3

Learning

- In learning, an organism changes its future behaviour in response to the consequences of its previous behaviour, and forms novel associations between stimuli and responses.
- PAVLOVIAN OR CLASSICAL CONDITIONING involves a CONDITIONED STIMULUS producing a CONDITIONED RESPONSE, such as salivation, that normally would be produced as the result of an UNCONDITIONED REFLEX.
- SKINNERIAN OR OPERANT CONDITIONING involves an alteration in the rate of a behaviour, such as lever-pressing, due to REWARD or PUNISHMENT.
- Classical and operant conditioning seem to be separate processes, and differ procedurally, in the types of behaviour they apply to, and in their response to EXTINCTION.
- PUNISHMENT can decrease the frequency of an operant behaviour, and in the case of ONE-TRIAL AVERSIVE CONDITIONING after illness or poisoning can result in long-lasting behavioural change.
- Not all learning involves classical or operant conditioning. Other types include LATENT LEARNING, and MODELLING or IMITATION LEARNING.

Benefiting from experience requires an organism to change its behaviour in different circumstances; the process is LEARNING and the information stored is called MEMORY. Mainly for practical reasons, learning is usually studied in animals and memory in man, and despite different methodologies it is the same process being studied.

The first systematic studies of learning were the famous experiments of the Russian physiologist, Ivan Pavlov (1849–1936), who measured the amount of salivation in dogs in his laboratory. Dogs reflexly produce saliva when food is presented. More interestingly, Pavlov showed that if a bell is rung before food is presented then dogs will salivate to the sound of the bell alone. This is PAVLOVIAN or CLASSICAL CONDITIONING. In learning theory terms, the food is an UNCONDITIONED STIMULUS (US) that produces an UNCONDITIONED RESPONSE (UR) via a reflex. The bell is a CONDITIONED STIMULUS (CS) that eventually also produces salivation, the CONDITIONED RESPONSE (CR). Although the UR and CR appear to be identical, they are not precisely identical, and hence have different names. In classical conditioning, an animal acquires new behaviours (e.g. salivating to a bell), which are potentially adaptive.

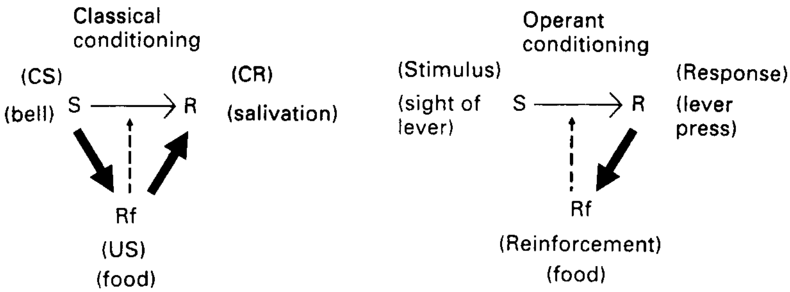

Fig. 3.1 The relations between the stimulus (S), the response (R), and the reinforcement (Rf) in classical and operant conditioning. Invariant links are indicated by heavy arrows, either being inbuilt reflexes (as in the case of the Rf-R link in classical conditioning) or being designed into the experiment as invariant (as in the S-Rf and Rf-R links in classical and operant conditioning respectively). Learned connections are indicated by light arrows. The influence of the reinforcer is shown by a dashed line, in strengthening a learned connection.

A different form of learning, described in the 1930s by the American ɔychologist B F Skinner (1904–1990), is called OPERANT, INSTRUMENTAL : SKINNERIAN CONDITIONING. At first it seems very different to classical ɔnditioning. A hungry rat is placed in an experimental cage (a :INNER BOX) that contains a lever, which the rat can push, and a 'ough in which a food pellet may appear. Eventually, perhaps by ccident, the rat pushes the lever and a food pellet appears. Soon the at is pushing the lever continuously to obtain food. In the terminology f operant conditioning, the lever press is a RESPONSE, the food is a EINFORCER. The response is REWARDED and hence increases in rate (to uch an extent that a hungry rat may spend much of its day lever-ɔressing). The reinforcer acts because it satisfies a basic DRIVE (hunger n this case, but perhaps thirst, sleep, sex or warmth).

Much controversy has arisen as to whether classical and operant :onditioning are the same fundamental process, or are separate (a 'two-process theory'). Most researchers now accept there are indeed :wo separate processes, which are differentiated in several ways. Firstly, there are procedural differences. Consider classical conditioning (Fig. 3.1). A stimulus, S, is *always* followed by a reinforcer (Rf) (indicated by the solid arrows). That reinforcer *always* causes a response (R). The reinforcer then causes a *direct* link to be set up between S and R, which gradually becomes stronger on each presentation of S and R. (Note that although this is classical conditioning, I have purposely used the language of operant conditioning to emphasize the similarities.) Figure 3.1 also shows operant conditioning. The animal sees the lever (S), and makes the response (R) of pushing it. This response *always* causes reinforcement to appear, in the form of food. The effect of the reinforcer is to strangthen the link between S and R so that in future the sight of the lever is more likely to make the animal press it. It should now be obvious that in both types of conditioning, new links are created between stimulus and response; this whole area is sometimes called S-R PSYCHOLOGY. The difference is that in one case the experimenter controls the stimulus (i.e. the bell is always rung before food) and in the other it is the reinforcer that is controlled (i.e. food is always given when the lever is pressed). There is also an additional link in the case of classical conditioning, in that the reinforcer (the US) automatically causes a response (the UR) by a reflex, whereas in operant conditioning no such prior links exist. In addition, for operant conditioning to work organisms need to be able to monitor their own behaviours (i.e. in general they are voluntary actions), whereas no such feedback is necessary for classical conditioning to occur, which frequently involves involuntary autonomic responses.

A final difference between the two types of learning emerges when reinforcement is withdrawn. If the bell is rung but *no* food is subsequently presented then the salivation responses to the bell gradually die away, a process known as EXTINCTION. By contrast if, in operant conditioning, a press of the lever produces *no* food then the rat *increases* its rate of lever pressing, the EXTINCTION BURST, and only then does the behaviour finally extinguish completely.

It has been necessary to describe these two types of learning in some detail because they underlie many behaviours, both human and animal, and can be used to explain a wide range of abnormal behaviours, from temper tantrums in children, to the development of phobias. Consider even the everyday observation of seeing somebody walk up to a lift, press the button and find the lift doesn't come; invariably they then press the button perhaps half a dozen more times, an extinction burst, before finally walking up the stairs. Rationally, there is little justification for such behaviour, because it s most unlikely that the switch itself is faulty.

In classical conditioning, the phenomenon of *secondary conditioning* s of great importance. Consider a dog trained to salivate to a bell. If ve now turn on a light, and follow the light by the bell, but do not ollow the bell by food on that occasion, the bell will produce its onditioned response of salivation, and eventually the animal will alivate to the light, even though the light and food have never hemselves been presented. By such mechanisms, long complex chains behaviour can be created.

Operant conditioning has developed a massive and complex terminogy. A few terms are worth knowing. If instead of rewarding the nimal for every response (CONTINUOUS REINFORCEMENT) one rewards only fter, say, *every* tenth lever press, this is called a FIXED RATIO (FR) chedule of reinforcement, and if one rewards only *on average* each enth press, but sometimes after two and sometimes after forty presses, then this is VARIABLE-RATIO (VR) reinforcement, which has the property

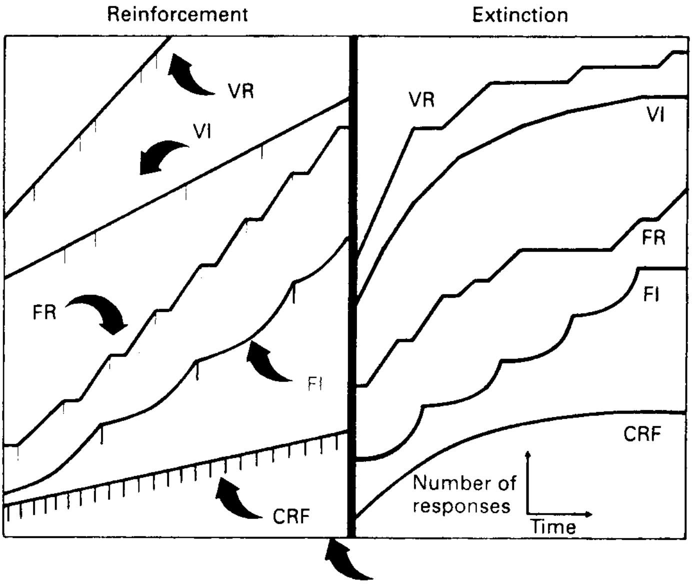

Fig. 3.2 Behaviour under different operant schedules (CRF Continuous reinforcement; FI Fixed interval; VI Variable interval; FR Fixed rate; VR Variable rate), both during reinforcement and during extinction. The CUMULATIVE RECORDS show time along the abscissa and responses on the ordinate, each lever press moving the pen upwards by a small fixed amount. Presentation of rewards is indicated by a downward tick on the record. Redrawn with permission from Walker S (1984), *Learning theory and behaviour modification*, London, Methuen, 54.

being very resistant to extinction and of simulating many reward ocesses in the real world (for instance the gambler at the roulette ble). If a reinforcer is given only after, say, *exactly* thirty seconds ive passed since the previous reinforcer, then this is called a FIXED-TERVAL (FI) reinforcement, and it produces its own characteristic ittern of responses, SCALLOPING, whereby the animal responds at a igh rate just before the end of the critical time-interval (see Fig. 3.2). ı contrast variable interval (VI) rewards, in which the animal is ewarded *on average* every 30 seconds, produce a steady sustained ite of responding (Fig. 3.2). In each type of reinforcement the animal an be considered to act in a way that maximizes its return for a ıinimum of effort. DISCRIMINATION LEARNING is when an animal learns) respond, say, to one lever when a blue light is on and to another ever when a red light is on. Such techniques can be used to ask ubtle questions about, for instance, the colour perception of animals, articularly if combined with the phenomenon of STIMULUS GENERALIZ-TION, in which a stimulus like, but not identical to, the training timulus is tested. We may ask whether a purple colour looks more ke red or blue to a rat, by observing whether the rat trained as described above presses the 'blue' or the 'red' lever when presented with various purplish lights. Generalization also underlies the increasing range of objects to which phobic patients become sensitive, so that a phobia of spiders may generalize to a phobia of all insects, or perhaps to all small dark animals, and then to any animal.

A final but important variant on learning experiments is that although the reinforcers described so far (food, but also water, warmth, and in human societies, money) have increased the probability or the rate of responding, there are also PUNISHMENTS, which are aversive or unpleasant, and decrease the likelihood of responding; examples are mild electric shocks in animals, withdrawal of attention in the case of children, or fines or imprisonments for adults. Aversive, or punishment, schedules have the characteristic that the behaviour is reduced in frequency, so much so in many cases that it becomes very difficult for the organism to unlearn the association; extinction cannot readily occur as the response is never made and so the lack of a relationship with the action cannot be realized. ONE-TRIAL AVERSIVE CONDITIONING is particularly important in situations where a rat feels nauseous or ill after eating a particular food, and avoids that food in future. Such conditioning is probably responsible for many human food fads and preferences, and for CANCER ANOREXIA (see Chapter 26); if you eat strawberries for the first time at a party, and develop food poisoning within the next few hours (perhaps because of infected meat, or some other cause unrelated to strawberries) you may well develop a strong aversion to strawberries in the future. NEGATIVE REINFORCEMENT is technically not the same as punishment, being the *removal* of an *aversive* event, and therefore causing an *increase* in behaviour (since all reinforcers are defined as events that *increase* the rate of behaviour and all punishments as events that *decrease* the rate of behaviour; a negative reinforcer must therefore increase the rate of a behaviour and can only do this by removing something that is aversive). Therefore an animal being continually given electric shocks will work to press a lever to terminate the shocks, and the frequency of the lever-pressing behaviour is increased.

Thus far this chapter has emphasized classical and operant conditioning, the two forms of ASSOCIATIVE LEARNING. It might be objected that this emphasis is undue, and that there is no sense in which you might learn anatomy or psychology by schedules of reinforcement of reward for particular responses. That is indeed so, and there are other types of learning. However, the important thing about conditioning is that, so far as we can tell, it is the most primitive form of learning, occurring in all vertebrates and many invertebrates, and still being present and even frequent in man. It is the 'bottom-line'; it can always be used to modify behaviour, and frequently can be used to explain away apparently more complex and sophisticated behaviours. The most famous case is the horse, Clever Hans, who reputedly could

Fig. 3.3 Child modelling parent smoking a cigarette. Anti-smoking advertisement published by the Health Education Council, and reprinted with permission.

›lve arithmetic problems, tapping its hoof on the ground to count ıt the answers, but in fact simply having been operantly conditioned › respond to different expressions on the owner's face. In the mentally ıbnormal and the mentally ill, conditioning becomes of great nportance, both in understanding and in treating abnormalities, and ı producing more socially acceptable behaviours, by such devices as)KEN ECONOMIES in which patients earn tokens for good behaviour, lose ıem for antisocial behaviour, and can 'spend' them on rewards ;weets or other reinforcers) — see Chapter 31.

Not all learning involves obvious, or direct, reinforcement. Edward Tolman (1886–1959) described the process known as *latent learning*. . hungry, control rat learns to run through a complicated maze for food reward, and on each trial it runs faster and faster, as it learns ıe route. A second non-hungry animal is placed in the maze without)od and is simply allowed to explore for a number of trials. Later it ; put into the maze when hungry and has to run though for food; it learns the route in less trials than the control, showing that is was learning about the maze even when it was exploring, and when there was no direct reinforcement. The learning was apparently latent and only revealed later by testing, although it might be argued that because exploration is itself rewarding, it may have reinforced the learning. In MODELLING OR IMITATION LEARNING, two rats are placed in adjacent cages separated by a glass wall. The control rat learns a complex discrimination task and is watched by the second rat, which when tested learns the task more quickly than the control rat. The test rat has modelled its behaviour on the other animal. Such learning is probably of great importance during development and children frequently model the actions of their parents or other adults; this occurs when a child imitates adults smoking by putting a pencil in its mouth (Fig. 3.3).

In summary, theories of learning are in essence very simple, involving the *association* of stimuli and responses, the *effects* making future behavioural associations more or less likely; nevertheless such simple processes can become very convoluted and almost certainly underlie many apparently sophisticated and complex human behaviours.