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Introduction

The scope of this book

This book is intended as a guide to all those who are about to start work involving the measurement of directly observed behaviour. We hope it will also be useful for those wanting to refresh their memories about both the possibilities and the shortcomings of available techniques.

Those who have never attempted to measure behaviour may suppose from the safety of an armchair that the job is an easy and straightforward one, requiring no special knowledge or skills. Is it not simply a matter of writing down what happens? In sharp contrast, those attempting to make systematic measurements of behaviour for the first time are often appalled by the apparent difficulty of the job facing them. How will they ever notice, let alone record accurately and systematically, all that is happening? The truth is that measuring behaviour *is* a skill, but not one that is especially difficult to master, given some basic knowledge and an awareness of the possible pitfalls.

The purpose of this book is to provide the basic knowledge in a succinct and easily understood form, enabling the beginner to start measuring behaviour accurately and reliably. A great deal of high-quality behavioural research can be done without the need for specialised skills or elaborate and expensive equipment.

Sometimes it is possible to carry out behavioural research simply by relying on written descriptions of what the subjects do. Usually, though, worthwhile research will require that at least some aspects of the behaviour are measured. By *measure* we mean quantify by assigning numbers to observations according to specified rules. Therefore, measurement

Table 1.1 *The four problems of behavioural biology.*

	Current	Historical
Proximate:	How does it work?	How did it develop?
Ultimate:	What is it for?	How did it evolve?

The control and development questions are sometimes grouped as proximate, and the functional and evolutionary questions as ultimate. They may also be grouped as historical and current issues to do with fully formed behaviour. From Tinbergen, 1963.

of behaviour, whether in the laboratory or in the field, is required by virtually all behavioural biologists and psychologists.

In this book, we are primarily concerned with the methods based on *direct observation* of behaviour developed for recording the activities of non-human species. These methods are not only applicable in advanced academic research. They may also be readily used in the behavioural projects that are commonly offered in university teaching courses and in some secondary schools. Moreover, even though the techniques do not deal with some important issues, such as the measurement and analysis of language, they may be applied fruitfully in some studies of human behaviour, and therefore have important uses in the social and medical sciences.

The four problems

A number of fundamentally different types of question may be asked when studying behaviour. Probably the most useful and widely accepted classification was formulated by the Nobel prize-winning ethologist, Niko Tinbergen (1963), who pointed out that four distinct types of problem are raised by the study of behaviour (see Table 1.1).

Proximate causation or ***control*** – ‘How does it work?’ How do internal and external causal factors elicit and control behaviour in the short term? For example, which stimuli elicit the behaviour pattern and what are the underlying neurobiological, psychological or physiological mechanisms regulating the animal’s behaviour?

Development or ***ontogeny*** – ‘How did it develop?’ How did the behaviour arise during the lifetime of the individual; that is, how is behaviour assembled? What factors influence the way in which behaviour develops during the lifetime of the individual and how do the developmental processes work? What is the interplay between the individual and its environment during the assembly of its behaviour? In addition, what aspects of the young animal's behaviour are specialisations for dealing with the problems of early life or the gathering of information required for behavioural development? Answering these questions is the behavioural side of developmental biology.

Function – 'What is it for?' What is the current use or survival value of the behaviour? How does behaving in a particular way help the individual to survive? How does its behaviour help it to reproduce in its physical and social environment?

Evolution or ***phylogeny*** – 'How did it evolve?' How did the behaviour arise during the evolutionary history of the species? What factors might have been involved in moulding the behaviour over the course of evolutionary history? How can comparisons between different species help to explain that history? How has behaviour itself driven the evolutionary process through mate choice and animals' adaptability and construction of their environments?

Evolutionary questions are concerned with the historical origins of behaviour patterns, whereas functional questions concern their current utility. The two are frequently confused. Questions of function and evolution are sometimes referred to as 'ultimate' questions when contrasted with proximate causation. In the case of fully formed behaviour, questions to do with control and function are current, whereas questions to do with evolution and development are historical.

The 'Four Problems' can perhaps best be illustrated with a commonplace example. Suppose we ask why it is that drivers stop their cars at red traffic lights. One answer would be that a specific visual stimulus – the red light – is perceived, processed in the central nervous system and reliably elicits a specific response (easing off on the accelerator, applying the brake and so on). This would be an explanation in terms of proximate causation. A different but equally valid answer is that individual drivers have learnt this rule by past observation and instruction. This is an explanation in terms of development. A functional explanation is that drivers who do not stop at red traffic lights are liable to have an accident or, at least, be stopped by the police. Finally, an 'evolutionary' explanation would deal with the historical processes whereby a red light came to be used as a universal signal for stopping traffic at road junctions. All four answers are equally correct, but reflect four distinct levels of enquiry about the same phenomenon.

While Tinbergen's Four Problems are logically distinct and should not be confused with each other, it can be helpful to ask more than one type of question at the same time. Correlations between the occurrence of behaviour and the circumstances in which it is seen often lead to speculations about current function. These speculations can lead in two directions. They may suggest what are likely to be important controlling variables and thence lead to experiment. Alternatively, they may suggest a design for the way in which the mechanism ought to work. Here again, the proposal can be tested against reality. For example, as an animal gathers information about its fluctuating environment, what rules should it use in deciding where it should feed? Should it go to a place where the food is always available in small amounts or one in which it is periodically available in large amounts? Ideas about the best ways to sort out such conflicts between foraging in different places have provided insights into the nature of the mechanism. Working the other way, knowledge of mechanism has provided understanding of how such behaviour might have evolved (Real, 1994).

Different approaches to studying behaviour

Scientists study behaviour in different ways and for very different reasons. Historically, **psychology** (which originally grew out of the study of the human mind) was distinguished from **ethology** (the biological study of behaviour) in terms of the methods, interests and the origins of the two sciences. In the twentieth century, comparative and experimental psychologists tended to focus mainly on questions about the proximate causation of behaviour (so-called 'how' questions), studying general processes of behaviour (notably learning) in a few species under laboratory conditions. In contrast, ethologists had their roots in biology and asked questions not only about how behaviour is controlled but also about what behaviour is for and how it evolved ('why' questions). A superb account of the origins of modern ethology is given by Burkhardt (2005).

Biologists have been trained to compare and contrast diverse species. Impregnated as their thinking is with the Darwinian theory of evolution, they habitually think about the adaptive significance of the differences between and within species. Indeed, many ethologists were primarily interested in the biological utility of behaviour and were wary of proceeding far with laboratory experiments without first understanding the function of the behaviour in its natural context. Studies in unconstrained conditions of animals, including humans, have been an important feature of ethology and have played a major role in developing the distinctive and powerful methods for observing and measuring behaviour. In contrast, psychologists traditionally placed greater emphasis on experimental design and quantitative methods.

Even so, it would be a fundamental mistake to represent modern ethology as non-experimental or psychology as non-observational. A great many people who call themselves ethologists have devoted much of their professional lives to laboratory studies of the control and development of behaviour. Conversely, many people who call themselves psychologists study their subjects in unconstrained environments.

Field studies that related behaviour patterns to the social and ecological conditions in which they normally occur led to the development of behavioural ecology. Another sub-discipline, sociobiology, brought to the study of behaviour important concepts and methods from population biology and stimulated further interest in field studies of animal behaviour. Sociobiology also spawned the subject of evolutionary psychology, which seeks to apply biological principles of evolution to human behaviour in particular (Barrett *et al.*, 2002). These subjects have sometimes ignored issues to do with the workings of behaviour. Gradually, however, it became apparent that such neglect of important areas of the biology of behaviour was a mistake. An understanding of the development and control of behaviour is important in stimulating (as well as constraining) ideas about function and evolution. The stimulus works both ways and all the sub-disciplines have started to merge.

For simplicity, we shall refer henceforth to ethology, behavioural ecology, sociobiology and the biological aspects of evolutionary psychology collectively as behavioural biology. Modern behavioural biology abuts many different disciplines and defies simple definition in terms of a common problem or shared ideas. The methods developed for the measurement of behaviour are used by neurobiologists, behaviour geneticists, social and developmental psychologists, anthropologists and psychiatrists, among many others. Considerable transfer of ideas and a convergence of thinking have occurred between behavioural biology and psychology, from which both subjects have greatly benefited. For example, experimental methods developed by psychologists are being used by behavioural ecologists interested in how animals forage for food. Conversely, many of the observational methods developed by behavioural biologists have proved highly effective in studying the developmental psychology of children.

Why measure behaviour?

Animals use their freedom to move and interact, both with their environment and with one another, as one of the most important ways in which they adapt themselves to the conditions in which they live. These adaptations take many different forms such as finding food, avoiding being eaten, finding a suitable place to live, attracting a mate and caring for young. Each species has special requirements, and the same problem is often solved in different ways by different species.

Even though much is already known about such adaptations and the ways in which they are refined, as individuals gather experience, a great deal remains to be discovered about the diversity and functions of behaviour. The principles involved in the evolution of increasingly complex behaviour and the role that behaviour itself has played in shaping the direction of evolution are still not well understood. Explanations of how behaviour patterns have arisen and what they are for will only come from the comparative study of different species and by relating behaviour to the social and ecological conditions in which an animal lives.

Animals are studied for many reasons. In addition to its intrinsic interest (and, let us be frank, the fun of it), the study of behaviour is both intellectually challenging and practically important. Medical research, to which behavioural work often contributes, aims for outcomes that are of direct benefit to humans. Such work on animals is justified in the eyes of most members of the public, its usefulness having been vindicated by independent assessments (House of Lords, 2002; Nuffield, 2004). However, much research on animals is not directed primarily towards producing human benefit, even if this may be a longer-term consequence. While it may play a role in the conservation of the animal in question, first and foremost it is aimed at the fundamental understanding of biology. Animals such as rats or pigeons may be used for studying general processes of associative learning. Other animals may be studied because they are particularly appropriate subjects in which to investigate an important or remarkable phenomenon such as song development in birds or communication in honey bees.

What about mechanism? Molecular and cellular approaches to biology have made remarkable progress in the last 50 years. The neurosciences have been uncovering how nervous systems work, and the long-standing goal of understanding behaviour in terms of underlying processes is becoming attainable at last. The neurophysiological, biochemical and hormonal mechanisms underlying a number of relatively simple behaviour patterns have been uncovered in a variety of species. Powerful techniques are enabling neuroscientists to analyse the electrical and chemical functioning of specific regions of the conscious human brain. Many behavioural biologists use molecular techniques (such as the measurement of satellite DNA) to establish how closely related are the individuals in their study group.

So why bother with the measurement of *behaviour* – meaning the actions and reactions of whole organisms – when you could instead look at its underlying mechanisms? The answer is illustrated, in part, by a simple analogy. Perfect knowledge of how many times each letter of the alphabet occurs on this page would give no indication of the text's meaning. The letters must be formed into words and the words into sentences

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Figure 1.1 A jumble of letters at one level forms an understandable phrase at a higher level of organisation, illustrating the point that detailed knowledge about behaviour at, say, the physiological level would not be helpful in making sense of what was happening at the behavioural level.

(see Fig. 1.1). Each successive level of organisation has properties that cannot be predicted from knowing the lower levels of organisation.

Thus, even when the understanding of the neural elements underlying behaviour is complete, it will not be possible to predict how they perform as a whole without first understanding what they do as a whole – and that means knowing how the whole organism behaves. Many neuroscientists and molecular biologists are beginning to appreciate that an understanding of the mechanisms underlying behaviour requires more than exquisite analytical techniques: it also requires an understanding of the behaviour itself.

Perhaps most satisfying of all, therefore, are the studies in which an analysis of an organism's behaviour is closely integrated with an analysis of the neural, physiological and molecular mechanisms that underlie its actions. Knowledge of mechanism can greatly inform understanding of behaviour – and vice versa. Behavioural studies of imprinting in birds led to extensive analyses of the neural basis of the recognition process. This work then raised questions about the role of the neural mechanisms involved in the classical and operant conditioning that occur in parallel with imprinting. Attention was drawn back to what happens at the behavioural level (Bateson, 2005b).

For these and other reasons we believe that an essential part of biology will be the thorough description and analysis of behaviour. We hope that this book will enable you to do just that.

Summary

The direct observation of behaviour is used for many purposes, ranging from understanding cognition and how it develops to investigations of the current utility of behaviour and how it evolved in the past. The techniques for measuring behaviour are being combined with molecular and physiological approaches, but their use is important in its own right and will always remain a central part of behavioural biology and psychology.

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Think before you measure

Many students are given ready-made problems on which to work but it pays to think carefully before you start a project, whatever stage you are at in your scientific career. Sage advice is given in the book by Cohen and Medley (2000). Here we are concerned with the particular issues that need prior thought in behavioural biology and psychology.

Choosing the level of analysis

Behaviour can be analysed at many different levels, from the complex social interactions within populations to the fine spatial detail of an individual organism's movements. A simple but fundamental point is that the form of measurement used for studying behaviour should reflect the nature of the problem and the questions posed. Conversely, the sorts of phenomena that are uncovered by a behavioural study will inevitably reflect the methods used.

A fine-grained analysis is only appropriate for answering some sorts of question, and a full understanding will not necessarily emerge from describing and analysing behaviour at the most detailed level. While a microscope is an invaluable tool, in some circumstances it would be useless – say, for reading a novel. In other words, the cost of gaining detail can be that higher-level patterns, which may be the most important or relevant features, are lost from view. For example, recording the precise three-dimensional pattern of movements for each limb may be desirable for certain purposes, such as analysing the neurophysiological mechanisms underlying a particular locomotor behaviour pattern. However, higher-level categories such as 'walk' or 'run' are often more appropriate.