrichment of human understanding and the alleviation of human suffering.*

A bill called the "Research Modernization Act" is now before Congress, where it is picking up influential support. The bill would ban most surgical experiments using live animals, on the theory that the same knowledge may usually be gained by computer simulations, experiments on bacteria, and so on (see Broad, 1980). The bill would establish a review committee that would allow at most one experiment of a given type to be done on live animals. The proponents of this legislation claim that the law is a moral imperative and that it would not cause serious harm to research in the life sciences. I wish to argue that this bill would devastate behavioral neurobiology and that it is an affront to moral sensibility.

Behavioral neurobiology tries to establish the manner in which the nervous system mediates behavioral phenomena. It does so by studying the behavioral consequences of one or more of the following procedures: (a) destruction of a part of the nervous system, (b) stimulation of a part, and (c) administration of drugs that alter neural functioning. These three techniques are as old as the discipline. A recent addition is (d) the recording of

electrical activity. All four procedures cause the animal at least some temporary distress. In the past they have frequently caused intense pain, and they occasionally do so now. Also, they often impair the animal's proper functioning, sometimes transiently, sometimes permanently.

From the beginning, this enterprise has provoked moral censure, to which the experimentalists have often reacted defensively. The terms of this debate have changed hardly at all in 200 years. Consider the following passage, written shortly after 1800 (Le Gallois, 1813, pp. 19–21):

Before I close this introduction, I wish in some degree to exculpate the physiologists who make experiments upon living animals, from the reproaches of cruelty, so frequently uttered against them. I do not pretend wholly to justify them. I would only remark, that the most part of those who utter these reproaches may be deserving of the same. For example, do they not go, or have they never gone a hunting? How can the sportsman, who for his own pleasure mutilates so many animals, and often in so cruel a manner, be more humane than the physiologist who is forced to make them perish for his instruction? Whether the rights we assume over those animals be lawful or not, it is certain that few people scruple to destroy, in a variety of ways, such of those animals as cause them the least inconvenience, though ever so trifling; and that we only feed the most part of those that surround us, to sacrifice them to our wants. I can scarcely comprehend that we should be wrong in killing them for our instruction, when we think we are right in destroying them for our food.

I own that it would be barbarous to make animals suffer in vain, if the object of the experiment could be obtained without it. But it is impossible. Experiments upon living animals are one of the greatest lights of physiology. The

This is a slightly revised version of a paper presented to the Symposium on the Ethics of Animal Experimentation at the meeting of the American Psychological Association, Toronto, August–September 1978.

Requests for reprints should be sent to C. R. Gallistel, Department of Psychology, University of Pennsylvania, 3813-15 Walnut Street T3, Philadelphia, Pennsylvania 19104.

difference between the dead and the living animal is infinite. If the ablest mechanic is unable to discover all the effect of a machine after having seen it work, how could the most learned anatomist devise, by the study only of the organs, the effect of a machine as prodigiously complicated as the body of an animal. To find out its secrets, it is not enough to observe the simultaneous exercise of all the functions in the animal, while in health; it is above all important to study the effect of the derangement, or the cessation of such or such a function. It is in determining by this analysis what the function of such or such an organ is, as well as its relation with the other functions, that the art of experiments upon living animals consists. But to be able to do it with some degree of precision, it is indispensably necessary to multiply the victims, on account of the variety of circumstances and accidents which may render their result uncertain or inconclusive. I should be tempted to say of physiological experiments, what has been said of charities: *perdenda sunt multa; ut semel ponas bene.* SENECA. [Translation: Many are a waste, that one may come out well.]

The passage just quoted seems to me to contain most of the basic facts and positions in the debate between behavioral neurobiologists and antivivisectionists. Let me first summarize what I take to be matters of fact:

1. Experimental surgery causes pain and distress to animals.
2. Researchers are well aware of this pain. Since the discovery of ether in 1847, they have used anesthetics to reduce or prevent the pain, wherever such reduction or prevention does not affect the conclusions that can be drawn from the experiment.
3. There is no way to establish the relation between the nervous system and behavior without some experimental surgery.
4. Most experiments conducted by behavioral neurobiologists, *like scientific experiments in general*, may be seen in retrospect to have been a waste of time, in the sense that they did not prove anything or yield any new insight.
5. There is no way of discriminating in advance the waste-of-time experiments from the illuminating ones with anything approaching certainty. Such judgments are necessarily made under conditions of high uncertainty. As shown by the theory of signal detection, a necessary consequence of this uncertainty is that any attempt to reduce the number of neurobehavioral experiments by prior evaluation of their possible significance will necessarily give rise to many "false negatives," without eliminating "false positives." That is, prior restraints on neurobehavioral experiments will lead to rejection of experiments whose results would in fact have been important and allowance of experiments

whose results will prove unimportant. This will be true no matter how stringent and cumbersome the a priori evaluation (see Figure 1).

These five statements must be taken as facts. Any attempt to advance a pro- or antivivisectionist position by denying one or another of these statements evades the ethical question by denying the very circumstances that give it force. The force of these circumstances can best be appreciated by the study of specific historical cases. One case that should be analyzed at length by anyone contemplating restricting neurobehavioral experiments is the discovery that the dorsal and ventral roots of the spinal cord are sensory and motor, respectively.

In 1822 François Magendie discovered that in young puppies the dorsal and ventral roots of the peripheral nerves come together outside the spinal column, so that they can be separately severed with relative ease. Magendie had been wondering for some time what would be the effect of cutting one or another root on the behavior of the limb or body segment served by the nerve. In the other animals he was familiar with, the roots fused before exiting from the spine. They could only be cut individually after breaking open the spine, which, in the days before anesthesia, was all but impossible to do without damaging the spinal cord. Soon after discovering the favorable anatomical disposition of the roots in young puppies, Magendie began exposing the spines of 6–8-week-old puppies and cutting either the dorsal or the ventral roots of one or more nerves. After several such experiments he was able to publish his famous three-page communication in which he concluded that the dorsal roots carried sensory signals while the ventral roots carried motor signals (Magendie, 1822).

Magendie's experiments place the ethical problems posed by neurobehavioral research in sharp relief for the following reasons: (a) The results were of the utmost importance. (b) The animals used were puppies and the pain of the necessary surgical procedure was both intense and unalleviated by anesthetics, whose discovery lay 25 years in the future. (c) Other very similar experiments had been conducted by some of the leading neuroscientists of the day—most notably the English anatomist Charles Bell—without yielding the decisive, all-important insight. (d) The experiments, because they rapidly became well-known and because they were sometimes performed in public, incurred widespread moral censure and helped fuel the antivivisection movement in 19th century England.

Let me elaborate on these points. First, as regards the significance of the results, I can do no

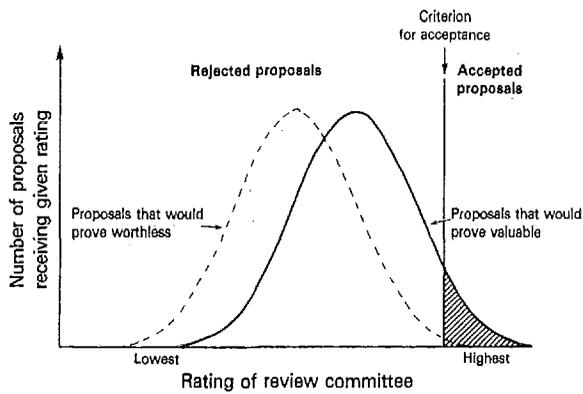


Figure 1. The dilemma faced by review committees that are determined to eliminate worthless experiments. The shaded area represents the proposals that are allowed to be carried out. Even though the criterion for acceptance has been set so high as to eliminate most of the research that if carried out would have proved valuable, some research projects that in fact prove worthless are still done. Before the fact, many worthless experiments (e.g., Bell, 1811) look as good as or better than many very valuable experiments (e.g., Magendie, 1822). The number of worthless experiments permitted becomes negligible only when the criterion is so high that nearly all the valuable experiments are rejected.

better than quote from the introduction to a recent book by Cranefield (1974) on the history of the Bell-Magendie precedence dispute:

The discovery that the dorsal and ventral roots are the sensory and motor roots is one of the most important in the history of biology. The importance of the discovery has never been doubted; as E. H. Ackerknecht has recently written to me, "it is, after Harvey, probably the most momentous *single* discovery in physiology, and it had a more immediate influence on practical medicine than Harvey's discovery. Romberg's book on neurology, the first of its kind, is unthinkable without it."

A comparison with Harvey is by no means idle, since just as no rational physiology of the cardiovascular system was possible before Harvey's discovery, so no rational physiology of the nervous system was possible before the discovery of the separate functions of the roots of the spinal nerves. It was the first unequivocal localization of function in the nervous system and it made possible and led directly to the study of the spinal reflex. The study of the spinal reflex culminated in the work of Sherrington, work that led to our modern concepts of the physiology of the entire central nervous system. (p. xiii)

As regards the pain caused the animals—the other horn of the dilemma, so to speak—little elaboration is necessary, except to note that the pain was hideous, that there was no way known to the science of the day of mitigating it, and last, for the reasons already explained, that the animal of

choice was the one most likely to arouse human sympathy—the puppy.

The third point, the similar but inconclusive experiments conducted by other leading neuroscientists of that time, requires considerable elaboration. The elaboration is rich both in its irony and in its implications for the question of whether antivivisectionist sentiment may be appeased without doing serious damage to the progress of neuroscience. In 1811, in a privately circulated pamphlet, Charles Bell reported the results of experiments on rabbits involving the sectioning of dorsal and/or ventral roots. The report of these experiments is sketchy, and the wording of the conclusions is diffuse and obscure; but, in essence, Bell concluded erroneously that the ventral roots subserved voluntary behavior while the dorsal roots subserved involuntary behavior. Bell's conclusions were steered in the direction of error by a theory of nervous system function that he had derived from his anatomical studies. In subsequent publications Bell made brief allusions to these results and to related results from experiments involving the sectioning of cranial nerves in donkeys; but he did not give any clear statement of their implications, nor did he attach much importance to them *until* Magendie published his paper in 1822. Immediately thereafter Bell and his students began a clamorous, unprincipled, but largely successful campaign to claim priority for what was properly Magendie's discovery.

In the course of this campaign, Bell advanced more or less self-contradictory claims. He repeatedly reproached Magendie for the cruelty of the experiments, claiming that the experiments were unnecessary and counterproductive and that the correct conclusion could be reached by anatomical observation alone. On the other hand, he argued that he, himself, had performed the crucial experiment first in 1811 and that Magendie had been inspired to "replicate" it by one of Bell's pupils, who demonstrated the related cranial nerve experiment to Magendie in late 1821. Bell even reissued "improved" versions of his earlier publications, in which crucial passages were reworded so as to appear to anticipate Magendie's conclusions.

Bell's reproaches and his claims that experiments were unnecessary were picked up by antivivisectionists and helped to get passed the laws that to this day make neurobehavioral work more difficult in England than in America or on the Continent. The claim that experiments on living animals are unnecessary finds its echo today in the claim made by antivivisectionists that it is possible to do neu-

robehavioral research by computer simulation, without ever cutting into a living animal.

These claims are absurd and nothing illustrates their absurdity better than the case at hand. There is nothing in anatomical observation per se that can do more than faintly suggest the functions of the roots. Bell himself knew that the results from the experiments on living animals were central to his claim of priority. Without them he had no claim, which is why—after 1822—he repeatedly emphasized his experiments on rabbits and donkeys. The irony is that Bell's erroneous inferences from anatomical observation played no small role in misleading his interpretation of his vivisection experiments. If anatomical observations are of little use, computer simulation is of still less use. What is there to simulate? You can make a computer whose input and output wires are segregated; you can make one in which they are intertwined; you can even make one in which the same wires are used for both functions. None of this modeling will tell you what the case is with the dorsal and ventral roots of mammalian nerves.

The sorry story of Bell's attempt to claim priority also illustrates the undesirability of setting up committees to pass in advance on whether the results to be obtained from a given experiment performed by a given experimenter are sufficiently important to outweigh the pain to be inflicted. Bell was one of the most important neuroscientists of his day. Furthermore, his vivisection experiments were inspired by a very general if vague and murky (in retrospect!) theory. Magendie was also a scientist of great stature, but he had no theory; indeed, he mistrusted and eschewed the system building that Bell was addicted to. Magendie just wanted to see what would happen. In Bell's hands, the crucial experiment led only to vague conclusions, to which Bell himself attributed little importance. In Magendie's hands, the experiment led to a clear conclusion whose importance was immediately obvious to all of the leading neuroscientists of his time.

Had Bell and Magendie simultaneously submitted proposals for the experiment to a Humane-Vivisection Committee for its permission, it is hard not to believe that they would have given the nod to Bell rather than to Magendie, assuming they gave either permission. If Magendie in 1822 had asked permission of a committee that happened to be aware of Bell's 1811 work—which is to assume an unusually well-informed committee—

they would no doubt have refused permission on the grounds that the experiment had already been done by a first-rate researcher with meaningless results.

In summary, the debate over the ethics of surgical experiments on animals in behavioral neurobiology must come to grips with the following two dilemmas:

1. While it is true that these experiments cause pain and/or distress to the animals, it is equally true that the science cannot progress without them.

2. While it is true that most of the animals which suffer in the course of neurobehavioral research suffer in vain, it is equally true that there is no way to restrict experimentation only to those experiments that will yield meaningful data.

A consideration of the Bell-Magendie case makes it clear why restricting research on living animals is certain to restrict the progress in our understanding of the relation between the nervous system and behavior. Therefore, one should advocate such restrictions only if one believes that the moral value of this scientific knowledge and of the many human and humane benefits that flow from it cannot outweigh the suffering of a rat.

It is an affront to my own ethical sensibility to hear arguments that the suffering of animals is of greater moral weight than are the advancement of human understanding and the consequent alleviation of human suffering. Like Le Gallois, I can scarcely comprehend how it can be right to use animals to provide food for our bodies but wrong to use them to provide food for thought. But, of course, I place a very high moral value on the advancement of human understanding. Those for whom science has no moral value will find my argument without force, assuming that they are also unmoved by the prospect that such understanding will alleviate human suffering.

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