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ABSTRACT

Many questions about animal welfare involve the affective states of animals (pain, fear, distress) and people look to science to clarify these issues as a basis for practices, policies and standards. However, the science of the mid twentieth century tended to be silent on matters of animal affect for both philosophical and methodological reasons. Philosophically, under the influence of Positivism many scientists considered that the affective states of animals fall outside the scope of science. Certain methodological features of the research also favoured explanations that did not involve affect. The features included the tendency to rely on abstract, quantitative measures rather than description, to use controlled experiments more than naturalistic observation, and to focus on measures of central tendency (means, medians) rather than individual differences. Much animal welfare science has dropped the philosophical stance but retained most of the methodological features. Thus, animal welfare scientists attempt to understand affect through quantitative measures, often in controlled experiments, with relatively little focus on individual differences. An alternative paradigm, seen in the work of Jane Goodall, Barbara Smuts and others, made a fundamental departure from these methodological features. These scientists collected qualitative, narrative data as well as quantitative; they described complex behaviour rather than measuring selected abstract features; and they attempted to understand the unique features of individual animals rather than averages for a species or type. Data produced by this alternative paradigm almost require scientists to involve affect in order to achieve plausible explanations of behaviour. Suitably developed, the alternative paradigm may provide a useful tool for fundamental studies relevant to animal affect and animal welfare.

1. Introduction

> “Indeed, the laboratory experimenter, in an attempt to reduce variability, often not only purposely restricts the behavior of the animal in which he is interested, but also limits sharply the aspects which he is willing to record. . . Of course, controlled experiments are essential in the study of behavior, but should come after qualitative study.” (Hinde, 1959, p. 566)

> "Already there are journals which demand a reduction of descriptive material to the absolute minimum required for an understanding of the experiments reported on. . . However, if we overdo this in itself justifiable tendency of making description subject to our analytical aims. . . we might forget that naïve, unsophisticated, or intuitively guided observation may open our eyes to new problems." (Tinbergen, 1963, p. 412)

The affective states of animals – those subjective states that are experienced as pleasant or unpleasant rather than hedonically neutral – play a central role in our understanding of animal welfare (Dawkins, 1988; Duncan, 1996). But what do we actually know about animals' affective states, and how can science help us improve this understanding?

Let us begin by considering two types of understanding that we have of animals. One we might call our "everyday" understanding, as illustrated by the following incident. Some years ago, my family looked after an exceptionally intelligent, middle-aged dog named "Angel", for friends from another city who were travelling for a year. Angel adjusted quickly to our family: she followed my wife faithfully on errands, she played with the children, and she was an enthusiastic participant in walks and games of catch. At the end of the year the owners returned and spent the day with us before taking Angel back to their home. After meeting them, Angel suddenly disappeared and was later found hiding beneath a desk in a top-floor room where she had never gone on her own. As the owners prepared to leave with her in tow, Angel appeared extremely down-cast. She entered their car very slowly, and then bolted out of the car and back into our house. Only with much patting and reassurance were we able to coax her into the car again. In this incident, although our understanding of Angel's behaviour was far from complete, there was no doubt in anyone's mind that any explanation of the events must involve Angel's own emotions and mental state.

In contrast, most scientific research has produced explanations of a very different type. To take one example, the theory of parent-offspring conflict predicts that as offspring approach the stage of independence, a parent (as a result of natural selection) will provide them with less parental investment (food, protection) than the young would obtain from the parent if they could control the interaction. My colleague Ed Pajor tested this prediction with domestic pigs by comparing the amount of contact that lactating sows maintained with their piglets in a pen where the mother could leave the offspring at will, or in a pen where the young had constant access to the mother. The study largely confirmed the prediction: regardless of the housing arrangement, the mothers remained in almost constant contact with the young during early lactation; but as the piglets aged, the mothers that were free to leave spent less time with the piglets, and nursed them less frequently, than the sows that were subjected to constant attention (Pajor et al., 2000).

Like the incident involving Angel's departure, this study also involved social attachment, but the "scientific" explanation of the behaviour – which is rooted in calculations of genetic relatedness and the theory of evolution – made no reference to the emotional states of the animals. No one was denying that the animals may have experienced emotions during the study; for example, the sows may well have been frustrated if they could not escape from the piglets, and the piglets may well have been distressed when the mother was absent. But the research sought a kind of explanation in which emotions played no role. And although this particular example involved an approach typical of behavioural ecology, other approaches to animal behaviour research – ethology, comparative psychology, physiological psychology have also tended to seek scientific explanations of behaviour that do not incorporate (or mention) animals' emotions.

This situation created a problem for the scientific study of animal welfare. Many of the important questions about animal welfare arise when people, drawing on their "everyday" understanding of animals, are concerned about animals' affective states. People want to know, for example, whether laboratory rodents

suffer from post-operative pain, whether hens are frustrated when they are kept in cages, and whether zoo animals are afraid if they are housed close to large predators. When regulators and policy makers attempt to deal with such issues, they generally make it clear that they will use science as the basis for animal welfare policies, practices and standards. But if most of the available science is silent on questions of affective states in animals, how will this be possible?

2. Affect and animal behaviour

A brief and selective history of the role of affect in animal behaviour research helps put the problem into perspective.

During the 1800s, the understanding of animals sought by scientists was much closer to everyday understanding. In his book, The Expression of the Emotions in Animals and Man, Darwin (1872) proposed that many species share similar emotional experiences – fear, pain, pleasure, affection, anger – and often express them in similar ways through vocalizations, facial expressions and other behaviour. Darwin's contemporary Romanes (1891) set out to classify the mental powers of the different animal species, much as a comparative anatomist might classify variations in anatomical traits. His method was to collect narrative accounts illustrating the mental abilities of animals, but he limited himself to accounts recorded by observers whom he considered reliable or to observations that he considered to have been corroborated by similar observations made by other observers. As one example, Romanes described the behaviour of an elephant that had developed a disease of the eyes and had been blind for several days. A local doctor agreed to try treating one of the eyes with silver nitrate. Here is Romanes' description of the event:

> "The animal was accordingly made to lie down, and when the nitrate of silver was applied, uttered a terrific roar at the acute pain which it occasioned. But the effect of the application was wonderful, for the eye was in a great degree restored, and the elephant could partially see. The doctor was in consequence ready to operate similarly on the other eye on the following day; and the animal, when he was brought out and heard the doctor's voice, lay down of himself, placed his head quietly on one side, curled up his trunk, [and] drew in his breath like a human being about to endure a painful operation." (p. 399)

Around the same time, a few scientists were using more experimental approaches to understand the mental lives of animals. In his book, The Mind of a Gorilla, primatologist Robert Yerkes (1927) described his experiences in studying "Congo", a captive gorilla aged about five years. Yerkes devised experiments that required the gorilla to use a stick, or to stack one box on top of another, in order to reach food. He noted that Congo's behaviour did not appear to be simple trial-and-error learning. Instead, Congo often seemed to solve a problem more by observation, reflection and insight.

These observations made an intriguing start at applying the tools of systematic investigation to understanding the affective states and other mental experiences of animals; but in the middle decades of the twentieth century, the scientific study of animals moved strongly towards different kinds of explanation.

As philosopher Bernard Rollin (1990) has pointed out, the change reflected the influence of Positivism, the school of thought associated with the "Positive Philosophy" of the French sociologist Auguste Comte. Comte, working in an emerging discipline during the nineteenth century, was trying to define a clear demarcation between science and such other fields as metaphysics and theology. Part of his solution was

to maintain that science deals only with the material world, not with immaterial souls or hypothetical entities (Kolakowski, 1968).

Positivism had widespread effects on science generally, and it influenced the place of affect in science in perhaps three ways. First, with its emphasis on tangible, observable phenomena, Positivism held that we should not postulate unobservable processes (immortal souls, divine will) to explain observable ones. Under this influence, the emotions, feelings and other mental states of animals tended to be banished as explanatory concepts.

Second, Positivism held that processes that cannot be observed, even if they may occur in the physical world, fall outside the scope of science. On this basis, whole areas of investigation – including evolution and the origin of the universe – were deemed by some Positivists to be unsuitable for scientific enquiry, and by the same token the subjective experience of animals was regarded as not amenable to scientific enquiry.

Finally, Positivism held that the sciences are built upon each other in a hierarchical manner (Lenzer, 1975). Thus, Comte considered that sociology rests on biology, which rests on chemistry, which rests on physics. According to this view, the behaviour of animals can ultimately be explained on the basis of underlying physiological processes. When the physiological processes cause the movements of animals that we call behaviour, perhaps the animal does experience some agreeable or disagreeable feeling, but the subjective experience is merely a byproduct – an "epiphenomenon" – which accompanies but does not cause or explain the occurrence of the behaviour. Charles Darwin's famous contemporary Thomas Huxley provided a classic example of this view:

> "The consciousness of brutes would appear to be related to the mechanism of their body simply as a collateral product of its working, and to be completely without any power of modifying that working as the steam-whistle which accompanies the work of a locomotive engine is without influence on its machinery." (Campbell, 2004, p. 361)

According to this view, the subjective experiences of animals are actually irrelevant to science because they play no role in causing events in the physical world.

In summary, then, under the influence of Positivist thinking, the subjective experiences of animals were seen (1) as inadmissible as explanatory concepts, (2) as not amenable to scientific study, and (3) as playing no role in the causation of behaviour. In line with such thinking, the American psychologist Watson (1924) proposed that psychologists should not attempt to study inner, mental ("subjective") experience in either humans or other species, but rather that they should limit their research to observable behaviour, specifically by discovering the laws whereby certain stimuli ("S") lead to certain responses ("R"). To the generation of "behaviourists" that followed, if we had a thorough knowledge of such S‑R laws – laws perhaps analogous to those that apply to the movement of objects in Newtonian physics – then we would be able to predict and control behaviour without any need to venture into the murky realm of mental experience.

A similar conclusion about subjective experience was reached by many scientists working within the tradition of ethology. The influential ethologist Niko Tinbergen (1963) advocated that research on animal behaviour should try to answer four questions: how is the behaviour caused? how did it evolve? how does it develop as the animal matures? and what functions does the behaviour serve in the animal's life? This was a much broader program than Watson had laid out; but Tinbergen joined Watson in proposing that the "subjective" experience of animals be excluded from scientific consideration. "Because subjective

phenomena cannot be observed objectively in animals," he wrote, "it is idle either to claim or to deny their existence" (Tinbergen, 1951, p. 4).

The philosophical positions of Watson, Tinbergen and others were not universally accepted by animal behaviour researchers during the mid twentieth century. For example, the eminent British ethologist Julian Huxley insisted that through the objective study of behaviour, "we can deduce the bird's emotions with much more probability of accuracy than we can possibly have about their nervous processes" (Burkhardt, 1997, p. 8). Psychologist Bierens de Haan (1947) regarded Tinbergen's attempt to understand behaviour without reference to subjective experience as a temporary vogue that would abate and be replaced by meaningful understanding of animal psychology. Other scientists simply carried on writing unapologetically about the affective states of animals. For example, Harry Harlow insisted that his research on maternal separation in monkeys was about "love" animals (Blum, 2002), and Young (1959) proposed a theory of motivation for both humans and animals based on the principle that "affective processes regulate and direct behaviour according to the principle of maximizing the positive and minimizing the negative" (p. 117).

Despite such disagreement about the goals and limits of science, much of the research on animal behaviour in the mid twentieth century followed certain methodological conventions which also had an important influence on the willingness of scientists to consider affective states in animals.

First, whether working within the paradigms of ethology, behavioural ecology, or experimental psychology, most scientists were attempting to establish general rules or principles (such as the Law of Effect or the optimization theories of behavioural ecology) that would apply to a taxonomic group (e.g., rats) or other category of animals (e.g., scatter-hoarders), or even to all organisms.

Second, given these goals, the individual animals under study tended to be viewed principally as exemplars of a category, serving mainly to establish measures of central tendency (mean, median) which were used to test hypotheses or create generalizations about a category to which the animals belonged. The differences between individual animals were often viewed as uninteresting variation that might be reported simply as dispersion around a mean, or treated as "sampling error" that researchers would attempt to minimize. If individual differences were seen as interesting at all, they were often reduced to quantitative scales such as dominance rank, or to a simple typology such as "active copers" versus "passive copers".

Third, the data gathered were almost invariably quantitative, often using numerical measures of relatively abstract aspects of behaviour. Researchers might record, for example, the number of times a micro-switch had been closed during a session when a rat could press a lever for food, or the percentage of time that animals spent with the head raised during foraging sessions as a measure of vigilance. Such abstract measures were valued in part because they were seen as "objective" and highly repeatable. However, the use of such measures also meant that much or most of the detail of the animals' behaviour was excluded from scientific consideration.

Fourth, the behavioural research of the mid twentieth century attached particular value to evidence derived from controlled experiments. This is understandable in that a well designed and controlled experiment can often give clear answers about which causal factors produce which effects. However, many experiments tend to focus on only a few of the possible causal or contributing factors. Hence, although experiments may give conclusive results concerning the factors tested (high internal validity), they may provide a very incomplete understanding of the phenomenon as it occurs in real life (low external validity). In addition, many experiments are performed under conditions that involve some simplification from real life such as highly controlled physical environments or very limited and predictable

social contexts. Such research often failed to capture the complexity and flexibility of animal behaviour in real-life situations. The picture of animals that emerged from controlled experiments tended to be somewhat mechanistic, portraying “the rat” or “the pigeon” as driven to act in certain uniform and predictable ways by homeostatic mechanisms, ecological triggers and genetic differences. Yerkes (1927) was sensitive to this limitation in his own experiments with Congo. “The experiment may be a human masterpiece,” he wrote, “but as likely as not it is so contrived as to give the animal meager opportunity to utilize its peculiar adaptive or expressive capacities” (p. 137).

These methodological conventions – seeking widely applicable principles, treating animals as exemplars of a category rather than as individuals, focusing on quantitative data based on simple measures of behaviour, and valuing experiments that gained internal validity at the expense of external validity – tended to make the affective states of animals irrelevant to scientific explanation. If, for instance, the data to be explained are merely the average speeds of rats running to food in a plastic runway after carefully controlled periods of deprivation and training, then the results can be expressed very simply, perhaps in mathematical notation, and we arguably gain no explanatory power by postulating any involvement of mental events, for example that the rats felt hungry or remembered where to find food.

In summary, although few scientists actively denied that animals have affective experiences (exceptions were Bermond, 1997, and perhaps Kennedy, 1992), the science of the mid twentieth century tended to exclude affective states in animals for both philosophical and methodological reasons. The philosophical stances were that affective states are not valid as explanatory concepts, cannot be studied scientifically, and do not play important roles in the causation of behaviour. Methodologically, the research tended to collect results of a general, abstract and simplified nature that lent themselves to explanation without reference to affective or other mental states.

3. Animal welfare science

The constraints that Positivism placed on the study of behaviour have been criticized by scientists and philosophers alike, in arguments that I will not attempt to review here (Griffin, 1984, 1992; Midgley, 1983; Rollin, 1990; Dawkins, 1990; Fraser, 1999). However, the practical outcome of these constraints was that the science of the mid twentieth century provided little guidance to animal welfare researchers who wanted to answer questions about animal affect.

The solution by many animal welfare scientists was to develop research methods designed specifically to shed light on the affective states of animals. Thus during the 1970s, even as many students were still being taught that the affective states of animals fall outside the scope of scientific enquiry, animal welfare scientists began publishing papers on topics such as “frustration” (Duncan, 1970), “distress” (Fraser, 1975a), and “suffering” (Dawkins, 1977). Such work rejected the philosophical exclusion of affective states from science, but it retained many of the methodological features of mid twentieth century research. The following examples illustrate three somewhat different approaches.

In some cases, animals are thought to have signals that communicate particular affective states to other animals, and the research is designed to “listen in” on this communication. For example, if an unweaned piglet is placed alone in an unfamiliar pen, its behaviour follows a typical sequence (Fraser, 1975a). The piglet begins by walking slowly and giving short, quiet grunts separated by a second or two of silence. During the first minute or two, its activity increases and its movements gradually take on a more agitated appearance. The animal defecates and urinates frequently, and some jump against the wall in what appear to be attempts to escape. The calling also becomes louder and more frequent, and the calls change from quiet, low-pitched grunts to loud, high-pitched squeals. Experiments have shown that newly separated piglets give more calls, especially more of the high-pitched squeals, if they have not been fed

recently or if they are in a cool environment; both of these are conditions that presumably increase their need to be re-united with the mother (Weary and Fraser, 1995a). Moreover, when the calls are played to sows through a hidden speaker, the sows respond more vigorously to calls given by piglets in conditions of greater need (Weary et al., 1997). The working hypothesis in this case is (1) that piglets have been shaped by natural selection to experience an unpleasant affective state ("separation distress") when separated from the mother and group-mates under conditions that would threaten their survival in the wild, (2) that this unpleasant state stimulates the agitated movement, the defecation, and the distinctive calling, (3) that variation in calling (between individuals and over time) is due to variation in the strength of the affective state, and (4) that the pattern of sound attracts the mother and is likely to lead to a reunion. On the basis of this working hypothesis, the calls have been interpreted as signals that communicate separation distress to the mother, and that can be used to identify (and to a degree quantify) this affective state (Weary and Fraser, 1995b).

In cases where animals do not signal an affective state to conspecifics, the state may still be accompanied by some characteristic behaviour or other change. For example, if a chicken (or animal of many other species) is held firmly on a flat surface for a few seconds and then released, the animal is likely to remain immobile for several minutes in a reaction commonly called "tonic immobility" or "death-feigning" (Gallup, 1981). Tonic immobility may be an adaptation that allows prey animals to survive capture because a predator may simply store immobile prey without making further attempts to kill them. A common hypothesis is that tonic immobility is an indicator of fear, and experimental evidence tends to support this view; in particular, procedures intended to calm the animals (tranquillizers, habituation) reduce the response, and procedures intended to create fear (loud noises) increase it (Jones, 1986).

An interesting application of this method occurred in a debate about fear in chickens. On many chicken farms, crews of people are employed to catch chickens for shipping when the birds reach market weight. Typically each catcher grabs several birds by the legs, carries them upside-down, drops them in a shipping crate, and then returns for more birds. A newer alternative is the mechanical "chicken harvester" – a large machine that moves slowly through the building, gathers birds in a set of rotating rubber fingers, and moves them onto a conveyor belt which then transfers them to the crates. When mechanical harvesters first appeared, there was concern that they would cause excessive fear in the birds. However, in testing the equipment, Duncan et al. (1986) found that immediately after being caught, birds captured by machine remained in tonic immobility for significantly less time than birds that had been captured by hand. The researchers also recorded the birds' heart rates as a general indicator of activity of the sympathetic nervous system. Although heart rate increased sharply during catching by both methods, it returned to normal more quickly for birds that had been captured by machine. Thus, both lines of evidence suggested that machine catching caused less fear than manual catching.

Even if there is no specific behaviour that accompanies an affective state, it may still be possible to use general changes in either behaviour or physiology as an indirect indicator. For example, Schwartzkopf-Genswein et al. (1997) used several general behavioural features to compare the painfulness of hot-iron branding versus freeze branding of beef cattle. In the study, cattle were restrained in a holding chute where they were branded in one of the two ways. The researchers used a combination of video-recording of the animals' behaviour, plus load cells and strain gauges to register the amount of force the animals applied to the restraining chute during the branding process. Cattle branded by a hot iron applied greater force and longer duration of force against the chute; they were also more likely to flick their tails, kick, fall and vocalize than the animals that received freeze branding. The freeze branding produced definite behavioural changes, but these were less pronounced. The team concluded that both methods cause pain but that hot-iron branding is the more painful of the two.

In these three examples and a host of others, we see many of the methodological features of mid twentieth century behavioural research: the focus on categories of animals (chickens, cattle) rather than the unique responses of individuals, the use of quantitative measures that represent only selected features of the behaviour performed, and the reliance on controlled experiments, sometimes in simplified or standardized environments. However, the principal goal of the research was to understand the affective states of animals: separation distress in piglets, fear in chickens, pain in cattle. The basic model of this research involves a causal event (branding) that is hypothesized to lead to an affective state (pain) as the outcome of interest, and behavioural and other measures are treated as indicators of the affective state. The hypothesis could then be tested and refined by seeing whether its predictions are confirmed in further research. For example, if different behavioural changes are indeed indicators of pain, then a treatment that leads to high scores for one behaviour should produce high scores for the others, and a drug (such as an analgesic) that reduces one behaviour should reduce the others.

Of course many of the scientists conducting animal welfare research clearly assumed that the affective states they studied played functional roles in the lives of the animals. For example, Duncan (1993, 1996), Dawkins (1990, 1998), and Broom (1998) clearly saw affective states as adaptations that had evolved because they motivate fitness-enhancing behaviour: pain, for instance, was seen as motivating animals to avoid or terminate behaviour that leads to injury. Nonetheless, the goal of the research was to identify (and if possible quantify) the affective states themselves rather than the functions they served. In such research (following a suggestion by Burghardt, 1995) it was as if a fifth question had been added to Tinbergen's four: not only do we study behaviour to understand its evolution, its ontogeny, its causation and its function – we also study behaviour to develop an understanding of the affective states of animals.

4. An alternative paradigm

But in most behavioural research, the outcome of interest is not an affective state but the behaviour itself. If affective states are invoked at all, they are used simply to help explain behaviour. In such research, is there a way to make affective states a more central and integral part of scientific explanation?

Around the time when some scientists began to turn their attention explicitly to animal welfare, another group of scientists began a very different departure from the animal behaviour research of the mid twentieth century. One of the pioneers was Jane Goodall whose methods of studying animals were closer to those of cultural anthropology than to traditional ethology or comparative psychology. As an example of her work, here is Goodall's description of how "Mike", an undistinguished male, rose rapidly in the hierarchy by intimidating his group-mates in a remarkable display of aggression. The scene began with five adult males grooming each other peacefully, and Mike sitting apart, frequently staring towards the group. Eventually Mike picked up two empty paraffin cans from near Goodall's tent:

> "Armed with his two cans, Mike continued to stare towards the other males and, after a few minutes, he began to rock from side to side. . . Gradually he rocked more vigorously, his hair slowly began to stand erect, and then, softly at first, he started a series of pant-hoots. As he called, Mike got to his feet and suddenly he was off, charging towards the group of males, hitting the two cans ahead of him. The cans, together with Mike's crescendo of hooting, made the most appalling racket: no wonder the erstwhile peaceful males rushed out of the way. Mike and his cans vanished down a track and, after a few moments, there was silence. Some of the males reassembled and resumed their interrupted grooming session, but the others stood around somewhat apprehensively. After a short interval that low-pitched hooting began again, followed, almost immediately, by the appearance of the two rackety cans with Mike close behind them. Straight for the other males he charged, and once more they fled. This time, even before the group could

> reassemble, Mike set off again: but he made straight for Goliath – and even he hastened out of Mike's way like all the others. Then Mike stopped and sat, all his hair on end and breathing hard. . ." (Goodall, 1971, p. 118)

After this incident, all the males except the dominant Goliath approached Mike submissively and groomed him. Only after further displays and counter-displays did Goliath also followed suit.

Goodall's work certainly included a great deal of quantitative data (Goodall, 1986), but as we see in this passage and many others, she also caused readers to pay attention to a type of evidence that had played little role in animal behaviour science during the previous 50 years. This was "qualitative data", including rich narrative detail, which seemed impossible to understand without postulating certain mental and affective states in animals, for example that Mike had a strong "desire" for dominance and that other chimpanzees reacted with "apprehension" (Goodall, 1971, p. 122).

The decades after Goodall's initial work saw a steady growth of other research on individually known animals observed closely in their natural lives or interacting with humans. Moss (1988) gave detailed descriptions of elephants greeting each other after periods of separation – observations that convinced her that the animals were experiencing "joy" (p. 125). Smuts (1999), in her detailed analysis of friendship in baboon societies, referred to the emotions of jealousy, trust, and affection to account for the behaviour she saw. Drawing partly on close observation of naturally occurring social behaviour, de Waal and Aureli (1996) discussed the evidence that chimpanzees and macaques possess sympathy for distressed group-mates. Galdikas (1995) developed an understanding of personality and emotions in orangutans based partly on her experience of raising orphan orangutans in her home and observing their large individual differences.

The work of Goodall, Moss, Smuts and many others differed from typical mid twentieth century science in several methodological features. First, researchers did not confine their attention to quantitative data based on abstract measures, but also included qualitative, narrative accounts of sequences of events that occurred in the lives of the animals. Second, instead of regarding animals simply as exemplars of a species or other category, and treating individual differences as dispersion around an average, much of this research treated individual differences as interesting data that demonstrate the complexity and variety of the animals' behaviour. Third, rather than emphasizing planned experiments done under controlled conditions, the research included observations made during the actual lives of the animals, whether in nature or under human care. Thus, the research was more likely to capture the factors that were important in the actual lives of the animals, rather than focussing on those factors selected by the researcher for attention, perhaps because of relevance to theory. Because of these methodological features, the data considered in the research were much more similar in nature to the kind of observations made by dog owners, horse trainers, zoo keepers, and others whose understanding of animals is of the everyday kind.

In such cases, the issue of affective and other mental states in animals arises not so much from a philosophical decision to reject the constraints of Positivism, nor from the practical desire to answer questions about animal welfare, but simply from a desire to understand and explain complex data. As noted above, so long as scientists restrict themselves to considering data that are abstract, quantitative, and pertain to a broad category of animals, there is little impetus to consider mental and emotional states. However, the narrative detail, individual differences and unique social relations that Goodall and others described almost force us to postulate insight, desire and emotion simply to make sense of the behaviour. One could not plausibly account for Mike's unique behaviour without postulating mental and emotional states, any more than we could account for Angel's complex responses to the arrival of her owners.

Fig. 1. Two models, from Miller (1959), for the explanation of behaviour. Three causal factors on the left (deprivation of water, ingestion of dry food, and injection of saline) lead to three types of response on the right (increased drinking, increased bar-pressing for water, and increased toleration of quinine in available drinking water). Miller noted that explanation could involve postulating nine Stimulus-Response links (above), or a smaller number of links if an intervening variable ("thirst") is included.

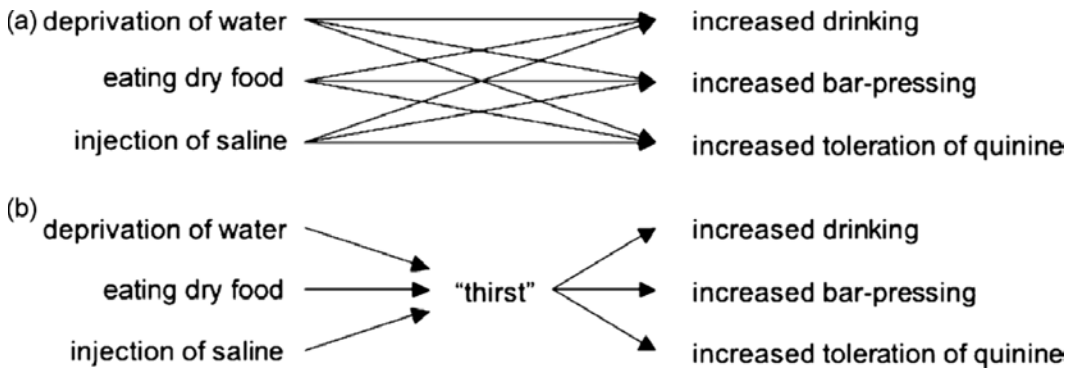
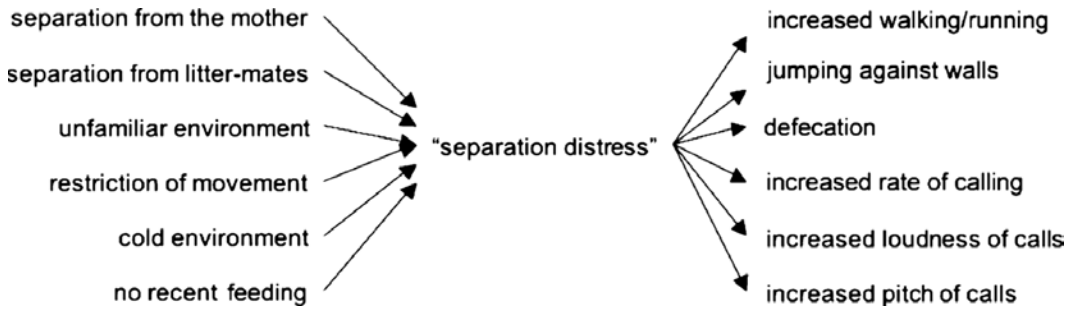


Fig. 2. A model, based on the logic proposed in Fig. 1b, for the behaviour of young pigs when placed alone in a pen. Various causal factors on the left lead to various responses on the right. An affective state, tentatively termed "separation distress", is postulated as an intervening variable that is influenced by the causal factors and leads to the responses. The figure summarizes research findings by Fraser (1974, 1975a, b) and Weary and Fraser (1995a).



5. Affect in scientific explanation

But does talk about affect actually contribute to explanatory power, or is it just a kind of speculation or sloppy thinking that people invoke when a truly "scientific" understanding is not available? A partial answer comes from an argument by the versatile psychologist Neal Miller (1959) who suggested a criterion for deciding when it is scientifically useful to postulate "intervening variables" as part of scientific explanation. Using the logic shown in Fig. 1, Miller noted that several causal factors on the left of the chart (deprivation of water, eating dry food, injection of saline) may have similar effects on several different response measures at the right of the chart (increased drinking, increased bar pressing to obtain water, increased toleration of quinine in water). To "explain" the behaviour solely in terms of Stimulus-Response (S-R) associations, one would need to postulate a large number of separate S-R links (Fig. 1a). However, if the various causal factors act by producing the same affective state ("thirst"), then it is more parsimonious to postulate the affective state as an intervening variable which is influenced by the causal factors and, in turn, influences the responses (Fig. 1b).

The causal factors and responses that Miller considered in his model were typical of the relatively abstract, quantitative measures used in experimental psychology at the time, and no clear consensus developed over whether postulating intervening variables is a useful step in developing explanatory theories. For one thing, the “thirst” caused by eating dry food may differ in its properties and persistence from the “thirst” caused by injections of saline. Hence, the model shown in Fig. 1b may actually be incorrect.

Miller’s model would seem well suited, however, to many examples from animal welfare research. For example, in the case of young pigs that are put into a pen alone, the animals’ behaviour changes in a number of ways (Fig. 2): they show increased walking or running; they jump against the walls; they defecate; they give an increased number of calls; and they increase the loudness and pitch of the calls. Moreover, a series of experiments shows that these various responses are increased by many different causal factors: separation from the mother, separation from litter-mates, unfamiliarity of the environment, restriction of movement, cold, and a lack of recent feeding (Fig. 2). Following Miller’s logic, there is good scientific justification for hypothesizing that the different causal factors produce an affective state (“separation distress”) that influences the various responses. One could then test the hypothesis by seeing whether it leads to correct predictions, for example that age, habituation or pharmacological interventions would influence all of the responses in similar ways.

Narrative data produce a somewhat different model, in that they greatly increase the number of response variables that need to be explained but may not increase the number of causal factors involved. Miller noted that if we have multiple causal factors (on the left) or multiple responses (on the right) but not both, then no parsimony is achieved by postulating an intervening variable. However, narrative data may show that certain changes in behaviour tend to occur together, for example by occurring in the same context. For example, on the return of Angel’s owners, why did she go to the top floor and spend the day under a desk, why did she walk so slowly with them to the car, why were her ears laid back, why did she bolt from their car? When we are confronted with this kind of detail, which amount to a large number of responses occurring together, then the only way to achieve a plausible explanation may be to develop theories that include affective and other mental states as unifying concepts. This is largely what happens in our everyday understanding of animals, and this also occurs in science when we expand our concept of “data” to include the kind of rich narrative detail recorded by Goodall and others.

In these cases, understanding the affective states of animals is not a separate task – not a fifth question – but an integral part of scientific explanation. Indeed, we can ask all four of Tinbergen’s questions about affect: how an affective state evolved, how it develops during ontogeny, how it is caused, and what functions it serves (Aureli and Whiten, 2003). In this way, perhaps as Bierens de Haan (1947) suggested, an understanding of affect becomes an integral part of the science of animal behaviour.

6. Concluding comments

The two types of research reviewed above – animal welfare science and the alternative paradigm of Goodall and others – were by no means the only developments in the scientific study of affect. A third line of research, which conformed much more closely to the norms of mid twentieth century science, applied the methods of experimental physiological psychology to investigating the physiological processes underlying affective states. For example, scientists recorded seemingly emotional behaviour in animals after stimulating clusters of neurons by electrodes implanted in the brain, or after creating lesions in specific brain centres. Part of the stimulus for this work was the view, shared with the animal welfare scientists but not by behaviourists in the tradition of Watson, that affective states are evolved adaptations that play important roles in causing behaviour and therefore warrant investigation as biological phenomena. As a result of such work, the end of the twentieth century saw books with titles like Affective

Neuroscience: The Foundations of Human and Animal Emotions (Panksepp, 1998), and The Brain and Emotion (Rolls, 1999), focused largely on brain mechanisms of emotion and drawing largely on the invasive experimental methods typical of physiological psychology in the previous half century.

A further line of research, whose link to affect was often more implied than explicit, centred on the cognitive powers of animals. Much of this work captured elements of the approach used by field primatologists; in particular it involved close observation of known individuals and careful attention to individual differences and to the context in which the behaviour occurred. However, the work generally added a degree of experimental control. For example, Pepperberg (2002) used highly controlled experimental methods to explore the mental capacities of birds, but she focused on very few individuals whom she came to know closely through years of interaction. In other cases, primatologists used the methods of the developmental psychologist Jean Piaget to understand the stages of cognitive development in the Great Apes in work typically involving few individuals studied closely over many years (Russon et al., 1996). Although this work was not specifically about the emotions of animals, it created a picture of animals as having complex information-processing capabilities that were fully compatible with their having rich emotional lives as well.

What links the examples from Romanes, Yerkes, Goodall and Angel the dog, is an attention to descriptive, narrative detail and individual responses. And it may be such a shift in attention, from quantitative measures of selected variables to narrative accounts of actual events, from averages to individual responses, from controlled conditions to more naturalistic observation, that could move the study of affect from the sidelines of behavioural science to a more central role. If we think of Feminist thought as focusing on the particular and contextual rather than the abstract and theoretical, as emphasizing relations and emotions more than rationality, and as involving empathy with others rather than objectification (e.g., Donovan, 1990), then we see some of the hallmarks of Feminist thought in the approach to science taken by Goodall, Smuts, and to some extent in Romanes and Yerkes. Thus, if science moved away from considering the experiential lives of animals at a time when Positivist thought was prevalent, perhaps at a time when Feminist thought is prevalent we will see that trend gradually reversed. Indeed, also in line with Feminist thought, the paradigm of Goodall and others provides a non-invasive and non-reductionist approach to building up an understanding of the affective states of animals, as an alternative to the methods of physiological psychology.

There is an interesting parallel between the study of animal behaviour and the study of human behaviour in the fields of sociology and anthropology. Social science researchers have often been accused of rushing too quickly into quantification, for example by collecting survey data on issues where basic understanding is poorly developed, or by asking research questions that are driven by theory rather than capturing important elements of actual human behaviour. A common recommendation is to begin with qualitative research, typically by observing or talking to people at length, so that questions for later quantification can be developed on the basis of a deep understanding of the issues, and so that theory can emerge from the data rather than being imposed in advance (Corbin and Strauss, 1990). Some of the arguments above, and the introductory quotations from Hinde and Tinbergen, suggest that similar cautions are (or remain) relevant in the study of animal behaviour and animal welfare.

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