CYBERNETICS

DURING the recent meeting in Liverpool of the British Association, a joint symposium was formed by Sections J (Psychology), A (Physics) and I (Physiology), under the general title of "Cybernetics". Under the chairmanship of Prof. Ross Ashby, three papers were read and discussed: "Organisms and Mechanisms — an Introductory Survey" (Dr. Colin Cherry), "The Impact of Information Theory on Psychology" (Dr. W. E. Hick), and "On Comparing the Brain with Machines" (Dr. D. M. MacKay).

In his introductory paper, Dr. Cherry referred to the origin of the word "La Cybèrnétique" as being due to André Ampère who, in his attempted classification of human knowledge (1834), defined the concept as 'the science of government', taking the word from κυβερνητης, meaning 'a steersman'. Government, whether it means the administration of a country, or the control of our own personal actions, bears some analogy to the steering of a ship. It implies a stabilized directing on to a definite course, or goal-directed activity. Our modern concern with cybernetics represents, Dr. Cherry stressed, a revival of an intense interest of the seventeenth- and eighteenth-century philosophers, namely, the comparison of machines, human beings and social bodies —but with some essential differences. Descartes, who was a focus of such interest, argued in extremely vague philosophical terms; nowadays we are using mathematical analysis and, furthermore, we have techniques for constructing actual machines. Some machines show action which simulates closely certain aspects of human behaviour, mental and physical. How far may such machines go, if only in principle, and what is the purpose of such mechanistic description?

Popular language suggests we readily lean towards mechanistic analogies; we speak of 'the man at the helm', or again, of a man 'running off the rails'. But such metaphors do not form true scientific statements. Our modern interest, however, is not a simple return to the mechanistic–vitalistic (man or machine?) controversy of Cartesian dualism—not in philosophy so much as in physics. Questions such as 'Can a machine think?' are more profitably interpreted as 'What aspects of psychology may validly be discussed in the language of mathematics and physics?' (for example, 'thinking', 'learning', 'recognizing'?).

Modern machines which have self-stabilizing or goal-directed action and which show some similarity to human behaviour are plentiful, and a great body of mathematical analysis has been constructed. These machines are conveniently divided into two classes, exhibiting respectively body-like and mind-like behaviour. The former includes the so-called servo-mechanisms or automatic controls, and the latter relates to computing machines, the so-called 'electronic brains' (though if such science fiction images are necessary, 'electronic brain-extensions' may be preferable).

One idea which runs like a thread through the pattern of relevant studies is the idea of 'information'; information circulates through servo-mechanisms, calculating machines, and all communication channels, and again in the nervous system; it is manifest in human social institutions and systems. But 'information', like 'language', is a many-sided concept; Dr. Cherry directed attention to three aspects, each of which is concerned in the relation of cybernetics to psychology. First, and most important, selective-information refers to the correct selection of signal-elements or signs from a given set (letters, words or other signs, purely at syntactic level, but without regard to their designata); this is the concern of statistical communication theory (and, in a broader sense, of information theory), which sets up a precise measure of selective-information content of messages in terms of the statistical rarity of the signals or signs. Secondly, there is the semantic information which emerges in some cases (involving humans), where the signals are regarded as 'meaningful'. Finally, there are the pragmatic aspects, or those aspects of messages which convey information to a specific recipient and which affect his personal response. Dr. Cherry ended with a brief description of the measure of selective-information content, and sounded warnings of the pitfalls which surround anyone who attempts to 'apply' information theory outside its legitimate sphere.

The second speaker, Dr. W. E. Hick, illustrated a number of ways in which some of the concepts of this theory may be employed, quite legitimately, in practical psychological studies. From this point of view the organism is regarded as a 'black box' to which stimuli are applied, and the responses of which are observed. The 'black box' is here regarded as if it were performing the dual role of communication channel and code-changing transducer—*as if* the organism were a channel along which information flows. From this point of view, a natural descriptive system for those aspects of behaviour which may be described statistically is provided by information theory.

Very broadly, such analysis has been applied in three fields of experimental psychology: (1) hearing, language and speech; (2) reaction times; (3) learning.

Dr. Hick referred to the value of having a precise theory and measure of information when working in these various fields; descriptive or qualitative results may then be made quantitative, construction of experiments may be suggested, and their results may more readily be interpreted.

It is essentially the selective aspect of information which is concerned here, and not the semantic or pragmatic. This may seem strange, in a psychological context, but is a logical consequence of the 'black-box' point of view of regarding the organism as if it were a communication channel. But it must also be remembered that it is only this selective aspect which has as yet been based on a solid foundation of mathematics, and it is only the selective-information content of signals which may be measured quantitatively.

Illustrations were given by Dr. Hick from these three fields of experimental psychology, showing how a human 'black-box' behaves, in comparison to a communication channel—inasmuch as an information theory description may be applied to both. For example, in the first field, the stimuli (or 'messages') applied to the input of the 'black-box' may be spoken words, as in studies of speech recognition. In the second, the stimuli may be represented by successive selections of visual signals from a simple alphabet of signals, to which the subject is required to respond in some prearranged manner; then the relation between the subject's times of response and the errors he makes is shown to bear direct analogy to the properties of a simple communication channel—

in terms of the established measure of selective information-rate. The interpretation of such experiments, and others of like kind, is that, under a considerable variety of error-making conditions, the rate of selective-information in the human 'black-box' channel remains substantially constant. Dr. Hick gave a number of illustrations of such experiments, involving stimuli and responses of several different forms, and of extensions of the method to apply to an alphabet of signal-stimuli having unequal (objective) probabilities of occurring. He afterwards discussed these experiments, and their interpretations by the selective-information-content measure, in relation to other studies of reactions, emphasizing at the same time that the common idea of 'reaction-time' as a kind of constant, so frequently employed in tests for drivers and air pilots, is grossly inadequate. Dr. Hick ended his lecture by emphasizing that his experiments consisted purely of observations of behaviour and that, where probabilities were mentioned, they were objective, relative frequencies; nevertheless, he suggested, information theory has further value for psychology in that it provides a number of general concepts and terms which may aid discussion, at the purely subjective levels—though care must be taken to distinguish such subjective inquiry from direct, quantitative applications of information theory to behavioural psychology.

The last speaker, Dr. D. M. MacKay, distinguished three different ways in which brains are often compared with machines, for three different purposes. The first is the popular comparison between brains and existing machines, notably electronic digital computers. It is a relevant comment that such machines are deliberately designed not to imitate the brain in most of its more characteristic functions; on the contrary, they may be said to take over some of the more machine-like functions of the mind. The second concerns the question as to whether we can ever design an artefact ('artificial mechanism') to imitate any specified aspect of human behaviour; for example, to frame novel hypotheses or (notoriously) to write sonnets.

But the third manner of brain/machine comparison to which Dr. MacKay referred really formed his main theme: Can we build a model working internally on the same principles as the brain? Such may not be an actual engineered machine, but a conceptual model, conforming to all conditions demanded by present knowledge, broad though they be, and having as its purpose the setting up of a description not in the distinct languages of psychiatry, or physiology, or anatomy, but in language common to all these; to provide working links between these various fields. The language of information and control theory promises to be of value in this move toward unification of concepts because, in a sense, it belongs to both the psychology field and the domain of direct physical observation (physics, physiology . . . 'mechanism'). The theoretical characteristics of such a model may then be checked against observation of the brain in action, the discrepancies yielding information towards refining or replacing the model; and so repeatedly, by the usual inductive–deductive procedure. It is important that such models, or descriptions, should not only 'work' in the manner of a normal brain, and meet all functional tests in a similar way, but also that they should 'go wrong' likewise—though Dr. MacKay stressed that this is very different from naïvely attributing mental illness to electronic computing machines that break down.

A further requirement of the model is that, like the brain, it must have been capable of 'growing that way'; such consideration has led to investigations of the possibilities of self-organizing statistical models—models in which the various elements not only are interconnected more or less randomly, but which also themselves function indeterministically to some controllable extent. Such a model should be capable of adjusting the rules of its activity according to the degree of success it attains, by adjusting the relative probabilities of different patterns of activity. Dr. MacKay elaborated upon such a model, describing how, given some positive indication of success or failure, it could continually improve its 'goal-seeking' activity, and "grope its way more and more quickly into a pattern of activity to 'match' any incoming patterns that persisted in occurring".

Finally, Dr. MacKay dealt with questions of purpose. Such theoretical models are intended, he stressed, as research tools. They represent a method of describing 'the thinking process' in disciplined language, suitably objective as to assist the physiologist, yet not divorced from psychiatric reality, so as to permit further assistance in diagnosis, study and treatment of mental illness.

Such work is so often misinterpreted as an attempt to depose man from his special position; man would be 'nothing but' a machine, we often hear, if the brain is described in physical terms. The fault with such reductionist argument, as Dr. MacKay stressed, lies not in the possible incompleteness of the description, but in confusion between two distinct language-systems. Models of the brain form descriptions in observer-language—a set of directions by which, for example, replicas can be made; but a man's personal experience, or rather his statements about his experience, are in actor-language. Questions of personal decision-making, or questions of responsibility, simply do not form part of the brain-model because they cannot be framed in observer-language. However great our understanding of brain structure and functioning, however accurate the model, we none of us are one jot relieved from responsibility for our actions.

The discussion which followed centred mainly around the different uses of the words 'model', 'artefact', or 'mechanism' in such contexts. In response to one speaker who asked if real working models had actually yet been made, Prof. Ross Ashby gave a brief account of his 'homeostat' model, and of its behaviour. E. Colin Cherry

UTILIZATION OF DIGITAL COMPUTING MACHINES

AT the recent meeting in Liverpool of the British Association, Section G (Engineering) held a symposium on the utilization of digital computing machines in engineering and industry. Prof. F. C. Williams, of the University of Manchester, opened the meeting. Before introducing the main speakers, he said that the object of the session was to strip the 'electronic brain' of some of its glamour and to present it to engineers in its everyday shape, which is that of a potentially powerful new tool to aid the solution of engineering design problems. Although at present this tool is in an early stage of development, it is none the less already capable of revolutionizing design procedures—for example, by the rapid