Multiple Book Review: *Animal Sentience* publishes multiple reviews of selected books whose Précis is published in the journal along with the reviews and the author's response(s). Most of the multiple book reviews are invited individually by the Editor but freely submitted reviews of the selected books whose Précis has appeared can also be considered for publication. Books can also be nominated and reviewers can be proposed by writing to the Editor.
Instructions: http://animalstudiesrepository.org/animsent/guidelines.html

Considering animals' feelings

Précis of *Sentience and animal welfare* (Broom 2014)

Donald M. Broom

Centre for Anthrozoology and Animal Welfare
University of Cambridge

Abstract: The concept of sentience concerns the capacity to have feelings. There is evidence for sophisticated cognitive concepts and for both positive and negative feelings in a wide range of nonhuman animals. All vertebrates, including fish, as well as some molluscs and decapod crustaceans have pain systems. Most people today consider that their moral obligations extend to many animal species. Moral decisions about abortion, euthanasia, and the various ways we protect animals should take into account the research findings about sentience. In addition, all animal life should be respected and studies of the welfare of even the simplest invertebrate animals should be taken into consideration when we interact with these animals.

Keywords: sentience, animal welfare, anthropomorphism, cognition, feelings, species-differences

Donald M. Broom dmb16@cam.ac.uk is Emeritus Professor of Animal Welfare at Cambridge University. He has developed concepts and methods of scientific assessment of animal welfare and studied: cognitive abilities of animals, the welfare of animals in relation to housing and transport, behaviour problems, attitudes to animals and ethics of animal usage.

http://www.animal-welfare-indicators.net/site/index.php/professor-donald-m-broom

Why Are We Interested in Sentience?

People have always wondered what is the essential quality that makes us human. We have the same basic brain and bodily capabilities as other animals, and observations of behavior indicate that many other animals need resources such as air, food, and resting places and that they know other individuals have such needs. However, we humans have always sought a means of differentiating ourselves, and efforts have been made to ascribe unique qualities to ourselves. In human societies, a soul, a psyche, or a spirit has been attributed to people, or at least to some people, with the assumption that this quality helps to define a human being. However, when defined objectively, each of these qualities has components that are also thought of as components of sentience, so soul, psyche, or spirit can mean the same as being sentient. Are there any solely human qualities? Which humans and which other animals are sentient? The book itself (Broom, 2014) is the source for the contents of this Précis and is fully referenced so only a few key citations are mentioned here.

The term "sentience" has generally been used to mean that the individual has the capacity to experience one or more of the various states we call "feelings" (DeGrazia, 1996; Kirkwood, 2006). This capacity involves awareness and cognitive ability, and is hence subserved by the brain. A major change in attitudes regarding awareness and feelings in humans and other animals has occurred as studies of behavior have become more detailed. Complex behavioral sequences can provide evidence for the presence of cognitive ability and emotional reactions. In addition, there are new methods that allow advances in the study of brain mechanisms, for example, electroencephalography (EEG), positron-emission tomography (PET-scanning), magneto-encephalography (MEG), and frequency-modulated magnetic resonance imaging (fMRI).

Sentience implies having a range of abilities, not just feelings. Abilities associated with sentience, including some necessary cognitive abilities, are listed below. The abilities and the underlying concepts call for both definitions and evidence. A sentient being is one that has some ability: to evaluate the actions of others in relation to itself and third parties, to remember some of its own actions and their consequences, to assess risks and benefits, to have some feelings, and to have some degree of awareness (Broom, 2006).

Which Humans Are Sentient?

When did humans or their forebears become sentient? The idea that some races of people alive today have significant inborn genetic differences in their level of brain function is now known to be incorrect. There is also no evidence for differences between races in sensory abilities and feelings, for example, the capacity to feel pain. The variation of human ability within each race is much greater than the variation across races. Similarly, the idea that early humans were primitive in every way and very different from modern humans is not supported by written or archaeological evidence.

When human cognitive and other abilities are compared with those of other species, conclusions have to be qualified in relation to the very young and some of the injured or old. At birth, a human child may have the potential to carry out impressive cognitive tasks later in life but has far less actual ability than many other animals have. A person who has suffered substantial brain damage after an accident or a person with advanced senile dementia may be much less able than the companion dog or the magpie

in the garden. Sentience is a capacity that normally grows during human development; it can also diminish and be lost. The same is true for other sentient species.

The concept of sentience is relevant to ethical decisions, for example, about abortion, killing young at birth or hatching, and the use of anaesthetics and analgesics. We now have much scientific evidence about the development of brain systems in the fetuses and newborns of humans and other species, as well as about the loss of function following brain pathology. It is clear that, when capabilities are considered, some people are sentient but others are not because they have not developed the abilities or have lost them. The same is true of other animals. How does this affect our ideas of individual value and acceptable treatment?

Morality and Attitudes to Others

Moral behavior is a successful strategy used by both human and nonhuman individuals living in stable, long-lasting social groups (Kummer, 1978; de Waal, 1996; Broom, 2003). The more efficient the information exchange amongst individuals, the more frequently moral behavior succeeds and the less frequently competitive behavior that harms others will succeed. Cognition, emotion, and awareness all facilitate efficient communication and learning about the environment. They also make it easier to identify other sentient beings and increase the likelihood that they will be considered the subjects of moral actions. In many societies today, educational levels are high and there is easy access to information about people in other countries and about animals whose abilities are complex. Hence there will be a continuing decline in the likelihood that people will cause, or tolerate, poor welfare in foreign people or in animals perceived to be sentient.

It is of particular interest that the changes in attitudes to humans and to nonhuman animals appear to be linked more closely to the educational level of people than to their affluence. In countries where the people are relatively poor, but well-educated, interest in human and animal welfare has changed in much the same way as in rich countries where people are well-educated. The people are willing to incur some degree of financial loss rather than benefit from poor welfare in other people or animals.

If we use a living animal in a way that gives us some benefit, we have some obligations to that animal. One obligation is to avoid causing poor welfare in the animal except where the action leads to a net benefit to that animal, or to other animals including humans, or to the environment. Such a utilitarian approach is not sufficient to determine all obligations, however: A deontological approach is also needed because there are some degrees of poor welfare that are never justified by benefit to others. For example, research scientists should not tear the limbs off a live cat even if they think that key information about curing disease might result from such an action.

It is my view that all human behavior and laws should be based on the obligations of each person to act in an acceptable way towards each other person and toward each animal that is used. It is better for strategies for living to be based on our obligations rather than to involve the concept of rights. This is because many "rights" can result in harm to others — for example, carrying a lethal weapon or choosing the sex of human offspring (Broom, 2003). This argument is also applicable to references to the freedom that an individual asserts, or that is supposed to be given to an individual. Each person should always focus on how they ought to behave.

The idea that animals used by people should not be treated like inanimate possessions and should be protected from actions that might cause suffering is very old and widespread in human society. The term sentient is now used in legislation about animals. The European Union Treaty of Lisbon (European Union, 2007) says in the course of a statement about animal protection and welfare (Article 6b), "since animals are sentient beings…." This wording had the intention to protect the animals commonly used by humans: for example, on farms, in the laboratory, or as companions. It came about because public concern about animal welfare has increased in many countries during the last 30 years and especially in the last 10 years.

The Development of Animal Welfare Science

Scientists and legislators now use animal welfare as a scientific concept describing a potentially measurable quality of a living animal at a particular time. Such usage has rapidly become widespread during the last 30 years. The author's definition of the welfare of an individual as its state in its attempts to cope with its environment (Broom, 1986) refers to all coping systems and so includes feelings and health (Dawkins, 2006). It is now used by most welfare scientists and is also, somewhat clumsily, used by the O.I.E. (World Organization for Animal Health). "Well-being" is the same concept, even if viewed as less scientific by many, and "quality of life" refers entirely to welfare but is not used for short timescales (Broom, 2007b). It is possible to consider the welfare of all animals, not just those who are sentient, but the abilities associated with sentience affect welfare.

Welfare can be assessed using a wide variety of behavioral, physiological, clinical, brain function, and other measures (Fraser, 2008; Broom & Fraser, 2015). It is important to assess how good the welfare is as well as to evaluate poor welfare. The major changes in animal welfare science during the last 30 years have been the refinement in direct measures of animal welfare and the development of welfare outcome indicators that can be used by veterinary and other inspectors, as well as by those who use animals. Welfare outcome indicators have been developed by many scientists, including those involved in the E.U. Welfare Quality and Animal Welfare Indicators (AWIN) projects. Information on the subject is available at the Animal Welfare Hub (2015).

Another key aspect of animal welfare science has been the investigation of differences in the needs of different animals (Rollin, 1989; Broom & Johnson, 2000). The first step in developing standards for the welfare of animals of a species is to describe clearly the needs of such animals. A knowledge of the biological functioning of the animal provides some information about needs, but careful studies of the strengths of preferences clarify what the animals need (Fraser, 2008). The principles used in these studies are those of microeconomics, but the experiments involve animals carrying out specific actions to obtain rewards or to avoid aversive effects, and they are based in part on the learning and memory abilities of the animals.

Cognition, Feelings, Awareness and Motivation

Some feelings require cognitive processes and a certain level of awareness (Mendl & Paul, 2004), with some components of sentience being dependent upon cognitive ability.

Moral actions are also facilitated by cognitive function. The cognitive abilities of humans and other animals depend on the quality of their brain function, but this is often not clearly related to brain size, nor are high levels of cognitive ability confined to one kind of brain structure. People often assume, incorrectly, that small animals, animals with small brains, cold-blooded animals, and animals with brain structures different from those of humans cannot have complex concepts and behavior. Much recent research has demonstrated that a wide range of animals have substantial cognitive ability, irrespective of size. For example, when primate cognition is claimed to be unique in some way, there is often subsequent work on other species such as dogs, pigs, corvids, and parrots that demonstrates they also have such cognitive capacities (Shettleworth, 2010).

Estimates of brain sophistication should take account of function rather than anatomy alone because animals vary in the parts of the brain that have complex analytical functions. Although some mammals have high-level functions in the cerebral cortex, a comparable level of analysis occurs in areas of the striatum in birds and in a variety of brain regions in fish, cephalopods, and other animal groups. The remarkable cognitive ability of some spiders is achieved with a small brain, but the processing speed during evaluation of complex situations is slower than it would be in a vertebrate brain. On the other hand, in some small animals, the rate of change of events in life, and hence their speed of decision-making, is greater than that of larger animals like humans. When the speed of evaluation of information and responding were compared for humans and many other animals, the fastest was that of a blowfly. Anyone who has watched hummingbirds taking their daily decisions and reacting to humans is likely to have gained the impression that these tiny birds probably view us as slow and hence perhaps of little consequence.

In recent years there have been many studies of cognitive ability that lead to the conclusions that: (a) hardly any ability is uniquely human, (b) the best bird brains allow greater cognitive abilities than any mammal except man, (c) learning by fish can be very complex, and (d) cognition in cephalopods, jumping spiders, ants, and bees is much more sophisticated than we had previously thought. Communicating using symbols is possible for many animals, so perhaps human language is not that unique. Using information from a mirror has been demonstrated in humans, chimpanzees, capuchin monkeys, pigs, elephants, dolphins, parrots, and magpies. The concept of future events is evident from work on many farm, companion, and other animals. There have been studies indicating capacities for metacognition (i.e. knowing what you know) in humans, monkeys and, dolphins. Tool use and other comparably complex innovative behaviors have been demonstrated in many species of primates, birds, and fish.

Emotion, which has long been viewed as necessarily separate from intellectual activity, is now shown to be a facilitator of learning and a consequence of learning (Rolls, 2005; Paul et al., 2005). Indeed, the evaluation of welfare can make use of this, for example, in studies of cognitive bias. All of the terms used to describe affective state, such as feelings, emotion, mood, pain, suffering, and pleasure require careful definition. For example, a feeling is a brain activity that involves at least perceptual awareness; it is associated with a life-regulating system and recognizable by the individual when it recurs, and it may change behavior or act as a reinforcer in learning. Feelings, such as pain and fear, are now thought to be widespread in mammals, birds, fish, cephalopods

and some other molluscs, and in decapod crustacea (Elwood, 2012; Broom, 2013; Mather, 2013).

There are several levels of awareness in individuals and in different phylogenetic groups of animals. Awareness has been categorized as ranging from unawareness to perceptual, cognitive, assessment, and executive awareness (Sommerville & Broom, 1998). A related concept, being conscious, is best considered as just the negation of being unconscious rather than as a synonym of awareness. Some key aspects of awareness are awareness of the actions of others, of one's own actions, of the interactions between one's own and others' actions, of the future, of the self, and of others having concepts (Mendl & Paul, 2008). To behave morally, brain functioning requires some degree of recognition, awareness, decision-making, and feelings. The decision-making depends on the existence of a motivational system.

Ethical Decisions: Using the Science

When decisions are made about whether a system for exploiting resources should be used, an important question is whether the system is sustainable (Aland & Madec, 2009). A system or procedure is sustainable if it is acceptable now and if its expected future effects are acceptable, in particular in relation to resource availability, consequences of functioning, and morality of action (Broom 2010; Broom et al., 2013). No system or procedure is sustainable if a substantial proportion of the local or world public find aspects of it now unacceptable, or if they consider now that its expected consequences in the future are morally unacceptable. More and more people will not buy products if their production method is considered unsustainable for any reason.

Factors considered by purchasers and high on the agenda of many discriminating consumers include (i) the welfare of the animals used in production; (ii) any impact on the environment, including conservation of wildlife; (iii) ensuring a fair payment for producers, especially in poor countries; (iv) the preservation of rural communities so that the people there do not go to live in towns; and (v) the carbon footprint in relation to global warming. Each of these factors is now also considered by increasing numbers of consumers to be an aspect of product quality.

The power of consumers in forcing change where production practices are unacceptable (Bennett et al., 2002) has had a great impact in changing laws, codes of practice, and food company policies in relation to farming practices. Examples of practices that lead to particularly poor welfare in farm animals and are already illegal or being phased out in many countries are confinement of pregnant sows or calves in small stalls or crates, keeping hens in battery cages, keeping mink or foxes in small barren cages, and transport conditions that cause suffering. Practices where change is likely to be mandatory in the near future are (i) the keeping of meat chickens using growth rates that result in a high incidence of leg disorders and skin lesions and (ii) selecting cows for high milk production with the consequence that there is a high incidence of leg disorders, mastitis, and reproductive disorders. Consumers have also had an impact on the banning of products to stop the use of leg-hold and other inhumane traps for wild mammals, inhumane killing of young seals, killing of whales, and the nonmedical use of genetically modified or cloned animals.

Scientific information about which individuals are sentient, and how good or poor is the welfare of the individual, inform some ethical decisions (Broom, 2007a).

There is a widespread desire for most people and certain nonhuman animals to be specially protected, either because they are considered to have some intrinsic value or because it is considered wrong for their welfare to be poor. In deciding whether the killing of a human embryo is justified, whether a brain-damaged or senile person should be allowed to die, which animals should be killed for human use, and for which animals we have concern about welfare, many people take account of the cognitive and emotional functioning of the individual. The question of the sentience of the individual is important in such decisions.

Which animals should be protected? Should the range of protected animals be limited to warm-blooded animals or vertebrate animals, or should it be extended to any of the invertebrate groups? Should protection begin at the point of formation of egg or sperm or zygote, on hatching from an egg or birth in the case of mammals, or should it begin at some point during fetal or embryonic development (EFSA, 2005)? At what point in development should there be protection, and in practice, immature forms of which kinds of animals could be protected? Does sentience mean that the individual has interests?

What follows is a list of conclusions about what should be done in relation to studies of sentience and the treatment of humans and other animals.

1. When investigating brain and behavior in humans and other animals, academics should use precise scientific methodology to describe observations, to experiment, to analyze results, and to write about them, but they should not be afraid to use concepts such as emotion, feeling, mood, pain, fear, happiness, awareness, consciousness, stress, need, and welfare in presenting results. No concept should be avoided because there may be those who would criticize the use of complex concepts on the grounds that there must be parsimony in all descriptions. If the subject is complex, some of the concepts must be complex.

2. Each concept used in research on cognition, awareness, and animal welfare should be properly defined in scientific writing rather than just being referred to in descriptive but imprecise ways.

3. It is possible to take account of sentience when considering whether abortion is acceptable. The fetus during pregnancy has a potential, increasing with time, of becoming a sentient individual. This argument is correct for humans and other sentient animals. However, the point at which the developing human fetus has the capacity for having feelings and being aware is about 60% through pregnancy. This corresponds to the age at which survival is possible.

4. The word "euthanasia", which means a good death, should be used solely to mean killing an individual for the benefit of that individual. If the benefit is for someone else, it should be called killing or humane killing but not euthanasia. Euthanasia in humans is not legal in most countries, in particular because of difficulties in formulating a law that would not allow the possibility that elderly people may be encouraged to agree to hasten their deaths. However, in public discussions about the subject, it is often stated that the expectation of loss of sentience may be a reason a person would request euthanasia for themselves. When a companion animal is suffering, the caregiver may decide that it would be

better for that animal to be dead than to continue suffering. It is assumed that the animal is sentient and would prefer not to suffer further.

5. An ability in individuals of a species does not necessarily mean that all members of the species have the ability; however, the level of complexity of functioning of the animal should be taken into account when designing housing and husbandry systems for the species. Careful studies of animal welfare are required for this.

6. High levels of cognitive ability may help animals to cope with their environment. Hence a given level of a problem, such as pain, may be easier for a complex animal to tolerate than for a simpler animal. There is a possibility that animals may have fear of possible future adversity. The relationships between negative feelings, such as fear and pain, and the role of cognition in the coping abilities of the animal should be investigated further and considered when evaluating the risk of poor welfare. Cognitive ability should also be considered when designing methods of enriching the environments of captive animals.

7. A substantial body of research on parrots, dogs, pigs, cattle, and other farm animals and companion animals shows that they have some ability for recognition, cognition, risk assessment, cognitive awareness, assessment awareness, emotions, and feelings and hence that they are sentient. Research on laboratory and wild mammals and birds is providing similar evidence. In particular, studies of birds in the crow family provide evidence of high levels of cognitive ability and awareness.

8. The information about learning, awareness, and capacity for pain and other feelings in amphibians, reptiles, fish, cephalopods, and decapod crustaceans is also clear enough to justify arguments for their protection if they are used in experimentation, for food, or for other purposes. Learning and awareness in stomatopod crustaceans is at least equivalent to that in decapod crustaceans.

9. Spiders have substantial cognitive ability and perhaps executive awareness; and some insects such as bees and ants have quite a high level of cognitive ability and probably assessment awareness. There is clear evidence for aspects of a pain system in gastropod molluscs, such as snails, slugs, and swimming sea slugs, but we cannot be sure that they have the processing capacity needed to feel pain. Because some aspects of the pain system exist in leeches and swimming sea slugs, these animals are used as models for human pain. Evidence for a pain system is significantly less for insects and spiders than it is for molluscs. Cognitive ability and awareness in gastropod molluscs have not been shown to be as great as they are in spiders or insects. There is a case for some degree of protection for spiders, gastropods, and insects. However, the case is not as strong as the one for vertebrates, cephalopods, and decapod crustaceans.

10. All animal life should be respected, and studies of the welfare of even the simplest invertebrate animals should be taken into account when we interact with these animals. Even if we do not protect the animals by law, we should try to avoid cutting an earthworm in half, mutilating a snail, or damaging the wing of an insect.

Summary

When scientists describe a complex system like the brain, terms such as awareness, sentience, welfare, emotion, and feeling should be carefully defined and used. If they are not used, important aspects of biological function are missed. The reluctance of some in the scientific community to do this has slowed the development of knowledge.

The concept of sentience, which concerns the capacity to feel, has some parallels with ideas of the soul or psyche that have often been used to propose that humans are fundamentally different from other animals. There is evidence for sophisticated cognitive concepts and for both positive and negative feelings in a wide range of nonhuman animals. Are primates more advanced than other mammals, are bird brains second-rate, and are farm animals stupid? The cognitive capacities of parrots and corvids are comparable with — or even better than — those of apes. Cows, pigs, and sheep are better in some abilities than dogs, cats, and horses. Studies of spiders and cephalopods indicate impressive brain function. All vertebrates, including fish, as well as some molluscs and decapod crustaceans, have pain systems. In addition, the points at which sentience arises in human embryos and disappears in brain-damaged people need to be considered.

The concept of animal welfare is relevant to all animals, and animal welfare science has developed rapidly. The results of such research are being used when laws and standards are designed and adopted because, for an increasing proportion of the public, animal welfare is coming to be regarded as an important factor in the sustainability of systems and the quality of animal products.

Most people now consider that their moral obligations extend to many animal species. Moral decisions about abortion, euthanasia, and the various ways in which we protect animals should take account of information about sentience. All animal life should be respected and studies of the welfare of even the simplest invertebrate animals should be taken into account when we interact with these animals.

Multiple Book Review: *Animal Sentience* publishes multiple reviews of selected books whose Précis is published in the journal along with the reviews and the author's response(s). Most of the multiple book reviews are invited individually by the Editor but freely submitted reviews of the selected books whose Précis has appeared can also be considered for publication. Books can also be nominated and reviewers can be proposed by writing to the Editor.
Instructions: http://animalstudiesrepository.org/animsent/guidelines.html

References

Aland, A. and Madec, F. (Eds.). 2009. Sustainable animal production. Wageningen Academic Publishers, Wageningen.

Animal Welfare Hub 2015. Retrieved from http://animalwelfarehub.com.

Bennett, R.M., Anderson, J. and Blaney, R.J.P. 2002. Moral intensity and willingness to pay concerning farm animal welfare issues and the implications for agricultural policy. Journal of Agricultural and Environmental Ethics, 15, 187-202.

Broom, D.M. 1986. Indicators of poor welfare. British Veterinary Journal, 142, 524-526.

Broom, D.M. 2003. The evolution of morality and religion (p. 259). Cambridge: Cambridge University Press.

Broom, D.M. 2006. The evolution of morality. Applied Animal Behaviour Science, 100, 20-28.

Broom, D.M. 2007. Cognitive ability and sentience: Which aquatic animals should be protected? Diseases in Aquatic Organisms, 75, 99-108

Broom, D.M. 2007. Quality of life means welfare: How is it related to other concepts and assessed? Animal Welfare, Suppl. 16, 45-53.

Broom, D.M. 2010. Animal welfare: an aspect of care, sustainability, and food quality required by the public. Journal of Veterinary. Medical Education. 37, 83-88.

Broom, D.M. 2013. The welfare of invertebrate animals such as insects, spiders, snails and worms. In T. A. van der Kemp and M. Lachance, Animal Suffering: From Science to Law, International Symposium. Paris: Éditions Yvon Blais.

Broom, D.M. 2014. Sentience and animal welfare. Wallingford: CABI.

Broom, D.M. and Fraser, A.F. 2015. Domestic animal behaviour and welfare (5th ed.). Wallingford U.K.: CABI.

Broom, D.M., Galindo, F.A. and Murgueitio, E. 2013. Sustainable, efficient livestock production with high biodiversity and good welfare for animals. Proceedings of the Royal Society B. 280, no. 1771, 20132025.

Broom, D.M. and Johnson, K.G. 2000. Stress and animal welfare. Dordrecht: Kluwer/Springer.

Dawkins, M.S. 2006. Through animal eyes: What animal behaviour tells us. Applied Animal Behaviour Science, 100, 4-10.

DeGrazia, D. 1996. Taking animals seriously. Cambridge: Cambridge University Press.

de Waal, F. 1996. Good natured. Cambridge, MA: Harvard University Press.

European Union. 2007. Treaty of Lisbon. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.C .2007.306.01.0001.01.ENG

EFSA. 2005. Aspects of the biology and welfare of animals used for experimental and other scientific purposes (Report and Opinion). The EFSA Journal, 292, 1-136.

Elwood, R.W. 2012. Evidence for pain in decapod crustaceans. Animal Welfare, 21(S2), 23-27.

Fraser, D. 2008. Understanding animal welfare: The science in its cultural context. Chichester: Wiley Blackwell.

Kirkwood, J. K. 2006. The distribution of the capacity for sentience in the animal kingdom. In J.Turner and J. D'Silva (Eds.), Animals, Ethics and Trade: The Challenge of Animal Sentience (pp. 12-26). Petersfield: Compassion in World Farming Trust.

Kummer, H. 1978. Analogs of morality among non-human primates. In G.S. Stent (Ed.), Morality As a Biological Phenomenon (pp. 31-47). Berkeley and Los Angeles: University of California Press.

Mather, J.A. 2013. Do cephalopods have pain and suffering? In T. A. van der Kemp and M. Lachance (Eds.), Animal Suffering: From Science to Law, International Symposium. Paris: Éditions Yvon Blais.

Mendl, M. and Paul, E.S. 2004. Consciousness, emotion and animal welfare: Insights from cognitive science. Animal Welfare, 13, 17-25.

Mendl, M. and Paul, E.S. 2008. Do animals live in the present? Current evidence and implications for welfare. Applied Animal Behaviour Science, 113, 357-382.

Paul, E.S., Harding, E.J. and Mendl, M. 2005. Measuring emotional processes in animals: the utility of a cognitive approach. Neuroscience and Biobehavioral Reviews, 29, 469-491.

Rollin, B.E. 1989.The unheeded cry: animal consciousness, animal pain and science. Oxford: Oxford University Press.

Rolls, E.T. 2005. Emotion explained. Oxford: Oxford University Press.

Shettleworth, S, J. 2009. Cognition, evolution and behavior (2nd ed.). Oxford: Oxford University Press.

Sommerville, B.A. and Broom, D.M. 1998. Olfactory awareness. Applied Animal Behaviour Science, 57, 269-286.