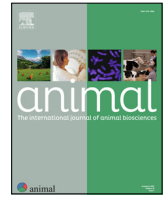




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Review: The Five Domains model and promoting positive welfare in pigs

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ABSTRACT

Public concern for the welfare of farm animals has increased over recent years. Meeting public demands for higher animal welfare products requires robust animal welfare assessment tools that enable the user to identify areas of potential welfare compromise and enhancement. The Five Domains model is a structured, systematic, and comprehensive framework for assessing welfare risks and enhancement in sentient animals. Since its inception in 1994, the model has undergone regular updates to incorporate advances in animal welfare understanding and scientific knowledge. The model consists of five areas, or domains, that focus attention on specific factors or conditions that may impact on an animal's welfare. These include four physical/functional domains: nutrition, physical environment, health, and behavioural interactions, and a fifth mental or affective state domain. The first three domains draw attention to welfare-significant internal physical/functional states within the animal, whereas the fourth deals with welfare-relevant features of the animal's external physical and social environment. Initially named "Behaviour" Domain 4 was renamed "Behavioural Interactions" in the 2020 iteration of the model and was expanded to include three categories: interactions with the environment, interactions with other animals and interactions with humans. These explicitly focus attention on environmental and social circumstances that may influence the animal's ability to exercise agency, an important determinant of welfare. Once factors in Domains 1–4 have been considered, the likely consequences, in terms of the animal's subjective experiences, are assigned to Domain 5 (affective state). The integrated outcome of all negative and positive mental experiences accumulated in Domain 5 represents the animal's current welfare state. Because the model specifically draws attention to conditions that may positively influence welfare, it provides a useful framework for identifying opportunities to promote positive welfare in intensively farmed animals. When negative affective experiences are minimised, providing animals with the opportunity to engage in species-specific rewarding behaviours may shift them into an overall positive welfare state. In domestic pigs, providing opportunities for foraging, play, and nest building, along with improving the quality of pig-human interactions, has the potential to promote positive welfare.

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Implications

This paper provides an overview of the development of Five Domains model for animal welfare assessment and describes the structure of the current model and its practical application to welfare assessment. Furthermore, it specifically considers how the most recent iteration of the model can be applied within the pig industry to (a) identify areas of potential risk to pig welfare, and (b) identify opportunities for welfare enhancement.

Introduction

Public and consumer concern for the welfare of animals, including farm animals, has increased over recent years (Alonso et al., 2020). This has led to a rise in demand, and willingness to pay, for higher welfare animal products. Meeting public demands for higher animal welfare products requires robust animal welfare assessment tools that enable users to identify areas for potential welfare enhancement in addition to identifying areas of compromise.

Animal welfare is a subjective state within the animal itself that reflects the integrated outcome of all its mental or affective experiences at a given point in time (Mellor et al., 2009), i.e., how the animal is experiencing its own life at that time (Fraser and Duncan, 1998). Although it is now widely accepted that mental experiences largely determine an animal's welfare status (the 'af-

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fective state' orientation towards animal welfare), this has not always been the case. Two other orientations towards animal welfare have also featured prominently in animal welfare science: 'biological function' and 'naturalness'. Proponents of the biological function orientation considered physical health and biological function to be the major determinants of welfare status. This orientation predominated in the late 1900s, where scientific research focussing on biological function led to major advances in farm animal health, longevity, reproduction and productivity (Fraser, 2008). Such research contributed to improved welfare through, for example, identifying sub-optimal stocking densities, and identifying features of the rearing environment that contributed to the prevalence of injuries or disease (Fraser, 2008). In the intervening years, science has established clear links between biological function and affective state – it is now recognised that biological processes give rise to affective states, and that affective states can in turn impact on biological function (Fraser et al., 1997; Mellor and Beausoleil, 2015). Thus, the affective state orientation effectively incorporates biological function when making inferences about animal welfare. The third orientation, naturalness, contends that an animal's welfare is largely determined by the similarity of its captive environment to that in which it evolved, and the capacity for the animal to be able to express its full range of natural behaviours (Fraser et al., 1997). Whilst there are several limitations associated with assessing the welfare of domesticated animals from this orientation alone (e.g., Learmonth, 2019), it may nevertheless provide a useful reference point when considering which environmental and social features may be important to the welfare of animals in captive environments (Dawkins, 2004).

The Five Domains model is a prominent welfare assessment framework that facilitates the structured, systematic, and comprehensive evaluation of animal welfare risks and opportunities for welfare enhancement (Mellor, 2017). Whilst the model adopts an affective state orientation, it is based on the premise that biological mechanisms underly the generation of affective experiences (Fraser et al., 1997). Additionally, the structure of the model draws attention to environmental, health and behavioural factors that may impact on welfare, thus effectively incorporating all three major welfare orientations. Since its inception, the model has been applied to welfare assessment in a broad range of contexts, including research animals, farmed livestock, companion animals, and captive and free-living wildlife.

The purpose of this paper is firstly to provide a brief history of the Five Domains model, followed by a description of the model's structure and its application to animal welfare assessment. This will be followed by a brief explanation of the scientific basis for inferring affective experience in animals. Finally, the most recent version of the model will be used to identify opportunities for promoting positive welfare in commercially farmed pigs.

The Five Domains Model

A brief history

The Five Domains model was first conceived in 1994 by David Mellor and Cam Reid as a tool for assessing welfare compromise in sentient animals used in research, teaching, and testing (Mellor and Reid, 1994). In keeping with other animal welfare approaches at the time, this early version of the model focussed solely on assessing welfare compromise. This is largely because the major focus of animal welfare science at the time was optimising biological function to prevent negative outcomes. Furthermore, the range of negative affective states included in the original model was limited to thirst, hunger, anxiety, fear, pain and the catch-all term 'distress' (Mellor and Reid, 1994). Again, this was in line with current approaches to animal welfare at

that time, where the focus on affective state was relatively new (Fraser and Duncan, 1998).

Whilst the basis of the model has remained relatively unchanged since its inception, it has undergone regular updates to reflect current advances in animal welfare science in the years since. This initially involved expansion of the accepted range of negative affective experiences in the model. As the focus on affective state became more widely accepted and understanding of the processes underlying specific affective experiences improved, the catch-all term 'distress' was replaced with additional specific negative affective states such as breathlessness, nausea, debility and weakness (Mellor, 2011; Mellor and Beausoleil, 2015). This was followed by the incorporation of a range of positive affective experiences (Mellor and Beausoleil, 2015; Mellor, 2017), as it became widely accepted that good welfare, or a 'life worth living' required positive experiences in addition to the alleviation of negatives (Mellor et al., 2009). Most recently, Domain 4 was renamed 'Behavioural interactions' and was expanded to specifically include interactions with the physical environment, other animals and humans (Mellor et al., 2020). It should be noted that the welfare implications of such interactions were not excluded from consideration in previous versions of the model; however, the introduction of sub-categories in the most recent model specifically directs attention towards a wider range of behavioural interactions.

Since 1997, the model has been incorporated into the regulatory approval system governing the use of animals for research, teaching and testing in New Zealand. In recent years, it has been applied to welfare assessment in zoo animals (Sherwen et al., 2018), domestic and free-living horses (McGreevy et al., 2018; Harvey et al., 2020), wild cetaceans (Nicol et al., 2020), and used as a forensic tool to assess suffering in cases of animal cruelty (Ledger and Mellor, 2018).

Overview of model's structure and its application

The model consists of five areas, or domains, that focus attention on specific factors or conditions that may impact on an animal's welfare (Mellor, 2017). These include four physical/functional domains, namely Nutrition, Physical environment, Health, and Behavioural interactions, and a fifth Mental or Affective state domain (Fig. 1). The first three domains draw attention to welfare-significant internal physical/functional states within the animal that arise from nutritional, environmental or health-related factors, whereas the fourth deals with welfare-relevant features of the animal's external physical and social environment. Initially named "Behaviour" this domain was renamed "Behavioural Interactions" in the 2020 iteration of the Model to better clarify its role (Mellor et al., 2020). It was further subdivided into three categories: Interactions with the environment, Interactions with other animals and Interactions with humans. These serve to explicitly draw attention to, and illustrate, the different types of behavioural interactions an animal may engage in and how these might impact on welfare. An important facet of Domain 4 is the concept of 'agency'. An animal is said to exercise agency when it engages in voluntary, goal-directed behaviours (Špinko, 2019). This may also be thought of as an animal having the opportunity to make choices and therefore exert a sense of control over its circumstances. Indices of welfare in Domain 4 typically relate to an animal's ability to exercise agency in its interactions with the environment, other animals, and humans (Mellor et al., 2020).

Once factors in Domains 1–4 have been considered, the likely consequences, in terms of the animal's subjective experiences, are then assigned to Domain 5 (affective state). The integrated outcome of all negative and positive mental experiences accumulated in Domain 5 represents the animal's current welfare state (Mellor et al., 2009).

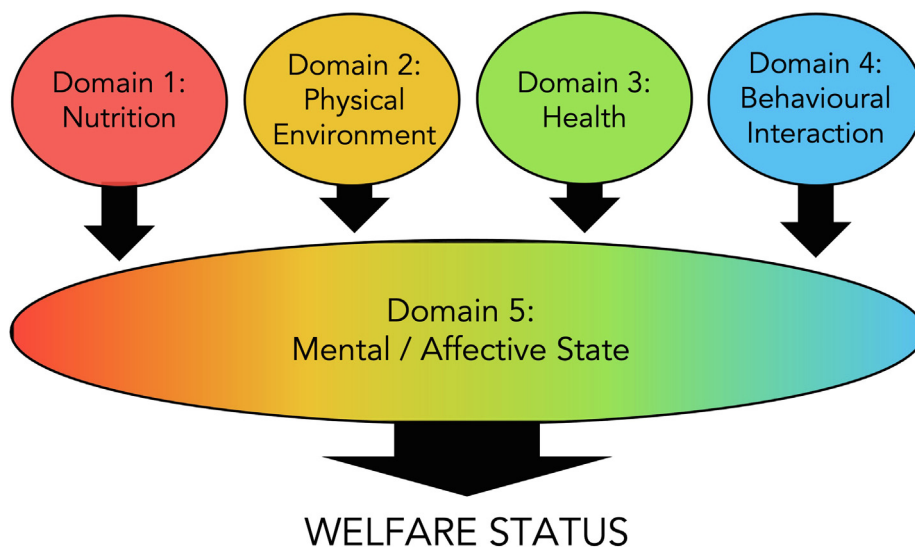


Fig. 1. The structure of the Five Domains Model, illustrating how welfare impacts in Domains 1–4 (Nutrition, Physical environment, Health, and Behavioural interaction) contribute to an animal's affective state (Domain 5), the integrated outcome of which determines its welfare status (adapted from Mellor and Reid, 1994).

It is important to note that whilst Domain 5 is structurally separate from Domains 1–4, it is not functionally separate, nor should it be evaluated separately: i.e., it is not intended that physical/functional well-being and mental well-being are assessed independently. Rather, the outcomes of negative or positive conditions in Domains 1–4 are used to infer likely mental experiences in Domain 5. Tables 1 and 2 provide some examples of welfare-significant conditions that animals may encounter in Domains 1–3, and their anticipated affective consequences in Domain 5, whilst Tables 3–6 provide examples of interactions with the environment, other animals, and humans in Domain 4 which may impede or promote an animals ability to freely exercise agency, and their likely affective outcomes in Domain 5. A more extensive list of examples is provided in Mellor et al. (2020). Bearing in mind that the Five Domains model is generic, rather than species-specific, the examples provided in the Model are intended as guides only – they do not provide a complete list of all possible conditions and their associated affective states, nor are they necessarily applicable to all species and contexts (Mellor et al., 2020). It is the responsibility of the user to determine which conditions and affective experiences are applicable to the species and context in question.

Table 1

Selected examples of negative conditions in Domains 1–3 (nutrition, physical environment, and health) and their likely affective consequences in Domain 5 (mental/affective state), derived from Mellor et al. (2020).

Domain	Negative Conditions	Affective consequences (Domain 5)
1. Nutrition	Restricted water intake	Thirst
	Restricted food intake	Hunger
	Poor food quality	Malaise of malnutrition
	Low food variety	Eating-related boredom
2. Physical environment	Close confinement/lack of space	Stiffness and muscle tension
	Exposure to thermal extremes	Chilling or overheating
	Loud or unpleasant noise	Impaired hearing or ear pain
	Unpredictable events	Anxiety, fear, hypervigilance
3. Health	Presence of physical injury or disease	Pain, debility, breathlessness, nausea
	Poor physical fitness	Weakness and exhaustion

Table 2

Selected examples of positive conditions in Domains 1–3 (nutrition, physical environment, and health) and their likely affective consequences in Domain 5 (mental/affective state), derived from Mellor et al. (2020).

Domain	Positive Conditions	Affective consequences (Domain 5)
1. Nutrition	Drink sufficient water	Wetting/quenching pleasure of drinking
	Eat correct quantity of food	Comfort of satiety
	Eat a variety of foods	Pleasures of food tastes/smells/textures
2. Physical environment	Space for spontaneous locomotion	Physical comfort
	Effective shelter and shade available	Thermal comfort
	Effective noise controls	Auditory comfort
	Predictability through established routines	Calmness and ease
3. Health	Absence of injury or disease	Comfort of good health and functional capacity
	Physically fit	Vitality of fitness

Grading welfare compromise and enhancement using the model

The Five Domains model uses a qualitative grading system to assess specific features of welfare compromise and/or enhancement (Mellor, 2017). Compromise and enhancement are graded separately within each domain, using different scales. Welfare compromise is graded using a five-tier scale from A to E, where A indicates no compromise and E indicates very severe compromise with B, C and D indicating increasing degrees of compromise in the intermediary range (Mellor and Beausoleil, 2015). Grades are allocated based on three criteria: (1) the severity of physical/functional impacts or unpleasant external circumstances in Domains 1–4; (2) the intensity and duration of the inferred negative affects and their reversibility; and (3) whether or not the impacts require urgent mitigation (Mellor, 2017).

In contrast, welfare enhancement is graded using a four-tier scale (0, +, ++, +++) indicating no, low-level, mid-level and high-level enhancement, respectively (Mellor and Beausoleil, 2015). When grading welfare enhancement, potential interactions between negative affects generated by physical/functional imbal-

Table 3

Selected examples of conditions in Domain 4 (behavioural interactions) that impede the exercise of agency, and their likely affective consequences in Domain 5 (mental/affective state) (derived from Mellor et al., 2020).

Interactions with	Exercise of agency is impeded by	Affective consequences (Domain 5)
The environment	Barren, invariant environment	Boredom, helplessness, depression
	Constraints on environment-focussed activity Impedance of foraging drive	Frustration, anger, hypervigilance Frustration, anger, hypervigilance
Other animals	Constraints on animal-to-animal interactive activity Limits on threat avoidance, escape or defence activity	Loneliness, depression, sexual frustration Anxiety, fear, anger, panic

Table 4

Selected examples of conditions in Domain 4 (behavioural interactions) that impede the exercise of agency, and their likely affective consequences in Domain 5 (mental/affective state) (derived from Mellor et al., 2020).

Interactions with	Exercise of agency is promoted by	Affective consequences (Domain 5)
The environment	Varied and novel environment	Interested, pleasantly occupied
	Availability of engaging choices	Calmness, sense of control
Other animals	Exploration and foraging	Energised, focussed
	Bonding/reaffirming bond Playing Ability to retreat, take refuge or mount defensive attack	Affectionate sociability pleasures Excitation, pleasure Sense of security, confidence

Table 5

Selected examples of negative human attributes and behaviour towards animals in Domain 4 (behavioural interactions), their effects on animal behaviour, and their likely affective consequences in Domain 5 (mental/affective state) (derived from Mellor et al., 2020).

Negative human attribute or behaviour	Animal behaviour consequences	Affective consequences (Domain 5)
Uncertain, fearful, impatient, cruel attitude	Long flight distance, hypervigilant, escape-avoidance, hyper-reactive,	Anxiety, fear, panic, confusion, persistent unease, pain from injuries
Hesitant, angry, loud, shouting voice	freezing, cowering, non-compliant	
Lack of skills, training, experience, qualifications in husbandry		
Erratic, rough, forceful, violent, or punishment-focussed handling		

ances in Domains 1–3 and positive affects generated by utilisation of opportunities to exercise agency in Domain 4 must be considered. When the intensity of negative affects arising from Domains 1–3 is significant, animals may not engage in rewarding behaviours even when opportunities are available (Mellor, 2017).

Therefore, the assignment of grades takes into consideration both the availability of opportunities for the animal to exercise agency and the actual utilisation of such opportunities. Where

Table 6

Selected examples of positive human attributes and behaviour towards animals in Domain 4 (behavioural interactions), their effects on animal behaviour, and their likely affective consequences in Domain 5 (mental/affective state) (derived from Mellor et al., 2020).

Positive human attribute or behaviour	Animal behaviour consequences	Affective consequences (Domain 5)
Confident, caring, patient, empathetic attitude	Short flight distance, calm alertness, at ease, compliant, responsive, seeks contact, bonded with humans	Calm, confident, sense of control, reward of human bonding
Confident, calm, clear, encouraging voice		
Skilled, trained, experienced, qualified in husbandry		
Gentle, skilled, restrained, reward-focussed handling		

opportunities are present, but the animal does not utilise these (e.g., due to severe physical/functional impairment), this would be considered ‘no enhancement’ or grade 0. As such, the mere presence of environmental or social factors that promote agency are not sufficient to infer welfare enhancement – this is contingent on their utilisation. Examples of grading are provided in Table 7. Once all likely affective experiences have been graded, a judgement is made about the overall impact on the animal and an overall welfare compromise grade may be assigned to Domain 5. This is usually the same as the highest of the grades assigned in Domains 1–4, reflecting the most severe mental experience. However, the value of assigning a single overall grade is questionable, given the attendant loss of detail in identifying the source of compromise. Furthermore, assigning a single grade implies that the impacts incurred within the different domains are equally important, which may not be the case. For the purposes of identifying areas of welfare compromise or enhancement, the separate grades derived for Domains 1–4 are more informative and therefore of more practical value. For additional details on the assignment of grades, see Mellor and Beausoleil (2015).

It is important to note that inferences about welfare compromise or enhancement, however cautiously made, require that subjective judgements be made. For example, judgements must be made about the relative impacts of qualitatively different affective experiences, such as pain, breathlessness, or nausea. Similarly, difficulties arise in judging the relative impacts of affective states of different intensities and duration. For example, is a mild impact for a long duration better or worse than a moderate impact of brief duration? As a result of such issues, the grades assigned by different users of the model in the same context may differ. Despite these limitations, the model does allow distinctions to be made between broadly different degrees of welfare compromise and enhancement and serves to identify areas where improvements could be made.

Inferring affective experience: scientific basis

The mental experiences of animals, like humans, are subjective, meaning they cannot be directly observed or measured. Furthermore, unlike humans, animals cannot tell us about their mental experiences using a shared language. We can therefore only infer

Table 7

Scales used to grade animal welfare compromise and enhancement using the Five Domains Model, and a conceptual matrix of possible combined grades (Mellor and Beausoleil, 2015).

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	–	–	–

– Indicates designated level of welfare enhancement (indicated by column header) unlikely to be achieved within designated compromise grade.

* Theoretically possible but unlikely to be encountered as the absence of welfare compromise would require at least low-level enhancement (Mellor and Beausoleil, 2015).

an animal's likely mental experiences, based on the available evidence. Affective states arise through the neural processing of sensory information from the animal's internal (e.g., hydration status, glucose levels, core temperature) and external (e.g., visual or olfactory information about a conspecific, mechanical information about substrate texture) (Denton et al., 2009) environments. In recent years, affective neuroscience research has greatly increased our understanding of the brain processes underlying the generation of specific affective states (e.g., Panksepp, 2005; Boissy et al., 2007). This detailed understanding allows us to cautiously infer some affective experiences on the basis of specific internal (physiological, pathophysiological, biochemical, immunological, neurological) states or expressed behaviours (Mellor, 2017). Therefore, appropriate welfare indicators may be used to infer some specific mental experiences.

The selection of appropriate welfare indicators in each domain should be based on scientific evidence providing credible links between the selected indicator and the affective state it is proposed to identify. It is beyond the scope of this paper to discuss the criteria for indicator validity – such information is available elsewhere (e.g., Beausoleil and Mellor, 2017). Generally speaking, animal-based indicators (recorded from the animal itself) are preferred as they provide a more direct reflection of the animal's experience. However, practical considerations, such as the number of animals to be assessed, time and resources available, and the need to conduct assessments within the context of normal production routines, may also affect the selection of indicators. Where it is impractical or impossible to assess features of the animal itself, it may be acceptable to assess features of the animal's environment or management system (using resource or management-based indicators). In this case, indicators with scientifically demonstrable links to appropriate animal-based indicators should be used where available (Beausoleil and Mellor, 2017). For example, in the nutrition domain, water intake is important for maintaining fluid balance. Inadequate hydration can lead to dehydration (functional impairment) and the associated negative experience of extreme thirst. The most direct indicators of adequate hydration are those taken from the animal itself, for example, urine specific gravity or skin turgor (Kavouras, 2002). However, when assessing water intake in a large group of animals, it may be prohibitively costly or time consuming to assess hydration status using such individual measures. In this case, resource-based indicators such as water availability or quality may be used instead, where it has been demonstrated that these influence water consumption in the species of interest.

Identifying opportunities for welfare enhancement

The intention of this section is not to carry out an assessment of the welfare of intensively reared pigs, but rather to highlight the potential interactions that can occur between negative and positive affective states and to demonstrate how the Five Domains

model can be used to identify opportunities for welfare enhancement.

As noted previously, the first four of the five domains draw attention to the animals' physical/functional status. The affective states arising from factors in these four domains can be further categorised into 'survival-critical' and 'situation-related' (Mellor, 2017).

Survival-related affective experiences

Negative conditions leading to welfare compromise in the first three Domains (nutrition, physical environment and health) give rise to negative affective states that are termed 'survival-critical' (Table 1) (Mellor and Beausoleil, 2015). These motivate the animal to perform specific behaviours designed to correct the physical/functional imbalances that give rise to them, therefore ensuring its continued survival. For example, restrictions on water intake (a negative condition) may lead to dehydration (a functional imbalance) and the associated negative experience of thirst. Thirst motivates the animal to seek and consume water, restoring normal fluid balance, which in turn alleviates the sensation of thirst. The more severe a physical/functional imbalance is, the more intense the associated negative affective state is likely to be (Denton et al., 2009). Survival-related negative affective states are thus an essential component of genetically preprogrammed mechanisms designed to maintain homeostasis (Panksepp, 2005; Denton et al., 2009). Their inherently negative nature helps to convey the sense of urgency needed for the animal to respond appropriately (Fraser and Duncan, 1998). As such, it is neither desirable nor possible to eliminate such negative experiences. Instead, from a welfare perspective, the aim should be to prevent the animal from experiencing extreme or prolonged experience of these, by providing for their species-specific requirements in Domains 1–3.

It should be noted that whilst achieving the behavioural goals of negative motivational states, for example restoring water balance through thirst-motivated drinking, may lead to transient positive states (such as the quenching pleasure of drinking, Table 2), alleviating survival-related negative affects can usually achieve an overall neutral welfare state at best (Mellor, 2017). Nevertheless, some conditions within domains 1–3 may provide opportunities for repeated short-term positive experiences that may benefit overall welfare. For example, providing an animal with a variety of foods with different tastes and textures may lead to pleasurable experiences associated with consumption and prevent the experience of eating-related boredom associated with invariant diets (Mellor, 2017). This may be particularly relevant to pigs, given that they are omnivores and are known to ingest a wide variety of foods when given the opportunity (Stolba and Wood-Gush, 1989).

Welfare status is determined by the integrated outcome of all current (positive and negative) experiences. Alleviation of negative experiences can achieve a neutral welfare state at best. Achieving positive welfare also requires the animal to have positive

experiences. Therefore, interventions aimed at promoting positive animal welfare are typically focussed on Domain 4.

Situation-related affective experiences

Welfare impacts in Domain 4, which give rise to what are termed 'situation-related' affective states (Mellor and Beausoleil, 2015), are closely linked to an animal's capacity to exercise agency. Unlike affective states arising from factors in Domains 1–3, affective states arising from factors in Domain 4 may be either negative or positive in character. Situations that impede or reduce the expression of agency-related behaviour, such as living in severely restrictive, oppressive, or challenging environments, may be associated with a range of negative affective states in Domain 5 (Mellor, 2017). These are thought to result from the prevention of genetically preprogrammed drives to engage in a rewarding behaviour, or through failure of a behaviour to achieve the anticipated rewards (Špinka, 2019). Negative affects arising from impedance of agency may include anger, frustration, boredom, loneliness, helplessness and isolation (Table 3) (Mellor, 2017).

On the other hand, situations that promote the exercise of agency, such as stimulus-rich environments which permit species-specific motivated behaviours such as exploration, hunting, various forms of bonding, or play, may be associated with a range of positive affects in Domain 5, such as feelings of engagement, pleasure, security, or excitement (Table 4) (Panksepp, 2005; Mellor, 2015). When negative experiences are reduced or eliminated, it may therefore be possible to shift an animal from an overall negative to overall positive welfare state by making improvements in the physical or social environment that provide it with opportunities to engage in voluntary, goal-directed behaviours that are inherently rewarding.

When assessing features of welfare in Domain 4, it is therefore necessary to understand which behaviours are likely to be rewarding to the animal or species in question. Such knowledge may be gained through observations of the animal (or its ancestors) in a natural, semi-natural, or extensive environment to determine which physical and biotic resources it engages with, and which social structures are present. Or it may be obtained through experimental research using preference and motivation tests to determine which resources the animal prefers and how hard it is willing to work to access these (Dawkins, 2004).

Situation-related affective experiences also arise in response to interactions with humans. It is well-recognised that the quality of the interactions between stockpeople and their animals can substantially influence the behaviour and welfare of farm animals (Hemsworth and Coleman, 2011). Negative or aversive animal handling (e.g., hitting, slapping, pushing, shouting) has been shown to increase fear of humans and is associated with acute and chronic stress (Gonyou et al., 1986; Hemsworth and Barnett, 1992), both of which indicate reduced welfare. On the other hand, positive human-animal interactions, characterised by a low level of fear and high level of trust in humans, may be intrinsically rewarding (Hemsworth and Coleman, 2011). A number of factors can influence the quality of human-animal interactions, including the attitude and skills or experience of stockpersons, as well as the tactile nature of the interaction (e.g., level of force used, or whether it is punishment- or reward-focussed) (Tables 5 and 6) (Hemsworth and Coleman, 2011; Mellor et al., 2020). The attitudes of stockpersons towards animals are particularly important in determining the nature of the human-animal relationship, as these may have both direct and indirect influences on welfare. Stockpersons' attitudes towards the animals in their care directly influence their behaviour towards the animal but also impact on factors such as job satisfaction and willingness to learn new skills and knowledge about the animal, which can in turn influence the human-animal

relationship (Hemsworth and Coleman, 2011). Therefore, improving both the attitudes and behaviour of stockpersons may have positive benefits for animal welfare.

Promoting positive welfare in pigs

Modern production systems often consist of barren, invariant, confined environments that provide little opportunity for pigs to engage in highly motivated species-specific behaviours such as exploration and foraging. Such behaviours are intrinsically motivated, and their performance is inherently rewarding (Stolba and Wood-Gush, 1989; Boissy et al., 2007). The thwarting of motivated behaviour, or impedance of agency, may be associated with a range of negative affective experiences such as frustration, boredom, anger, or helplessness (Panksepp, 2005; Mellor, 2015). Conversely, providing opportunities for pigs to perform more species-specific behaviours and/or providing a wider range of behavioural choices can not only alleviate some negative experiences but may enhance their welfare (Mellor and Beausoleil, 2015).

Two highly motivated behaviours that, when present, are considered indicative of positive welfare in pigs are exploration and play (Špinka, 2017; Lawrence et al., 2018). Play behaviour is almost ubiquitous among mammals and is thought to have evolved as a means of training or preparing animals for the unexpected, enabling them to better cope with challenge in later life (Held and Špinka, 2011). Moreover, play is thought to be inherently rewarding (Held and Špinka, 2011). Importantly, play behaviour is usually only observed in situations where there are no threats to fitness, making it a promising indicator of positive welfare (Boissy et al., 2007; Held and Špinka, 2011). In pigs, play is thought to enrich cognitive ability and facilitate social bonding (Horback, 2014). Providing pigs with an environment that encourages play may therefore enhance their welfare. Experimental evidence indicates that pigs play more in enhanced environmental conditions. For example, in piglets, play behaviour was enhanced by the addition of straw to farrowing and weaning pens, the use of free-farrowing pens versus crates, when birth litter composition was maintained (as opposed to fostering), when ammonia levels in the housing unit were lower, and in prepubertal gilts when straw, bark and tree branches were added to barren pens (reviewed by Lawrence et al., 2018). Furthermore, play behaviour preweaning may have positive benefits on postweaning social affiliative behaviour, thus potentially reducing physiological stress and injuries associated with aggressive interactions (Martin et al., 2015). Providing young pigs with increased space and manipulable materials, and/or maintaining birth litter composition may therefore enhance their welfare through promoting play.

Exploratory behaviour in confined systems can be encouraged through the provision of rooting materials. A number of studies have investigated the welfare benefits of different types of rooting materials or objects, such as straw, peat, sawdust, hanging ropes or chains, tyres, and plastic toys, among others (reviewed by Godyń et al., 2019). A common finding across studies was that materials which are ingestible, chewable, and deformable were associated with more exploratory behaviours than simple hanging objects such as chains or tyres (Godyń et al., 2019; Ocepek et al., 2020). Whilst straw is often considered the optimal enrichment material for promoting exploratory behaviour, there is some evidence that a combination of materials (such as straw, silage, peat, or sawdust) may be better than a single substrate (Ocepek et al., 2020). Regardless of material, replacement or replenishment over time may be necessary to ensure pigs' continued engagement (Godyń et al., 2019). In addition to providing positive welfare benefits through stimulation of exploratory behaviour, the addition of manipulable materials to piglets preweaning has also been associated with

persistent reductions in undesirable or pathological behaviours such as tail and ear biting (Telkänranta and Edwards, 2018).

Another highly motivated behaviour that is associated with positive welfare in preparturient sows is nest building. In free-range or semi-natural conditions, pregnant sows will self-isolate a few days prior to farrowing and engage in intensive nest-building activity until just prior to farrowing (Jensen, 1986; Stolba and Wood-Gush, 1989). Despite there being no functional need for nest building in intensive systems which are thermally neutral and free of predators, domestic sows remain highly motivated to perform this behaviour (Špinková, 2017), as evidenced by increased activity, rooting and pawing at floors, and mouthing of pipes and waterers prior to farrowing (Wischnier et al., 2009). Thwarted nest-building activity in preparturient gilts has been associated with acute stress hormone secretion (Jarvis et al., 1998; Yun and Valros, 2015). Providing sows with opportunities to perform nest-building behaviour may therefore reduce physiological stress prepartum as well as promoting positive welfare by allowing them to exercise agency (Mellor, 2015). Whether provision of nesting material is equally effective across parities is uncertain; Oliviero et al. (2008) demonstrated no difference in plasma cortisol between multiparous sows housed in farrowing crates or enriched pens with straw, with both groups showing acute cortisol increases preparturition. There is evidence that nest building may also benefit piglet welfare through improved sow-piglet interactions and reduced piglet mortality (Jarvis et al., 1998; Oliviero et al., 2010; Yun and Valros, 2015). Housing sows in pens with straw i.e., providing both space and substrate for nesting, has the greatest potential to improve sow welfare, although there is evidence that either increased space or provision of straw alone may positively benefit welfare (Wischnier et al., 2009).

Lastly, I would like to address the potential for positive human-pig interactions to enhance pig welfare. Incorporating regular positive tactile interactions into routine management may benefit pig welfare through reducing fear of humans. Repeated gentle contact with humans has been shown to reduce pigs' fear of humans in subsequent interactions, and to ameliorate negative responses to future aversive situations (Hemsworth and Coleman, 2011; Muns et al., 2015). For example, piglets that were regularly stroked or patted for short periods early in life were shown to have reduced fear of humans later in life (Hemsworth and Barnett, 1992). Piglets that were gently stroked during suckling on their first day of life showed less responsiveness to tail docking the following day (Muns et al., 2015). Sows that received two minutes of patting or scratching per day from a familiar handler during gestation showed less avoidance of the stockperson during pregnancy testing and vaccination (Hayes et al., 2021). Regular positive handling can establish a bond between the animal and handler, such that approach and contact with familiar human handlers may elicit positive emotions (Tallet et al., 2018). Signs of anticipation, pleasure or relaxation provide evidence for such interactions being perceived as rewarding (Rault et al., 2020). This is further reinforced by evidence indicating that pigs show a preference for interactions with a familiar gentle handler rather than a familiar aversive handler (Sommavilla et al., 2011). Incorporating positive tactile interactions with pigs, such as belly-rubbing, patting, scratching, or stroking into normal management routines, may therefore promote welfare in the short term through positive experience, as well as providing longer term benefits in the form of stress resilience (Rault et al., 2020). Furthermore, if interactions with familiar humans are mainly positive, pigs may generalise this positive response towards unfamiliar humans as well (Rault et al., 2020).

Whilst incorporating regular positive tactile interactions throughout the growth period may prove challenging on large-scale farms, positive interactions with preweaned piglets during

routine inspections and when performing routine husbandry procedures may still be feasible and have positive welfare benefits.

As noted previously, stockpersons' attitudes towards their animals can also influence their behaviour towards animals and therefore the animal's welfare. In addition to providing training on positive behavioural interactions, producers may also consider undertaking training designed to improve stockpersons' attitudes towards pigs, for example by using cognitive behavioural modification techniques (Hemsworth and Coleman, 2011), or using screening methods to identify people with desirable attitude traits as part of their job application procedures.

Conclusion

The Five Domains model is a structured, systematic, and comprehensive welfare assessment framework that may be used to identify welfare compromise and enhancement in a range of animal species and contexts. The model provides a useful basis for identifying opportunities to promote positive welfare in intensively farmed animals. When negative affective experiences are minimised, providing animals with the opportunity to engage in species-specific rewarding behaviours may shift them into an overall positive welfare state. In domestic pigs, providing opportunities for foraging, play, and nest building and improving the quality of pig-human interactions are potential avenues for promoting positive welfare.

Ethics approval

Not applicable.

Data and model availability statement

None of the data were deposited in an official repository.

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Author contributions

Nikki Kells: Conceptualisation, Writing - Original draft preparation, Writing - Reviewing and Editing.

Declaration of interest

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Transparency Declaration

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