SUFFERING IN NON-HUMAN ANIMALS:
Perspectives from Animal Welfare Science and Animal Welfare Law

by Peter Fordyce*

Abstract

The paper argues that suffering is an aversive/negative subjective mental state originally inferred in animals, by humans, using an anthropomorphic interpretation of an animal's situation, and the consequences of that situation on the animal's behaviour or physical state. Over the last half century, developments in the field of animal welfare science have provided a substantial body of data about what actually matters to animals, and how their responses to adverse events manifest, by examining their preferences, and measuring changes in their anatomy, physiology and behaviour over a range of states of welfare – from good to very poor welfare.

Data from animal welfare science can provide an objective reference point for data collected and used as evidence in criminal proceedings for un-necessary suffering. Animal welfare science can therefore assist the courts by providing objective criteria on which the premise of an argument regarding whether or not an animal has suffered can be assessed, rather than relying on conjectural opinion based on well meaning, but often uninformed, anthropomorphically driven emotions. Animals, like humans who are incapable of verbally communicating their mental state and preferences by virtue of age, or physical or mental infirmity, cannot verbally communicate whether they are enduring an aversive/negative subjective mental state. Animal welfare science provides an indirect, but rational and robust mechanism to infer what an animal's subjective state was/is in relation to what has happened to it, by examining scientific data relating to its physiology, pathology and behaviour, and considering this in the context of published animal welfare science data derived from animals in situations they are known to find aversive, and would choose not to endure. The paper explores some of the concepts and data on which animal welfare science is predicated, additionally examining difficulties that can arise with use of language in this field, and in animal welfare legislation.

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1. Introduction

Since the passage of Martin's Act in 1822 in the United Kingdom, non-human animals (henceforth referred to as animals) in the United Kingdom have enjoyed an ever widening and increasing degree of statutory protection of their welfare (Radford 2001). The 1822 Act used the concept of 'cruelty' (to wantonly and cruelly) to determine the guilt or innocence of a defendant in relation to their actions involving an animal protected under the Act. Some ninety years after this landmark Act, the 1911 Protection of Animals Act similarly included the terms 'cruelly' in the statute, but additionally included the term 'un-necessary suffering' in the legislation (Protection of Animals Act 1911). Following various amendments during the next ninety years, the 1911 Act was superseded by the Animal Welfare Act 2006 (AWA) in England and Wales (with similar, although not identical, legislation in the devolved jurisdictions of the UK). This Act dropped the term 'cruelly' from the statute, and in order to gain conviction under this Act under Section 4, the prosecution must demonstrate to the court that a protected animal (as defined in the Act) had suffered and that the suffering was 'un-necessary' (Section 4 Animal Welfare Act 2006). The change in the framing of the legislation in relation to what was commonly referred to as the 'offence of cruelty' in the previous Acts has practical significance in prosecutions. To obtain a conviction under Section 4 of the Act, the prosecution is required to prove that an animal suffered. Only once this has been established is the issue of whether the suffering was 'un-necessary' (or not) relevant to obtaining a conviction.

Unlike the term 'cruelty', which conflates issues of suffering and necessity, the above formulation of the offence reflects current thinking in animal welfare discourse, where suffering is a matter for science and evidence, while the issue of necessity is a matter of ethics, with this being dependent on the circumstance under which the suffering occurred (Broom 2004). The AWA 2006 provides guidelines relating to what a court might consider both 'acceptable' (or otherwise) in relation to activities involving animals (e.g. Section 5 specifies which mutilations are legally acceptable and when; Section 58 deals with regulated biomedical research; while Section 59 exempts fishing), as well as the issues a court might consider in relation to *necessity* in a case involving suffering. Section 4(3) sets out the following criteria for consideration in relation to necessity:

> (a) whether the suffering could reasonably have been avoided or reduced;
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> (b) whether the conduct which caused the suffering was in compliance with any relevant enactment or any relevant provisions of a licence or code of practice issued under an enactment;

(c) whether the conduct which caused the suffering was for a legitimate purpose, such as –

(i) the purpose of benefiting the animal, or

(ii) the purpose of protecting a person, property or another animal;

(d) whether the suffering was proportionate to the purpose of the conduct concerned;

(e) whether the conduct concerned was in all the circumstances that of a reasonably competent and humane person.[1]

While the above guidance on necessity is relatively comprehensive, the Act provides limited guidance regarding how a court might interpret the term '*suffering'*. Section 62 of the Act simply states: 'Suffering means physical or mental suffering and related expressions shall be construed accordingly'. As discussed above, for a prosecution to succeed, the first hurdle is to show the animal suffered, and success will turn on what the court accepts as evidence that an animal did indeed 'suffer'. Hence, what that word means is critical to the success or failure of the case. Many prosecutions brought under Section 4 of the Act in England are conducted by the Royal Society for the Prevention of Cruelty to Animals (RSPCA), a charity founded shortly after the 1822 Act for that purpose, and whose prosecutorial activities continue alongside state prosecutors in the UK. This activity has recently been examined by the House of Commons Environment, Food and Rural Affairs Committee (House of Commons Environment, Food and Rural Affairs Committee 2016–2017). In an independent review of the prosecution activity of the RSPCA – a report commonly referred to as The Wooler Report –, Stephen Wooler examined problems faced by the RSPCA when prosecuting under Section 4 of the Act (Wooler 2014). Wooler discusses the difficulties caused by lack of a precise statutory definition of suffering in the Act, along with a lack of assistance provided by established case law in England and Wales. He further comments on the role of expert witnesses in obtaining convictions under the Act, along with the practical problems that may arise in court due to disagreements between veterinary surgeons on the meaning and nature of suffering in animals. One resulting recommendation to come from the report was the suggestion that the Royal College of Veterinary Surgeons (RCVS) (who regulate the veterinary profession in the UK under the Veterinary Surgeons Act 1966) be invited to take the lead, along with 'other practitioners', to develop a common standard or guidance on the approach to assessment of suffering. A recent paper by Baumgartner et al. (2016), which reviews the assessment of unnecessary

[1] Further guidance is also provided in a set of Explanatory Notes which state that they 'do not form part of the Act and have not been endorsed by Parliament', but have been produced 'in order to assist the reader in understanding the Act'.

suffering in animals by veterinary experts in 42 'expert witness reports' submitted to English courts, highlights the problems raised by Wooler. The paper demonstrates the prevalence of disputes between experts concerning the definition of suffering, the significance of clinical findings in relation to the animal(s) involved, and the relevance of different assessment methods used to assess suffering, and provided a range of definitions of suffering to exemplify the point. These definitions for suffering are reproduced in the glossary at the end of this article, along with others from other sources.

In this article, I argue that 'suffering' in animals (as with humans) is an unpleasant/aversive subjective mental state, caused by physical or psychological stressors that impinge on the animal in such a way that a failure to avoid (or adapt easily to) them threatens (or potentially threatens) its viability as an organism. I use the term 'adapt' in the context of Donald Broom's definition of adaptation, that is, to describe 'the use of regulatory systems, with their behavioural and physiological components, to allow an animal to cope with its environmental conditions', with 'coping' defined as 'having control of mental and bodily stability' (Broom 2014). Like with humans who are unable to verbally communicate their feelings about their situation for reasons of age or mental debility, reasonable inferences may be made about the internal subjective state of animals on the basis of objective analysis of their situation. Such an approach includes an analysis of the situation they find themselves in, and scientific data relating to how they are responding to it, including behavioural changes, and changes in their physiology and anatomy. Since the passage of Martin's Law, such inferences have almost always been based on anthropomorphic concerns arising from the situation the animal has found itself in, and how the animal reacted to that situation. However, developments in animal welfare science concerning the needs of animals, and an understanding of underlying motivational mechanisms to achieve these – along with data from measurement of physiological, pathological and behavioural parameters in animals in situations that have been shown to be aversive as a consequence of their motivation to avoid such situations – have provided objective criteria against which data from an animal that is the subject of proceedings for 'un-necessary suffering' can be compared. While requiring care in interpretation, such objective data can provide a scientific rationale on which to conclude whether or not an animal has suffered, rather than relying on a purely empathetic response to the animal's situation. By considering suffering to be an aversive/negative subjective mental state, words used in animal welfare protection legislation such as 'pain' and 'distress' are easily accommodated under the term suffering as they are 'unpleasant/aversive subjective mental states', along with many other such unpleasant states not defined in Primary legislation but widely used in animal welfare science discourse, such as 'fear' and 'hunger'. The wording of Section 62 of the AWA

2006 clearly allows for such a concept,[2] although I argue that all 'suffering' is mental, even if it may have 'physical' or 'mental' (psychological) causes. This article attempts to explore the concept of sentience as it relates to animal welfare science and animal welfare protection legislation, the link between objectively measurable criteria reported in animals involved in proceedings for 'un-necessary' suffering and their mental states, and highlight some of the potential problems arising from ambiguity in use of language in such cases. In order to try and avoid such confusions of ambiguity surrounding the terms from animal welfare science that are used in this article, I have included referenced definitions of how I have used the terms and have added a glossary at the end of the article containing definitions of the most commonly used terms.

2. The legal recognition of sentience in animals

While pre-dating Martin's Act by three decades, Jeremy Bentham's famous philosophical question regarding whether animals should be given moral consideration has clearly informed animal welfare protection legislation since 1822.[3] The issue has however remained a topic for debate amongst a small number of philosophers such as Carruthers (Carruthers 1992) and Frey (Frey 2008), in part because of the difficulties of attributing subjective mental states to animals who, by virtue of their species, are unable to report their experiences verbally directly to humans (e.g. Mendl et al. 2009). The debate about accessing the subjective mental state of animals in many ways mirrors that of the problem of 'solipsism' in humans (e.g. Stanford Encyclopaedia of Philosophy 2014) and will not be laboured here as it has been discussed extensively elsewhere, e.g. Broom (2014), or more briefly by 'Compassion in World Farming' (2006), Mendl and Paul (2008) and Cartmill (2001). However, many legislatures now appear to concur with the modern utilitarian philosopher Peter Singer, who states that 'the limit of sentience (using the term as a convenient, if not strictly accurate, shorthand for the capacity to suffer or experience enjoyment of happiness) is the only defensible boundary of concern for the interests of others' (Singer 1979). Hence, a number of jurisdictions have in recent years conferred degrees of legal protection on animals on the basis of them being 'sentient', citing scientific evidence as the justification. Such jurisdictions include the European Union (Treaty of Lisbon 2009), New Zealand (Animal Welfare Amendment Act (No 2) 2015), Australia (Australian Government 2008) and Colombia (Contreras, C. 2016). Examples from EU

[2] 'Suffering means physical or mental suffering and related expressions shall be construed accordingly'.
[3] 'The question is not can they reason? Nor, can they talk? But can they suffer?' (Bentham 1789).

legislation which include this formulation include Directive 2010/63/EU on the Protection of Animals Used for Scientific Purposes where the introductory paragraph 6 states: 'New scientific knowledge is available in respect of factors influencing animal welfare as well as the capacity of animals to sense and express pains suffering, distress and lasting harm' (Directive 2010/63/EU). Another example is Regulation 2009/1099/EU on the Protection of Animals at the Time of Killing, where paragraph 19 states: 'There is sufficient scientific evidence to demonstrate that vertebrate animals are sentient beings'.

While some may still think that animals are not sentient, this paper starts from the de facto position that they are, given the science on which the above mentioned legislation is based. However, if suffering is one of several internal subjective mental states associated with sentience, the questions arise: how might this be demonstrated in a court room in order to obtain a conviction for un-necessary suffering, and how might the clarity Wooler seeks on the issue of suffering be brought to court proceedings? In his recent review of the science surrounding sentience and animal welfare, Broom suggests that sentience involves 'having the awareness and cognitive ability necessary to have feelings' (Broom 2014). He then goes on to suggest that a sentient being will have a number of abilities, including: a) the ability to evaluate the actions of others in relation to itself, and third parties; b) to remember some of its own actions and their consequences; c) to assess risks and benefits; d) to have some feelings; and e) to have a degree of awareness (which Broom defines as 'a state during which the concepts of environment, of self and of self in relation to the environment, result from complex analysis of sensory stimuli or constructs based on memory'). From Broom's perspective, determination of whether sentience exists in a species of animal therefore depends on scientific observation of how that species behaves in a variety of situations to establish whether they exhibit those criteria. Similarly, scientific examination of a range of observable criteria in animals that are involved in court cases for unnecessary suffering can be used to determine whether they are enduring an 'unpleasant/aversive subjective mental state' by comparing such findings with those seen in animals in situations known to be aversive to them.

An understanding of concepts from animal welfare science such as homeostasis, motivational drivers, needs, and the link between feelings and emotions may be helpful in clarifying how measurable parameters relating to an individual animal are used to infer a subjective mental state, and this is discussed subsequently. However, a caveat is required at this point because of the potential for misunderstanding due to how language is used in both animal welfare science and legislation. Broom, in a paper examining animal welfare in the European Union, comments on the problem of inaccurate terminology used in some European Animal Welfare Protection Laws (AWPL), due to incorporation of outdated or inaccurate

concepts of animal welfare (Broom 2017). Like Wooler in the context of judicial interpretation of legislation, Broom argues for the importance of accurate use of terms and concepts from animal welfare science discourse within the legislative branch of government. Across animal welfare science literature, different authors may use the same term to mean slightly different things, or different words to mean the same thing. I would not wish to adjudicate on the 'correctness' of the use of terminology. However, for reasons of clarity of argument, I argue that there is much to be said for requiring those making legal arguments in expert reports, for example, to define and reference the terms they use, so the meaning is explicit in the context in which they are using them. As discussed above, I have tried to do this here, along with a glossary of terms used, at the end.

Sentience and welfare

The Treaty of Lisbon contains a provision on the *sentience* of animals, according to which Member States

> shall, since animals are sentient beings, pay full regard to the welfare requirements of animals, while respecting the legislative or administrative provisions and customs of the Member States relating in particular to religious rites, cultural traditions and regional heritage (Treaty of Lisbon 2009).

However, the Treaty does not define the term 'sentience' in relation to animals, nor hint at its nature, the range or degree of its presence within different species. While not stated in Primary legislation, Australia's 2008 Australian Animal Welfare Strategy does define a sentient animal as 'one that has the capacity to have feelings and experience suffering and pleasure', this formulation having obvious similarities with Singer's view of sentience, Broom's above mentioned view, and similarities with John Webster's definition of a sentient animal as 'one for whom its feelings matter' (Webster 2006).

What 'matters' to animals is the imperative that has driven animal welfare science since at least the Brambell Report of 1965 in the UK (Brambell 1965), and the history of this is reviewed by Keeling et al. (2011). While there are many definitions of what '*animal welfare*' is, most incorporate the view that welfare involves consideration of the animal's subjective experience.[4] Scientific assessment of an

[4] Cf. e.g. Webster's view that 'good welfare is fit, feeling good' (Webster 2005); Fraser et al.'s view that an animal's welfare consists of three components, 'Health (fitness), naturalness (Telos) and subjective experience (feelings)' (Fraser et al. 1997); or Broom's view, according to which welfare is 'the state of an animal with regard to its ability to cope with its environment' defining 'coping' as 'having mental and bodily stability' (Broom 2014).

animal's welfare therefore incorporates objective measurements of factors such as its physical health (with 'health' defined as 'the state of an animal with regard to its ability to cope with pathology' and 'pathology' defined as 'the detrimental derangement of molecules, cells and functions that occur in living organisms in response to injurious agents or deprivations' (Broom 2014)), observations about its behaviour in the circumstances it is in, and the physiological changes that are occurring within it as it attempts to cope with its situation. From these observations, deductions are then made about the animal's subjective state, that is, its feelings (Fraser et al.), whether or not it 'feels good' (Webster), and its 'mental stability' (Broom). Such a multifactorial assessment of welfare fits with the view of the World Organisation for Animal Health (OIE) according to which

> [t]he scientific assessment of animal welfare involves diverse elements which need to be considered together, and that selecting and weighing these elements often involves value based assumptions which should be made as explicit as possible (World Organisation for Animal Health, Terrestrial Animal Health Code nd).

Establishing exactly what matters to animals is based in part on the assumption that animals are programmed by evolution and experience to be motivated to make choices that are in their own best interests (Fraser and Nicol 2011). As animals try and cope with challenges to their bodily and mental stability from threats to their viability as an organism from their environment, observable physical changes occur in the behaviour and physiology in animals in situations. If they find difficulty in making these changes (or cannot make them), pathological changes occur in their physiology, anatomy and behaviours. This is perhaps most explicitly expressed by Jean Decety (2011) in a paper discussing the evolution of empathy in humans, who suggests that

> the human social brain, as well as all other mammalian brains, is fundamentally built on ancient emotional and motivational value systems that generate affective states as indicators of potential fitness trajectories (Decety 2011).[5]

Motivation to instigate or change behaviours is driven by the animal's interaction with its environment, such interactions causing motivational changes in the brain to bring about behavioural

[5] Motivation has been defined by Broom as 'the process in the brain controlling which behaviours and physiological changes occur, and when' (Broom 2014), and affective states refer to 'a wide range of pleasant and unpleasant (subjective mental) states' (Verbeek and Lee 2014).

changes that are in the best interest of the animal (either by acquiring something they need or want, or avoiding something that is a threat to their best interests), as a result of the generation of 'affective states' in the brain. It is therefore perhaps useful to briefly examine the science behind motivational research in animals, and its origins in the Brambell Report.

3. What really matters to animals – Motivational research and ethograms

The Brambell Report of 1965 came about due to societal concern raised about the change to modern 'factory' farming methods in the UK in the late 1950's and the impact on the welfare/quality of life of animals used in such practices. This is exemplified by the assertion in Ruth Harrison's 1964 book Animal Machines that '[t]he greatest condemnation of intensive animal rearing is that the animals do not live before they die, they only exist' (Harrison 1964). William Thorpe, in an appendix to the 1965 Brambell Report that examined the assessment of pain and distress in animals, suggested that '[t]he reactions of animals to the kind of stimuli that cause pain or fear in ourselves are very often but not always similar to our own, so we immediately have a sympathetic feeling for the animal' (Thorpe 1965).

Such 'sympathetic feelings for the animal' under the circumstances that Thorpe describes above have undoubtedly been the driver for much AWPL across many jurisdictions, setting limits on the harm animals must endure in different husbandry systems. For example, within the UK, the Agriculture (Miscellaneous Provisions) ACT 1968 was a direct outcome of the Brambell Report, with its legal principle behind statutory 'Codes of Recommendations for Welfare' (of various farm species) later being incorporated into the AWA 2006 (Sections 14–17). Other examples within the European context might include the raft of directives and regulations to provide protection for animals across a range of usages and species such as regulations concerning the husbandry of animals kept for farming purposes (98/58/EC), for scientific purposes (EU/2010/63) or zoological purposes (EU/1999/22), along with requirements for how they may be transported (EU/2005/1) or killed (EU/2009/1099), with many similar examples of legislation protecting different utilities of animals across the world. It does not seem unreasonable to suggest that Thorpe's concept of 'sympathetic feeling for the animal' was also the basis on which many convictions for 'cruelty' or 'un-necessary suffering' were made in the past. That is, they were based upon 'the reactions of animals to the kind of stimuli that cause pain or fear in ourselves'.

Such an anthropomorphic approach to reducing or avoiding suffering in animals is admirable (with anthropomorphism being defined as 'the attribution of human characteristics (including the

projection of subjective states and feelings) to non-human entities' (Morton et al. 1990)) and has undoubtedly contributed massively to protecting animal welfare. However, as the UK's Farm Animal Welfare Committee (FAWC)[6] discusses, over recent years there has been a shift from 'heuristic' approaches to the policy making in relation to animal welfare, (i.e. based on 'belief, anecdote, tradition and hearsay'), to one where animal welfare science has 'provided evidence for animal suffering, sentience and consciousness' (Farm Animal Welfare Committee 2014). Indeed, part of FAWC's remit is to provide such scientific evidence to the UK government on the subject of animal welfare to assist with policy making, mirroring similar functions in the EU's European Food Safety Agency (European Food Safety Agency nd). Such scientific evidence is often able to provide objective criteria about what animals actually want, or want to avoid, and data about the consequences on an animal's physiology, behaviour and potential pathological state if its specific needs are not met by the husbandry system, or situations that an animal finds itself in.[7] In the UK, the Brambell Report was a significant stimulus to beginning such scientific work, with early work focusing on preference and *motivation*.

Both the history and current state of research into preferences and motivation have been succinctly reviewed (e.g Fraser and Nicol 2011, Widowski 2010), and will not be laboured here. However, the principle behind such scientific studies is that by providing animals (including differing species, and at different stages of their life) with different choices, 'preference/choice tests' can be used to determine what factors in an environment an animal prefers, or finds aversive, by observing their behaviour and measuring physiological changes in them. Operant tests, where an animal is made to work for something it wants, or wants to avoid, can similarly be used to determine the relative value of a resource to an animal, that is, the strength of their preferences or aversions. Here, a 'resource' is defined as 'a commodity (e.g. food, warmth, space), or opportunity to carry out an activity (e.g. interact with another animal, or escape from a threat' (modified from Broom and Fraser 2007)), and definitions for preference and operant tests are given in the glossary. An early example of such research was the choice tests conducted by Hughes and Black (1973) that (unexpectedly) found that chickens kept in intensive poultry houses did not prefer the type of wire flooring that the Brambell Report had recommended be installed for the benefit of their welfare, but the type of wire floor that the committee had (from an anthropomorphic perspective) deemed unsuitable. Similarly, Manser et al. (1996) report studies in rats

[6] The FAWC has its origins in the Brambell Report.
[7] Needs are defined here as 'a requirement, which is part of the basic biology of an animal, to obtain a particular resource or respond to a particular environmental or bodily stimulus' (Broom 2014).

demonstrating the importance of the nature of the floor in this species by requiring them to lift weighted trap doors to access the different floor types (wire vs. solid). By applying different weights to the doors required to access the different floor types, it was possible to ascertain how hard the rats are prepared to work to access the different resources (potential environmental comfort for their feet and a sense of security), with the workload involved in lifting the weighted doors giving an indication of the importance of the resource to the animal. Another, and more current, example of a zoocentric (animal centric) approach to research into animal welfare are the studies of the relative averseness of various anaesthetic agents and gasses to animals that may be used to kill them in abattoirs, or during biomedical research. Such studies have shown that many species find carbon dioxide particularly aversive (in comparison to a number of other anaesthetic agents or hypoxic gas mixtures used for killing), by examining the strength of their preference to avoid it, and/or their behaviour and physiological responses when unable to escape from it (e.g. Llonch et al. 2012, Rodríguez et al. 2016, Wong et al. 2012).

In addition to studies on choices and the strength of preferences demonstrated in the above testing situations, studies on the range of behaviours exhibited by animals over a period of time can also be used to provide data on what might be defined as 'normal behaviour' in a species. Different types of behaviour can be classified, and the relative amount of time spent conducting these various behaviours catalogued (time budgets). Such observational studies generate what are referred to as '*ethograms*' (defined as 'a detailed description of the behavioural features of a particular species') and can be used to record what the behavioural characteristics are for a particular species or for an individual animal of that species (Broom and Fraser 2007). Information from ethograms provides data about what normal activities/actions/behaviours the species normally exhibits, allowing an assessment of what is important to the animal by virtue of the amount of time devoted to it (time budgets). While such assessments require a degree care in interpretation – both at a species level and at the level of an individual animal's ethogram – significant deviations in an individual animal's ethogram from that of the species may indicate that its needs are not being met, with measurable changes in its physiology also potentially giving an indication of this.

'Abnormal behaviour' has been defined as 'behaviour in an individual animal that differs in pattern, frequency or context from that shown by most members of a species (in conditions that allow a full range of behaviour)' (Broom and Fraser 2015). Classification systems exist to formally describe these (e.g. Broom and Fraser 2007c) and can be used as an indicator that an animal's needs are not being met in some way. By depriving animals of something in their environment that might be considered

important to them, and examining their ethograms in the context of those of a similar species who are having this potential need addressed, deviations in behaviour can be compared, and an assessment of the importance of the resource to the animal made. Similarly, changes in the animal's physiology or anatomy (at gross and microscopic level) can be studied and catalogued as its body attempts to cope with such deprivations. In terms of motivational mechanisms, if a need is not being met, this would be expected to generate inputs into the brain to bring about behavioural change to enable an animal to try and meet these needs. The stronger and more urgent the input (in terms of the threat to the animal's viability), the more likely the animal is to try and address its 'need deficit' by changing its behaviour to address this need. Broom and Fraser (2007) refer to these inputs to the brain as 'causal factors', defining them as 'inputs into a decision making centre, each of which is a representation of an external change or internal state of the body'. Hence, an animal whose need for nutrition is not being met would be expected to be more motivated to acquire food than those not in this situation. It would do so, for example, by showing a greater 'time budget' devoted to behaviours involved in acquiring it. And when the deprivation becomes more severe, the emergence of abnormal behaviours may be observed, such as aggression, and/or eating of food sources or objects not normally consumed, through to weakness and collapse. Similarly, physiological changes associated with food deprivation would be expected to occur, and eventually changes in its anatomy at gross and microscopic level, such as emaciation, and loss of fat storage cells in the tissues.

In summary, motivational studies from animal welfare science can provide data about what actually matters to animals (their needs) by examining their preferences, and the strength of these, by observing their behaviour, and the consequences of depriving them of these on their behaviour, their physiology and their anatomy. Deprivation of these needs induces motivational changes in their brains to modify measurable aspects of their behaviour and physiology to cope with the deprivation (adaptation) to remedy the situation. A failure in the ability to adapt to the deprivation results in measurable pathological changes in their behaviour, physiology and anatomy.

Physiology, homeostasis, stress, distress and suffering

As discussed above, observation of changes in an animal's behaviour in various environmental situations can give an indication of what an animal finds important to it, in terms of what is in its best interests. Clearly maintenance of mental and bodily stability is important to its survival as it copes with variations

in its environment. Failure to do so may result in its death or a reduction in its evolutionary fitness from a Darwinian perspective (e.g. Orr 2009, Dawkins, M. 1998, Dawkins, R. 2016 for further discussion). If it is unable to adapt, it may die, or at least be less likely to be able to propagate its genes into future generations. This approach has been summarised in a statement by the National Research Council of the USA (1992) which states:

> The ability to avoid, escape from, or control pain and other inducers of stress and distress is critical to the survival and well-being of many animals. Mechanisms that contribute to those abilities involve biochemical, physiological or psychological changes, and can be expressed behaviourally as the homeostatic processes of adjusting to altered environmental conditions.

There are many definitions of '*homeostasis*', including 'the tendency of the body to maintain behavioural and physiological equilibrium' (NRC 1992), 'the maintenance of a body variable in a steady state by means of physiological or behavioural regulatory action' (Broom and Fraser 2007b) and 'the steady state obtained by the optimum action of counteracting processes (physiological regulation)' (Cannon 1914, cited by Fowler 1995). However, the underlying principle is that an animal will use homeostatic mechanisms as an attempt to maintain bodily and mental stability because it is in their best interests to do so. The NCR's statement involves the term 'inducers of stress and distress' and aside from the fact that the term 'distress' is used in some animal welfare protection legislation and hence has consequences both in terms of policy making and litigation,[8] some understanding of these terms from animal welfare science (in the context of homeostasis and their relationship to suffering) may be helpful. This will now briefly be discussed.

There are some excellent reviews of concepts of what is meant by '*stress*' in relation to animal welfare science (e.g. NCR 1992, Fowler 1995, Broom and Fraser 2007a, NCR 2008, and Blanche et al. 2011). The subject can be complex, however, and the language confusing due to unclear terminology. As Dominique Blanche et al. (2011) point out, in engineering terms, stress is the load applied to a structure, and the word strain is used to describe the response of the structure to that stress, bemoaning the similar lack of clarity in biological discourse. I have therefore tried to be clear about the meaning of words used in this paper, by overtly defining the terms used, and referencing the source of those

[8] E.g. in national legislation deriving from Article 13 of EU Regulation 2010/63/EU.

definitions where possible. A useful (if inaccurate from an engineering perspective) definition of stress is cited by Murray Fowler (1995) as 'the cumulative response of an animal resulting from interaction with its environment via its receptors'.[9] Fowler thus argues that a stressor can be defined as 'a stress producing factor which interacts with a receptor system in the animal's body'. Similar definitions may also be helpful, such as that of the NRC, who define stress as 'the effect produced by external (i.e. physical or environmental) events or internal (physiological or psychological factors), referred to as stressors, which induce an alteration in an animal's biological equilibrium' (NRC 1992). Another useful definition is Gary Moberg's (2000) who defines stress in animals as 'the biological response elicited when an individual perceives a threat to its homeostasis'. Moberg argues that once an animal's central nervous system perceives a threat to its homeostasis (both physical and psychological), 'it develops a biological response or defence'. Usefully he goes on to outline four categories of responses which the animal may make in attempt to regain its mental and bodily stability, and which are capable of objective scientific measurement: the behavioural response, the autonomic nervous system response, the neuro-endocrine response and the immune response. While interpretation of data relating to the stress response in an animal may be complicated, and require expert input, measurement of parameters relating to the animal's physiological state, and particularly the last three categories of the stress response, in addition to observed behavioural changes, can provide a sound basis for determining the extent of stress an animal is enduring.

As discussed earlier, adaptation is 'the use of regulatory systems, involving behavioural and physiological mechanisms that allow an animal to cope with its environment' and coping has been defined as 'having mental and bodily stability'. In this context, and that of a discussion of stress, Broom's definition of welfare as 'the state of an animal with regard to its ability to cope with its environment' is particularly helpful. When an animal struggles to, or cannot pay the behavioural and/or metabolic costs of homeostatic mechanisms to enable it to cope with its environment, it can be considered not to be coping well and therefore to have poor welfare. Hence, objective measures of the parameters outlined by Moberg can provide a basis on which to determine the degree of (the) stress (response) an animal is undergoing – i.e. the extent to which it is able to cope – and hence the state of its welfare. However, at a

[9] In engineering terms, that would be the 'strain' shown by the animal, or in biological terms perhaps more correctly 'the stress response' (Moberg 2000).

practical level, the NRC (1992) point out that it is 'sometimes difficult to determine whether an animal is undergoing a normal process of adapting to a state of stress, or whether it is in distress'.[10]

Having introduced '*distress'* into the discussion, it is important at this stage to distinguish between the term 'distress' as used in the context of a failing biological or mechanical system, and as used in more common language to refer to a negative and unpleasant feeling experienced by a sentient animal. This is discussed subsequently in detail, but in this current context, the term distress is being used to describe objectively verifiable scientific data that suggests an animal's homeostatic mechanism is struggling, or failing, to cope with stressors.

Moberg (2000) uses the concept of stress and strain from engineering to look at measurable physiological and pathological indicators in animals to determine when an animal moves from a state in which it is coping well with stressors, to one where the system starts to, and finally, breaks down. If an animal is easily meeting the metabolic and/or physiological requirements for adaption, with no significant adverse effect on its functioning (the elastic state of the strain response), he considers the animal's welfare to be good. This equates with what the NRC describes as a 'state of comfort' for an animal, which they define as 'a state of physiological, psychological and behavioural equilibrium in which the animal is accustomed to its environment, and engages in normal activities'. Such a state should be scientifically definable in terms of the animal's behaviour and physiology, with parameters being in the 'normal' range for that species when its needs are being met. As the effect of the stressors on an animal's system increases to the point where it exceeds the 'tensile strength' of the system (in engineering terms) to cope with that level of stress, some deviation from the animal's normal biological function can be measured, in terms of its physiology/and/or behaviour.[11] While the system may recover from the effect of the stressors, because these have exceeded the system's 'elastic limit', some cost is incurred to the animal in terms of its ability to maintain its homeostatic balance, and while not yet becoming pathological, physiological and behavioural changes in the animal would suggest that the animal is becoming stressed. When the homeostatic mechanisms deployed to enable an animal to cope with stressors in its environment fail, Moberg considers that the animal starts to enter a 'pre-pathological

[10] In Broom's terms, when that cost to the animal of coping with the adaptation required is high.
[11] This state appears similar to what the NRC (1992) describe as discomfort, which they define as 'a minimal change in an animal's adaptive level or baseline state as a result of changes in its environment or biologic, physical, social or psychological alterations; physiological or behavioural changes that indicate a state of stress might be observed, but be not so marked as to indicate distress'.

state'. This eventually leads to behavioural, physiological and anatomically describable pathologies from which the animal cannot recover. Such a situation resembles the description of distress in animals suggested by the NRC (an aversive state in which the animal is unable to adapt completely to stressors and the resulting stress, and shows maladaptive behaviours and pathological conditions). It also has considerable similarly with Moberg's own view of distress, according to whom it is 'the point at which the stress response is sufficiently severe or prolonged it shifts sufficient resources to impair other biological functions'. Moberg goes on to say that 'when this occurs, the animal enters the pre-pathological state, is at risk of developing a pathological state and experiencing distress' (Moberg 2000).[12]

The concept of the stress response provoked in animals, as a result of a failure of the environment to provide them with their biological needs, is invaluable in determining whether an animal is *suffering*. By examining objectively measurable physiological, behavioural and pathological data from an individual animal (as for example presented in evidence in a court case), it is possible to reasonably determine the extent to which a failure to provide for its needs has impacted on its welfare and to what extent its homeostatic mechanisms have reached a point of distress. Since the Brambell Report of 1965, animal welfare science has provided a huge body of objectively verifiable peer-reviewed data on the physiology, anatomy and behaviour of animals in situations where their needs are being met, and the changes that occur in these parameters when they are not, and therefore, when their homeostatic mechanisms are becoming distressed. Space precludes a resume of biochemical/physiological, behavioural and anatomical/pathological parameters that can be used to examine the four areas of an animal's biology that Moberg states are important criteria to examine in relation to the stress response.[13] However, good overviews of some of the parameters and methodologies used for such assessments are available (e.g. Gregory 2004, Broom and Fraser 2007a, and Blanche et al. 2011) and include parameters such as ethograms, hormone levels, biochemical and haematological parameters, clinically observable data such as that relating to the animal's heart and breathing rate, and temperature, as well as anatomical observations at gross and microscopic level. Provided experts in the field of animal welfare interpret data

[12] Perhaps confusingly, these descriptions of 'distress' are very similar to definitions that have been used for 'stress' by other authors (e.g. Broom 2014 and Fraser et al. 1995); these have been included in the glossary under the term 'stress', but put in italics to delineate the difference between how I use the terms 'stress' and 'distress' in this article, and how they are used by the above authors.

[13] To wit, the behavioural response, the autonomic nervous system response, the neuro-endocrine response and the immune response.

which is produced in evidence in court about animals that are the subject of cases brought for un-necessary suffering, courts can be in a position to make valid and reasonable assumptions about the state of an animal's welfare. Hence, by examining scientifically demonstrable parameters relating to aspects of an animal's physiology and behaviour, the court can come to a decision based on objective criteria as to whether the animal's homeostatic mechanisms had been compromised to the point at which they had become distressed. An example of this approach is exemplified by Broom and Andrew Fraser (2007) who ask a number of questions in relation to an animal's physiological and behavioural parameters to determine the state of its welfare. These questions are shown in Table 1.

Behavioural parameters	**Physiological parameters**
What physiological indicators of pleasure are demonstrable?	What physiological indicators of pleasure does the animal demonstrate?
What is the extent to which strongly preferred behaviours are shown?	To what extent are normal physiological processes and anatomical developments are possible?
What is the extent to which the variety of normal behaviours is exhibited?	Is the animal demonstrating physiological attempts to cope?
To what extent are behaviours associated with attempting to cope with its environment shown?	What is the extent to which the animal is undergoing suppression if its immune system?
To what extent are aversive behaviours shown?	What are the extent of disease processes in the animal?
To what extent does the animal demonstrate behavioural pathologies?	What is the extent of damage to its body?
	To what extent are its circumstances reducing its ability to grow and reproduce, and shortening its life expectancy?

Table 1. Questions that may be asked in assessment of an animal's welfare based on its behaviour, its physiology, and its anatomical state (modified from Broom and Fraser 2007a).

4. Welfare, sentience, emotions and feelings

The astute reader of this article will have noticed that much of the above discussion about animal *welfare* is couched in terms of the language of engineering, reflecting an almost Cartesian mechanistic approach to animal welfare, where animals are merely machines that have evolved to propagate their genes into the future in a way suggested by Dawkins. According to this view, failure to meet its needs results in a breakdown of the machine in much the same way as failure to meet a car's needs by not servicing it at the required times will cause it to fail. This is certainly likely to be the case for some lower animals, although the limits at which sentience emerges in the evolutionary phylogeny is still a topic for debate. In legislation there are often inconsistencies even within the same country. In the UK, for example, some invertebrates are protected under the Animal (Scientific Procedures) Act 1986 amendment regulations 2012, Section 3, but not at present under Section 1 of the AWA 2006. However, the three definitions of animal welfare quoted at the beginning of the article all refer to the animal's internal mental state ('feeling good' (Webster 2005), 'subjective experience' (Fraser et al. 1997) and 'mental stability' (Broom 2014)), along with the overtly describable physical characteristics pertaining to the state of its welfare.

As discussed in the first part of this article, the presence of *sentience* in a species is increasingly the boundary at which legal protection is being afforded to an animal in terms of its welfare (see e.g. Section 1 (4) of the AWA 2006 in the UK), and in terms of what sentience is. Webster's view that a sentient animal is 'one for whom its feelings matter to it' is a useful starting point. The questions therefore arise: what are feelings, and how do we know they occur in animals (human or non-human) who cannot directly report their internal mental state to us? Again, as previously discussed, Thorpe's assertion that '[t]he reactions of animals to the kind of stimuli that cause pain or fear in ourselves are very often but not always similar to our own, so we immediately have a sympathetic feeling for the animal' provided an anthropomorphic justification for the assumption that animals have feelings and are therefore sentient.

This heuristic and anthropomorphic approach is not unreasonable, and has been argued for as a 'precautionary principle' in regard to protecting animal welfare in legislation (e.g. Robertson 2015). Such an approach to animal welfare is exemplified by the Organisation for Economic Co-operation and Development's (OECD) guidance document on the use of experimental animals used in safety evaluation. This document states: 'If something is known to cause suffering in humans, it should be assumed to cause suffering in animals', where it defines suffering as '[a] negative emotional state that in human beings is produced by persistent pain/and/or distress' (Organisation for Economic Co-operation

and Development 2000). Similarly, this anthropomorphic precautionary principle overtly forms part of legislation to protect animals used in biomedical research in the USA.[14] However, data from animal welfare science can be used to better inform the validity of anthropomorphic concerns by providing objective criteria on which to determine what an animal's subjective feelings are, along with a more nuanced approach to what their needs are, and how they respond when they are deprived of them.

The above assertion is based on the link between the words '*emotions*' and '*feelings*' as used in animal welfare science and the assumption that from an evolutionary perspective, 'feelings' did not arise *de novo* in *Homo sapiens sapiens*. This will now be discussed. A useful starting point for this discussion is the afore mentioned assertion from Decety who suggests that 'the human social brain, as well as all other mammalian brains, is fundamentally built on ancient emotional and motivational value systems that generate affective states as indicators of potential fitness trajectories'. This statement is predicated on findings that 'emotional and motivational value systems' have evolved in animal species over time, and confer some form of evolutionary advantage on species that have them. It is therefore unlikely that they are unique to our species. As discussed, animals are motivated to act in ways that are in their own interests, and make physiological and behavioural changes to enable them to cope with their environments. Part of this motivational mechanism is the generation of 'feelings' in the brain which cause behavioural change in response to changes perceived in the animal's body, or its environment. These changes are a result of inputs into the brain from receptors that monitor the environment at a distance (teleceptors), the interaction with the animal's surface structures (exterioceptors) or the consequences on the animal's biochemistry (interceptors) (Fowler 1995). These receptors cause changes in the animal's physiology and behaviour. The effect of these interactions between the animal and its environment is measurable and such describable physiological and behavioural states are often referred to as 'emotional states' in animal welfare science. This view of the role of feelings in motivating behaviour has been discussed by Mendl (2009), who suggests:

> Most emotion researchers consider that emotions arise in situations that are 'important' to the organism, in the sense that they may influence its survival and reproductive success. The primary function of emotions in these contexts is widely hypothesised to

[14] See U.S. Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training which state in principle 4: 'Unless the contrary is established, investigators should consider that procedures that cause pain or distress in human beings may cause pain or distress in other animals' (U.S Government nd).

> be to guide the animal's behavioural decisions in order to achieve survival goals – the attainment of valuable resources/rewards, and the avoidance of harm/punishment – perhaps by providing a 'common currency' that the animal uses to determine which behaviour or sequence of behaviours is most likely to enhance survival.

The expression 'emotional state' has a relatively well defined meaning in animal welfare science,[15] and is different from that used in every day language common parlance, where the words 'emotion' and 'feelings' are often used interchangeably. In animal welfare science, the word 'feeling' is usually used to describe an internal subjective mental state.[16] The term emotion has a different meaning, although one which may involve feelings. Broom defines emotions as 'physiologically describable conditions in individuals characterised by electrical and neurochemical activity in particular areas of the brain, autonomic nervous system activity, hormone release and peripheral consequences, including behaviour' (Broom and Fraser 2007b). The emotional state of an animal can thus be determined with reference to scientifically observable parameters in that animal, such as those discussed above in the section on homeostasis. Broom also acknowledges that emotions may be associated with 'awareness' (feelings), but he argues that this is not necessarily always so (Broom 2003). Boissy et al. 2007 take a similar approach to defining emotion as 'an intense affective response to an event that is associated with specific bodily changes'. Here, like Broom's definition, a specific emotional state can be described in terms of 'specific bodily changes'.[17] Subsequently Boissy has gone on to state that

> an emotion may be considered as having three components; a subjective component (what one feels), and two expressive components, a behavioural component (what the animal shows to others, e.g. facial expressions) and a neurophysiological component (how the body responds, e.g. physiological responses to stress) (Jones and Boissy 2011).[18]

Animal welfare science therefore argues that in sentient animals, describable physiological and behavioural states (Boissy and Jones's 'expressive component' of emotions) can provide a direct and

[15] It may vary slightly from author to author, however.
[16] E.g. a brain construct, involving at least perceptual awareness, associated with a life regulating system, which is recognisable by the individual when it recurs, and may change behaviour, or act as a reinforcer to learning' (Broom, and Fraser 2007b)
[17] Although Boissy et al. infer that it always contains an affective component as well, that is, it involves feelings.
[18] This view also resonates with that of Mendl et al. 2009.

objective mechanism for determining what the subjective component of the emotion is (what it feels about its situation). These feelings are important drivers of behaviour to address the challenges from the environment that are perceived by receptors in the animal and fed to the brain to motivate behaviours to regain the mental and bodily stability required for survival. Ewbank (1988) and Wolfensohn and Lloyd (1998) both provide a definition of distress that integrates Moberg's view of distress (a predominantly 'expressive' view in terms of emotional states) with that of Boissy et al. in relation to feelings and emotions. These definitions are reproduced in the glossary, and suggest that distress could be considered as a severe stress response in which there is some evidence that the animal is conscious of what is going on and finds it unpleasant – hence linking observable (expressed) behavioural and physiological and pathological changes in the animal to its conscious experience.

To exemplify the argument, one might consider an animal whose nutritional needs are being compromised. An absence of food will lead to receptors in the animal to signal that metabolic changes are required to adapt to this challenge to its homeostasis, causing measurable changes in its physiology and generating negative affective states (such as hunger) in the brain. These affective states will motivate the animal to seek nutrition to restore its metabolic balance and, once restored, the motivation will subside. However, should the need for nutrition not be met, the animal's mental and bodily stability will deteriorate as it is unable to adapt to the challenge to its homeostasis and its homeostatic mechanisms become distressed. Such severe challenges to the animal's homeostasis are manifest as an observable and measurable severe stress response, which suggests that it is the point at which the animal consciously finds its situation unpleasant as its attempts to cope with its situation are unsuccessful.[19]

If, as I suggest, suffering is considered to be a 'negative aversive unpleasant subjective feeling', while animals cannot verbally communicate their feelings to us, examining objective parameters relating to an individual animal's physiology and behaviour (and any pathological changes that may be occurring) provides an objective and valid mechanism to deduce what they are. By examining such parameters in the context of published data from welfare science literature, these objective measurements can be used to give a good indication of an animal's feelings about its situation, and hence whether its subjective feelings are negative, aversive and unpleasant, or not.

[19] That is, they are frustrated, defined as 'when an action generated by causal factors can not be achieved' (Broom and Fraser 2007b).

5. Freedoms, needs and welfare assessment systems

One of the early recommendations from the Brambell Report was that animals should be kept free from certain negative aversive mental states, by provision of needs which they describe in broad terms. These have become known as The Farm Animal Welfare Council's '*Five Freedoms*' and have become a foundation for informing AWPL, government and food industry policy across many jurisdictions (Farm Animal Welfare Council 2009). Briefly revisiting FAWC's Five Freedoms may be useful given my contention that suffering is a negative/aversive mental state. They are the following (FAWC nd):

1. Freedom from hunger and thirst, by ready access to water and a diet to maintain health and vigour.
2. Freedom from discomfort, by providing an appropriate environment.
3. Freedom from pain, injury and disease, by prevention or rapid diagnosis and treatment.
4. Freedom to express normal behaviour, by providing sufficient space, proper facilities and appropriate company of the animal's own kind.
5. Freedom from fear and distress, by ensuring conditions and treatment which avoid mental suffering.

Much of the work of animal welfare science since the Brambell Report has subsequently tried to address the issue of what, for example, is *an appropriate diet* for a particular animal at a particular state in its life (and in certain conditions of husbandry) to avoid hunger (1), or *what conditions and treatments* cause, or do not cause, mental suffering (5). As discussed previously, this has been done by using motivational studies and examining the consequences on the biology of animals in failing to meet their *needs*. Such studies providing objective data about the animal's behaviour, physiology and any pathological changes that may occur in situations where their needs are not being met. In the UK, such data has been used to inform 'Codes of Practice' regarding how animals must be kept in order to meet their needs to the minimum extent required in law. Such Codes have legal effect when it comes to prosecutions for causing un-necessary suffering when these needs are not met, as 'failure to comply with a relevant provision of a code of practice issued under this section may be relied upon as tending to

establish liability' (Section 14 (4)a Animal Welfare Act 2006). Similar approaches are used across many countries.[20]

At the level of practical *welfare assessment*, a number of authors and research organisations have reverse engineered FAWC's Five Freedoms to categorise the source of environmental factors that may give rise to subjective feelings. In this context, the work of David Mellor is helpful, as it provides a useful matrix on which affective states can be considered in relation to environmental factors which may challenge an animal's homeostatic mechanisms. It is referred to as 'Mellor's Five Domains Model' (Mellor and Beausoleil 2015). An excellent explanation is available at this reference, but Table 2 below may be helpful in explaining the principle behind Mellor's approach.

Physical/Functional Domains							
Survival related domains						*Situation related domain*	
1. Nutrition		**2.** Environment		**3.** Health		**4.** Behaviour	
Lack of food	Plenty of food	Too hot	Thermo-neutral	Injury	Fitness	Predator presence	Nursing offspring
5. Affective Experience Domain							
Negative affect	Positive affect	Negative affect	Positive affect	Negative affect	Positive affect	Negative affect	Positive affect
Hunger	Satiety	Heat distress	Comfort	Pain	Vitality	Fear	Contentment

Table 2. Mellor's Five Domains, showing examples of different situations relating to the four physical functional domains, and the consequences on the fifth affective experience domain, relating to nutritional needs, thermal requirements, health parameters and behavioural opportunities.

Mellor combines the imperatives in FAWC's Five Freedoms required to ensure that animals are free from the negative aversive states into four 'domains', which he refers to as the four 'physical/functional domains'. Of these four domains, Mellor refers to the first three as 'physical domains'. These include nutrition challenges, environmental challenges relating to the animals 'comfort'

[20] See e.g. the pan-European Directive 2010/63/EU which, in Annex iii, sets out requirements for the keeping of various species used in biomedical research.

and challenges relating to the animal's health (which he refers to as 'survival related factors'). Additionally, there is a fourth domain which he refers to as the 'functional domain' and in which he considers factors that may challenge an animal's behavioural needs (which he refers to as 'situational related factors' affecting the animal centred on restriction of 'agency'). In this context Mellor defines 'agency' as 'engagement in voluntary, self-generated and goal-directed behaviours' and this could be considered as the ability to carry out certain behaviours that are part of the animal's evolutionary Telos, such as specific exploration or threat avoidance behaviours. As has been described previously, objective physiological, behavioural and pathological data relating to challenges to the animal's homeostasis from the four physical/functional domains can be demonstrated if an animal's needs are not being met. Examples from the four domains might include: physiological, behavioural and pathological data relating to the nutritional status of an animal (nutritional domain); excessively high body temperatures recorded in animals (or vehicles) transporting animals (environmental domain); the presence of disease processes such as septic arthritis found at clinical examination or post mortem (health domain); or description of behavioural pathologies that are observed, such as excessive fear responses or stereotypic behaviour (behaviour domain).[21] Mellor then links these four physical domains with an 'affective experience domain' (the fifth domain) in a similar way to that which Boissy et al. use to link the expressive component of an emotional state with the subjective component of that emotional state (i.e. how the animal feels about its situation). Hence, while to some extent Mellor's 'Five Domain's Model' is not conceptually new (given FAWC's Five Freedoms), it brings together the concept of what an animal's affective state is (its feelings) by linking them explicitly to the demonstrable component of emotional states caused by challenge to an animal's homeostasis from specific components of the environment in which it lives. By scientifically examining the effect on these challenges on the animal's homeostatic mechanisms, the likely effect on the animal's 'affect' can be rationally inferred and hence whether it is experiencing suffering or pleasure.

Mellor refers to a number of affective states that an animal may be enduring (and can reasonably be linked with the describable component of their emotional state by virtue of objective measurements of their physiology, behaviour and any pathology present) – both positive (pleasurable) and negative (aversive). Aversive terms used include words such as thirst, hunger, nausea, pain, fear, anxiety,

[21] Stereotypical behaviour is a form of behaviour associated with poor welfare and is defined as 'repeated relatively invariant sequence of movements having no obvious purpose' (Broom and Fraser 2007 b; for a more detailed review of stereotypies see Mason et al. 2007).

frustration, debility, breathlessness (air hunger), helplessness and boredom. These affective states could reasonably be construed as forms of suffering if the challenge to the animal's homeostasis that generated these states was sufficiently severe that the animal was not able to cope with the challenge, that is, if it was becoming distressed.[22] Such an approach is also used by the EU Welfare Quality system for welfare assessment, although here, the scientific measures used to assess the animal's welfare state are made more explicit than in Mellor's Five Domain Model (which infers that measures can be made, rather than specifying what methods are used at a technical level). The EU funded 'EU Welfare Quality' project (Welfare Quality Network) was established to provide scientific data on which validated welfare assessments could be conducted in order to help consumers make purchasing decisions based on the welfare of the animals they are eating when they were alive (European Union). Like Mellor's approach it uses four welfare principles (good feeding, good housing, good nutrition and appropriate behaviour) as aims against which to measure an animal's welfare (i.e. whether these aims are achieved) and then asks observers to assess a number of criteria associated with these. The system then requires the development of validated measures to access the criteria (behavioural, physiological or anatomical) and define the methodology to access the measures. The relationship between the four principles and the twelve criteria are set out in Table 3, along with their relationship to FAWC's Five Freedoms and Mellor's Four physical domains.

[22] See the glossary for definitions of the ways some of the terms for these affective states are used in animal welfare science.

Principle	**Criteria**
Good Feeding *(Nutritional domain and Freedom 1)*	1. Absence of prolonged hunger 2. Absence of prolonged thirst
Good Housing *(Environmental domain and Freedom 2)*	1. Comfort around resting 2. Thermal comfort 3. Ease of movement
Good Health *(Health domain and Freedom 3)*	1. Absence of injuries 2. Absence of disease 3. Absence of pain induced by management procedures
Appropriate Behaviour *(Behaviour domain and Freedoms 4 and 5)*	1. Expression of social behaviour 2. Expression of other behaviours 3. Good human-animal relationships 4. Absence of general fear

Table 3. EU Welfare Quality Principles and Criteria, with FAWC's '5 Freedoms' and Mellor's 'Four physical domains' added in italics.

Welfare assessment methods such as those described above – using behavioural, physiological and pathological data from animals in different circumstances – can reasonable and objectively be used to determine whether an animal is suffering by virtue of enduring a negative aversive subjective mental state (feeling). As discussed, such an approach is used, for example, in relation to using validated measures of animal welfare to inform consumers of the welfare standards the animals they eat enjoyed (or otherwise) while they were alive. Such an approach also finds legislative expression in the field of biomedical research where it is used to inform decisions about granting legal permissions to conduct such research.

Statutory protection and assessment of animal welfare in biomedical research

In many jurisdictions across the world, prior legal approval of biomedical experimental procedures using animals is required before the research can begin. Such legal approval for causing harm to these animals usually requires a prospective ethical analysis of the proposed work, involving an assessment of the likely aversive impact of the research on the animal's welfare. Examples include Directive 2010/63/EU in the European Union, where an assessment of the harms caused to the animals protected under the Directive

must be balanced against the likely wider benefits that might accrue (Introduction, paragraph 39 Directive 2010/63/EU). A similar role for ethical analysis of animal use is required by Institutional Animal Care and Use Committees being mandated in the United States of America and established under the Health Research Extension Act 1984 (National Institute of Health nd).

Such 'harm-benefit analysis' prior to legal authorisation of research clearly requires an analysis of the degree of harm that is likely to occur to an animal as a result of different experimental procedures. Based on this analysis, the harms can then be weighed against the proposed likely benefits that will accrue to society. In the case of 2010/63/EU, these harms are classified into bands of severity of harm: non-recovery, mild, moderate and severe (Article 15 (1)), using the assignment criteria set out in Annex VIII of the Directive. This Annex sets out a comprehensive list of techniques that might be used in biomedical research and assigns them to the various bands of severity of harm.[23] While such a classification system for 'harms' animals may endure may be based in part on anthropomorphically driven assessments of the consequences of challenges to the animal's homeostasis by the various procedures it may undergo as part of the biomedical research, a substantial body of scientific evidence relating to the consequences for the animal's welfare has been generated on which an objective justification for such a classification system can be based (e.g. National Centre for the Replacement, Refinement and Reduction of Animals in Research (NC3Rs nd).

Such research is based in part on the legal requirement to minimise suffering to the animals in many jurisdictions and also the legal requirement to monitor the level of welfare of individual animals during the procedures, so that severity levels set during the licencing process for the research are not breached (e.g. Articles 24 and 39 of 2010/63/EU in the European Union, with a similar requirement in legislation in the USA (National Research Council 1992)). This therefore requires scientific methods for assessing the levels of suffering that occur during the experimental procedures, which can further inform decisions about the classification of the severity of suffering caused by various procedures. Annex VIII of 2010/63/EU may therefore provide a useful 'a priori' starting point for courts in determining whether an animal is likely to have suffered as a consequence of the situation it found itself in (and also the degree

[23] Within the Directive, procedure is defined as 'any use, invasive or non-invasive, of an animal for experimental or other scientific purposes, with known or unknown outcome, or educational purposes, which may cause the animal a level of pain, suffering, distress or lasting harm equivalent to, or higher than, that caused by the introduction of a needle in accordance with good veterinary practice'.

of suffering caused) by virtue of the scientific evidence that has been accepted by legislators in the European Union as sufficiently sound to justify its inclusion in the Directive.

6. Conclusions and summary

The above arguments have attempted to justify why the formulation for the definition of suffering in the Animal Welfare Act 2006 in the UK (as devolved)[24] is useful from the perspective of animal welfare science. This is because it allows the courts to consider a definition of suffering as an aversive/negative subjective mental state. Many aversive/negative subjective mental states may occur in animals as a result of challenges to their homeostatic state from the environment, should they be unable to cope with them. These mental states can reasonably be deduced with reference to observable changes in the animal's physiology, behaviour and pathological state. Such data can be used as evidence in court to show whether or not an animal has undergone an aversive/negative subjective mental state as a result of deprivation of its needs. Such an approach allows for the incorporation of a wide range of aversive/negative subjective mental states which are not defined in Primary legislation, with Mellor's 'Five Domains Model' being a recognised example of such an approach.

The subject of animal welfare science is a complex one, and evidence relating to objective data collected from animals that may have suffered may require careful interpretation by experts. However, provided experts in the field are clear about the terminology they are using in their reports, animal welfare science can be of considerable value by providing objective criteria on which a decision can be made about whether an animal has suffered. Unlike the purely anthropomorphic approach discussed by Thorpe, objective data presented in evidence and considered in the context of the published canon of findings from animal welfare science (i.e. about what really matters to animals and the consequences on their biology if these needs are egregiously frustrated) can be used to take a more 'zoocentric' approach to whether an animal has suffered. Such a zoocentric approach has been championed by Burghardt, who uses the term 'critical anthropomorphism' to describe a zoocentrically nuanced approach to interpretation of data relating to animal welfare. According to Burghardt, critical anthropomorphism involves 'statements about animal joy and suffering, hunger and stress, images and friendships which are based on a careful knowledge of the species, and the individual, careful observation, behavioural and

[24] 'Suffering means physical or mental suffering, and related expressions shall be construed accordingly'.

neuroscience research, our own empathy and intuition, and constantly refined publically verifiable predictions' (Burghardt 1997). As such, animal welfare scientists are therefore in a strong position to justify (or refute) claims about whether an animal has suffered, because of their training.

While I do not agree with Wooler's view that the definition of suffering in the UK's Animal Welfare Act 2006 is problematic for the reasons above, considerable sympathy for the problems associated with expert witness testimony in achieving convictions is warranted. Experts in the field of animal welfare science can provide considerable assistance to the court, but clearly defined use of terminology within the context of opinions offered by experts is important in avoiding fallacies of ambiguity, as is referencing from the literature of the justification for opinions presented. The paper by Baumgartner et al. (2016) cites reports from 42 veterinary experts, and the disagreements that may arise between them in relation to what suffering is and whether it has occurred. However, it does not state how many of these veterinary surgeons had additionally achieved recognised qualifications in the field of animal welfare science. Clearly it is for a court to decide whether to grant a witness 'expert status', but it is possible that the level of expertise in the field of animal welfare science may have varied considerably between the authors of the reports.

Veterinary surgeons, by virtue of their undergraduate training, will have had some formal education in assessment of animal welfare, as well as their predominant training in the field of animal health. Some may have postgraduate education leading to internationally recognised qualifications in the field. However, I would contend that in the same way that not all individuals who are experts in the field of animal welfare are veterinary surgeons, not all members of the veterinary profession can be considered experts in the field of animal welfare science (even if they have some basic knowledge of it). It is therefore possible that in some courts in the UK, confusing testimony from 'witnesses of fact' with that from 'expert witnesses' may have contributed to the problem that Wooler has identified. Some of the problem he describes in relation to expert witnesses does not originate from a failure of animal welfare science in assisting the court (by providing objective verifiable data on animals that can be interpreted in the light of the published science in that field) but may rather depend on the criteria by which the court accepts the status of a witness as 'expert'.

Glossary of terms from animal welfare science used in this paper

Adaptation

The use of regulatory systems, involving behavioural and physiological mechanisms, that allow an animal to cope with its environment (Broom and Fraser 2007 b).

Affective states

A wide range of pleasant and unpleasant (mental) states (Verbeek and Lee 2014).

Agency

Engagement in voluntary, self-generated and goal-directed behaviours (Mellor and Beausoleil 2015).

Animal Welfare

An animal's capacity to avoid suffering and sustain fitness (good welfare is fit, feeling good) (Webster 2005).

The state of an animal with regard to its ability to cope with its environment (Broom 2014).

Three components: health (fitness), naturalness (Telos) and subjective experience (feelings) (Fraser et al. 1997).

The quality of an animal's subjective experience (pain, fear, warmth pleasure) (CAWC 2003).

Anthropomorphism

The attribution of human characteristics (including the projection of subjective states and feelings) to non-human entities (Morton et al. 1990).

Anxiety

The reaction to a potential (as yet unreal) threat (Jones and Boissy 2011).

Arousal

The degree to which an emotional experience is calming or excitatory (after Kensinger 2004).

Awareness

A state in which complex brain analysis is used to process sensory stimuli or constructs based on memory (Broom and Fraser 2007b).

Behavioral Needs

Activities that animals have instinctive, intrinsic propensities to perform whatever the environment is like, even when the physiological needs that the behaviour serves are fulfilled and

even when these behaviours are not necessary for fitness (Mason and Burn 2011).

Boredom

The absence of behavioral opportunities (nothing to do) (Mason and Burn 2011).

Causal Factors

Inputs into decision making centres, each of which being an interpretation of an external change or internal state of the body (Broom and Fraser 2007b).

Comfort

A state of physiological, psychological and behavioural equilibrium in which the animal is accustomed to its environment and engages in normal activities (NRC 1992).

Consciousness

The ability to perceive and respond to sensory stimuli (Broom 2014).

Coping

Having mental and bodily stability (Broom 2004).

Critical anthropomorphism

Statements about animal joy and suffering, hunger and stress, images and friendships, based on a careful knowledge of the species, and the individual, careful observation, behavioural and neuroscience research, our own empathy and intuition, and constantly refined publicly verifiable predictions (Burghardt 1997).

Discomfort

A minimal change in an animal's adaptive level or baseline state as a result of changes in its environment or biologic, physical, social or psychological alterations; physiological or behavioural changes that indicate a state of stress might be observed, but are not so marked as to indicate distress (NRC 1992).

Distress

The point at which the stress response is sufficiently severe or prolonged it shifts sufficient resources to impair other biological functions (Moberg 2000).

An aversive state in which the animal is unable to adapt completely to stressors and the resulting stress and shows maladaptive behaviours and pathological conditions (NRC 1992).

The high level (stress) response which has high biological cost, is damaging to the the animal

and probably sensed by the animal as unpleasant (Ewbank 1988).

(When) considerable effort has been put into the (stress) response, of which the animal is aware. The animal can be considered to be suffering (Wolfensohn and Lloyd 1998).

A severe stress response in which there is some evidence that the animal is conscious of what is going on and finds it unpleasant (Fordyce, P.).

Emotion

Physiologically describable conditions in individuals characterised by electrical and neurochemical activity in particular areas of the brain, autonomic nervous system activity, hormone release and peripheral consequences, including behaviour (Broom and Fraser 2007b).

An intense affective response to an event that is associated with specific bodily changes (Boissy et al. 2007).

Empathy

The ability to recognize the emotions and feelings of others with a minimal distinction between self and the other (Decety 2010).

Ethogram

A detailed description of the behavioural features of a particular species (Broom and Fraser 2007).

Fear

A response to the perception of actual danger (Jones and Boissy 2011).

Feelings

A brain construct, involving at least perceptual awareness, associated with a life regulating system, which is recognisable by the individual when it recurs, and may change behaviour, or act as a reinforcer to learning (Broom, and Fraser 2007b).

Fitness

Reduced mortality, increased growth and reproductive success (modified from Broom 2014).

Frustration

When an aim generated by causal factors cannot be achieved (after Broom and Fraser 2007b).

Health

The state of an animal with regard to its ability to cope with pathology (Broom 2014).

Homeostasis

The maintenance of a body variable in a steady state by means of physiological or behavioural regulatory action (Broom and Fraser 2007b).

The tendency of the body to maintain behavioural and physiological equilibrium (NRC 1992).

The steady state obtained by the optimum action of counteracting processes (physiological regulation) (cited by Fowler 1995).

Motivation

The process in the brain controlling which behaviours and physiological changes occur, and when (Broom and Fraser 2007b).

Nausea

An unpleasant sensation often associated with the urge to vomit (Holmes et al. 2009).

Need

A requirement, which is part of the basic biology of an animal, to obtain a particular resource or respond to a particular environmental or bodily stimulus (Broom 2014).

Operant Test

Where a cost is imposed on an animal on access to a resource, or escape from an aversive situation, by requiring an animal to perform a task (cost is defined as expenditure of time, energy,or risk of adverse events) (after Broom and Fraser 2007).

Pain

An aversive sensation and feeling associated with actual or potential tissue damage (Broom 2014).

Pathology

The detrimental derangement of molecules, cells and functions that occur in living organisms in response to injurious agents or deprivations (Broom 2014).

Preference Test

When an animal is required to make a sacrifice of some kind when it gains access to some quantity of a resource, or spends a certain amount of time consuming it (anonymous).

Resource

A commodity (e.g. food, warmth, space) or opportunity to carry out an activity (e.g. interact with another animal, escape from a threat) (after Broom and Fraser 2007).

Sentient animal

One that has the capacity to have feelings and experience suffering and pleasure (Australian Government 2008).

One for whom its feelings matter (Webster 2006; Compassion in World Farming).

One having the capacity to suffer or experience enjoyment of happiness (Singer 1979).

One that has the awareness and cognitive ability necessary to have feelings (Broom 2014).

Stereotypic behaviour

Repeated relatively invariant sequence of movements having no obvious purpose (Broom and Fraser 2007b).

Stress

The biological response elicited when an individual perceives a threat to its homeostasis (Moberg 2000).

The effect produced by external (i.e. physical or environmental) events or internal (physiological or psychological factors), referred to as stressors, which induce an alteration in an animal's biological equilibrium (NRC 1992).

The cumulative response of an animal resulting from interaction with its environment via its receptors (cited by Fowler 1995).

The animal's state when it is challenged beyond its behavioural and physiological capacity to adapt to its environment (Fraser et al. 1975).

An environmental effect on an animal that overtaxes its control systems resulting in adverse consequences, and eventually reduced fitness (Broom 2014).

Stressor

A stress producing factor (Fowler 1995).

Suffering

A negative emotional state that in human beings is produced by persistent pain/and/or distress (OECD 2000).

One or more bad feelings continuing for more than a short period (Broom and Fraser 2007).

Essentially the extended experience of negative feeling in the spectrum from pain, through it to frustration (cited by Baumgartner et al. 2016).

Strong negative affective states such as severe hunger, pain or fear (cited by Baumgartner et al. 2016).

The physical and emotional syndrome that develops as a result of unrelieved severe pain (cited by Baumgartner et al. 2016).

Experiencing one of a wide range of extremely unpleasant subjective (mental) states (cited by Baumgartner et al. 2016).

A set of negative emotions such as fear, pain and boredom, and recognised operationally as states caused by negative emotions (cited by Baumgartner et al. 2016).

Suffering means physical or mental suffering, and related expressions shall be construed accordingly (Animal Welfare Act 2006 (as devolved in the UK), cited by Baumgartner et al. 2016).

The bearing or undergoing of pain, distress or tribulation (cited by Baumgartner et al. 2016).

A negative emotional state that in human beings is produced by persistent pain/and/or distress (OECD 2000).

Sympathy

The feeling of concern about the welfare of others (Decety 2010).

Telos

The set of needs and interests, physical and psychological, genetically encoded and environmentally expressed that makes up the animal's nature. It is the pigness of the pig, the dogness of the dog. (Rollin 1986, cited by Verhoog, H. 2005).

Valence

A positive or negative subjective mental state arising from experience (after Kensinger 2004).

'Zoocentric approach'

Considering the animal's needs from the perspective of its Telos (see 'Telos' above).

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