



Animal Welfare and the Paradox of Animal Consciousness

Marian Dawkins¹

Department of Zoology, University of Oxford, Oxford, UK

¹Corresponding author: e-mail address: marian.dawkins@zoo.ox.ac.uk

Contents

1. Introduction	1
2. Animal Consciousness: The Heart of the Paradox	2
2.1 Behaviorism Applies to Other People Too	5
3. Human Emotions and Animals Emotions	7
3.1 Physiological Indicators of Emotion	7
3.2 Behavioral Components of Emotion	8
3.2.1 <i>Vacuum Behavior</i>	10
3.2.2 <i>Rebound</i>	10
3.2.3 <i>"Abnormal" Behavior</i>	10
3.2.4 <i>The Animal's Point of View</i>	11
3.2.5 <i>Cognitive Bias</i>	15
3.2.6 <i>Expressions of the Emotions</i>	15
3.3 The Third Component of Emotion: Consciousness	16
4. Definitions of Animal Welfare	24
5. Conclusions	26
References	27



1. INTRODUCTION

Consciousness has always been both central to and a stumbling block for animal welfare. On the one hand, the belief that nonhuman animals suffer and feel pain is what draws many people to want to study animal welfare in the first place. Animal welfare is seen as fundamentally different from plant “welfare” or the welfare of works of art precisely because of the widely held belief that animals have feelings and experience emotions in ways that plants or inanimate objects—however valuable—do not (Midgley, 1983; Regan, 1984; Rollin, 1989; Singer, 1975). On the other hand, consciousness is also the most elusive and difficult to study of any biological phenomenon (Blackmore, 2012; Koch, 2004). Even with our own human consciousness, we are still baffled as to how

the wealth of subjective experience we all know from first-hand experience can actually arise from a lump of nervous tissue weighing less than 2 kg. Unable to understand our own consciousness, we are even more at a loss when it comes to its possible existence in other species (Dawkins, 2012).

There is thus a seeming paradox at the heart of a science of animal welfare (Dawkins, 1980; Fraser, 2008). To be comprehensive enough to include what most people mean by animal welfare, it must involve understanding what animals consciously feel and experience. But to be a science, it has to embrace the one thing that biology currently finds very difficult, if not impossible to study, namely, animal consciousness.

Generally speaking, there are four different ways of dealing with this paradox that can be found among people who all call themselves animal welfare scientists:

1. Animal consciousness is not a problem for scientific study. There is therefore no paradox.
2. Animal consciousness is a problem for scientific study but although we cannot study it directly, we can do the next best thing and study the behavioral and physiological correlates of it.
3. Animal consciousness is problematic at the moment because we do not yet have the right research methods for studying it. However, with more research we will solve this problem and so the paradox will disappear.
4. Animal consciousness is likely to remain beyond scientific methods for the foreseeable future but solving it is not central to a scientific study of animal welfare. The paradox therefore exists but it does not matter.

These views are clearly very different from each other and reflect fundamentally different ideas about animal consciousness and therefore what the aims of a science of animal welfare should be. This article examines how animal welfare science has dealt with the problem of animal consciousness and whether it has successfully resolved the paradox.



2. ANIMAL CONSCIOUSNESS: THE HEART OF THE PARADOX

Fifty years ago, there was no science of animal welfare. Biology, like psychology, was in the grip of a behavioristic philosophy that saw any mention of “feelings” or “suffering” as unscientific (Lashley, 1949; Watson, 1929). Over the course of the twentieth century, the study of animal

behavior grew from its beginnings in natural history into the science of ethology (Klopfer & Hailman, 1967) but whereas some ethologists such as Lorenz (1958) and Huxley (Tax & Callender, 1960) argued that the subjective experiences of animals should be part of any study of their behavior, others, notably Tinbergen (1951) set out to be as objective as possible, which meant avoiding mention of anything that could not be observed directly such as subjective feelings. “Because subjective phenomena cannot be observed objectively in animals,” Tinbergen wrote in *The Study of Instinct*, “it is idle either to claim or deny their existence” (1951).

It is important to stress here that Tinbergen was not saying that animals have no feelings. He says quite explicitly later in the same book: “I do not want to belittle the importance of either directiveness of behaviour or of the subjective phenomena accompanying our and possibly the animal’s behaviour.” The problem he saw was not whether animals were conscious but that it was impossible to use the established methods of science to discover whether they were or not: “Hunger, like anger, fear, and so forth, is a phenomenon that can be known only by introspection. When applied to another subject, especially one belonging to another species, it is merely a guess about the possible nature of the animal’s subjective state.” It was this guesswork and the use of introspection that Tinbergen was objecting to, not the idea that animals might have conscious experiences. Many scientists at the time did in fact believe in the reality of conscious experiences in both humans and nonhumans, but were also convinced that *as scientists* they could not study them (Hebb, 1974).

Then, in 1964, there were signs of change. That year saw the publication of Ruth Harrison’s *Animal Machines*, which drew public attention to the new ways in which animals were being farmed for food—hens in battery cages, calves in crates, sows in stalls, and so on (Harrison, 1964). The book created such a public outcry that within weeks of its appearing, the UK Government set up a special commission (Brambell, 1965) to look into the welfare of farm animals and the possible suffering caused by the ways in which they were now being kept. When the Committee reported its findings in the following year, the Report contained a remarkable Appendix by the Cambridge ethologist W.H. Thorpe (1965), that issued a direct challenge to the prevailing ethological view that subjective feelings in animals were not for scientific study.

Seemingly embarrassed by the fact that ethology could not and would not answer questions about animal suffering that the public were demanding answers to, Thorpe wrote (1965): “...we are often extraordinarily ignorant

of just those things we want to know most. In fact quite a number of lines of special research would have to be undertaken over some years before we could get much further towards a fully scientific answer to many of our problems. What is required is to examine the incidence of those expressive movements which are known to be associated with damaging situations in order to assess whether animals brought up with a certain of deprivation ‘suffer’ from deprivation and stress in adulthood” (1965, p. 79).

The question of animal subjective awareness was voiced even more loudly a few years later by Donald Griffin (1976, 1992). Griffin urged ethologists to throw off what he called the obsolete behaviorist “taboo” and start developing ways of making animal consciousness amenable to scientific enquiry. He argued that the increasing evidence for the complexity of animal behavior (such as tool use, communication, and problem solving) had revealed complexity of mechanism, which in turn suggested conscious awareness. He pointed out that biologists accept the evolutionary continuity between humans and other species for physical features and should do the same for features of mind as there was, in his view, no sharp divide between our mental experiences and theirs.

By “mental experiences,” Griffin meant the capacity to think about objects and events that are remote in time and space from the immediate flux of sensations (1976, p. 15) and under “conscious awareness” he included everything from toothache to an astronomer’s concept of the universe. Subsequently, the philosopher Block (1995) divided up these very different kinds of awareness and made a useful distinction between *phenomenal consciousness* (the immediate sensation of pain, pleasure, and sensations such as color and smell and *access consciousness* (the ability to think and reason). In retrospect, we can see the development of two different scientific disciplines concerned with whether these two different sorts of consciousness might exist in animals. Cognitive ethology (Shettleworth, 2010a) concentrated on the intellectual abilities of animals and the possibility of access consciousness, while animal welfare science was more concerned with phenomenal consciousness (sometimes called ‘sentience’) and in particular whether animals could feel pain and experience positive and negative emotions. The distinction between phenomenal and access consciousness—in other words, the distinction between awareness of feelings and awareness of thoughts—is critically important for a science of animal welfare because evidence for one sort of consciousness does not necessarily provide evidence of the other. With all the cognitive ethology’s emphasis on the intellectual achievements of primates, elephants, birds (Shettleworth,

2010a), it is easy to lose sight of the fact that animals with only limited cognitive abilities might still suffer pain or hunger (Dawkins, 1990, 2012). In other words, it is not necessary to be clever to experience hunger or to feel pain. Even Descartes, famous for saying that animals were machines that lacked the ability to think or reason, appeared to believe that they could feel pain and pleasure and experience passions (Malcolm, 1973).

Animal welfare science has therefore been concerned with what animals feel, initially with their ability to suffer and feel pain (Broom & Johnson, 1993; Dawkins, 1980; Fraser, 2008; Webster, 1994) more recently with their capacity to experience pleasure and more positive emotions (Boisey et al., 2007; Whiteham & Wielbrowski, 2013). But what exactly happened? How did ethology go from being a science that needed behaviorism to guarantee its scientific credibility (Klopfer & Hailman, 1967) to regarding behaviorism as an outdated approach no longer needed by the new exciting studies of animal cognition and animal emotion? Did animal welfare science somehow discover a miraculous new way of studying animal consciousness scientifically? How does animal welfare science resolve the apparent paradox that it cannot both be a science and study animal consciousness?

2.1 Behaviorism Applies to Other People Too

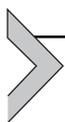
Animal welfare scientists can take comfort from the fact that, if there is a paradox at the heart of their science, it is the same paradox that lies at the heart of human psychology. Behaviorism grew out of a conviction that the methods of introspection widely used in the nineteenth century to explore the human mind were invalid (Watson, 1929) and was even more a criticism of the methods of human psychology than of those of animal psychology. The major criticism was that introspection only yielded data that were private (known only to the person experiencing them) and therefore fell outside the usual standards of scientific methodology (which demand public scrutiny and independent verification by different observers). I can never know for certain what you are feeling or whether you have the same experience of 'red' as I do when we both look at light of a particular wavelength. As Skinner (1963) put it, as far as conscious experiences are concerned, "we are locked within our own skins."

However, while this may be logically true, we do not, in practice, let it stand in the way of our dealings with other people. We make the assumption that other people have feelings and experiences like our own on the grounds that they are sufficiently similar to us in what they do and what they say that

the assumption is justified. We use the so-called argument from analogy to make the leap from what we can observe (physiology, behavior, words) to what we cannot. We use the indirect evidence of what other people say about what they are feeling and how they behave to infer the existence of what we cannot directly observe. Most of the time it works reasonably well. Certainly it works better than assuming we can infer absolutely nothing at all about the private feelings of other people.

This commonsense view of human consciousness began to be adopted by human psychologists only in the second half of the twentieth century (Blackmore, 2012; Dietrich, 2007), as up until then behaviorism had effectively prevented the study of human as well as animal consciousness. Once the behaviorist straitjacket was removed, there was a huge increase in scientific studies of human consciousness and the proliferation of books and papers on the subject that we see today (e.g., Dennett, 1991; Denton, 2005; Frith, 2007; Humphrey, 2012; Koch, 2004; Seth, Baars, & Edelman, 2005; Velmans, 2009). This was not achieved by suddenly being able to invade the ‘private’ worlds of other peoples’ subjective experiences but by making the simple assumption that what people report verbally about their experiences is a reasonably good indirect measure of what they are actually experiencing (Stoerig, 2007). This indirect source of information—expressing feelings in words—may not be open to us in quite the same way in the study of nonhuman animals. But animal welfare science grew out of the conviction that there are other indirect ways of finding out about animal feelings and how they ‘express their emotions’ that are just as valid as the evidence we have about other humans through speech. After all, our understanding of other people is also built up of what they do and how they ‘vote with their feet’ to get what they want, of their facial expressions and body postures. We can use these other sources of information to understand people whose languages we do not speak, which suggests that it should be possible to adapt those same methods to apply them to organisms that cannot speak to us in words but can express themselves in other ways. Indeed, the history of animal welfare science, is, broadly speaking, the history of the search for indicators of animal emotions, both the negative ones we call suffering and the more positive ones we call pleasure (e.g., Appleby & Hughes, 1997; Barnett & Hemsworth, 1990; Broom, 1988; Curtis, 1987; Dawkins, 1980; Duncan, 1974; Fraser, 2008; Mendl, Burman, & Paul, 2010; Moberg, 1985; Webster, 1994; Wemelsfelder, 2001). Because human psychology has taken the lead and been prepared to use what people say as indirect evidence of their conscious emotional experiences, the study of

human emotions provides a starting point for studying nonhuman emotions and nonhuman consciousness.



3. HUMAN EMOTIONS AND ANIMALS EMOTIONS

Human emotions are widely regarded as having three separate components (Keltner, Oatley, & Jenkins, 2013; Oatley & Jenkins, 1996). The first component includes physiological changes such as increased heart rate, increased temperature, and changes in hormone levels. These changes prepare our bodies to take some sort of action, such as escaping, and are very similar in nonhuman animals (Boissey et al., 2007; Cannon, 1929; Panksepp, 1998; Selye, 1956, 1974). The second component includes all the behavior, facial expressions, and sounds that people make when they are in the grip of an emotion. Many of these, too, we share with other species, as Darwin (1872) recognized. The third component is the conscious experience of emotions. We know we humans have private subjective experiences of fear, anger, and so on that occur while the other two outward and visible components (the behavior and the physiology) are occurring. A crucial question for animal welfare science is to understand how these three components of emotion are related and therefore how valid it is to use the first two observable components as indirect ‘indicators’ of the third unobservable component of subjective experience, that is for many people the essence of animal well-being and suffering (Dawkins, 1990; Duncan, 1993; Fraser, 2008).

3.1 Physiological Indicators of Emotion

Emotions such as fear, anger, and frustration are associated with activation of the autonomic and endocrine systems that lead to changes such as increased heart rate and the release of adrenaline and other hormones (Cannon, 1929; Selye, 1956, 1974; Toates, 1995). As measures of emotional state, these physiological changes have frequently been used as measures of how good or bad an animal’s welfare is (Broom & Johnson, 1993). For example, Red deer (*Cervus elaphus*) that have been chased by dogs show levels of the ‘stress’ hormone cortisol and the muscle enzyme creatine kinase that are much higher than in deer that have been killed by rifle shots without being chased, leading to the conclusion that hunting with dogs causes suffering to the deer (Bateson & Bradshaw, 2000). For more positive emotions, the hormone oxytocin, which is found in both humans and other mammals, is

commonly released during tactile contact such as nursing, mating, grooming, and massage. It is reported to be pleasant by humans and is therefore thought to be indicative of good welfare in both humans and other species (Uvnäs-Moberg, 1998). It would be a mistake, however, to think of positive and negative emotions as tidily indicated by any specific bodily changes (Barnett & Hemsworth, 1990; Dawkins, Edmond, Lord, Solomon, & Bain, 2004; Dantzer & Mormède, 1983; Mason, 1975; Mendl, 1991; Moberg, 1985; Rushen, 1991; Toates, 1995). Changes in heart rate, skin conductance, and facial temperature are very similar whether the emotion we are experiencing is anger, fear, or even happiness (Cacioppo, Klein, Berntson, & Hatfield, 1993). Furthermore, other animals, like humans, show a rise in corticosteroid hormones not just when confronted with a predator (implying fear or a negative emotion) but also in anticipation of food, sex, and in other situations normally associated with positive emotions (Rushen, 1991; Toates, 1995). The physiological components of emotions are thus very similar between humans and nonhumans and present similar problems for interpretation. They are only a rough guide to which emotions are occurring and seem primarily to indicate that the person or animal is active or aroused. They do not clearly distinguish between emotions of different valence (i.e., whether they are positive or negative) and are therefore used by animal welfare scientists as an important but limited guide to animal emotions. They need supplementary evidence from other sources.

3.2 Behavioral Components of Emotion

The second component of human emotions, which has the potential to supply this evidence, includes all the behavior, facial expressions, and sounds that people make when they are in the grip of an emotion, many of which are shared with nonhuman species (Darwin, 1872; Panksepp, 1998). However, different animals have very different 'equipment' with which to express their behavior. Some (like dolphins) have rigid inflexible faces but a wide range of vocal signals. Others (like birds) have a repertoire of songs and the ability to raise and lower their feathers. Some can communicate with tiny changes of facial expression. Some can change color in an instant. So identifying the behavioral component of emotion for each species is an extensive task requiring an understanding of each species.

Furthermore, within each species, there is potentially a large range of emotions each with different outward behavioral signs. What we describe as 'suffering,' for example, covers a wide range of emotions such as fear,

frustration, anxiety, boredom, deprivation of social contact, physical discomfort (Dawkins, 1990), that may have little in common beyond the fact that they all arise from situations that we and other animals would avoid if we could (in this sense they can be described as ‘negative’ emotions). These states appear to have evolved by natural selection as part of complex mechanisms that all animals have for avoiding danger and restoring physiological deficits (Broom, 1998; Cabanac, 1992). Their significance for animal welfare is that they come into operation at an early stage or even *before* the animal is physically damaged (Dawkins, 2001a). For example, fear occurs before an animal has been actually caught and injured by a predator, causing it to flee or hide so that the predator does not even get close. Hunger occurs long before the animal is in danger of dying of starvation, and is part of a mechanism leading it to search out food and so restore a food deficit before it gets more critical. This anticipatory element of emotion (what Berridge (2004) calls “wanting”) is why we need to be aware that captive animals may be physically healthy but still ‘suffering,’ since they may be kept in conditions in which they are unable to carry out behavior they are highly motivated to do (Dawkins, 1990). If the natural coping mechanisms (e.g., fleeing) do not achieve the natural end result (escape from danger), the animal will remain highly motivated for long periods of time and keep attempting to flee, suggesting prolonged and intense emotional disturbance (Broom & Johnson, 1993; Thorpe, 1965).

Since the natural world provides many different causes of death and reproductive failure, wild animals have been selected to respond to different dangers in different ways. An animal whose fitness (and well-being) is threatened by a predator will have a completely different set of ‘indicators’ of its emotional state from an animal whose fitness (and well-being) is threatened by dehydration. Furthermore, the way an animal responds to a ground predator may be different from the way it responds to an aerial predator and different again from the way it responds ‘fearfully’ to an aggressive conspecific.

It follows that we cannot expect to find simple or universal indicators of good and bad welfare because animals and people have not evolved to have simple or universal responses to threats to their fitness. What they have are physiological and behavioral responses to a wide variety of situations and it is up to us to read the signs (Mason & Mendl, 1993; Mendl, 1991). Sometimes these signs will be obvious, such as a bird constantly fluttering against the bars of a cage indicating motivation to escape. Sometimes the animals themselves will have evolved indicators that are signals of their emotional state,

such as the ‘distress’ calls of domestic chicks or the vocalizations of piglets (Weary & Fraser, 1995). But for many other cases, we have to look much harder to understand what state the animal is in. There are now several complementary methods for deciphering the emotional state of animals through their behavior (Boissy et al., 2007).

These include the following:

3.2.1 Vacuum Behavior

Lorenz (1937) used this term to describe behavior performed when the normal stimuli are not present, implying that the animal is highly motivated to do the behavior (van Putten & Dammers, 1976). For example, hens kept in battery cages go through all the motions of dust-bathing on bare wire floors even though there is no dust or litter at all (Vestergaard, Damm, Abbott, & Bildsoe, 1999). The sequence appears to be identical to that shown by birds actually dust-bathing in sand or litter, even though the bird does not receive the usual feedback of covering its body with particles or dust.

3.2.2 Rebound

A related finding is that animals prevented from performing certain kinds of behavior may show a greatly increased tendency to perform that behavior when eventually given the chance—the so-called ‘rebound’ effect (Vestergaard, 1982; Nicol, 1987). Just as people make up for lost sleep by sleeping more when eventually able to, so chickens make up for deprivation of dust-bathing (Vestergaard, 1982) and cows make up for deprivation of lying (Metz, 1985; Munksgaard, Jensen, Pedersen, Hansen, & Matthews, 2005) by doing more when they can, suggesting rising motivation during the period of deprivation.

3.2.3 “Abnormal” Behavior

This ill-defined category covers a wide range of different behavior, including displacement activities and stereotypies, linked only by the fact that researchers regard them as unexpected or unusual. For example, rats prevented from reaching food, or failing to find water where they have learned to expect it, may exhibit a range of behaviors apparently unrelated to feeding or drinking such as pacing, aggression, or grooming (Roper, 1984). Such irrelevant or ‘displacement activities’ (Tinbergen, 1951) have been used as evidence of strong motivation to do something that cannot normally be done in these environments, so the animal does something else instead (Duncan & Wood-Gush, 1972).

The same interpretation has been made of stereotypies, sometimes seen in caged zoo or farm animals. [Mason \(1991\)](#) defined stereotypies as behavior that is “repetitive, invariant, and has no obvious goal or function.” Examples would be repetitive walking of caged bears or foxes ([Meyer-Holzappel, 1968](#)), swaying in zoo elephants, and bar-biting in caged sows.

Obviously if this abnormal behavior leads to physical damage such as self-biting in caged macaques ([Reinhardt & Russell, 2001](#)) or sows causing their mouths to bleed through repeated bar chewing, this abnormal behavior is having a damaging effect on the animal’s welfare, but stereotypies may not always be as functionless and ‘irrelevant’ as was once thought. Animals performing them may even gain some benefit ([Mason & Latham, 2004](#)). For example, young calves fed on milk from a bucket will still suck for long periods on a dry teat from which they get no milk at all—an apparently functionless stereotypic behavior. However, calves that suck the teat after drinking milk showed more evidence of secretion of the hormones insulin and cholecystokinin, which improved their digestion ([De Passillé, Christopherson, & Rushen, 1993](#)). Sucking is ‘irrelevant’ for obtaining food but apparently not for digesting it. The heterogeneity of both cause and function of stereotypies and other ‘abnormal’ behaviors has led to the view that although they may be a useful ‘flag’ for a behavior that needs investigating, abnormality or apparent irrelevance are not in themselves useful in determining an animal’s emotional state.

3.2.4 The Animal’s Point of View

A major thread in animal welfare science has been the development of various methods of more directly ‘asking’ animals for their view of what is happening to them. Animals may not be able to tell us in so many words what they like and dislike or what they want or want to escape from but their behavior can, in various ways, be used as a convincing substitute. One of the earliest attempts to do this was by [Hughes & Black \(1973\)](#) who asked hens what floor they preferred to stand on. The UK Government Committee ([Brambell, 1965](#)) set up to look into the welfare of farm animals recommended that the floors of cages should be made of heavy-gauge wire rather than fine-gauge wire netting on the grounds that they thought this was more comfortable for the hens’ feet and less likely to injure them. Giving the hens a choice between different gauge wire gave a different result. The hens actually preferred the fine-gauge wire netting judged by where they chose to stand ([Hughes & Black, 1973](#)). This simple choice method has subsequently been used to show a wide range of animal

preferences, from showing that hens prefer an outdoor run to a battery cage (Dawkins, 1977), to asking whether dairy cows want to graze outside (Charlton, Rutter, East, & Sinclair, 2011) to showing that rats (commonly killed at the end of an experiment with CO₂) will quickly leave a chamber containing only 20% carbon dioxide, a concentration much too low to kill them (Leach, Bowell, Allan, & Morton, 2002; Niel & Weary, 2006).

Animal preferences can even be tested in the wild. Lack (1933) pointed out that the distribution of bird species reflects a choice on each individual's part about where to nest. Dolphins of the coast of New Zealand were shown to avoid certain feeding areas if tourist whale-watching boats came too frequently (Constantine, Brunton, & Dennis, 2004; Lusseau, 2004). By using GPS trackers to find out where wild elephants choose to go, Wall, Douglas-Hamilton, & Vollrath (2006) found that the elephants were carefully avoiding going up hills with steep gradients even if it meant taking longer routes or missing out on food, an important piece of information in designing elephant conservation areas. For farm animals, too, spatial and temporal distribution can be used to indicate their preferences for certain parts of an environment such as trees or shade (Dawkins, Cook, Whittingham, Mansell, & Harper, 2003), how close they like to be to each other (Febrer, Jones, Donnelly, & Dawkins, 2006; Keeling, 1995; Stricklin, Graves, & Wilson, 1979) and even whether they like to feed at the same time (Collins & Sumpter, 2007).

Simple choice tests do not, however, indicate how strong an animal's preferences are (a preference for one of two unpalatable foods does not indicate that either of them are 'liked'). Also, an initial preference the first time an animal encounters something may be different from its choice when it has more experience of the consequences of that choice (Fraser & Matthews, 1997; Fraser & Nicol, 2011). There are, however, ways of obtaining an animal's point of view that take account of both of these problems at once. These involve getting animals to make repeated choices (thus making sure that they do have experience of what they are getting) and to arrange that they have to pay a cost to obtain what they want, for example, by pressing a lever or pecking a key many times or having to overcome obstacles or push weights to get what they want (Kilgour, 1976). Rats, for example, do not just prefer to be with other rats than in a cage on their own, they will work hard (press a lever many times) to gain access to companion rats, much harder than they will work to be allowed into a large cage or a cage with novel objects (Patterson-Kane, Hunt, & Harper, 2002). Mink (*Mustela vison*) will push extremely heavy doors to gain access to water where

they can swim (Mason, Cooper, & Clareborough, 2001) and the rise in urinary cortisol when they are locked out of their swimming bath is only slightly lower than that which occurs when they are locked out of the food compartment. Chickens will learn to push weighted doors to gain access to perches and dust-bathing areas (Olsson, Keeling, & McAdie, 2002). In each case, the animals will learn to do something for a reward that they 'want' and their willingness to pay a price for it indicates how much they want it (Dawkins, 1990). The 'price' can be either a cost in energy or time or it can be willingness to give up some other commodity such as food (Cabanac & Johnson, 1983). Problems associated with using operant conditioning in welfare studies are discussed by Patterson-Kane, Pittman, and Pajer (2008) and Fraser and Nicol (2011).

The same approach can be used to discover what animals dislike and what they will pay a cost to avoid (Abeyesinghe, Wathes, Nicol, & Randall, 2001; Stephens, Bailey, Sharman, & Ingram, 1985) and, like simpler preference tests, can also be used to answer specific welfare questions. For example, sheep appear to dislike having their fleeces sheared. They struggle violently and run away if they can. Rushen (1986a, 1986b) used an aversion-learning technique to show what parts of the shearing process were the most aversive to sheep. Sheep were placed individually in a race (corridor) down which they could run. At the far end of the race, they were treated in one of three ways: they were allowed to run unhindered back to the flock, they were restrained for a few minutes in a sheep-handling machine or they were put into the machine, and subjected to simulated shearing (clippers moved backward and forward but no wool was removed). The sheep were then subjected to these procedures for a total of seven separate trials and on each trial their reluctance or willingness to run down the race was recorded. Sheep that were not handled or restrained ran down the race without hesitation and without needing to be pushed. Sheep that were restrained, however, showed great reluctance to move at all once they had learned what was at the other end. By the fourth trial, the sheep that had been restrained had to be pushed to make them move down the race at all. Rushen concluded that sheep find both restraint and shearing aversive but that they find shearing even more aversive than restraint alone.

Rushen next wanted to know whether the welfare of the sheep could be improved by electroimmobilization, because the manufacturers of commercial electroimmobilization machinery claimed that they were a safe and humane way of reducing the distress of shearing for the sheep as they no longer struggled or tried to run away. Using the same technique of how

quickly sheep would move down a race once they had experienced electro-immobilization, he found that electroimmobilization was even more aversive to the sheep than physical restraint (Rushen, 1986b). The electro-immobilization acted like a neuromuscular blocking agent. Rushen further argued that the aversion-learning technique gave a more reliable and direct insight into the sheep's view of the shearing process than commonly available physiological measures such as corticosteroid or β -endorphin levels because the time the sheep took to run down the race was directly related to the amount of current applied (voltage levels and duration) whereas the physiological measures showed no difference in response to shearing, physical restraint, or electroimmobilization.

But asking animals what they want and how much they want, it has a methodological objection (common also to asking people what they want). This is that the asking may itself change the emotional state. Just as asking someone if they were hungry or offering them a snack might cause them to want food that they did not want before, so presenting animals with choices may similarly induce them to want one of the options that they had not wanted before (Petherick, Waddington, & Duncan, 1990). Even hiding the options behind a door and requiring animals to make an operant response to even see or smell them does not overcome this problem as the pecking key or lever may itself become a secondary reinforcer.

Rolls (1990, 2014) distinguishes between two main categories of choice mechanisms: fixed innate responses such as the phototactic response of plants in 'choosing' to grow toward the light and even 'working' to do so by pushing up concrete on the one hand and choices that involve performing an arbitrary operant response on the other. He argues that because taxes are innate and can be hard-wired by natural selection, there is no need for any dimensions of pleasure or suffering to be associated with the approach or avoidance that such mechanisms give rise to. In other words, they represent preference without emotion. On the other hand, natural selection cannot prepare an animal in advance that a completely arbitrary action (such as pushing a lever either up or down or approaching one man-made pattern rather than another), is either good or bad for it. All that natural selection can do is to build in a tendency to repeat certain actions because they feel 'good' (are positively reinforcing) and this feeling good or pleasure then guides the subsequent behavior of the organism. Rolls therefore argues that emotions only evolved with the evolution of reinforcement learning and would, by definition, exclude emotions in plants.

3.2.5 Cognitive Bias

A recent development in the study of animal preferences that overcomes at least some of the problem of offering choices is that of *cognitive bias* (Harding, Paul, & Mendl, 2004; Mendl, Burman, Parker, & Paul, 2009). Instead of giving animals choices or making them work for reinforcements to find out what they like and dislike, the animals are trained to discriminate between two previously neutral stimuli such as one tone that is associated with food and another that is associated with something unpleasant such as burst of white noise. They are then exposed to a stimulus that is intermediate between the two tones. The question is whether they classify the intermediate stimulus as negative or positive. Animals that have been living in less preferred environments are more likely to interpret the intermediate stimulus as similar to the negative stimulus (they show a ‘negative bias’) than animals that have been living in enriched or preferred environments (Bateson & Mather, 2007; Destrez, Deiss, Le Terrier, Calandreau, & Boissy, 2014; Paul, Harding, & Mendl, 2005).

The importance of this approach is that it measures the long-term effects of a stimulus or of living in a particular environment—that is, it measures an animal’s ‘mood’ and does so when the stimulus or environment is no longer present, rather than its immediate short-term preference for one environment over another. As such, it has the potential to provide the animal’s point of view of living in that environment over a long period of time. Unfortunately, however, negative and positive bias are often referred to as “pessimism” and “optimism,” giving the impression that cognitive bias is somehow a direct indicator of conscious state or necessarily indicative of poor welfare. But being more cautious and more likely to classify an ambiguous stimulus as a predator than a nonpredator if an animal has just been exposed to a fearful stimulus could be highly adaptive and part of natural adaptive responses.

3.2.6 Expressions of the Emotions

Once animals have shown, from their point of view, what in the world they like and what experiences they want to repeat (positive reinforcers) and what they dislike and want to avoid repeating (negative reinforcers), then we can begin to understand their body language and sounds from their point of view too. We can begin to interpret their behavior as indicating what they want even for things that are not present, provided we have done the background research to show how the two are linked. For example, Sandem and Braastad (2005) and Sandem, Braastad, and Boe (2002) showed

that if cows were shown something that they had previously been shown to find positively reinforcing (food in the form of silage or their own calf) but then were prevented from obtaining it, they showed characteristic behavior: they started rolling their eyes so that a high percentage of eye white became visible. This is thus an operationally defined measure of frustration, because it is empirically found to be linked to situations the cows found emotionally negative (denial of access to a positive reinforce in the form of food or a calf out of reach. Such behavior can then be used to indicate that a cow is frustrated even if it is not clear what is causing it. Similarly the facial expressions and calls of rats can be ‘decoded’ once it is known what they like and dislike (Berridge & Robinson, 2003; Makowska & Weary, 2013).

3.3 The Third Component of Emotion: Consciousness

There are, then, major similarities between humans and nonhumans in the first two components of emotion—the physiological and the behavioral. The absence of words has not proved to be a serious obstacle in ‘asking’ animals about their preferences and the practical difficulties encountered in doing so now appear to be only quantitatively rather than qualitatively more difficult than asking other humans and establishing their emotional state. Where, then does that leave the third component of human emotions—conscious awareness? Does it now fit uncontroversially into a science of animal welfare and, if so is there still a paradox about wanting to be scientific about something that cannot yet be studied with normal scientific methods? The same empirical findings have led to quite different conclusions being drawn by different animal welfare scientists.

View 1. There is now no problem with studying animal consciousness.

For Charles Darwin 1871, it was obvious beyond the need for any argument that nonhuman animals are sentient: “...the lower animals, like man,” he wrote in 1871 (p. 19) “manifestly feel pleasure and pain, happiness and misery.” And “The fact that the lower animals are excited by the same emotions as ourselves is so well established that it will not be necessary to weary the reader by many details.” In *The Expression of the Emotions* (1872), he catalogs the different ways in which animals express a variety of emotions such as fear, anger, and affection, stressing the evolutionary continuity between humans and other animals and taking it for granted that they not only behaved similarly but experienced those emotions as well.

Cabanac (1971) argued that the behavior and physiological responses of humans and nonhuman animals to conditions such as water deprivation, cold, and fatigue, are extremely similar. As many animals also show a whole

gamut of the same physiological symptoms to danger as we do such as a rise in body temperature, blushing, the hairs rising on the back of the neck and a racing heart, he argued (1992), that it is implausible to claim that they are not like us in what they consciously experience. He is even prepared to draw the line between animals that do and do not experience emotions. He draws his line between amphibians and reptiles on the grounds that handling a lizard causes its heart rate to go up and its body temperature to rise, whereas neither of these physiological symptoms of emotion occur in either fish or toads (Cabanac, Cabanac, & Parent, 2009).

Similar views that when other animals suffer they too *experience* unpleasant emotional states that matter to them have also been expressed by among others, Zayan and Duncan (1987), Dawkins (1990), Broom (1998) and Bekoff (2002). Both Panksepp (2011) and LeDoux (2000) also argue that humans and other mammals share certain core emotions such as fear, rage, lust, panic, and play and feel them equally strongly.

For some people, Griffin's admonition to throw off the straitjacket of behaviorism has been taken quite literally to mean doing without it altogether (Balcombe, 2006; Bekoff, 2007; Morrell, 2013) with little time or patience for those who urge caution e.g., Bermond, 2001; Burghardt, 1998; Dawkins, 2012; Wynne, 2004. Some even discuss awareness in plants (Chamovitz, 2012). For many animal welfare scientists, however, the problems of animal consciousness are still there in theory but are overcome in practice by using words such as 'affective state,' 'affect,' or 'emotion' which can be used ambiguously to either include conscious awareness or not, depending on the audience. Words borrowed from everyday usage such as 'optimism' applied to animals immediately imply that animals feel optimistic and pessimistic in the same way that we do. This 'flirting with consciousness' is probably a good survival strategy for scientists as a way of convincing the public that serious issues are being addressed but it does give the impression that animal welfare scientists are confused or do not fully understand what the problems of consciousness are (Jones, 2013).

View 2. Animal consciousness is a problem for scientific study but although we cannot study it directly, we can do the next best thing and study the behavioral and physiological correlates of it.

A more cautious view is that consciousness, even human consciousness, is still such a hard problem (Chalmers, 1996) and there are still so many things we do not understand about it that the most scientific approach is to admit that all we can do is to study what we hope are the correlates of consciousness rather than claiming to have solved the deepest biological mystery of all.

This approach is somewhat “killjoy” (Dawkins, 2012; Dennett, 1983; Shettleworth, 2010b) in that it sounds less exciting than studying conscious awareness itself, but it has the advantages that it is firmly rooted in observable behavior and physiology. It basically means sticking to the physiological and behavioral components of emotion in animals along the lines already discussed.

There are several reasons for this more cautious approach. First, we know from our own experience that the three components of human emotion (autonomic/behavioral/cognitive) do not necessarily correlate with each other (Oatley & Jenkins, 1996). Sometimes, for example, strong subjective emotions occur with no obvious autonomic changes, as when someone experiences a rapid switch from excitement to fear on a roller coaster. This does not mean that the change in emotional experience has no physiological basis. It just means that it is probably due to a subtle change in brain state rather than the obvious autonomic changes that are what are usually referred to as physiological (autonomic) measures of emotion. We may possibly look forward to a greater understanding of brain function getting round this problem.

Second, there is increasing evidence that much more human behavior than we had realized takes place without consciousness at all. Many complex tasks in humans, such as driving a car, playing a musical instrument, or even breathing can be carried out either consciously or unconsciously (Blackmore, 2012; Paul, Harding, & Mendl, 2005; Rolls, 2014; Weiskrantz, 2003). Some human patients with certain sorts of brain damage can successfully reach out and touch objects in front of them but then say they are not conscious of having seen them at all (Weiskrantz, 2003). They are simultaneously blind (as far as their verbal reports go) but also sighted (unconsciously guided reaching). For much of what we humans do there appears to be multiple routes to the same behavior, only some of which reach consciousness (Rolls, 2014). But if the same action (e.g., breathing or touching an object) can occur in humans through either an unconscious or conscious pathway, the argument that if the behavior of another animal is similar to that of a human, that animal must be conscious (der Waal, 2005) is seriously weakened. An animal could be doing the same behavior as a human using his or her unconscious circuits (McPhail, 1998). Unconscious mechanisms explain much more of human behavior than previously thought and may also underlie much animal behavior (Shettleworth, 2010b). Many of the more complex aspects of animal behavior, such as corvid re-caching, that had previously thought to involve awareness can be

mimicked by relatively simple computer programs without a theory of mind (van der Vaart, Verbrugge, & Hemelrijk, 2012). In fact, a recent trend in comparative psychology has been away from emphasizing the complexity of animal behavior and toward emphasizing the simplicity of human behavior (Shettleworth, 2010b).

Humans can even have unconscious emotions and changes of emotional state that they are completely unaware of (Morris, Öhman, & Dolan, 1998; Berridge & Winkielman, 2003; Sato & Aoki, 2006). This has important implications for our interpretation of animal emotions, because if we can have unconscious emotions, then the fact that animals behave ‘like us’ says much less about their consciousness or otherwise than we might think (Dawkins, 2001b, 2012).

View 3. Animal consciousness is problematic at the moment because we do not yet have the right research methods for studying it. However, with more research we will solve this problem and so the paradox will disappear.

Most animal welfare scientists accept that the private nature of subjective experiences makes them peculiarly difficult to study by the usual methods of science but remains optimistic, if cautious, about one day being able to be more certain about animal consciousness, or at least about which animals have conscious awareness. Even without solving the hardest problem of all (how the lump of nervous tissue that makes up our brains gives rise to the vivid conscious experiences of scents, sounds, colors, memories, and fears that we all experience every day), it may be possible to tie down the neural correlates of consciousness (Block, 1995) so that we can at least say where our consciousness appears to be located if not what it is. And if we understood much better than we do now the neural correlates of our own consciousness, we might then be in a much better position to look for something similar in other species. A broadly behavioristic approach thus remains an important restraining force on what we might conclude at the moment but not a complete prohibition on the questions we ask in the future.

A promising line of evidence is that of using some form of brain imaging to correlate neural activity in human brains with human reports of conscious experience (Metzinger, 2000) and then to look for similar activity in the brains of nonhuman animals (Bekoff & Sherman, 2004). The implication would be that if the same ‘neural correlates of consciousness’ were found in nonhuman animals, this would indicate that they had similar conscious experiences. In practice, several problems have arisen with this approach (Blackmore, 2012). The first is that the search for the neural correlates of

consciousness in humans has turned out to be much more complex than might be hoped, in that there is no simple connection between consciousness and what a brain is doing (Blackmore, 2012; Merker, 2007; Morsella, Krieger, & Bargh, 2010; Stoerig, 2007; Zeki, 2003). Consciousness can be associated with a generalized effect in many parts of the brain, as in anesthesia (Kulli & Koch, 1991) or it can be associated with activity in a particular area, but only for particular tasks (Dehaene & Naccache, 2001). For other states of awareness, several different parts of the brain need to be active at the same time (Rees & Frith, 2007).

A second problem is that different species have very different brain structures, making the comparison extremely difficult. Bird and mammal brains have been evolving separately for hundreds of millions of years (Simpson, 1983). Birds lack the highly developed cortex characteristic of mammalian brains but it appears that a completely different structure, the archistriatum, has taken over the function of learning and other cognitive tasks so that birds are cognitively comparable to mammals (Shettleworth, 2010a), but achieve this with a different brain that has evolved quite independently.

To try to answer some of these problems, Mashour and Alkire (2013) have recently suggested that studying the way in which different animals recover from anesthesia might offer a 'common ground' for comparing neural correlates of consciousness across species. Reviewing recent studies using a variety of methods, they conclude that the core of human awareness (phenomenal consciousness) lies in the most phylogenetically ancient parts of the brain—the brain stem and the diencephalon—which mediate arousal and are associated with 'primitive' emotions (hunger for air, hunger for food, thirst etc.) found in all vertebrates (Denton, McKinley, Farrell, & Egan, 2009; Långsjö, et al., 2012). Brain imaging such as positron emission tomography or functional magnetic resonance may one day provide a way of studying, if not consciousness itself, then at least brain activity that correlates with consciousness. However, at the moment studying brains has led to completely opposite conclusions being drawn about how similar animal consciousness is to our own. McPhail (1998), for example, concludes that only humans are conscious, while Baars (2005) among others concludes that at least all vertebrates are.

The problem is that we still know so little about our own consciousness, how it arises or which neural structures give rise to it that, even with increasing knowledge of anatomy and technology that allows us to see brains in action in real time, we do not know what *feelings*, if any, those brains are giving rise to (Bateson, 2004). We therefore do not even know what to look

for in the brains of other people to know what they are feeling. It is true of human brains that are like our own, of fetal brains (Mellor & Diesch, 2007) and it is even more true of brains that are quite unlike ours such as those of fish (Braithwaite, 2010; Chandroo, Duncan, & Moccia, 2004; Rose, 2002; Sneddon, Braithwaite, & Gentle, 2003) and invertebrates (Elwood, Barr, & Patterson, 2009; Sherwin, 2001). The search is as fascinating as it is important, but it is proving to be a lot more complex than we thought. Consequently, some animal welfare scientists think that animal welfare is too important to be made to wait until these problems have been solved and have looked for ways of studying animal welfare scientifically, that avoid the consciousness issue altogether.

View 4. Animal consciousness is likely to remain beyond scientific methods for the foreseeable future but solving it is not central to a scientific study of animal welfare. The paradox therefore exists but it does not matter.

Many animal welfare issues can be addressed completely independently of any concern about whether the animals are conscious or not (Arlinghaus, Schweb, Cooke, & Cowx, 2009; Dawkins, 2012; Wuerbel, 2009). For example, feather-pecking in laying hens (Gunnarsson, Keeling, & Svedberg, 1999) and tail-biting in pigs (Taylor, Parker, Mendl, Edwards & Main, 2012) can all lead to serious injury and even death. Basic concerns to maintain the health, survival, and even commercial value of the animals are enough to drive the search for solutions to such problems which, if found, will inevitably improve the well-being of the animal concerned. Similarly, finding ways of preventing animals injuring themselves through self-mutilation, or breaking their bones through ill-constructed environments will also improve their welfare, as will finding ways of preventing outbreaks of disease. In fact, there is a great deal to be done toward improving the welfare of animals in zoos, farms, and laboratories that owe nothing to the belief that the animals are conscious and everything to do with improving the physical health of the animals by changing the conditions in which they live so that their chances of dying or succumbing to disease and injury are reduced and their chances of remaining healthier for longer are increased.

But, the objection will be raised, there is more to good welfare than just not dying of disease and injury. Physical health may be one important component of good welfare but it is not the only one. What about the mental health of animals, the component concerned with what animals 'feel,' the component that gives animal welfare its particular moral weight? By leaving out consciousness, have not we left out the most important element of all?

First, to concentrate our primary efforts on physical health is not to deny consciousness in animals. It is simply an acknowledgment that there is much we can do to understand and improve animal welfare that has nothing to do with whether there is or even can be scientifically valid evidence about consciousness in nonhuman animals. We do not have to solve the hard problem of consciousness that has baffled philosophers and brain scientists for millennia before having a science of animal welfare that covers many of the most serious welfare issues that currently exist (Carruthers, 2005). Improving physical health is a first major step that improves mental health as a by-product (although not always—for example, keeping disease at bay with heavy doses of antibiotics or confining animals in small cages on wire so that they are kept away from their own feces).

Second, physical health is most likely to appeal to people otherwise unconvinced of the importance of animal welfare, or, who are convinced but are constrained by economics from implementing what they see as expensive welfare improvements. This is because the physical health of animals is one thing that impacts all humans directly.

The majority of new diseases that affect humans come from animals or animal products (World Health Organization, 2011), and many of these have the potential to become global pandemics such as bird flu and swine flu. Many more serious diseases such as anthrax and rabies are carried by animals, as are some of the most virulent foodborne pathogens such as *Campylobacter*. Around 80% of antibiotics sold are used on livestock and many are excreted as waste, contributing directly to the crisis in antibiotic resistance (Cabello, 2006; Levy & Marshall, 2004). The human consequences of running out of drugs to combat disease, let alone the financial consequences have not been calculated but at the very least keeping farm animals in conditions where their health levels were such that they did not need antibiotics or could be targeted if they did fall ill would seem to be a case where animal welfare directly affects human welfare. We will gain nothing from increasing the efficiency of livestock production if the health and welfare of the animals is so compromised that it gives rise to pandemics, drug resistance, food poisoning, and pollution.

Animal health also affects food quality and food safety. The way in which food animals are reared does affect the way some people buy their meat, but even more people are affected in their meat-buying habits by what they perceive to be threats to their own health or that of their children (Rozin, Fischler, Imada, Sarubin, & Wrzesniewski, 1999). They want to be sure that any animal products they eat come from healthy animals, so stressing

the human health value of good welfare is more likely to lead to improvements in animal welfare than animal welfare alone. Farmers gain directly and financially from lower mortality, less need for medication, higher quality products that do not have to be downgraded, and other benefits that come from keeping animals in conditions where their welfare is improved, or transporting them with care (Warriss et al., 1998). Meat production across the world has tripled over the last 4 decades and is projected to increase by 73% by 2050 (Food and Agriculture Organization, FAO, 2013). Much of this increase will occur in Asia, Africa, and other places where cultural values and the pressure to feed people is such a priority that animal welfare takes lower priority than in richer Western societies. Protection of animals is most likely to occur if the human benefits of keeping animals healthy are researched and spelled out. Other benefits that farmers derive from higher standards or health and welfare of their animals include increased ability to retain staff through the satisfaction of looking after thriving animals, lowered veterinary and medication bills, and public approval of the farmer leading to a willingness to pay more for high-welfare locally produced food. The true financial value of these benefits has yet to be calculated but when it has been, it could make a significant contribution to the way animals are treated because of the commercial advantage it could bring. Grandin (2012) has achieved major improvements in the welfare of animals at slaughter plants by using the simplest possible measures of physical welfare (such as preventing falls) and showing the commercial value of handling animals with concern for their welfare. In other fields, too, animal welfare has direct human gains. There are scientific gains of repeatability and consistency of results that come from high standards of animal welfare (Richter, Garner, & Wuerbel, 2009). Animal welfare science needs to do more to link animal health to direct human benefits.

For some people, this emphasis on the human benefits of animal welfare that makes no reference to animals as conscious beings is upsetting and even offensive. The trend over the last 50 years has been to see nonhuman animals as worthy of ethical consideration in their own right because of their capacity to suffer and feel pain, a view that has had a major impact on bringing about change in public opinion, voluntary codes, and legislation around the world over the last 40 years (Christensen, Lawrence, Lund, Stott, & Sandøe, 2012). But a pragmatic, utilitarian view of animal welfare based on its value to humans does not replace an ethical view based on the assumption that they are also conscious beings worthy of ethical consideration in their own right. It simply adds to the arguments in favor of taking animal welfare

seriously in just the same way as ecologists increasingly make the case for conserving habitats and preventing the loss of biodiversity by putting a monetary value on the “services” or “natural capital” that a healthy environment provides, such as water retention, soil fertility, pollination, and tourist attractions (Balmford et al., 2002). These financial arguments do not replace moral or aesthetic arguments for caring for the environment (which remain paramount for many) but they do show how human self-interest can become an ally rather than an enemy and so make conservation projects more likely to succeed irrespective of cultural background or income. In the same way, the belief that animals are consciously aware and through this deserve ethical consideration in their own right will remain for many people the cornerstone of their concern for animal welfare. But there is an important role for a branch of animal welfare science that says, regardless of the scientific evidence that may or may not exist about animal consciousness, the welfare of nonhumans is important for the welfare of humans and for purely pragmatic reasons needs to be brought into the definition of “sustainability” (Dawkins, 2012; Garnett et al., 2013). Animal welfare on its own may not be a sufficient “driver” to secure its place as part of sustainability. Consumer preferences are too fickle and too price dependent to ensure that farmers can invest in good welfare unless good welfare has other gains. One important area for future research is finding ways and systems where animal welfare can provide even more benefits economically, environmentally, and in other ways that benefit human health and well-being.



4. DEFINITIONS OF ANIMAL WELFARE

It may seem odd not to have given a definition of animal welfare earlier, but it will be clear by now that such a definition will depend critically on a particular person’s view of how consciousness is related to animal welfare. As I have shown, there is a range of different views about this within animal welfare science and this is reflected in the extraordinary number of different definitions that have been proposed over the last 50 years (Fraser, 2008). Some of the definitions explicitly say that feelings (meaning conscious awareness of feelings of suffering pain and pleasure) are at the heart of any definition of animal welfare (e.g., Duncan, 1993), while others define it in ways that do not make specific reference to this, such as Broom’s definition of “the animal’s ability to cope with its environment” (Broom, 1998). Some definitions avoid the use of words like feelings, conscious

awareness and instead use ‘affect,’ ‘affective state,’ ‘emotionality,’ ‘emotions,’ etc., leaving the reader unclear whether consciousness is in or out of the definition. Some include physiological and behavioral “measures” of welfare but, as Webster (1994) points out often do not specify what they are measures of. Many people are convinced that good welfare has to include a provision that the animal’s behavior is ‘natural’ (Bracke & Hopster, 2006; Lund, 2006; but see Špinka, 2006).

In an attempt to make sense and clarify these definitions, I proposed that a simple working definition of good welfare was that the animal (1) was healthy and (2) had what it wanted (Dawkins, 2008). The first part of this definition covers the importance of good physical health, which is common to all definitions and applicable whatever the underlying view about animal consciousness. The second part of the definition gives an overt observable prescription of what needs to be measured about the animal’s behavior. The animal’s preferences (broadly measured) can be taken either to imply consciousness or not as the researcher chooses. What animals want, what they will work for, and, in particular, what they find positively and negatively reinforcing are the nearest approaches we can currently make to animal consciousness (Dawkins, 1990, 2001b) without actually claiming that they are telling us about conscious awareness itself. They could be seen as candidates for the role of ‘behavioral correlates of consciousness’ and as such are important in helping to provide at least some of the information that people want about animal welfare.

But ‘what animals want’ would also be important to welfare even without the belief that the ‘wanting’ is conscious. An animal that indicates that it ‘wants’ a certain kind of food may be indicating a dietary deficiency while an animal that indicates that it ‘wants to avoid or obtain something’ may be indicating that unless some changes are made, its health will deteriorate in the long run (Dawkins, 2001a). Animal choices may therefore be a valuable clue to what is going to keep them healthy. Of course, what animals want may not always be good for their health, any more than it is in humans, which is why their choices are just clues that might be useful and need to be checked out for their long-term implications. Animals in unnatural environments such as zoos and farms can no more be relied on to choose what is good for their health than can humans in modern societies. That is why the definition of good welfare proposed contains the two basic elements—it must be good for health and what the animal wants.

This simple pragmatic two-part definition is also able to clarify questions inherent in other definitions. For example, if someone claims that an

animal's welfare can be judged by how natural its behavior is and therefore that it should be given an 'enrichment,' we can ask whether providing that animal with the opportunity to behave naturally (1) improves its health and (2) is something it wants to do. If it is neither, there is no evidence that it improves welfare, however 'natural' it may be. Thus 'natural behavior' is not excluded from 'good welfare' but is only used when there is independent evidence that it matters to the animal itself.



5. CONCLUSIONS

Two major problems in the study of animal consciousness are the essentially subjective and private nature of conscious experiences (so that they are known only to the organism experiencing them) and a complete ignorance of the way in which conscious subjective experiences arise from brain tissue in either ourselves or other species. These problems mean that consciousness, in ourselves but particularly in other species, cannot currently be studied by the usual methods of science.

Within animal welfare science, these problems have led different researchers to take different attitudes to the study of animal consciousness, some of which lead inadvertently to a paradox: they want to study animal welfare scientifically but they also want to include the study of animal consciousness.

Some researchers have taken the view that there is no problem and therefore no paradox. This gives the impression that animal welfare scientists do not understand just how hard the problem of consciousness is and in not accepting that there are problems, become cut off from one of the most exciting investigations in the whole of biology.

More commonly, animal welfare scientists acknowledge the problems but then carry out their research as if the problems did not exist and even use words like 'affect' and 'emotion' in ways that allow them to imply that they have overcome the problems but without explicitly saying how. Here the dangers of appearing paradoxical are at their greatest.

The paradox can be avoided by admitting that consciousness is still such a problem that we cannot study it directly (as indeed has occurred in the study of human consciousness and that all we can do is to look for the next best thing—in other words the most likely correlates of consciousness (Blackmore, 2012; Block, 1995; Koch, 2004)). This is less ambitious but leaves animal welfare science on a sound objective basis, doing what it can to

incorporate consciousness into its research but not claiming to have achieved more than it has.

The paradox can also be avoided by studying elements of animal welfare that are important independently of whether animals are conscious or not, specifically studying conditions that improve animal health, their immune systems, their disease resistance, and other conditions that have positive impact on human well-being. This will go a long way to improving animal welfare in a world that has other goals such as feeding a rising human population that may otherwise take priority over the welfare of nonhumans.

Defining animal welfare as animals being healthy and having what they want avoids paradoxical thinking about animal consciousness and still leaves open the possibility for animal welfare scientists to make major contributions to one of the greatest of all biological puzzles of all—why pain, suffering, and pleasure *feel* like anything at all.

REFERENCES

- Abeyesinghe, S., Wathes, C. M., Nicol, C. J., & Randall, J. M. (2001). The aversion of broiler chickens to concurrent vibrational and thermal stressors. *Applied Animal Behaviour Science*, *73*, 199–216.
- Appleby, M. C., & Hughes, B. O. (Eds.). (1997). *Animal welfare*. Wallingford, UK: CAB International.
- Arlinghaus, R., Schweb, A., Cooke, S. J., & Cowx, I. G. (2009). Contrasting pragmatic and suffering-centred approaches to fish welfare on recreational angling. *Journal of Fish Biology*, *75*, 2448–2463.
- Baars, B. J. (2005). Subjective experience is probably not limited to humans: the evidence from neurobiology and behaviour. *Consciousness and Cognition*, *14*, 7–21.
- Balcombe, J. (2006). *Pleasurable kingdom: Animals and the nature of feeling good*. Basingstoke: Macmillan.
- Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R. E., et al. (2002). Economic reasons for conserving wild nature. *Science*, *297*, 950–953.
- Barnett, J. L., & Hemsworth, P. H. (1990). The validity of physiological and behavioural measures of animal welfare. *Applied Animal Behaviour Science*, *25*, 177–187.
- Bateson, P. (2004). Do animals suffer like us? *Veterinary Journal*, *168*, 110–111.
- Bateson, P. P. G., & Bradshaw, E. L. (2000). Physiological effects of hunting red deer (*Cervus elaphus*). *Proceedings of the Royal Society, B*, *264*, 1707–1714.
- Bateson, M., & Mather, M. (2007). Performance on a categorization task suggests that removal of environmental enrichment induces “pessimism” in captive European starlings. *Animal Welfare*, *16*, 33–36.
- Bekoff, M. (2002). *Minding animals: Awareness, emotion and heart*. Oxford: Oxford University Press.
- Bekoff, M. (2007). *The emotional lives of animals*. Novato, CA: New World Library.
- Bekoff, M., & Sherman, P. W. (2004). Reflections on animal selves. *Trends in Ecology and Evolution*, *19*, 176–180.
- Bermond, B. (2001). A neuropsychological and evolutionary approach to animal consciousness and animal suffering. *Animal Welfare*, *10*, S47–S62.

- Berridge, K. C. (2004). Motivation concepts in behavioral neuroscience. *Physiology and Behavior*, *81*, 179–209.
- Berridge, K. C., & Robinson, T. E. (2003). Parsing reward. *Trends in Neuroscience*, *26*, 507–513.
- Berridge, K. C., & Winkielman, P. (2003). What is an unconscious emotion? The case for unconscious ‘liking’. *Cognition and Emotion*, *17*, 181–211.
- Blackmore, S. (2012). *Consciousness: An introduction* (2nd ed.). Hodder Education.
- Block, N. (1995). On a confusion about a function of consciousness. *Behavioral and Brain Sciences*, *18*, 227–247.
- Boissy, A., Manteuffel, G., Jensen, M. B., Opperman, M., Spruijtt, B., Keeling, L. J., et al. (2007). Assessment of positive emotions in animals to improve their welfare. *Physiology and Behavior*, *92*, 375–397.
- Bracke, M. B. M., & Hopster, H. (2006). Assessing the importance of natural behavior for animal welfare. *Journal of Agricultural and Environmental Ethics*, *18*, 77–89.
- Braithwaite, V. (2010). *Do fish feel pain?* Oxford: Oxford University Press.
- Brambell, F. W. (1965). *Report of the technical committee to enquire into the welfare of animals kept under intensive livestock husbandry systems*. Cmnd. 2836. Reprinted 1970. London: Her Majesty’s Stationery Office.
- Broom, D. M. (1988). The scientific assessment of animal welfare. *Applied Animal Behaviour Science*, *20*, 5–19.
- Broom, D. M. (1998). Welfare, stress and the evolution of feelings. *Advances in the Study of Behavior*, *27*, 371–403.
- Broom, D. M., & Johnson, K. G. (1993). *Stress and animal welfare*. London: Chapman and Hall.
- Burghardt, G. M. (1988). Anecdotes and critical anthropomorphism. *Behavioral and Brain Sciences*, *11*, 248–249.
- Cabanac, M. (1971). Physiological role of pleasure. *Science*, *173*, 1103–1107.
- Cabanac, M. (1992). Pleasure the common currency. *Journal of Theoretical Biology*, *155*, 173–200.
- Cabanac, M., Cabanac, A. J., & Parent, A. (2009). The emergence of consciousness in phylogeny. *Behavioral Brain Research*, *198*, 267–272.
- Cabanac, M., & Johnson, K. G. (1983). Analysis of a conflict between palatability and cold exposure in rats. *Physiology and Behavior*, *31*, 249–253.
- Cabello, F. C. (2006). Heavy use of prophylactic antibiotics in aquaculture: a growing problem for human and animal health and for the environment. *Environmental Microbiology*, *8*, 1137–1144.
- Cacioppo, J. T., Klein, D. J., Berntson, G. C., & Hatfield, E. (1993). The psychophysiology of emotion. In M. Lewis, & M. Hatfield (Eds.), *Handbook of emotions* (pp. 119–142). New York: Guilford.
- Cannon, W. B. (1929). Organization for physiological homeostasis. *Physiological Reviews*, *9*, 399–431.
- Carruthers, P. (2005). Why the question of consciousness may not matter very much. *Philosophical Psychology*, *18*, 83–102.
- Chalmers, D. J. (1996). *The conscious mind: In search of a fundamental theory*. Oxford: Oxford University Press.
- Chamovitz, D. (2012). *What a plant knows: A field guide to the senses of your garden – and beyond*. Oxford: Oneworld Publications.
- Chandroo, K. P., Duncan, I. J. H., & Moccia, R. D. (2004). Can fish suffer? Perspectives on sentience, pain, fear and stress. *Applied Animal Behaviour Science*, *86*, 225–250.
- Charlton, G. L., Rutter, S. M., East, M., & Sinclair, L. A. (2011). Preference of dairy cows: indoor cubicle housing with access to a total mixed ration vs. access to pasture. *Applied Animal Behaviour Science*, *130*, 1–9.

- Christensen, T., Lawrence, A., Lund, M., Stott, A., & Sandøe, P. (2012). How can economists help to improve animal welfare? *Animal Welfare*, 21(S1), 1–10.
- Collins, L. M., & Sumpter, D. J. T. (2007). The feeding dynamics of broiler chickens. *Journal of the Royal Society Interface*, 4, 65–72.
- Constantine, R., Brunton, D. H., & Dennis, T. (2004). Dolphin-watching tour boats change bottlenose dolphin (*Tursiops truncatus*) behaviour. *Biological Conservation*, 117, 299–307.
- Curtis, S. E. (1987). Animal well-being and animal care. *Veterinary Clinics of North America: Food Animal Practice*, 3, 369–382.
- Dantzer, R., & Mormède, P. (1983). Stress in farm animals: a need for reevaluation. *Journal of Animal Science*, 57, 6–18.
- Darwin, C. (1871). *The descent of man and selection in relation to sex*. Reprinted by Princeton University Press (1981).
- Darwin, C. (1872). *The expression of the emotions in man and animals*. Reprinted by Chicago University Press (1965).
- Dawkins, M. S. (1977). Do hens suffer in battery cages? Environmental preference and welfare. *Animal Behaviour*, 25, 1034–1046.
- Dawkins, M. S. (1980). *Animal suffering: The science of animal welfare*. London: Chapman and Hall.
- Dawkins, M. S. (1990). From an animal's point of view: motivation, fitness and animal welfare. *Behavioral and Brain Sciences*, 13, 1–61.
- Dawkins, M. S. (2001a). How can we recognize and assess good welfare? In D. M. Broom (Ed.), *Coping with challenge: Welfare in animals including humans*. Berlin: Dahlem University press.
- Dawkins, M. S. (2001b). Who needs consciousness? *Animal Welfare*, 10, 319–329.
- Dawkins, M. S. (2008). The science of animal suffering. *Ethology*, 114, 937–945.
- Dawkins, M. S. (2012). *Why animals matter: Animal consciousness, animal welfare and human well-being*. Oxford: Oxford University Press.
- Dawkins, M. S., Cook, P. A., Whittingham, M. C., Mansell, K. A., & Harper, A. E. (2003). What makes free-range broilers range? *In situ* measurements of habitat preference. *Animal Behaviour*, 66, 151–160.
- Dawkins, M. S., Edmond, A., Lord, A., Solomon, S., & Bain, M. (2004). Time course of changes in egg-shell quality, faecal corticosteroids and behaviour as welfare measures in laying hens. *Animal Welfare*, 13, 321–327.
- De Passillé, A. M. B., Christopherson, R., & Rushen, J. (1993). Non-nutritive sucking by the calf and postprandial secretion of insulin, CCK and gastrin. *Physiology and Behavior*, 54, 1069–1073.
- Dehaene, S., & Naccache, L. (2001). Towards a cognitive neuroscience of consciousness: basic evidence and a workspace framework. *Cognition*, 79, 1–37.
- Dennett, D. C. (1983). Intentional systems in cognitive ethology. The “Panglossian paradigm” defended. *Behavioral and Brain Sciences*, 6, 343–390.
- Dennett, D. C. (1991). *Consciousness explained*. Boston: Little, Brown and Co.
- Denton, D. A. (2005). *The primordial emotions: The dawning of consciousness*. Oxford: Oxford University Press.
- Denton, D. A., McKinley, M. J., Farrell, M., & Egan, G. F. (2009). The role of primordial emotions in the evolutionary origins of consciousness. *Consciousness and Cognition*, 18, 500–514.
- Destrez, A., Deiss, V., Le Terrier, C., Calandreau, L., & Boissy, A. (2014). Repeated exposure to positive events induces optimistic-like judgment. *Applied Animal Behaviour Science*, 154, 30–38.
- Dietrich, A. (2007). *Introduction to consciousness*. New York: Palgrave.
- Duncan, I. J. H. (1974). A scientific assessment of welfare. *Proceedings of the British Society for Animal Production*, 3, 9.

- Duncan, I. J. H. (1993). Welfare is to do with what animals feel. *Journal of Agricultural and Environmental Ethics*, 6(2), 8–14.
- Duncan, I. J. H., & Wood-Gush, D. G. M. (1972). Thwarting of feeding behaviour in the domestic fowl. *Animal Behaviour*, 19, 500–504.
- Elwood, R. W., Barr, S., & Patterson, L. (2009). Pain and stress in crustaceans. *Applied Animal Behaviour Science*, 118, 128–136.
- Febrer, K., Jones, T. A., Donnelly, C. A., & Dawkins, M. S. (2006). Forced to crowd or choosing to cluster? Spatial distribution indicates social attraction in broiler chickens. *Animal Behaviour*, 72, 1291–1300.
- Food and Agriculture Organization of the United Nations. FAOSTAT (2011). <http://www.aostat.org> (Rome, 2013).
- Fraser, D. (2008). *Understanding animal welfare: The science in its cultural context*. Oxford: Wiley-Blackwell.
- Fraser, D., & Matthews, L. R. (1997). Preferences and motivation testing. In M. C. Appleby, & B. O. Hughes (Eds.), *Animal welfare*. Wallingford: CAB International.
- Fraser, & Nicol, C. J. (2011). Preference and motivation research. In M. C. Appleby, J. A. Mench, I. A. S. Olsson, & B. O. Hughes (Eds.), *Animal welfare* (2nd ed.). (pp. 183–199). Wallingford: CAB International.
- Frith, C. (2007). *Making up the mind: How the brain creates our mental world*. Oxford: Blackwell.
- Garnett, T., Appleby, M. C., Balmford, A., Burlingame, B., Dawkins, M., Dolan, L., et al. (2013). Sustainable intensification in agriculture: Premises and policies. *Science*, 342, 33–34.
- Grandin, T. (2012). The feasibility of using vocalization scoring as an indicator of poor welfare during cattle slaughter. *Animal Welfare*, 21, 351–356.
- Griffin, D. R. (1976). *The question of animal awareness: Evolutionary continuity of mental experience*. New York: The Rockefeller University Press.
- Griffin, D. R. (1992). *Animal minds*. Chicago: Chicago University Press.
- Gunnarsson, S., Keeling, L. J., & Svedberg, J. (1999). Effect of rearing factors on the prevalence of feather-pecking in commercial flocks of loose housed laying hens. *British Poultry Science*, 40, 12–18.
- Harding, E. J., Paul, E. S., & Mendl, M. (2004). Cognitive bias and affective state. *Nature*, 427, 312.
- Harrison, R. (1964). *Animal machines: The new factory farming industry*. Wallingford: CAB International (Reprinted 2013).
- Hebb, D. O. (1974). What psychology is about. *The American Psychologist*, 29, 71–79.
- Hughes, B. O., & Black, A. J. (1973). The preference of domestic hens for different types of battery cage floor. *British Poultry Science*, 14, 615–619.
- Humphrey, N. K. (2012). *Soul dust: The magic of consciousness*.
- Jones, R. C. (2013). Science, sentience, and animal welfare. *Biological Philosophy*, 28, 1–30.
- Keeling, L. J. (1995). Spacing behaviour and an ethological approach to assessing optimal space allowances for laying hens. *Applied Animal Behaviour Science*, 44, 171–186.
- Keltner, D., Oatley, K., & Jenkins, J. M. (2013). *Understanding emotions*. New Jersey: Hoboken; Oxford: Wiley-Blackwell.
- Kilgour, R. (1976). The contribution of psychology to a knowledge of farm animal behaviour. *Applied Animal Ethology*, 2, 197.
- Klopfer, P. H., & Hailman, J. P. (1967). *An introduction to animal behavior: Ethology's first century*. New Jersey: Prentice-Hall.
- Koch, C. (2004). *The quest for consciousness: A neurobiological approach*. Englewood, Colorado: Roberts and Company.
- Kulli, J., & Koch, C. (1991). Does anaesthesia cause loss of consciousness? *Trends in Neuroscience*, 14, 6–10.
- Lack, D. (1933). Habitat selection in birds. *Journal of Animal Ecology*, 2, 239–262.

- Långsjö, J. W., Alkire, M. T., Kaskinoro, K., Hayama, H., Maksimow, A., Kaisti, K. K., et al. (2012). Returning from oblivion: imaging the neural core of consciousness. *Journal of Neuroscience*, *32*, 4935–4943.
- Lashley, K. S. (1949). Persistent problems in the evolution of mind. *Quarterly Review of Biology*, *24*, 28–92.
- Leach, M. C., Bowell, V. A., Allan, T., & Morton, D. B. (2002). aversion to gaseous euthanasia agents in rats and mice. *Comparative Medicine*, *52*, 249–257.
- LeDoux, J. (2000). Emotion circuits in the brain. *Annual Review of Neuroscience*, *23*, 155–184.
- Levy, S. B., & Marshall, B. (2004). Antibacterial resistance worldwide: causes, challenges and responses. *Nature Medicine*, *10*, S122–S129.
- Lorenz, K. Z. (1937). Über die Bildung des Instinkt Begriffes. *Naturwissenschaften*, *25*, 289–300.
- Lorenz, K. Z. (1958). Methods of approach to the problems of behavior. In *Studies of animal and human behavior (Vol. II)*. Cambridge, Mass: Harvard University Press, 1971.
- Lund, V. (2006). Natural living – a precondition for animal welfare in organic farming. *Livestock Science*, *100*, 71–83.
- Lusseau, D. (2004). The hidden cost of tourism: detecting long-term effects of tourism using behavioral information. *Ecology and Society*, *9*, 1–2.
- Makowska, J., & Weary, D. M. (2013). Assessing the emotions of laboratory rats. *Applied Animal Behaviour Science*, *148*, 1–12.
- Malcolm, N. (1973). Thoughtless Brutes. *Proceedings and Addresses of American Philosophical Association*, *46*, 5–20.
- Mashour, G. A., & Alkire, M. T. (2013). Evolution of consciousness: phylogeny, ontogeny, and emergence from general anesthesia. *Proceedings of the National Academy of Sciences*, *110*, 10357–10364.
- Mason, J. W. (1975). Emotion as reflected in patterns of endocrine integration. In L. Levi (Ed.), *Emotions – their parameters and measurement* (pp. 143–182). New York: Raven Press.
- Mason, G. J. (1991). Stereotypies: a critical review. *Animal Behaviour*, *41*, 1015–1037.
- Mason, G. J., Cooper, J., & Clareborough, C. (2001). Frustrations of fur farmed mink. *Nature*, *410*, 35–36.
- Mason, G. J., & Latham, N. (2004). Can't stop, won't stop: is stereotype a reliable welfare indicator? *Animal Welfare*, *13*, S57–S69.
- Mason, G., & Mendl, M. (1993). Why is there no simple way of measuring animal welfare? *Animal Welfare*, *2*, 301–320.
- McPhail, E. (1998). *The evolution of consciousness*. Oxford: Oxford University Press.
- Mellor, D. J., & Diesch, T. J. (2007). Onset of sentience: potential for suffering in fetal and newborn farm animals. *Applied Animal Behaviour Science*, *100*, 48–57.
- Mendl, M. (1991). Some problems with the concept of a cut-off point for determining when an animal's welfare is at risk. *Applied Animal Behaviour Science*, *31*, 139–146.
- Mendl, M., Burman, O. H. P., Parker, R. M. A., & Paul, E. S. (2009). Cognitive bias as an indicator of emotion and welfare: emerging evidence and underlying mechanisms. *Applied Animal Behaviour Science*, *118*, 161–181.
- Mendl, M., Burman, O. H. P., & Paul, E. (2010). An integrative and functional framework for the study of animal emotion and mood. *Trends in Neuroscience*, *26*, 507–513.
- Merker, B. (2007). Consciousness without a cerebral cortex: a challenge for neuroscience and medicine. *Behavioral and Brain Sciences*, *30*, 63.
- Metz, J. H. M. (1985). The reaction of cows to a short-term deprivation of lying. *Applied Animal Behaviour Science*, *13*, 301–307.
- Metzinger, T. (Ed.), (2000). *Neural correlates of consciousness*. Cambridge MA: MIT Press.
- Meyer-Holzappel, M. (1968). Abnormal behavior in zoo animals. In M. W. Fox (Ed.), *Abnormal behavior in animals* (pp. 476–503). Philadelphia: W.B.Saunders.

- Midgely, M. (1983). *Animals and why they matter: A journey around the species barrier*. Harmondsworth: Pelican Books.
- Moberg, G. P. (1985). Biological response to stress: key to assessment of animal well-being? In G. P. Moberg (Ed.), *Animal stress* (pp. 27–49) Bethesda: American Psychological Society.
- Morell, V. (2013). *Animal wise: The thoughts and emotions of our fellow creatures*. New York: Random House Inc.
- Morris, J. S., Öhman, A., & Dolan, R. J. (1998). Conscious and unconscious emotional learning in the human amygdala. *Nature*, *393*, 467–470.
- Morsella, E., Krieger, S. C., & Bargh, J. A. (2010). Minimal neuroanatomy for a conscious brain: homing in on the networks constituting consciousness. *Neural Networks*, *23*, 14–15.
- Munksgaard, L., Jensen, M. B., Pedersen, L. J., Hansen, S. W., & Matthews, L. (2005). Quantifying behavioural priorities: effects of time constraints on behaviour of dairy cows *Bos taurus*. *Applied Animal Behaviour Science*, *92*, 3–14.
- Nicol, C. J. (1987). Behavioural responses of laying hens following a period of spatial restriction. *Animal Behaviour*, *35*, 1709–1719.
- Niel, L., & Weary, D. M. (2006). Rats avoid exposure to carbon dioxide and argon. *Applied Animal Behaviour Science*, *107*, 100–109.
- Oatley, K., & Jenkins, J. M. (1996). *Understanding emotions*. Oxford: Blackwell.
- Olsson, I. A. S., Keeling, L. J., & McAdie. (2002). The push-door measure of motivation in hens: an adaptation and a critical discussion of the method. *Animal Welfare*, *11*, 1–10.
- Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions*. Oxford: Oxford University Press.
- Panksepp, J. (2011). The basic emotional circuits of mammalian brains: do animals have affective lives? *Neuroscience and Biobehavioral Reviews*, *35*, 1791–1804.
- Patterson-Kane, E. G., Pittman, M., & Pajer, E. A. (2008). Operant animal welfare: productive approaches and persistent difficulties. *Animal Welfare*, *17*, 139–148.
- Patterson-Kane, E. G., Hunt, M., & Harper, D. (2002). Rats demand social contact. *Animal Welfare*, *11*, 327–332.
- Paul, E. S., Harding, E., & Mendl, M. (2005). Measuring emotional responses in animals: the utility of a cognitive approach. *Neuroscience Biobehavioral Reviews*, *29*, 469–491.
- Petherick, J. C., Waddington, D., & Duncan, I. J. H. (1990). Learning to gain access to a foraging and dustbathing substrate by domestic fowl: is out of sight out of mind? *Behavioral Processes*, *22*, 213–220.
- van Putten, G., & Dammers, J. (1976). A comparative study of the well-being of piglets reared conventionally and in cages. *Applied Animal Ethology*, *2*, 339–356.
- Rees, G., & Frith, C. (2007). Methodologies for identifying the neural correlates of consciousness. In M. Velmans, & S. Schneider (Eds.), *The Blackwell companion to consciousness* (pp. 553–566). Oxford: Blackwell.
- Regan, T. (1984). *The case for animal rights*. University of California Press.
- Reinhardt, V., & Russell, M. (2001). Self-biting in caged macaques: cause, effect, and treatment. *Journal of Applied Welfare Science*, *4*, 285–294.
- Richter, H. S., Garner, J. P., & Wuerbel, H. (2009). Environmental standardization: cure or cause of poor reproducibility in animal experiments? *Nature Methods*, *6*, 257–261.
- Rollin, B. (1989). *The unheeded cry*. Oxford: Oxford University Press.
- Rolls, E. T. (1990). A theory of emotion, and its application to understanding the neural basis of emotion. *Cognition and Emotion*, *4*, 161–190.
- Rolls, E. T. (2014). *Emotion and decision-making explained*. Oxford: Oxford University Press.
- Roper, T. (1984). Response of thirsty rat to absence of water: frustration, disinhibition, or compensation? *Animal Behaviour*, *32*, 1225–1235.

- Rose, J. D. (2002). The neurobehavioural nature of fishes and the question of awareness and pain. *Reviews in Fisheries Science*, 10, 1–38.
- Rozin, P., Fischler, C., Imada, S., Sarubin, A., & Wrzesniewski, A. (1999). Attitudes towards food and the role of food in life in the USA, Japan, Flemish Belgium and France: possible implications for the diet-health debate. *Appetite*, 33, 163–180.
- Rushen, J. (1986a). Aversion of sheep to electro-immobilization and mechanical restraint. *Applied Animal Behaviour Science*, 15, 315–324.
- Rushen, J. (1986b). The validity of behavioural measures of aversion: a review. *Applied Animal Behaviour Science*, 16, 309–323.
- Rushen, J. (1991). Problems associated with the interpretation of physiological data in the assessment of animal welfare. *Applied Animal Behaviour Science*, 28, 381–386.
- Sandem, A. I., & Braastad, B. O. (2005). Effects of cow-calf separation on visible eye white and behaviour in dairy cows – a brief report. *Applied Animal Behaviour Science*, 95, 233–239.
- Sandem, A. I., Braastad, B. O., & Boe, K. L. (2002). Eye white may indicate emotional state on a frustration-contentedness axis in dairy cows. *Applied Animal Behaviour Science*, 79, 1–10.
- Sato, W., & Aoki, S. (2006). Right hemispheric dominance in processing of unconscious negative emotion. *Brain and Cognition*, 62, 261–266.
- Selye, H. (1956). *The stress of life*. New York: McGraw-Hill.
- Selye, H. (1974). *Stress without distress*. Toronto: McClelland and Stewart.
- Seth, A., Baars, B. J., & Edelman, D. B. (2005). Criteria for consciousness in humans and other mammals. *Consciousness and Cognition*, 14, 119–139.
- Sherwin, C. M. (2001). Can invertebrates suffer? Or how robust is the argument from analogy? *Animal Welfare*, 10, S103–S118.
- Shettleworth, S. J. (2010a). *Cognition, evolution and behavior*. New York: Oxford University Press.
- Shettleworth, S. J. (2010b). Clever animals and killjoy explanations in comparative psychology. *Trends in Cognitive Sciences*, 14(11), 477–481.
- Simpson, G. C. (1983). *Fossils and the history of life*. New York and San Francisco: W.H. Freeman.
- Singer, P. (1975). *Animal liberation: A new ethics for the treatment of animals*. London: Jonathan Cape.
- Skinner, B. F. (1963). Behaviorism at fifty. *Science*, 140, 951–958.
- Sneddon, L. U., Braithwaite, V. A., & Gentle, M. J. (2003). Do fish have nociceptors? Evidence for the evolution of a vertebrate sensory system. *Proceedings of the Royal Society of London*, 270, 1115–1121.
- Špinková, M. (2006). How important is natural behaviour in animal farming systems? *Applied Animal Behaviour Science*, 100, 117–128.
- Stephens, D. B., Bailey, K. J., Sharman, D. F., & Ingram, D. L. (1985). An analysis of some behavioural effects of the vibration and noise components of transport in pigs. *Quarterly Journal of Experimental Physiology*, 70, 211–217.
- Stoerig, P. (2007). Hunting the ghost: towards a neuroscience of consciousness. In P. D. Zelazo, M. Moscovitch, & E. Thompson (Eds.), *The Cambridge handbook of consciousness* (pp. 707–730). Cambridge: Cambridge University Press.
- Stricklin, W. R., Graves, H. B., & Wilson, L. L. (1979). Some theoretical and observed relationships of fixed and portable spacing behavior of animals. *Applied Animal Ethology*, 5, 201–214.
- Tax, S., & Callender, C. (Eds.), (1960), *Issues in evolution: Vol. III. Evolution after Darwin*. Chicago: Chicago University Press.
- Taylor, N. R., Parker, R. M. A., Mendl, M., Edwards, S. A., & Main, D. C. J. (2012). Prevalence of risk factors for tail-biting on commercial farms and intervention strategies. *Veterinary Journal*, 194, 77–83.

- Thorpe, W. H. (1965). *Assessment of pain and distress in animals. Appendix III to report of the technical committee to enquire into the welfare of animals kept under intensive livestock husbandry systems*. Cmnd. 2836. Reprinted 1970. London: Her Majesty's Stationery Office.
- Tinbergen, N. (1951). *The study of instinct*. Oxford: Oxford University Press.
- Toates, F. (1995). *Stress: Conceptual and biological aspects*. John Wiley and Sons.
- Uvnäs-Moberg, K. (1998). Oxytocin may mediate the benefits of positive social interaction and emotions. *Psychoneuroendocrinology*, 23, 819–835.
- van der Vaart, E., Verbrugge, R., & Hemelrijk, C. K. (2012). Corvid re-caching without 'Theory of Mind': a model. *PLoS*, 7(3), 332904.
- Velmans, M. (2009). *Understanding consciousness* (2nd ed.). London and Philadelphia: Routledge.
- Vestergaard, K. (1982). Dustbathing in the domestic fowl: diurnal rhythm and dust deprivation. *Applied Animal Ethology*, 8, 487–495.
- Vestergaard, K. S., Damm, B. I., Abbott, U. K., & Bildsoe, M. (1999). Regulation of dustbathing in feathered and featherless domestic chicks: the Lorenzian model revisited. *Animal Behaviour*, 58, 1017–1025.
- der Waal, F. (2005). Animals and suspicious minds. *New Scientist*, 2502, 48.
- Wall, J., Douglas-Hamilton, I., & Vollrath, F. (2006). Elephants avoid costly mountaineering. *Current Biology*, 16, R527–R529.
- Warris, P. D., Brown, S. N., Gade, P. B., Santos, C., Costa, L. N., Lambooij, E., et al. (1998). An analysis of data relating to pig carcass quality and indices of stress collected in the European Union. *Meat Science*, 49, 137–180.
- Watson, J. B. (1929). *Psychology from the standpoint of a behaviorist*. Philadelphia: Lippincott.
- Weary, D. M., & Fraser, D. (1995). Calling by domestic piglets: reliable signals of need? *Animal Behaviour*, 50, 1047–1055.
- Webster, J. (1994). *Animal welfare: A cool eye towards Eden*. Oxford: Blackwell.
- Weiskratz, L. (2003). Roots of visual awareness. *Progress in Brain Research*, 144, 229–241.
- Wemelsfelder, F. (2001). Assessing the 'whole animal': a free choice profiling approach. *Animal Behaviour*, 62, 209–220.
- Whiteham, J. C., & Wielbrowski, N. (2013). New directions for zoo animal welfare science. *Applied Animal Behaviour Science*, 147, 247–260.
- WHO World Health Organization.** www.who.int/zoonoses/vph/eu Accessed 10.11.11.
- Wuerbel, H. (2009). Ethology applied to animal ethics. *Applied Animal Behaviour Science*, 118, 118–127.
- Wynne, C. (2004). The perils of anthropomorphism. *Nature*, 428, 606.
- Zayan, R., & Duncan, I. J. H. (1987). *Cognitive aspects of social behaviour in the domestic fowl*. Elsevier.
- Zeki, S. (2003). The disunity of consciousness. *Trends in Cognitive Sciences*, 7, 6–10.