The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK
www.ufaw.org.uk

Animal Welfare 2015, 24: 241-253
ISSN 0962-7286
doi: 10.7120/09627286.24.3.241

Extending the 'Five Domains' model for animal welfare assessment to incorporate positive welfare states

DJ Mellor and NJ Beausoleil*

Animal Welfare Science and Bioethics Centre, Institute of Veterinary, Animal and Biomedical Sciences, Massey University PN452, Palmerston North 4442, New Zealand
* Contact for correspondence and requests for reprints: D.J.Mellor@massey.ac.nz

Abstract

Contemporary animal welfare thinking is increasingly emphasising the promotion of positive states. There is a need for existing assessment frameworks to accommodate this shift in emphasis. This paper describes extensions to the Five Domains model, originally devised to assess welfare compromise, that facilitate consideration of positive experiences that may enhance welfare. As originally configured, the model provided a systematic method for identifying compromise in four physical/functional domains (nutrition, environment, health, behaviour) and in one mental domain that reflects the animal's overall welfare state understood in terms of its affective experiences. The specific modifications described here now facilitate additional identification in each domain of experiences animals have which may be accompanied by positive affects that would enhance welfare. It is explained why the grading scale and indices for evaluating welfare compromise necessarily differ from those for assessing welfare enhancement. Also, it is shown that the compromise and enhancement grades can be combined to provide a single informative symbol, the scaled use of which covers the range from severe welfare compromise and no enhancement to no compromise and high-level enhancement. Adapted thus, the Five Domains model facilitates systematic and structured assessment of positive as well as negative welfare-related affects, the circumstances that give rise to them and potential interactions between both types of affect, all of which extend the utility of the model. Moreover, clarification of the extended conceptual framework of the model itself contributes to the growing contextual shift in animal welfare science towards the promotion of positive states whilst continuing to minimise negative states.

Keywords: *animal welfare, assessment framework, Five Domains model, grading system, positive welfare states, welfare enhancement*

Introduction

In contrast to an earlier almost exclusive focus on correcting negative welfare states, contemporary animal welfare science thinking is increasingly emphasising the promotion of positive states (Fraser 2008), a trend that has gained considerable momentum during the last 15 years (Fraser & Duncan 1998; Yeates & Main 2008; Broom 2010). Thus, conceptual frameworks originally developed to identify and manage mainly negative welfare states have needed to be modified or extended to accommodate the additional requirement to recognise and promote positive states (Farm Animal Welfare Council 2009; Webster 2011; Edgar *et al* 2013).

The Five Domains model was originally developed to assess welfare compromise in sentient animals used in research, teaching and testing (RTT) (Mellor & Reid 1994). Indeed, in 1997 the model was adopted as a mandatory part of the New Zealand regulatory approval system for all such RTT manipulations and, with minor modifications (Williams *et al* 2006), has been used ever since. Subsequently, its non-regulatory applications were broadened to include welfare assessment, for example, in farm livestock, companion animals, captive or free-living wildlife, and animals designated as pests (Mellor *et al* 2009; Beausoleil *et al* 2012; Portas 2013). In common with other approaches, the predominant emphasis was on negative welfare states. However, the increasing drive to include positive states in welfare assessments highlighted the need for the Five Domains model to be adapted to accommodate consideration of such states which, until now, had been given only limited attention using the model (Mellor *et al* 2009; Green & Mellor 2011). Accordingly, the major aim of the present review is to address this.

The paper begins with an outline of the key features of the model and its use to assess animal welfare compromise, and supports this with a brief explanation of the genesis of major experiences that give rise to negative welfare states. The paper then details specific modifications to the model that facilitate its use in identifying and evaluating experiences animals may have that contribute to positive welfare states. The grading of welfare compromise and enhancement is then considered, and the necessarily different frameworks for doing so are explained. Finally, the rationale underlying a scale that combines the grading of welfare compromise and enhancement is discussed.

The model is not intended to be an accurate functional representation of the body (Mellor & Reid 1994; Mellor *et al* 2009). Its key features are introduced using examples (Figure 1). As these are not exhaustive, and may in some species be inappropriate or unsupported, users of the model are encouraged to consider adding some examples and deleting others, as appropriate, in light of the biology and ecology of the species with which they are most familiar.

The principal benefit of the model is that it facilitates systematic and structured welfare assessments based on current understanding of the functional bases of negative and positive subjective experiences that animals may have. It is important to distinguish between these experiences, collectively known as affective states or affects (Fraser 2003; Duncan 2005), and the welfare states to which they contribute. Whereas only negative and positive affects, and not neutral ones, have major welfare significance, the negative-positive affective balance that represents an animal's overall welfare state can be neutral as well as negative or positive (Yeates & Main 2008; Farm Animal Welfare Council 2009; Green & Mellor 2011).

The Five Domains model for assessing welfare compromise

The original focus of the Five Domains model was on animal welfare compromise and the functional origins of the contributing negative affective experiences (Mellor & Reid 1994).

Basic structure of the model

The model distinguishes between four interacting physical/functional domains, ie 'nutrition', 'environment', 'health' and 'behaviour', and a fifth domain of 'mental state' (Figure 1). These domains are numbered 1 to 5. In the context of welfare compromise, the first four domains focus on *internal* physiological and pathophysiological disturbances due to nutritional, environmental and health-related problems (domains 1–3), and on *external* physical, biotic and social conditions in the animal's environment that may limit its capacity to express various behaviours or may otherwise pose significant challenges (domain 4) (Mellor *et al* 2009). Once such internal and external factors are assessed, their anticipated affective consequences are assigned to the fifth 'mental' domain, and it is these experiences that determine the animal's welfare state (Mellor *et al* 2009). Three examples illustrate this: (i) water deprivation causes dehydration which leads to osmoreceptor-stimulated neural impulses passing to the brain and generating the affective experience of thirst; (ii) tissue injury stimulates nociceptors to propagate neural impulses to the brain where they may be transduced into the experience of pain; and (iii) threatening external circumstances registered via cognitive processing of sensory inputs from visual, auditory and/or olfactory receptors may give rise to fear (Gregory 2004; Panksepp 2005; Denton *et al* 2009).

There are several areas of possible overlap between domains, one of which merits particular comment. Environmental influences are noted for both domain 2 (environment) and domain 4 (behaviour). The internal generation of affects (domain 5) associated with impacts in domain 2 (eg auditory discomfort due to loud noise) does not involve a major component of cognitive appraisal (Denton *et al* 2009), whereas most affects elicited by factors aligned with domain 4 (eg fear when loud noise is interpreted as threatening) specifically involve the animal's cognitive assessment of its external circumstances (Boissy *et al* 2007; Boissy & Lee 2014).

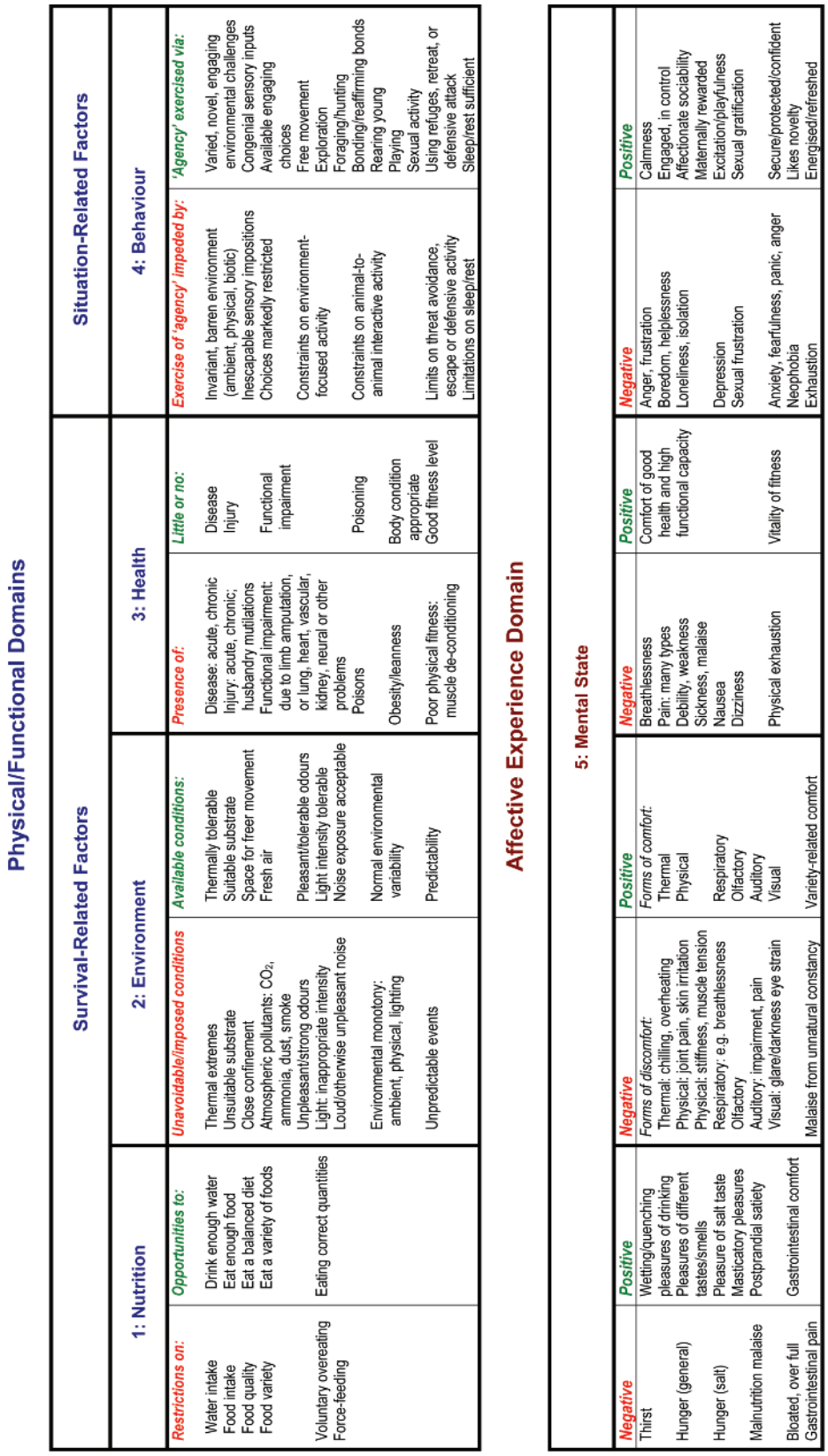
Expanding the range of negative affective states

The negative affects noted in the Five Domains model in 1994 were limited to thirst, hunger, anxiety, fear, pain and distress (Mellor & Reid 1994), mirroring those included in the Five Freedoms concept developed in 1979 (Webster 1994; Farm Animal Welfare Council 2009). Subsequently, attention was given to expanding this list in order to clarify what additional specific affects may be included under the generic term 'distress' (Mellor 2012a). This beneficially focused attention on a much wider range of possible negative impacts that need to be considered to give greater depth to welfare assessments conducted using the Five Domains model. The current list, supported by behavioural, physiological and neuroscience evidence (McMillan 2003; Gregory 2004; Panksepp 2005; Boissy *et al* 2007; Fraser 2008), includes breathlessness, thirst, pain, hunger, nausea, dizziness, debility, weakness and sickness, which are mainly associated with sensory inputs generated internally, and anxiety, fear, frustration, anger, helplessness, loneliness and boredom, which are associated mainly with the animal's cognitive assessment of its external circumstances. A recent example of the use of this wider list is the application of the Five Domains model to evaluate the *relative* negative impacts of poisons used to control vertebrate pests (Beausoleil *et al* 2012; Beausoleil & Mellor 2015a).

Survival-related negative motivational affects

The negative motivational affects referred to in this section are generated by conditions that arise in domains 1–3 of the Five Domains model and are grouped under a general heading of survival-related factors. Such affects are recognised as being essential constituents of genetically preprogrammed homeostatic mechanisms that impel animals to engage in specific goal-directed behaviours that are crucial for their survival (Fraser & Duncan 1998; Panksepp 2005; Denton *et al* 2009). Thus, for example: breathlessness elicits urgent respiratory effort to rectify compromised oxygen supply and carbon dioxide disposal; thirst elicits water-seeking and drinking to correct dehydration; hunger stimulates eating to reverse inadequate nutrient availability; and some forms of pain evoke avoidance or withdrawal behaviours to minimise physical injury (Denton *et al* 2009; Mellor 2012b). Death, injury or serious physiological impairment would usually result when such an elicited behaviour does not achieve its specific goal, especially when the eliciting situation becomes extreme. This observation highlights two points: first, the unmistakably negative character of such affects is essential to convey a strong sense of urgency to engage in the behaviour (Fraser & Duncan 1998; McMillan

Figure 1



The Five Domains model adapted to highlight survival-related and situation-related factors and their associated physical/functional domains, and examples of aligned negative or positive affects assigned to the mental domain. The overall affective experience in the mental domain equates to the welfare status of the animals (see text for details). Note that an animal exercises 'agency' (domain 4: behaviour) when it engages in voluntarily, self-generated and goal-directed behaviours (Wemelsfelder 1997; Spinka & Wemelsfelder 2011).

2003); and second, the intensity of each negative affect and its accompanying sense of urgency usually increase as the situation approaches its extreme (Denton *et al* 2009). Importantly, when the goal of the behaviour is achieved, the negative affect and the urge to engage in the elicited behaviour both subside (Denton *et al* 2009).

The pivotal role of such genetically pre-programmed negative affects in eliciting survival-critical behaviours calls into question the Five Freedoms notion that being free of these affects is the benchmark for good welfare (Webster 1994). More realistically, however, animals need to be managed in ways that avoid extremes of such experiences by keeping their intensity within tolerable limits that nevertheless still motivate essential life-sustaining behaviours. Hence, the original Five Domains model was conceptually focused on welfare compromise and its minimisation, not on the unrealistic and, in the above sense, undesirable objective of eradicating the negative affects that may constitute such compromise (Mellor & Reid 1994).

Whereas the examples of negative affects referred to above usually motivate animals to be behaviourally active in particular ways, other negative affects appear to motivate them to be inactive (Mellor *et al* 2009). Thus, debility, weakness and sickness are generally disabling and often induce inactivity, which may be accompanied by sleep and seeking isolation from others (Gregory 1998). Lingering moderate pain can have similar effects, as can breathlessness, dizziness and nausea (McMillan 2003; Gregory 2004; Mellor *et al* 2009). It has been suggested that the behaviours elicited by such affects may facilitate recovery from disease and injury, thereby enhancing survival. For example, the induced inactivity would beneficially minimise oxygen consumption when respiratory function is compromised, and it may also refocus metabolic support towards defensive inflammatory reactions and tissue repair following injury (Mellor *et al* 2009). Also, the induced isolation may promote rest (Gregory 1998) and reduce the risk of injury from other animals. It is obvious that virtually all animals will become diseased or be injured at some time in their lives (Mellor *et al* 2009; Green & Mellor 2011) so that attempts to completely eradicate the associated negative affects will almost always fail. However, the incidence, duration and intensity of such affects can often be minimised by the knowledgeable application of preventative and remedial husbandry and veterinary medical interventions (McMillan 2003; Wathes 2010; Green & Mellor 2011).

Situation-related negative affects

The Five Domains model helps to identify those situation-related negative affects that reflect cognitive responses of animals to being kept in impoverished environments or being confronted by threatening situations. Impoverishment is characterised by restricted opportunities to engage in environment-focused and animal-to-animal interactive behaviours (domain 4) as a result of, for example, limited space and barren or invariant features in enclosures, nutrient-dense feeds being provided as small meals that are consumed rapidly, and animals having little or no access to the company of others (Mason & Rushen 2006; Boissy *et al* 2007). Such negative affects (domain 5) may include feelings of anger, frustration, boredom, depression, helplessness, loneliness and isolation (see: Wemelsfelder 1997; Panksepp 2005; Mason & Rushen 2006; Boissy & Lee 2014). The development of such affects in severely restricted circumstances is considered to result from the thwarting of genetically pre-programmed or learned motivations to engage in behaviours that animals find rewarding, and/or to a failure to gain the anticipated rewards (Kirkden & Pajor 2006; Mason & Rushen 2006; Spinka & Wemelsfelder 2011).

Situations in the external environment that may be cognitively perceived as threatening are also referenced by considerations aligned with domain 4 of the model. These include possible or actual attack by predators, conspecific victimisation in confined spaces, separation from the protection of others, the presence of humans, overstimulation or challenging novelty, and hazardous environmental events such as flood or fire, situations which may generate negative affects (domain 5) of anxiety, fear, panic and/or nervous vigilance (Panksepp 2005; Boissy *et al* 2007; Beausoleil *et al* 2008).

The Five Domains model and promoting positive welfare states

The adapted model described here now refers to some survival-related physical/functional states and situation-related behaviours that may be accompanied by positive affects which, when experienced, would be welfare enhancing. Two types are described below: first, positive affects that may accompany or result from behaviours that are directed at minimising negative affects; and second, positive affects that may replace negative ones when animals are given or have opportunities to express more of their behavioural repertoire.

Positive affects elicited when some negative ones are minimised

The correction of particular physical/functional states that generate survival-related negative affects at high intensities (domains 1–3), representing compromised welfare, is characterised by reductions in the intensities of those affects to easily tolerated levels (Mellor 2012b). However, neuroscience evidence shows that this may at best only neutralise those affects (Denton *et al* 2009; Mellor 2012b). Yet a positive sense of well-being may arise indirectly if relief from intensely negative affects were to be experienced as hedonically positive, although such relief might be quite short-lived (Farm Animal Welfare Council 2009; Boissy & Lee 2014). Also, the removal of dominating negative affects may enable the animal to refocus on engaging in behaviours it would find rewarding (Fraser & Duncan 1998; Spinka *et al* 2001; Held & Spinka 2011). Such rewarding behaviours are assigned to domain 4 of the model and are briefly discussed in the next section and in more detail elsewhere (Mellor 2015a,b).

Table 1 The different grades of welfare compromise and welfare enhancement, and a conceptual matrix of combined grades derivable using the Five Domains model.

Welfare compromise grade	Welfare enhancement grade			
	None (0)	**Low-level (+)**	**Mid-level (++)**	**High-level (+++)**
A None	[A/0]*	A/+	A/++	A/+++
B Low	B/0	B/+	B/++	–
C Mild to moderate	C/0	C/+	–	–
D Marked to severe	D/0	–	–	–
E Very severe	E/0	–	–	–

* Theoretical possibility not likely to be encountered in practice (see text).

Some positive experiences (domain 5) may also result from sensory inputs generated as adjuncts of survival-focused behaviours motivated primarily by negative affects. Examples of these positive affects aligned with domain 1 include the oral wetting and quenching pleasures of drinking water initiated by thirst, the smell, taste, textural and masticatory pleasures of eating a range of foods initiated by hunger, and the comfort of post-prandial satiety as a behavioural goal of eating (Deag 1996; Fraser & Duncan 1998; Balcombe 2009). Aligned with domain 2 is the example of primarily negative affects that motivate behavioural avoidance responses to markedly cold or hot ambient conditions (Gregory 2004; Mellor *et al* 2009; Webster *et al* 2015), as these responses may lead to pleasurable experiences of, respectively, radiant heat on the skin or the cooling effects of immersion in cold water and/or its evaporation from the skin (Gregory 2004; Cabanac 2005). As such adjunct experiences are pleasurable (domain 5), anticipation of them may add an element of positive motivation for animals to engage in behaviours that are initially generated by negative affects (Fraser & Duncan 1998; Yeates & Main 2008; Broom 2010). Hence, depending on the circumstances or the stage of the behavioural response, such positive motivational affects might reduce, reinforce or substitute for the otherwise dominant affectively negative motivation (McMillan 2003; Mellor 2015b).

Replacing some negative affects with positive ones

An important distinction needs to be made between survival-related and situation-related negative affects. As noted above, remedial action taken to minimise the negative intensity of most survival-related motivational affects can at best reduce their intensity to easily tolerated levels, but this reduction in negative experiences usually would not of itself give rise to anything more than transient positive experiences (Mellor 2012b). In contrast, some situation-related negative affects may be replaced by positive ones when improvements made to impoverished or otherwise inappropriate environments enable animals to engage in more of the behaviours they would find rewarding (Yeates & Main 2008; Mellor 2012b, 2015b). This possibility has now been incorporated into the Five Domains model by including consideration of affects (domain 5) that may be associated with *restricting* or *providing* opportunities for animals to respond behaviourally to environmental variability and/or for them to actively engage in other environment-focused and animal-to-animal interactive behaviours (domain 4). Obviously, the provision of such opportunities is the basis of environmental enrichment (Young 2003; Mason & Rushen 2006; Edgar *et al* 2013) which, if successful, may lead to several impoverishment-induced or other negative affects being replaced by positive affects (Mellor 2012a,b). Of course, enrichment initiatives may also shift animal welfare states from being neutral (ie the negative and positive affects are in balance overall) to positive (ie positive affects predominate), and some existing positive welfare states may be further enhanced.

As noted above, impoverishment-induced negative affects may include feelings of anger, frustration, boredom, depression, helplessness, loneliness and isolation (Wemelsfelder 1997; Panksepp 2005; Mason & Rushen 2006). In contrast, stimulus-rich environments enable animals to engage in behaviours which are often characterised by a range of positive affects (Panksepp 2005; Boissy *et al* 2007; Spinka & Wemelsfelder 2011). These behaviours may involve, for example, various aspects of exploration, hunting or foraging, bonding or bond affirmation, maternal care, play and sexual activity (Panksepp 2005; Balcombe 2009; Mellor 2015b); and the associated positive affects may include, for example, feeling energised, engaged, affectionately sociable, maternally rewarded, nurtured, secure, protected, excitedly joyful and/or sexually gratified (McMillan 2003; Panksepp 2005; Mellor 2015a,b). Although some of these positive affects may still require validation (Boissy *et al* 2007; Yeates & Main 2008), emphasising that such a wide range is potentially available could lead custodians of animals to re-evaluate what further enrichment strategies they might implement. Thus, inclusion of these considerations in the behavioural domain fully aligns the Five Domains model with environmental enrichment initiatives that are explicitly focused on the promotion of positive welfare states (eg Spinka & Wemelsfelder 2011; Baumans & Van Loo 2013; Edgar *et al* 2013).

Grading animal welfare status using the Five Domains model

The foregoing discussion has dealt with the first step in the assessment of animal welfare status, ie the systematic and structured identification of the origins, valence (negative or positive) and character of significant affective experiences. The second step is to grade their impact, where the approaches to doing so are necessarily different depending on whether the affects in question are mainly negative, ie potentially welfare compromising, or mainly positive, ie potentially welfare enhancing.

Grading welfare compromise

Conceptually, the defining point of reference for animal welfare compromise is the most intensely unpleasant affects animals may experience, equated with severe suffering (Mellor *et al* 2009), and the primary objective of grading compromise is to facilitate the application of management practices designed to minimise those experiences (Mellor & Reid 1994). As noted above, the original focus of the Five Domains model on negative impacts of RTT procedures was subsequently extended to welfare assessments in a wider range of animal use contexts (Mellor *et al* 2009). Key principles underlying use of the model for such grading are emphasised here, whilst details of graded examples from different contexts may be accessed elsewhere (Mellor & Reid 1994; Sharp & Saunders 2008; Mellor *et al* 2009; Beausoleil *et al* 2012; Littin *et al* 2014).

The grading system applies a five-tier impact scale (A to E) to each of the five domains of potential welfare compromise (Mellor *et al* 2009); note that originally the scale designations were O, A, B, C and X (Mellor & Reid 1994). The grades represent increasingly negative impacts on the animals in question (Table 1; left hand column). Distinctions between grades are largely made on the basis of the following three factors: (i) the severity of the physical/functional impacts in domains 1–4; (ii) the related intensity and duration of the inferred affective impacts and their reversibility; and (iii) whether or not these impacts may need to be mitigated and/or ended by relocation to more benign conditions, by animal care or veterinary therapeutic interventions, and/or by euthanasia (Mellor *et al* 2009).

The severity of physical/functional disturbances underlying specific negative affective consequences may be graded as mild, moderate, marked, severe or very severe, ie A to E, on the basis of well-validated indices commonly used in numerous animal management and veterinary clinical assessments aligned with the nutritional, environmental, health and behavioural domains of the model (eg Morton & Griffiths 1985; Aitken 2007; Blache *et al* 2011). Such physical/functional grading is then used to guide the grading of the anticipated severity of all negative affective experiences likely to be associated with each of the first four domains, also on the A to E scale. Once all likely affects have been so graded, a judgement is made about their overall affective impact on the animal, and a grade is cautiously assigned for that *overall* impact (domain 5). Grades A and B represent no and low-level but tolerable negative affects, respectively, grade E represents exceptionally unpleasant negative affects experienced at very high intensities, and grades C and D represent intermediate levels. Thus, these grades equate to different degrees of welfare compromise ranging from none to very severe (Mellor *et al* 2009).

Note that designating the tiers numerically was explicitly rejected in order to avoid facile, non-reflective averaging of 'scores' as a substitute for considered judgment and to avoid implying a degree of precision that is not achievable (Mellor & Reid 1994; Williams *et al* 2006). Moreover, the grades are ordinal (Beausoleil & Mellor 2015a), so that an impact graded '4' would not necessarily indicate that it is twice as bad as one graded '2'. Likewise, intervals between mild and moderate impacts would not necessarily be the same as those between moderate and severe impacts. Also, terms such as mild and severe are relative, and their meaning will depend upon the affect being considered. For example, human report reveals that although mild pain and mild breathlessness may both be experienced as somewhat unpleasant, the dominant focus of severe pain may often be the extreme unpleasantness of the sensation itself, whereas with severe breathlessness the experience is almost always dominated by an acute fear of imminent death (Mellor *et al* 2000; Beausoleil & Mellor 2015b). Finally, there is uncertainty with regard to the relative impacts of different affects, such as breathlessness, thirst and nausea, and the relative impacts of a particular affect experienced for short periods at a very high intensity compared to long periods at a moderate intensity (Mellor *et al* 2009; Rushen & de Passillé 2014; Beausoleil & Mellor 2015a). Nevertheless, the Five Domains model does enable meaningful distinctions to be made between broadly different levels of welfare compromise of different types (eg Mellor & Reid 1994; Sharp & Saunders 2008; Mellor *et al* 2009), provided that its limitations are borne in mind (Beausoleil & Mellor 2015a).

Grading enhanced welfare

Whereas the defining point of reference for grading welfare compromise is suffering and its minimisation, the benchmark for the majority of positive welfare states needs to be different. Most indices of compromise aligned with the survival-related factors of domains 1–3 provide information about negative-to-neutral states, ie the presence or absence of physical/functional disruptions and, if present, their severity (Mellor 2012b). Consequently, most such indices, which include behavioural, anatomical, physiological, pathological and clinical diagnostic parameters (eg Morton & Griffiths 1985; Aitken 2007; Blache *et al* 2011), are not informative about the likely affective constituents of positive welfare states (Boissy *et al* 2007; Mellor 2015a). This highlights a significant disjunction, also recognised by others (Spruijt *et al* 2001; Boissy *et al* 2007; Edgar *et al* 2013), which needs to be accommodated within the model.

'Positive affective engagement' and 'agency'

It has been recommended that a new defining point of reference for welfare enhancement be adopted (Mellor 2015a). This focuses on the extent to which animals may experience 'positive affective engagement' (Mellor 2015a), as distinct from the absence of suffering which is denoted by grades A and B on the A to E scale of welfare compromise (Mellor *et al* 2009). Positive affective engagement represents the experience animals may have when they actively respond to motivations to undertake behaviours they find rewarding, and it potentially incorporates all of the associated affects that are positive (Mellor 2015a,b). It is argued that the genetically pre-programmed or learned, affectively positive impulses to engage in such behaviours and to also experience positive affects related to anticipation, goal achievement and memory of success (Fraser & Duncan 1998; Panksepp 2005; Biossy *et al* 2007), stand as sufficient justification in themselves to frame a reference standard that acknowledges the importance to animals of having opportunities to express those behaviours (Mellor 2015a,c). Accordingly, positive affective engagement aligns with the rewards an animal may experience when exercising 'agency', ie when it engages in voluntary, self-generated and goal-directed behaviours (Wemelsfelder 1997), which align with a general sense of being in control (Spinka & Wemelsfelder 2011). More specifically, agency denotes the intrinsic propensities (genetic or learned) of an animal to actively engage with its physical, biotic and social environment, beyond the degree demanded by its momentary needs, in order to gather knowledge and enhance its skills for future use in responding effectively to varied and novel challenges (Wemelsfelder 1997; Spinka & Wemelsfelder 2011). Thus, positive affective engagement includes the rewarding content of an animal's experiences whilst exercising agency. Note, however, that positive experiences may also arise in ways not directly related to the exercise of agency.

As noted above, evidence of positive experiences is not obtainable using most of the familiar physical/functional indices of negative affects aligned with domains 1–3; rather, an animal's behaviour (domain 4), understood to include its appearance, demeanour, activity/inactivity and vocalisations/silence, and evaluated in light of its circumstances, is likely to be more informative (Knierim *et al* 2001; Duncan 2005; Fraser 2008; Mellor 2015b). Indeed, changes in such behavioural attributes have long been recognised as indices of health and welfare (Morton & Griffiths 1985) and have been the primary indices used within animal behaviour science for many decades (Fraser 2008).

An increasing alignment of evidence from behavioural science (eg Dawkins 2006; Mason & Rushen 2006; Fraser 2008) and affective neuroscience (eg Panksepp 2005; Boissy *et al* 2007; Rolls 2007) is providing growing support for three key propositions: first, certain behaviours of animals, principally mammals and birds, may be interpreted in terms of what the animals may intend to achieve, ie their goals; second, such goal-directed behaviours themselves and behavioural responses to success or failure in achieving those goals may allow cautious inferences to be made about the accompanying positive or negative affects; and third, positive affects would likely become manifest whilst an animal actively engages in behaviours that involve impulse processing in reward-associated neural circuits (Mellor 2015a).

Several affects and related behaviours have been suggested to be reflective of positive affective engagement (Mellor 2015a) associated with the exercise of agency (Spinka & Wemelsfelder 2011). They include states of focused attention that may accompany some facets of an animal's goal-directed, energised exploration of, and interactions with, a stimulus-rich environment (Berridge 1996; Panksepp 2005; Spinka & Wemelsfelder 2011). Likewise, they include equally energised, highly focused predatory stalking by carnivores whilst hunting or the focused and engaged selective foraging by herbivores whilst grazing, where both take place in natural environments with abundant and varied food sources (Panksepp & Zellner 2004; Panksepp 2005; Spinka & Wemelsfelder 2011). Positive affects may also be anticipated to accompany some aspects of reciprocated affiliative interactions between animals (Nelson & Panksepp 1998; Carter & Keverne 2002; Lim & Young 2006), the dedicated maternal nurturing and care of young (Pfaff 1999; Fisher *et al* 2006; Panksepp 2006), the joyfulness of rough-and-tumble play (Vanderschuren *et al* 1997; Burgdorf & Panksepp 2006; Held & Spinka 2011) and the eroticism and orgasmic pleasures of sexual activity (Pfaff 1999; Fisher *et al* 2006; Balcombe 2009).

A framework for grading enhanced welfare

These observations raise the question of how the extent of welfare enhancement, understood in terms of positive affects associated with the exercise of agency, might be graded. The conceptual framework described here rests on three key elements. The first two are the availability of *opportunities* for animals to engage in self-motivated rewarding behaviours and the animals' actual *utilisation* of those opportunities. Grading opportunity and use separately helpfully provides more detail to underpin the third element, ie the making of cautious judgements about the overall level of positive affective engagement which, conceptually, is equated with the graded extent of *welfare enhancement* (Mellor 2015a). It may also be useful for exploring why resources expected to be valued are not utilised by animals (see below). Three interacting scales are therefore envisaged: an opportunity scale (Op), a use scale (Use) and a welfare enhancement scale (En), where each scale incorporates four tiers (adapted from Edgar *et al* 2013) representing zero (0), some (+), moderate (++) and extensive (+++) opportunity, use or enhancement (see Table 1; second row which shows the En scale).

The following are details of potential operational interactions between the different scales:

• Opportunity constrains use which therefore cannot be graded higher than opportunity, for example, an absence of opportunity (Op0) precludes any use (Use0), and high level opportunity (Op+++) enables all levels of use up to and including the high level (Use0 to Use+++);

• Thus, for all opportunity grades above Op0, use may be equal to or less than the maximum available opportunity and would be graded accordingly, so that Op+++ allows all grades of use from Use+++ down to Use0, Op++ from Use++ to Use0, and Op+ allows Use+ and Use0;

• Grades that are lower for use than for opportunity could arise in several ways, illustrated as follows: the available resources provide low-level stimulation or initially high-level stimulation declines due to over familiarity (eg Federation of Animal Science Societies 2010); the resources provided are not recognised by the animal as opportunities or seem threatening and are therefore not utilised (Dawkins *et al* 2003); neophobia inhibits or prevents use (Voelkl *et al* 2006; Marples *et al* 2007); and/or physical/functional compromise inhibits animals from taking advantage of otherwise stimulating resources (McMillan 2003) (see *Combining the grades* below);

• Use constrains welfare enhancement (En) so that an absence of use (Use0) precludes any enhancement (En0). However, exceptions to this principle might occur if positive affects were to arise in ways other than via the exercise of agency, for example, if animals experienced a sense of security or safety due to the presence of a resource, such as a refuge, which was not actively utilised;

• Each use grade above zero, once interpreted in terms of the possible extent of an overall experience of positive affective engagement, is assigned an equal grade on the welfare enhancement scale, thus Use+ equates to En+, Use++ to En++, and Use+++ to En+++;

• Grading the extent of positive affective engagement is based on cautious inferences regarding observed behaviours, including, but not limited to, potentially rewarding aspects of the exercise of agency via exploration, hunting or foraging, bonding or bond affirmation, maternal care, play and sexual activity, as summarised in Figure 1.

Identifying opportunities

Opportunities are defined here as resources expected to be perceived as valuable by an animal and thus as having the potential to enhance welfare, either by facilitating positive affective engagement through the exercise of agency or by promoting positive experiences in other ways. Identification of opportunities, so defined and, in some cases, the cautious grading of the relative value of different opportunities is undertaken in various complementary ways. Thus, the ways in which animals interact behaviourally with physical, biotic and/or social resources in natural, rangeland or other extensive environments can suggest opportunities for animals to experience positive affective engagement. Importantly, behavioural-neuroscience evidence suggests that such behaviours are likely to be affectively rewarding in such circumstances (Spinka & Wemelsfelder 2011; Mellor 2015b,c). In addition, in intensively managed confinement systems the choice of resources designed to provide enriching opportunities is informed both by insights such as those just mentioned and by behavioural science conclusions about animals' preferences, aversions and priorities evaluated in such systems (eg Kirkden & Pajor 2006; Fraser & Nicol 2011; Spinka & Wemelsfelder 2011). Determining the precise characteristics of resources that would distinguish different grades of opportunity above zero would depend, for example, on the animal type (eg avian or mammalian livestock, draught animals, sports animals, pets, wildlife), the lifecycle stage (eg newborn, juvenile, mature, pregnant, lactating, aged), and the context (eg free-range or confinement farming, use for motive power, recreational use, household companionship, game parks or zoos). In addition, the relative value of a particular opportunity may vary among individuals within a group and even for an individual animal over time depending on its experience, expectations and the available alternatives. In general, however, the wider the spectrum of available opportunities the wider the range of positive affects animals may experience, so that the grades Op+ to Op+++ would usually be distinguished by an increasing breadth of accessible resources that animals would find stimulating (eg Edgar *et al* 2013).

Use of welfare-enhancing opportunities

The relative impacts of different opportunities also need to be assessed by comparing how frequently, for how long, and in what ways animals may utilise them in relation to their usual unimpeded daily or seasonal time budgets. The highest grade of welfare enhancement might be assigned, for example, when mature animals utilise opportunities for engaged exploration, pleasurable food acquisition or enjoyable bonded companionship available each day (Use+++). A lower grade might be assigned to the maternal care of young where the overall time committed to nurturing and protecting them is largely seasonal (Use ++). And, finally, a much lower grade might be applied to mature animals exhibiting play behaviour in species where play is usually intermittent and mainly expressed by juveniles, and for sporadic sexual activity in those species where mating is usually seasonal (Use+). Of course, species' differences in grade should be considered as well. For example, a higher grade (eg Use++) may be assigned to play in those animals, including domestic dogs (Stafford 2007; Beaver 2009), where play behaviour continues to be expressed into adulthood (Held & Spinka 2011; Spinka & Wemelsfelder 2011), and may also be assigned to sexual activity when that occurs frequently during each day such as in the bonobo (*Pan paniscus*) (Manson *et al* 1997).

It is important to note with regard to the grading of welfare enhancement that no attempt is made at this time to include an assessment of the relative hedonic value of, for example, the different pleasures of exploring non-threatening environments, eating liked foods and companionable activities with bonded others. In addition, it is currently not possible to estimate the relative value of utilised opportunities that vary in terms of the frequency or duration of use, eg engaged foraging every day versus brief seasonal engagement in mating or parenting behaviour. These activities are regarded only as having facets that are affectively positive, ie rewarding, as outlined above and elsewhere (eg Fraser 2008; Mellor 2015a,b), and are simply accumulated for grading purposes on that basis. It is accepted that the hedonic significance of different positive affects probably differ, but

specific suggestions about this at present remain largely unsupported. Nevertheless, cautious interpretation of the overall affective impact in different situations as described here still permits helpful distinctions to be made between the broadly separated grades of inferred welfare enhancement, namely none, low- , medium- and high-level (Table 1).

Combining the grades for welfare compromise and enhancement

The above discussion shows that grading welfare compromise and welfare enhancement requires different frameworks and that both may be accommodated within the Five Domains model. This raises the issue of how these separate grades may be combined into an overall welfare grade. The simple solution is to include the designations for the compromise grades and the enhancement grades as two components in a single symbol. For example, spanning the full range of welfare status from worst to best, E/0 would represent very severe compromise and no enhancement, and A/+++ no compromise and high-level enhancement.

A matrix of possible combined grades has been provided in Table 1, but note that some combinations have been excluded. This is because for those grades the degree, nature and/or timing of compromise may hinder animals' utilisation of the available enhancement opportunities (McMillan 2003). Various examples will help to clarify different features of the matrix.

The state of no compromise/no enhancement (A/0) may never occur in practice because when negative affects elicited by physical/functional factors have been minimised, pleasures associated with, for example, drinking, eating and satiety may be experienced (see above). Also, to assign an A grade, there should be very low levels of negative affects that arise due to restrictions on the expression of pleasurable situation-related behaviours (Figure 1), thereby implying that some opportunities to engage in such behaviours would be both available and utilised. Thus, a combined grade of A/+ might represent a more realistic starting point than A/0 for grading different levels of welfare enhancement when there is no welfare compromise (Table 1).

Note that in the absence of welfare compromise (grade A) there would be few obstacles to animals fully utilising any genuine enhancement opportunities that are available, in which case the assigned grades on the enhancement scale (En+ to En+++) would directly reflect the range and features of the resources that are available (Op+ to Op+++). For example, if good bonding opportunities were available for a social species, but exploration and foraging opportunities were not, the combined grade assigned might be A/+, the availability of both bonding and foraging opportunities might lead to an A/++, and all three might attract an A/+++.

However, the situation is quite different when welfare compromise exists (ie grades B to E). In such cases, compromise-induced hindrances to the utilisation of potentially enhancing resources (McMillan 2003) and the availability of those resources (Edgar *et al* 2013) must both be considered. Thus, when resource availability is high (Op+++), specific features of compromised welfare at grades B to E would be the main determinants of resource use and any related enhancing benefits. In these cases, therefore, lower graded levels of enhancement (ie 0, + or ++) would reflect greater compromise-related hindrances to the utilisation of those resources, and *vice versa*. The conceptual matrix in Table 1 illustrates this. It shows that as the levels of compromise increase from grades B to E, associated increases in barriers to enhancement are reflected by enhancement at grade B being limited to + and ++, and at grade C to +, and no significant enhancement being possible at compromise grades D and E. Finally, lower resource availability (Op0 to Op++) in each situation would restrict utilisation independently of compromise-associated factors and would therefore need to be considered in the final grading of such enhancement and the related explanation.

Four examples illustrate potential interactions between predominantly physical/functional compromises to welfare represented by negative affects and an animal's ability or motivation to engage in behaviours it would find rewarding.

• Significant acute or chronic pain, whether caused by traumatic injury or pathological processes (Gregory 2004), may induce immobility, restrict movement or otherwise impair behavioural responsiveness to potentially pleasurable opportunities (McMillan 2003).

• Acute or chronic cardio-respiratory or respiratory impairment leading to breathlessness may restrict animals to low levels of physical activity (Packer *et al* 2012; Roedler *et al* 2013; Beausoleil & Mellor 2015b), thereby hindering their capacity to, for example, hunt vigorously, forage extensively, or respond actively to circumstances requiring escape or defensive attack.

• Sickness, weakness, nausea, dizziness and other debilitating affects (Gregory 2004; Beausoleil & Mellor 2015a,b) may motivate animals to remain inactive and isolated from others, and may make them disinclined to engage in activities that might be pleasurable (McMillan 2003).

• Amputation, traumatic deformation or paralysis of a limb that severely hinders mobility could engender a sense of helplessness or infirmity by limiting the capacity and the motivation to fully utilise resources requiring agility (McMillan 2003), for example, in tree-dwelling or climbing animals. Of course, in less-severe cases, for example, in cats or dogs with one limb amputated, the animals may retain the capability to engage in a wide range of behaviours, including enjoyable ones.

Clearly, those responsible for animals in such situations should adopt alleviation strategies where practicable. In the first three situations therapeutic interventions would likely be required, whereas successful welfare enhancement in the last situation would depend on the opportunities provided being within the animal's capability to utilise them beneficially.

Human factors and the Five Domains model

For many domestic and captive wild animals, humans have almost complete control over food and water availability, quality and variety, as well as other important features such as space, environmental complexity and social groupings (eg Cronin *et al* 2014). Thus, in such cases, humans will be the major factor determining compromise or enhancement in domains 1, 2 and 4 at least and any associated negative or positive affects in domain 5. Regarding domain 3, humans may impose some negative impacts on animals, for example, via husbandry amputations, intentional poisoning or when researching disease (Aitken 2007; Mellor *et al* 2008; Beausoleil *et al* 2012). In contrast, humans may remediate disease states or improve function or fitness (domain 3) in order to ameliorate their negative or enhance their positive affective consequences (domain 5), for example, by administering pain relief after surgical procedures or providing opportunities for self-motivated exercise that enhances muscle tone and vigour.

The relationship between humans and animals varies so that, with regard to domain 4, the effects of human presence or absence on animal welfare may vary too. For example, some animals may perceive humans as a threat leading to negative affects in domain 5. However, other animals may perceive humans as a resource, companion, conspecific or even pseudo-parent. In these cases, human presence may elicit positive affects in domain 5 while absence may elicit negative affects. Thus, for dogs, a preferred human's presence may provide opportunities for play or bond affirmation, whereas their absence may cause anxiety or loneliness (Stafford 2007).

As well as their presence or absence, the behaviour of humans has potential to compromise or enhance animal welfare. Human behaviour is influenced by various factors including the reason for interacting with the animals (eg food production vs pet ownership), and the person's knowledge, attitudes, skills, training and familiarity with the animals, as well as broader social and cultural factors (Hemsworth & Coleman 2011; Coleman & Hemsworth 2014). For example, improving stockperson attitudes towards their dairy cows was shown to positively influence both cow behaviour and productivity (Hemsworth *et al* 2002).

Such factors can also influence the recognition and grading of welfare compromise and/or enhancement along with the likelihood and success of any interventions. For example, human recognition of pain is poorer for rodents than for companion animals (Mellor *et al* 2008). Likewise, although it is recognised that farm and companion animals are equally capable of experiencing pain, companion animals are far more likely to receive pain relief (Mellor *et al* 2008). In addition, different priority may be given to avoiding or mitigating compromise or facilitating enhancement in certain domains. To illustrate, pig producers using confinement-based production systems emphasised the importance of minimising compromise and maximising enhancement in areas aligned with domains 1–3 rather than those relating to domain 4 (Spooner *et al* 2014). Use of the extended Five Domains model by those who hitherto have not made such detailed welfare assessments may beneficially broaden their perspectives and reveal ways to enhance welfare that they had not previously recognised.

Concluding remarks

It is apparent that the Five Domains model, which has well-established utility for identifying and grading animal welfare compromise, can be readily adapted to accommodate the analysis and grading of welfare enhancement (Figure 1). It is important to recognise, however, that the predominant foci of the grading scales for compromise and enhancement differ, being suffering and its mitigation for the compromise scale, and, for the enhancement scale, the capacity of animals to experience particular behaviours and/or their outcomes as rewarding (Mellor 2012a, 2015a). Hence, the informative indices for each scale are also different: many of those for welfare compromise reflect largely internal physical/functional disruptions associated with negative survival-related motivational affects (eg Mellor *et al* 2009), whereas many welfare enhancement indices are behavioural, reflecting mainly situation-related positive affects animals may experience when engaging in various pleasurable activities (Mellor 2015a,b). The emphasis of the model on cautiously made inferences about a wide range of affects is supported by extensive neuroscience and behavioural science observations, as indicated above and outlined in more detail elsewhere (eg Gregory 2004; Boissy *et al* 2007; Fraser 2008; Denton *et al* 2009; Boissy & Lee 2014), and this increases the confidence that may be placed in such inferences (Panksepp 2005; Fraser 2008; Mellor 2015a). Adapted thus, the model facilitates systematic and structured assessment of negative as well as positive welfare-related affects, the circumstances that give rise to them and potential interactions between both types of affect, all of which extend the utility of the model.

These observations are relevant to the assessment of quality of life (QoL), which is equivalent to animal welfare status, as QoL represents the overall balance between negative and positive affects an animal may experience at any particular time and/or over a particular period (McMillan 2003; Wemelsfelder 2007; Green & Mellor 2011). Thus, the combined symbol described here, by incorporating affect-based grades for welfare compromise and enhancement (Table 1), may have utility for expressing the negative-positive balance that characterises QoL. The systematic and structured assessment of QoL offered in this way by the Five Domains model may therefore be particularly helpful when making what are often fraught decisions about whether or not to relocate, treat or euthanise, for example, much-loved domestic pets or zoo animals that have engaged public attention.

With regard to resources that potentially promote positive welfare states, a distinction should be made between having a primary focus on grading the presence of resources which, if used effectively by the animals, would be anticipated to enhance their welfare (Edgar *et al* 2103) and, as outlined here, grading the animals' actual behavioural utilisation of such welfare-enhancing resources. An advantage of the former approach is that once there is agreement on what those resources should be, it would take little time to determine if they are present or absent (Edgar *et al* 2013). However, this approach relies on prior demonstrations of the sustained beneficial use of such resources when provided, as is the case,

for example, with layer hen use of perches and nest-boxes (Federation of Animal Science Societies 2010). An advantage of the latter Five Domains approach is that, despite a need to observe animals for longer periods to ascertain if they do beneficially utilise such resources, it may reveal whether or not various forms of welfare compromise hinder animals from experiencing such benefits (see Table 1), thereby providing more information about the significance of a particular compromise. However, this greater time commitment may mean that the Five Domains model would have more utility for assessing individual animals or small groups of them as opposed to larger numbers.

The extended Five Domains model is a device to facilitate systematic recognition and grading of both the negative and positive features of animal welfare states and their potential interactions in a wide range of circumstances. As such grading depends upon subjective interpretation of observable physical/functional and behavioural signs and other information, accessing scientifically informed expert opinion would enhance confidence in this use of the model. Thus, there would be merit in engaging panels or consultative networks with wide expertise and experience (eg Edgar *et al* 2013; Buckland *et al* 2014; Littin *et al* 2014). Collectively, such groups should be configured to provide detailed input on species-specific biology, behaviour, ecology, physiology, pathophysiology, health and management, as well as affect-related neuroscience-supported behavioural expertise and experience with the operation of the Five Domains model.

In conclusion, use of the Five Domains model to arrive at an overall grade helps to evoke fresh thinking by clarifying relationships between different circumstances that generate negative and positive states, and likely interactions between those circumstances and the related affects. Provided that the grading is done cautiously, and with due regard to the biology and ecology of the species concerned, the model can usefully guide welfare assessments in a wide range of circumstances and species. Also, the conceptual framework of the model itself has value in contributing to the growing contextual shift in contemporary animal welfare science thinking towards the promotion of positive states, whilst at the same time continuing to minimise negative states.

Acknowledgements

We express our sincere appreciation to the numerous colleagues who, over many years whilst discussing animal welfare and its diverse facets, contributed to the development of the ideas presented here.

References

Aitken ID 2007 *Diseases of Sheep, Fourth Edition.* Blackwell Science: Oxford, UK. http://dx.doi.org/10.1002/9780470753316

Balcombe JP 2009 Animal pleasure and its moral significance. *Applied Animal Behaviour Science 118*: 208-216. http://dx.doi.org/10.1016/j.applanim.2009.02.012

Baumans V and Van Loo PLP 2013 How to improve housing conditions of laboratory animals: The possibilities of environmental refinement. *The Veterinary Journal 195*: 24-32. http://dx.doi.org/10.1016/j.tvjl.2012.09.023

Beausoleil NJ, Blache D, Stafford KJ, Mellor DJ and Noble ADL 2008 Exploring the basis of divergent selection for 'temperament' in domestic sheep. *Applied Animal Behaviour Science 109*: 261-274. http://dx.doi.org/10.1016/j.applanim.2007.03.013

Beausoleil NJ, Fisher P, Mellor DJ and Warburton B 2012 Ranking the negative impacts of wildlife control methods may help advance the Three Rs. *Alternatives to Animal Experimentation Proceedings 1 (WC8)*: 481-485

Beausoleil NJ and Mellor DJ 2015a Advantages and limitations of the Five Domains model for assessing animal welfare impacts associated with vertebrate pest control. *New Zealand Veterinary Journal 63*: 37-43. http://dx.doi.org/10.1080/00480169.2014.956832

Beausoleil NJ and Mellor DJ 2015b Introducing breathlessness as an animal welfare issue. *New Zealand Veterinary Journal 63*: 44-51. http://dx.doi.org/10.1080/00480169.2014.940410

Beaver BV 2009 *Canine Behavior: Insights and Answers, Second Edition.* Saunders Elsevier: St Louis, USA

Berridge KC 1996 Food reward: brain substrates of wanting and liking. *Neuroscience and Biobehavioral Reviews 20*: 1-25. http://dx.doi.org/10.1016/0149-7634(95)00033-B

Blache D, Terlouw C and Maloney SK 2011 Physiology. In: Appleby MC, Mench JA, Olsson IAS and Hughes BO (eds) *Animal Welfare, Second Edition* pp 155-182. CAB International: Wallingford, UK

Boissy A and Lee C 2014 How assessing relationships between emotions and cognition can improve farm animal welfare. *Scientific and Technical Review, Office International des Epizooties 33(1)*: 103-110

Boissy A, Manteuffel G, Jensen MB, Moe RO, Spruijt B, Keeling LJ, Winckler C, Forkman B, Dimitrov I, Langbein J, Bakken M, Veissier I and Arnaud A 2007 Assessment of positive emotions in animals to improve their welfare. *Physiology and Behavior 92*: 375-397. http://dx.doi.org/10.1016/j.physbeh.2007.02.003

Broom DM 2010 Cognitive ability and awareness in domestic animals and decisions about obligations to animals. *Applied Animal Behaviour Science 126*: 1-11. http://dx.doi.org/10.1016/j.applanim.2010.05.001

Buckland EL, Corr SA, Abeyesinghe SM and Wathes CM 2014 Prioritisation of companion dog welfare issues using expert consensus. *Animal Welfare 23*: 39-46. http://dx.doi.org/10.7120/09627286.23.1.039

Burgdorf J and Panksepp J 2006 The neurobiology of positive emotions. *Neuroscience and Biobehavioral Reviews 30*: 173-187. http://dx.doi.org/10.1016/j.neubiorev.2005.06.001

Cabanac M 2005 The experience of pleasure in animals. In: McMillan FD (ed), *Mental Health and Well-being in Animals* pp 29-46. Blackwell: Iowa, USA. http://dx.doi.org/10.1002/9780470384947.ch3

Carter CS and Keverne EB 2002 The neurobiology of social affiliation and pair bonding. *Hormones, Brain and Behavior 1*: 299-337

Coleman GJ and Hemsworth PH 2014 Training to improve stockperson beliefs and behaviour towards livestock enhances welfare and productivity. *Scientific and Technical Review, Office International des Epizooties 33(1)*: 131-137

Cronin GM, Rault J-L and Glatz PC 2014 Lessons learned from past experience with intensive livestock management systems. *Scientific and Technical Review, Office International des Epizooties 33(1)*: 139-151

Dawkins MS 2006 Through the eyes of animals: what behaviour tells us. *Applied Animal Behaviour Science 100*: 4-10. http://dx.doi.org/10.1016/j.applanim.2006.04.010

Dawkins MS, Cook PA, Whittingham MJ, Mansell KA and Harper AE 2003 What makes free-range broiler chickens range? In situ measurement of habitat preference. *Animal Behaviour 66*: 151-160. http://dx.doi.org/10.1006/anbe.2003.2172

Deag JM 1996 Behavioural ecology and the welfare of extensively farmed animals. *Applied Animal Behaviour Science 49*: 9-22. http://dx.doi.org/10.1016/0168-1591(95)00663-X

Denton DA, McKinley MJ, Farrell M and Egan GF 2009 The role of primordial emotions in the evolutionary origin of consciousness. *Consciousness and Cognition 18*: 500-514. http://dx.doi.org/10.1016/j.concog.2008.06.009

Duncan IJH 2005 Science-based assessment of animal welfare: farm animals. *Scientific and Technical Review, Office International des Epizooties 24*: 483-492

Edgar JL, Mullan SM, Pritchard JC, McFarlane UJC and Main DCJ 2013 Towards a 'good life' for farm animals: Development of a resource tier framework to achieve positive welfare for laying hens. *Animals 3*: 584-605. http://dx.doi.org/10.3390/ani3030584

Farm Animal Welfare Council 2009 *Farm Animal Welfare in Great Britain: Past, Present and Future.* Farm Animal Welfare Council: London, UK

Federation of Animal Science Societies 2010 *Guide for the Care and Use of Agricultural Animals in Research and Teaching, Third Edition*. Federation of Animal Science Societies: Champaigne, Il, USA

Fisher HE, Aron A and Brown LL 2006 Romantic love: a mammalian brain system for mate choice. *Philosophical Transactions of the Royal Society B361*: 2173-2186. http://dx.doi.org/10.1098/rstb.2006.1938

Fraser D 2003 Assessing animal welfare at the farm and group level: the interplay of science and values. *Animal Welfare 12*: 433-443

Fraser D 2008 *Understanding Animal Welfare: The Science in its Cultural Context.* Wiley-Blackwell: Oxford, UK

Fraser D and Duncan IJH 1998 'Pleasures', 'pains' and animal welfare; towards a natural history of affect. *Animal Welfare 7*: 383-396

Fraser D and Nicol CJ 2011 Preference and motivation research. In: Appleby MC, Mench JA, Olsson IAS and Hughes BO (eds) *Animal Welfare, Second Edition* pp 183-199. CAB International: Wallingford, UK

Green TC and Mellor DJ 2011 Extending ideas about animal welfare assessment to include 'quality of life' and related concepts. *New Zealand Veterinary Journal 59*: 263-271. http://dx.doi.org/10.1080/00480169.2011.610283

Gregory NG 1998 Physiological mechanisms causing sickness behaviour and suffering in diseased animals. *Animal Welfare 7*: 293-305

Gregory NG 2004 *Physiology and Behaviour of Animal Suffering.* Blackwell Science: Oxford, UK. http://dx.doi.org/10.1002/9780470752494

Held SDE and Spinka M 2011 Animal play and animal welfare. *Animal Behaviour 81*: 891-899. http://dx.doi.org/10.1016/j.anbehav.2011.01.007

Hemsworth PG and Coleman GJ 2011 *Human-Livestock Interactions: The Stockperson and The Production and Welfare of Intensively-Farmed Animals, Second Edition.* CABI: Oxford, UK. http://dx.doi.org/10.1079/9781845936730.0000

Hemsworth PH, Coleman GJ, Barnett JL, Borg S and Dowling S 2002 The effects of cognitive behavioral intervention on the attitude and behavior of stockpersons and the behavior and productivity of commercial dairy cows. *Journal of Animal Science 80(1)*: 68-78

Kirkden RD and Pajor EA 2006 Using preference, motivation and aversion tests to ask scientific questions about animals' feelings. *Applied Animal Behaviour Science 100*: 29-47. http://dx.doi.org/10.1016/j.applanim.2006.04.009

Knierim U, Carter CS, Fraser D, Gartner K, Lutgendorf KS, Mineka S, Panksepp J and Sachser N 2001 Good welfare: improving quality of life. In: Broom DM (ed) *Coping with Challenge: Welfare in Animals including Humans* pp 79-100. Dahlem Workshop Report 87, Dahlem University Press: Berlin, Germany

Lim MM and Young LJ 2006 Neuropeptidergic regulation of affiliative behavior and social bonding in animals. *Hormones and Behavior 50*: 506-517. http://dx.doi.org/10.1016/j.yhbeh.2006.06.028

Littin K, Fisher P, Beausoleil NJ and Sharp T 2014 Welfare aspects of vertebrate pest control and culling: ranking control techniques for humaneness. *Scientific and Technical Review, Office International des Epizooties 33(1)*: 281-289

Manson JH, Perry S and Parish AR 1997 Nonconceptive sexual behavior in Bonobos and Capuchins. *International Journal of Primatology 18*: 767-786. http://dx.doi.org/10.1023/A:1026395829818

Marples NM, Quinlan M, Thomas RJ and Kelly DJ 2007 Deactivation of dietary wariness through experience of novel food. *Behavioural Ecology 18*: 803-810. http://dx.doi.org/10.1093/beheco/arm053

Mason G and Rushen J 2006 *Stereotypic Animal Behaviour: Fundamentals and Implications for Animal Welfare, Second Edition.* CAB International: Wallingford, UK. http://dx.doi.org/10.1079/9780851990040.0000

McMillan FD 2003 Maximizing quality of life in ill animals. *Journal of the American Animal Hospital Association 39*: 227-235. http://dx.doi.org/10.5326/0390227

Mellor DJ 2012a Affective states and the assessment of laboratory-induced animal welfare impacts. *Alternatives to Animal Experimentation Proceedings 1 (WC8)*: 445-449

Mellor DJ 2012b Animal emotions, behaviour and the promotion of positive welfare states. *New Zealand Veterinary Journal 60*: 1-8. http://dx.doi.org/10.1080/00480169.2011.619047

Mellor DJ 2015a Enhancing animal welfare by creating opportunities for 'positive affective engagement'. *New Zealand Veterinary Journal 63*: 3-8. http://dx.doi.org/10.1080/00480169.2014.926799

Mellor DJ 2015b Positive animal welfare states and encouraging environment-focused and animal-to-animal interactive behaviours. *New Zealand Veterinary Journal 63*: 9-16. http://dx.doi.org/10.1080/00480169.2014.926800

Mellor DJ 2015c Positive animal welfare states and reference standards for welfare assessment. *New Zealand Veterinary Journal 63*: 17-23. http://dx.doi.org/10.1080/00480169.2014.926802

Mellor DJ, Cook CJ and Stafford KJ 2000 Quantifying some responses to pain as a stressor. In: Moberg GP and Mench JA (eds) *The Biology of Animal Stress: Basic Principles and Implications for Welfare* pp 171-198. CAB International: Wallingford, Oxon, UK. http://dx.doi.org/10.1079/9780851993591.0171

Mellor DJ, Patterson-Kane E and Stafford KJ 2009 *The Sciences of Animal Welfare*. Wiley-Blackwell, Oxford, UK

Mellor DJ and Reid CSW 1994 Concepts of animal well-being and predicting the impact of procedures on experimental animals. In: Baker R, Jenkin G and Mellor DJ (eds) *Improving the Well-being of Animals in the Research Environment* pp 3-18. Australian and New Zealand Council for the Care of Animals in Research and Teaching: Glen Osmond, SA, Australia

Mellor DJ, Thornber PM, Bayvel ACDB and Kahn S 2008 The scientific assessment and management of animal pain. *Technical Series, Office International des Epizooties 10*: 1-210

Morton DB and Griffiths PH 1985 Guidelines on the recognition of pain, distress and discomfort in experimental animals and an hypothesis for assessment. *Veterinary Record 116*: 431-436. http://dx.doi.org/10.1136/vr.116.16.431

Nelson E and Panksepp J 1998 Brain substrates of infant–mother attachment: contributions of opioids, oxytocin, and norepinepherine. *Neuroscience and Biobehavioral Reviews 22*: 437-452. http://dx.doi.org/10.1016/S0149-7634(97)00052-3

Packer RMA, Hendricks A and Burn CC 2012 Do dog owners perceive the clinical signs related to conformation inherited disorders as 'normal' for the breed? A potential constraint to improving canine welfare. *Animal Welfare 21*: 81-93. http://dx.doi.org/10.7120/09627286.21.1.081

Panksepp J 2005 Affective consciousness: core emotional feelings in animals and humans. *Consciousness and Cognition 14*: 30-80. http://dx.doi.org/10.1016/j.concog.2004.10.004

Panksepp J 2006 Emotional endophenotypes in evolutionary psychiatry. *Progress in Neuro-Psychopharmacology and Biological Psychiatry 30*: 774-784. http://dx.doi.org/10.1016/j.pnpbp.2006.01.004

Panksepp J and Zellner MR 2004 Towards a neurologically based unified theory of aggression. *Revue Internationale de Psychologie Sociale/International Review of Social Psychology 17*: 37-61

Pfaff DW 1999 *Drive: Neurobiological and Molecular Mechanisms of Sexual Behavior*. MIT Press: Cambridge, MA, USA

Portas T 2013 Achieving positive animal welfare outcomes in zoos and aquariums. *Proceedings of the RSPCA 2013 Australia Scientific Seminar entitled, When coping is not enough: promoting positive welfare states in animals* pp 46-50. 26 February 2013, Canberra, Australia. http://www.rspca.org.au/sites/default/files/website/The-facts/Science/Scientific-Seminar/2013/SciSem_2013_Proceedings.pdf

Roedler FS, Pohl S and Oechtering GU 2013 How does severe brachycephaly affect dogs' lives? Results of a structured preoperative owner questionnaire. *The Veterinary Journal 198*: 606-610. http://dx.doi.org/10.1016/j.tvjl.2013.09.009

Rolls ET 2007 *Emotion Explained*. Oxford University Press: Oxford, UK

Rushen J and de Passillé AM 2014 Alone or together: a risk assessment approach to group housing. In: Appleby MC, Weary DM and Sandøe P (eds) *Dilemmas in Animal Welfare* pp 169-187. http://dx.doi.org/10.1079/9781780642161.0169

Sharp T and Saunders G 2008 *A model for assessing the relative humaneness of pest animal control methods*. Australian Government Department of Agriculture, Fisheries and Forestry, Canberra, ACT, Australia

Spinka M, Newberry RC and Bekoff M 2001 Mammalian play: training for the unexpected. *Quarterly Review of Biology 76*: 141-168. http://dx.doi.org/10.1086/393866

Spinka M and Wemelsfelder F 2011 Environmental challenge and animal agency. In: Appleby MC, Mench JA, Olsson IAS and Hughes BO (eds) *Animal Welfare, Second Edition* pp 27-43. CAB International: Wallingford, UK

Spooner JM, Schuppli CA and Fraser D 2014 Attitudes of Canadian pig producers toward animal welfare. *Journal of Agricultural and Environmental Ethics 27(4)*: 569-589. http://dx.doi.org/10.1007/s10806-013-9477-4

Spruijt BM, van den Bos R and Pijlman FTA 2001 A concept of welfare based on reward evaluating mechanisms in the brain: anticipatory behaviour as an indicator for the state of reward systems. *Applied Animal Behavioural Science 72*: 145-171. http://dx.doi.org/10.1016/S0168-1591(00)00204-5

Stafford KJ 2007 *The Welfare of Dogs*. Springer: Dordrecht, The Netherlands

Vanderschuren L, Niesnik R and Van Ree J 1997 The neurobiology of social play behavior in rats. *Neuroscience and Biobehavioral Reviews 3*: 309-326. http://dx.doi.org/10.1016/S0149-7634(96)00020-6

Voelkl B, Schrauf C and Huber L 2006 Social contact influences the response of infant marmosets towards novel food. *Animal Behaviour 72*: 365-372. http://dx.doi.org/10.1016/j.anbehav.2005.10.013

Wathes C 2010 Lives worth living? *Veterinary Record 166*: 468-469. http://dx.doi.org/10.1136/vr.c849

Webster J 1994 *Animal Welfare: A Cool Eye Towards Eden*. Blackwell Science: Oxford, UK

Webster J 2011 Zoomorphism and anthropomorphism: fruitful fallacies? *Animal Welfare 20*: 29-36

Webster JR, Schütz KE, Sutherland MA, Stewart M and Mellor DJ 2015 Consideration of key areas of potential animal welfare concern in pastoral dairy systems. *New Zealand Veterinary Journal 63*: 31-36. http://dx.doi.org/10.1080/00480169.2014.958117

Wemelsfelder F 1997 The scientific validity of subjective concepts in models of animal welfare. *Applied Animal Behaviour Science 53*: 75-88. http://dx.doi.org/10.1016/S0168-1591(96)01152-5

Wemelsfelder F 2007 How animals communicate quality of life: the qualitative assessment of behaviour. *Animal Welfare 16*: 25-31

Williams VM, Mellor DJ and Marbrook J 2006 Revision of a scale for assessing the severity of live animal manipulations. *ALTEX 23*: 163-169

Yeates JW and Main DCJ 2008 Assessment of positive welfare: A review. *The Veterinary Journal 175*: 293-300. http://dx.doi.org/10.1016/j.tvjl.2007.05.009

Young RJ 2003 *Environmental Enrichment for Captive Animals*. Blackwell Science Ltd: Oxford, UK. http://dx.doi.org/10.1002/9780470751046