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Animal welfare: A result of animal background and perception of its environment

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Implications

- Animal welfare is a growing issue in modern farming systems due to a perceived mismatch between animals' actual environments and their natural habitats, acknowledgement that animals are sentient beings, and societal awareness not only that animal production matters but also that the production methods matter.
- Welfare implies that the biological needs of animals are fulfilled and, more importantly, that the animals feel "well." What emotions animals can feel is now documented, and methods have been developed to assess how well an animal feels.
- The welfare of an individual depends on its living environment, genetics, and past experiences, with the result that each individual may perceive a triggering situation differently.
- Farming system design needs to evolve to encompass the welfare provided to animals based on actual living conditions and the animals' background. Improvements have been proposed so that it is now possible to integrate animal welfare into farming conditions that meet both animal requirements and societal concerns.

Key words: animal welfare, cognition, emotions, genetic, past experience, stress, temperament

Introduction

There is public concern not only on the quality of the food products, but also the way these products are obtained. For animal products like milk and meat, the conditions in which animals are reared and slaughtered are of prime importance (Miele et al., 2011). Indeed, animals are now acknowledged as sentient beings, capable of feeling emotions. This notion was even included in the European Union Treaty of Amsterdam (European Union, 1997, p. 110). Animals can no longer be considered machines that can be manipulated at will for human purposes. Because animals are sentient, their welfare matters (Duncan, 1993; Veissier and Boissy, 2007).

Over the last few decades, scientists have made huge progress in understanding how animals perceive their environment and the feelings prompted by this perception. First, in the 1970s, it became clear that the stress response, which was initially considered as a physiological concept (Selye, 1936), is triggered by psychological factors: an animal that does not perceive a threat in its environment will not be stressed, even if the threat is there. This became apparent from studies on monkeys progressively exposed to cold and heat and to fasting animals separated from normally fed counterparts (Mason, 1971). In both of these situations, the animals were not aware of the threat imposed on their body and were not stressed while their counterparts that were abruptly exposed to heat or cold, or fastened in presence of normally fed animals, showed signs of stress. Mason concluded that the non-specificity of stress responses, reported earlier by Selye, was due to the common emotion felt by the animal that triggers stress responses. We now know that stress responses vary in form depending on how the individual perceives the situation and its coping possibilities, such as whether the animal engages in a passive response (e.g., immobility) or an active one (e.g., fight or flight; Dantzer and Mormède, 1983; Veissier and Boissy, 2007).

The concept of pain was then broadly extended to vertebrate animals and at least some invertebrates (Bateson, 1991; Barras, 2007). Furthermore, it became clear that the ability to predict the occurrence of a stressful event, painful or not, and to control the termination of that event also affects stress responses (Weiss, 1972). This prompted scientists to suggest that animal welfare was closely linked to cognitive processes such as an awareness of some internal state (e.g., being hungry and diseased), expectancies about the environment (which help animals to detect whether something is absent or not), and the ability to predict or control the animal's environment (Wiepkema, 1987; Duncan and Petherick, 1989).

Welfare problems can be caused by the physical environment (e.g., poor housing and lack of food) or by diseases, provided the animal perceives that the situation does not match its needs or motivations or produces a degree of malaise. Welfare problems can also arise from "purely psychological" factors that do not directly affect the functioning of the animals. For instance, separating offspring from their dam generally leads to distress responses such as vocalizations, reduced weight gain, and a reorganisation of social relations between animals, even when the young animal was no longer suckling its dam (Veissier and Le Neindre, 1989; Haley et al., 2001).

The concept of animal welfare applies to beings having some perceptive capacities. The starting point of the welfare of an individual is his/her emotions, which may or may not evolve into prolonged affective states

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(Ursin and Eriksen, 2004). The objective of this paper is to highlight the subjective experiences of an animal (i.e., its emotions, and the mental mechanisms by which the welfare of an animal is built).

Do Animals Feel Emotions?

An emotion can be defined as an affective response to a triggering event, where this response is relatively intense and short-lasting (Dantzer, 1988). An emotion is traditionally described by three components: a subjective component, the emotional experience (what one feels), and two expressive components, one motor (what one shows to others, such as facial expressions and movements) and one physiological (how the body responds, such as stress responses; Dantzer, 1988). In humans, the subjective component is generally inferred from verbal self-reports. In animals, only the motor and/or physiological components are directly accessible. Therefore, while it is fairly easy to identify an animal responding to a triggering situation (e.g., a startle or fleeing reaction accompanied by tachycardia and a release of cortisol into the blood, typical of a stress response) and to quantify the magnitude of this response, it is more difficult to relate these responses to the qualitative nature of the emotion (i.e., negative or positive valence) felt by an animal. In addition, similar responses can be observed in non-stressful situations (e.g., during mating or physical exercise). Appraisal theories developed in cognitive psychology to probe human emotions have offered a window to answer this crucial question and gain a deeper understanding of animals' emotions (Désiré et al., 2002).

According to appraisal theories, emotions result from how an individual evaluates a triggering situation *per se* followed by his/her responses to that situation (Lazarus et al., 1970). This quasi-automatic evaluation process involves a sequence of checks that can be grouped into four classes (Scherer, 2001): i) relevance of the situation, including its novelty, suddenness, predictability, and pleasantness; ii) implications of the situation for the individual, including how far the situation is consistent with the individual's expectations; iii) coping potential, including the control offered by the environment and the ability of the individual to react; and iv) normative significance, including the check for internal standards (if one fails to respond correctly, will that affect his/her self-esteem?) and the check for external/social standards (are there responses that are expected by the individual's social group?). The outcomes of this limited number of checks determine the subjective component of the emotion. For instance, fear is elicited by exposure to an unpleasant event that is sudden, unfamiliar, unpredictable, and inconsistent with expectations; rage is experienced in similar situations, except that the individual's evaluation is that he/she can control this situation; happiness is triggered by an event evaluated as slightly sudden, quite predictable, very pleasant, and consistent with expectations; and so on (Sander et al., 2005). This subjective component of the emotion will in turn affect the physiological and behavioral responses.

The framework offered by appraisal theories was transposed to animals (Desire et al., 2002). We developed on sheep used as models various experimental situations that were designed to activate one or several evaluation checks in order to ascertain which ones are relevant to animals (Veissier et al., 2009). Cardiac and behavioral reactions were recorded to probe the links between presumed appraisal and measurable emotional outcomes. As already reported in many species, it was found that sheep reacted to sudden and novel events (Désiré et al., 2006; Figure 1). These checks appear rather automatic and may not require the animal to be aware

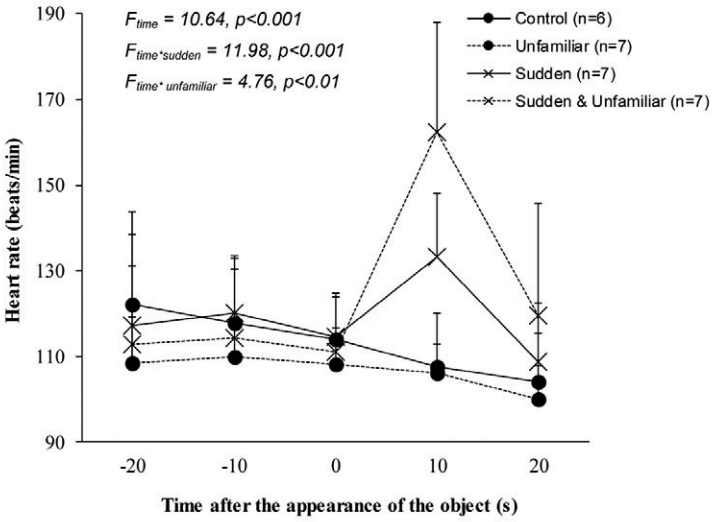
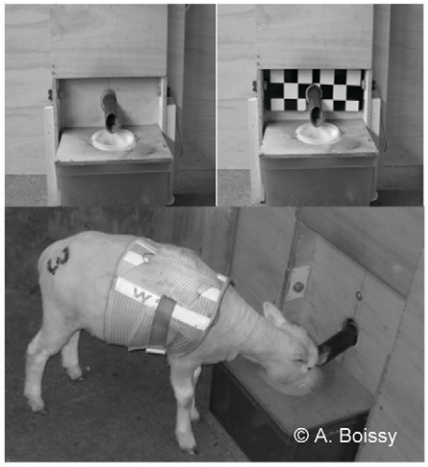
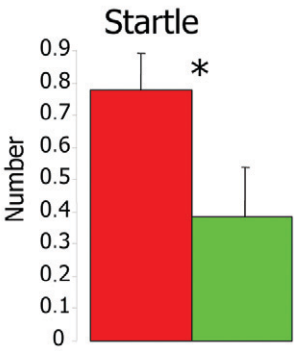


Figure 1. Heart rate of lambs before and after the appearance of either a known or unfamiliar object falling down behind the trough when the animal is eating, with the object falling either slowly or suddenly. Heart rate increases after the sudden appearance of the object, and especially strongly if the object is unfamiliar (from Désiré et al., 2006). These results show that the emotional responses of sheep to an event depend on the suddenness and the unfamiliarity of that event.

of its evaluation of the situation. More interestingly, it was found that the emotional responses of sheep (e.g., behavioral and cardiac responses) are also affected by the predictability of a situation (Figure 2), its controllability, or its consistency with the animal's expectations (Greiveldinger et al., 2007). All these checks require cognitive processing of the information. We argued that since emotional responses of sheep are influenced by such cognitive processes, sheep not only experience emotional responses (which could be considered reflexes), but really do feel emotions (Veissier et al., 2009). We further considered that if animals can use checks similar to humans, there was no reason to reject the idea that these animals can feel the emotions felt by humans as a result of the combined outcomes of these checks. Our findings on the checks sheep are able to use to evaluate their environment suggest that sheep can experience a wide range of emotions: i) fear and anger, as they are sensitive to suddenness, unpredictability, controllability, and social norms; ii) rage, as they respond to suddenness, unfamiliarity, unpredictability, discrepancy from expectations, controllability, and social norms; iii) despair, as they react to suddenness, unfamiliarity, unpredictability, discrepancy from expectations, and controllability; and iv) boredom, as they are sensitive to suddenness, unfamiliarity, unpredictability, discrepancy from expectations, and controllability (Table 1). Although this approach has not been completed for many farm animals, it is now widely accepted that not only mammals, but also poultry and farmed fish can feel emotions (Chandroo et al., 2004; Valance et al., 2008).

Much research has focused on the potential role played by conspecifics in the elicitation of emotions. Indeed, the vast majority of farmed animals are gregarious and react heavily to being separated from groupmates. This is valid both for mammals and birds (Boissy and Le Neindre, 1997; Valance et al., 2008). More recently, we found that the emotional responses of sheep to a threatening event are influenced by the animal's social environment: confronted with a sudden disturbing event (an object falling down behind a trough when the animal is eating), sheep are more





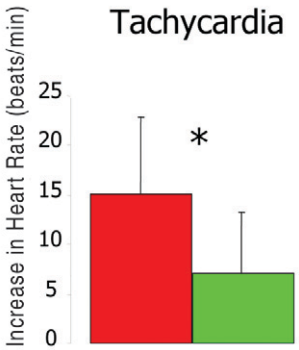


Figure 2. Startle responses and increase in heart rate (mean ± SEM) when a white and blue panel drops down behind the trough when the sheep is eating. Sheep for which the appearance of the panel was preceded by a light signal (green) are compared against sheep that have no cue for the appearance of the panel (red) (adapted from Greiveldinger et al., 2007). The specific emotional responses of sheep to sudden events (i.e., startle response and tachycardia) are affected by the predictability of that event. *, $P < 0.05$.

likely to display overt external responses (stepping back from the trough) when they are accompanied by a subordinate group-mate but internal responses (tachycardia) when they are accompanied by a dominant group-mate. Therefore, sheep are likely to form social standards of emotional responses according to their rank in hierarchy.

These findings add support to the argument that the animals used in farming are sentient animals and can feel a wide range of emotions. Whether short-lived processes such as emotions can lead to prolonged affective states is an issue discussed in this next section.

Prolonged Affective States

Emotions are transient processes while the welfare of an individual refers to its internal state, which is how it feels not only when facing triggering events, but also in between these events. Here, we discuss how emotions and their pattern over time define the welfare state of an animal.

It is now well known that repeated exposure to negative events results in long-term stress-related responses such as anxiety and depressive-like behaviors. For instance, chronic social stress induces depressive-like behaviors in various animal models, such as rodents (Veenema et al., 2003), tree shrews (Fuchs and Flügge, 2002), and birds (Carere et al., 2001). Similar effects have been reported in farm animals, namely cattle and pigs (Boissy et al., 2001; Coutellier et al., 2007). These social events induce behavioral changes, such as decrease in locomotor activity, self- and allo-grooming, feeding behaviors (both appetitive and consummatory components), and physiological changes such as altered circadian rhythm, body temperature, or body weight (Martinez et al., 1998). Similar changes have been identified in rodents submitted to various unpredictable aversive events not necessarily related to the social environment (Willner, 2005). These changes are considered to be symptoms of depressive-like states in animals.

In contrast to emotions, which are acute, transient, and focused on the event that triggered them (e.g., a tachycardia and a flight response that will help avoid a specific threatening event), exposure to repeated stressful events leads to a prolonged state where emotional responses to events unrelated to previous challenges are affected. Animals repeatedly exposed to stressors exhibit less positively motivated behaviors such as consumption of an appetitive sweet solution, a phenomenon called anhedonia (Willner, 2005). Similarly, both laboratory and farm animals submitted to repeated unpredictable aversive events are less prone to respond to a stimulus signaling the delivery of a positive or negative event, especially when the signal is ambiguous (i.e., between a positive and a negative signal; Harding et al., 2004; Doyle et al., 2011). These findings suggest that the repetition of negative emotional experiences affects the way animals appraise

Table 1. Emotions (bottom row) in relation to the outcome of the evaluation of a triggering situation (from Sander et al 2005; Veissier et al., 2009). According to appraisal theories, the nature of emotions felt by a human being results from the evaluation of the situation following a series of checks. Sheep can use the checks used by humans and mentioned in the table, and the outcome of the evaluation modifies their emotional responses. They are thus assumed to feel the corresponding emotions.

Checks	**Outcome of the evaluation**								
Suddenness	High	Low	High	High	Very low	Low		Low	
Familiarity	Low		Very low	Low	High				Low
Predictability	Low	Medium	Low	Low	Very high	Medium			Low
Pleasantness	Low					High			Very Low
Consistency with expectations	Low		Very low	Low	High	High			
Control		High	Very low	High	Medium				
Social norms		Low		Low			High	Low	
Emotion	*Fear*	*Anger*	*Despair*	*Rage*	*Boredom*	*Happiness*	*Pride*	*Shame*	*Disgust*

the environment to which they are exposed, making them less aware of positive cues and more susceptible to negative ones.

The type of experiences the animal has faced previously can also influence the nature of its responses. An animal's perceived controllability of its environment, not only when facing a short-lived event, but also permanently in its environment, is probably of high importance. Indeed, an animal that is able to control its environment through a learned behavior is less disturbed by new constraints compared with an animal facing an unpredictable, uncontrollable environment (Dantzer, 1989). In a recent study, we found that the overall welfare of dairy cows is higher if an automatic milking system is used, allowing cows to choose when to be milked, rather than a milking parlor where cows are led in by the farmer at fixed times during the day (De Boyer des Roches, personal communication). In contrast, an animal that has no control over its environment can develop apathy, as in the case of sows in gestation stalls becoming unresponsive (Broom, 1987). Apathy may come from learned helplessness: when an animal learns that it cannot exert control over its environment, it eventually loses its ability to learn to control and react to the environment (Danchev and Staneva-Stoytcheva, 1995).

Several authors reported large inter-individual variations in physiological and behavioral responses to a chronic stress procedure (Carere et al., 2001; Ruis et al., 2001). For instance, while depressive-like behaviors are expected after chronic mild stress, a significant proportion of animals (up to a third or half of samples) are resistant and do not develop these symptoms. Therefore, the emotional state of an animal seems to result from both its environment (especially previous stressful events) and its own individual characteristics.

These variations in animal susceptibility to stressors may come from their coping styles (i.e., their spontaneous bio-behavioral attitude in response to stressful events), which can be described, for example, as proactive vs. reactive coping styles (Koolhaas et al., 1999; Veenema et al., 2003). For instance, reactive mice, defined as animals remaining passive (e.g., immobility and freezing) in response to a stressor, are more susceptible to the deleterious effects of chronic stress and are slower to recover than proactive mice, defined by a propensity to develop active responses (e.g., fight or flight) to adapt to stressful events (Blanchard et al., 2001). Individual variations may also come from differences in appraisal processes. Subjects that tend to assess events as threatening may be more likely to develop chronic stress and to assess further events even more negatively (Becker et al., 2001). Coping strategies and appraisal processes are probably co-related, although to date, no study has established this probable link. These concepts are embraced in the more general concept of temperament, defined as the stable subject's bio-behavioral disposition to respond to stimuli in a specific way. Temperament relates to the animal as a whole, including its psychology, genetics, and physiology [Figure 3; read the review by Rodenburg and Turner (2012) for further discussion of the role of genetics on animal welfare]. Data on temperament remain scarce, but ideas are progressively emerging. For example, five major temperament traits have been proposed for animals: shyness-boldness, exploration-avoidance, activity, sociability, and aggressiveness (Réale et al., 2007). This proposition is still under-exploited but could provide a platform for better understanding animal temperament and its relevance to welfare issues.

In this section, we showed an animal's welfare is shaped by the string of its emotional experiences together with its temperament, including coping strategies and appraisal processes. Cognitive processes are pivotal in this chain of events and effects, acting as the mechanism by which triggering situations impact on the animals while at the same time being affected by these experiences. Evidence of systematic cognitive biases in the way an animal evaluates its environment, reduced anticipatory behavior to positive events, or low reactivity to the environment are likely to signal a persistent state of poor welfare.

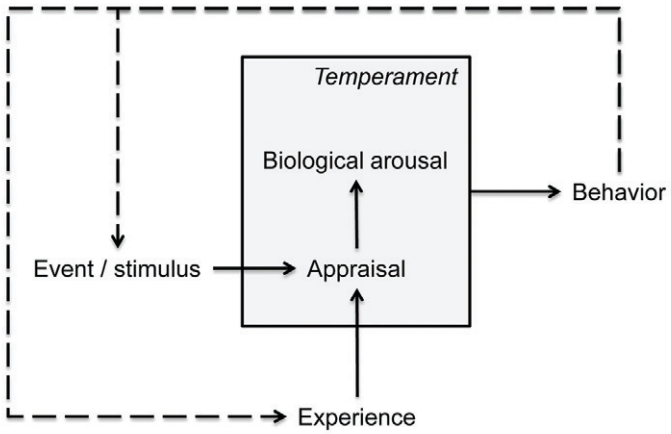


Figure 3. A convenient way to take into account the interindividual variability in the emotional responses and henceforth in the vulnerability to stressors would be to consider the temperament as a core variable. As illustrated, temperament relates to the animal as a whole, including its psychology (i.e., modes of appraisal), its physiology (i.e., biological reactivity), and also its life history (i.e., experience and learning).

Welfare, Discomfort, and Health

In the above sections, we focused on psychological factors involved in welfare. Note that we are not saying that an animal's physical environment or its physical state are irrelevant. As explained by Duncan (2002), living beings (plants, microbes, and animals) have essential needs that must be covered for this being to live, grow, and reproduce. However, this does not necessarily result in welfare issues for all these beings. In plants, these needs may be covered by tropisms (a plant placed in a dim room will bend towards a window to find light). In lower vertebrates, stimulus-response behaviors may serve to cover needs (eating food when it is available and avoiding predator-like cues) without requiring cognitive abilities. In other words, these organisms can react to a difficult situation without necessarily being aware of it. By contrast, in higher invertebrates (like octopus) and vertebrates, the non-fulfillment of needs is likely to result in negative feelings: hunger and thirst in response to insufficient provision of food and water and pain in response to injury (Broom, 1998). Broom defines welfare in terms of adaptation to the environment (which he calls coping) and asserts that feelings are important as they serve adaptation (e.g., they can protect the organism from dying of starvation, dehydration, physical damage). Contrary to Broom, we share the views of duncan, which argue that these feelings are important *per se* rather than simply because they serve adaptation.

There is evidence that animals voluntarily choose environments that are comfortable. For instance, cows prefer lying down on a compressible material like a mattress or sand rather than on bare concrete (Manninen et al., 2002). Note also that animals will avoid environments that we see as uncomfortable (e.g., wind; Faure and Lagadic, 1994). An animal's

Table 2. Perception of comfort in hens and preference for cages enriched with peat, perch, and nestbox (from Nicol et al., 2009). In choice tests, enriched cages are preferred to bare ones. Being in an enriched cage for a period of time induces fewer stress responses compared with when those same hens are housed in a barren cage.

Cage	Bare	Enriched
Frequency of choice	–	+
Blood glucose	+	–
Heterophil/lymphocyte	+	–
Response to novelty	+	–
Feed conversion	–	+
Self-grooming	–	+

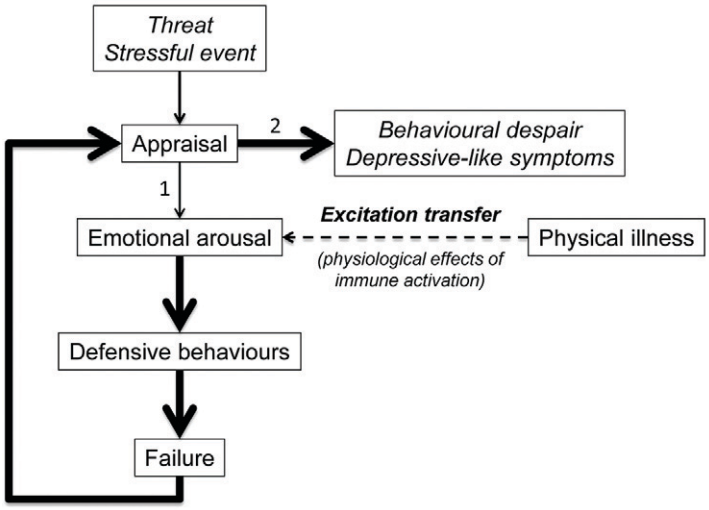


Figure 4. A probable mechanism involved in the increased vulnerability of physically ill organisms to stressful events has been argued to depend on an excitation transfer corresponding to the shared physiological effects of immune activation and emotional arousal (e.g., HPA axis activation). The consecutive increased emotional arousal would further support the expression of defensive behaviors, but in case of a failure to cope with the stressful events, this would also increase the deleterious consequences, i.e., the development of depressive-like symptoms (adapted from Renault and Aubert, 2006).

preference for a given environment and its behavioral and physiological responses in that environment are linked: in an experiment where hens were housed sequentially in two different environments (cage with a wire mesh floor vs. wood shavings, peat, a perch, and a nestbox) before being allowed to choose between the two environments, the less-preferred environment (cage with a wire mesh floor) was associated with higher body temperature, blood glucose, and heterophil:lymphocyte ratio, and response to novelty, plus lower feed conversion and less frequent self-grooming (Table 2; Nicol et al., 2009), and these signs are all generally considered as signals of stress. These experiments show that animals can perceive their environment as more or less comfortable and that the comfort of their environment really matters to them.

Although welfare and health are distinct concepts, health influences welfare. As argued by Duncan, it is not "being ill" that matters but "feeling ill"[1] (Duncan, 1993), and there is evidence that animals can feel ill and express specific bio-behavioral changes (e.g., drowsiness, hypophagia, curled-up posture, and social withdrawal) that are referred to as sickness behaviors (Aubert, 1999; Dantzer et al., 2008). Several studies have provided evidence of links among stress, immune response (notably through the action of inflammatory cytokines on the brain), and behavioral disorders such as depressive-like behaviors. Cytokines are mediators synthesized and released by immune-competent cells and involved in the communication of the immune system and the onset of immune response. Well-established effects of cytokines on the brain include the hyperactivity of the hypothalamic–pituitary–adrenal (**HPA**) axis (Besedovsky et al., 1991), which plays a key role in stress response. Moreover, cytokines have been shown to alter emotional processes (i.e., pleasure vs. displeasure) in animals. For example, the stimulation of cytokine release alters the consumption of palatable sweetened milk by mice (Dunn et al., 2005) or induces finickiness in response to bitter-sweet solution (Aubert and Dantzer, 2005).

In order to assess how an immune challenge can affect emotional reactivity to external stimuli, endotoxin-treated mice have been submitted to a forced-swimming procedure (Renault and Aubert, 2006). Subjects forced to swim in a narrow inescapable tank of water develop a characteristic immobility that may represent behavioral despair or be related to learned helplessness (Porsolt et al., 1977). Mice administered lipopolysaccharides, which are part of the membrane of some bacteria and elicit strong immune responses, increase the intensity of their defensive behaviors (i.e., swimming and climbing) during the first exposure to the inescapable water tank but subsequently decrease drastically these behaviors in the following sessions (i.e., higher immobility time). This decrease in defensive behavior cannot be accounted for by a putative decrease in physical capacities induced by endotoxin administration, since these mice were hyper-active at first exposure to the forced-swimming procedure, but rather by an increased impact of the failure to adapt to the behavioral challenge posed by immersion in the water tank (Figure 4; Aubert, 2012; Renault and Aubert, 2006).

Finally, there is thought to be a circular relationship between sickness-induced vulnerability and stress, since chronically stressed (i.e., distressed) animals are more susceptible to infectious disease due to the immunosuppressive effect of the HPA axis. Such circularity could be suspected in husbandry conditions in which poor welfare is observed.

Animal Welfare Assessment in Practice

The welfare of an animal depends on how it perceives the situation to which it is confronted and on how it perceives itself in that situation. In humans, quality-of-life questionnaires are used to assess how a person feels about his or her life (de Jong et al., 2012). This is evidently impossible in animals, and therefore, in day-to-day life, as in farm conditions or other commercial settings like slaughter plants, the animal's internal welfare state is usually inferred from indices of the effect of putative causal factors. In other words, there are a number of factors that can affect the welfare of animals (lack of food leading to hunger; poor housing condi-

1 Welfare is commonly defined as physical and mental health while the World Heath Organization defines health as a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity (https://apps.who.int/aboutwho/en/definition.html).

Table 3. Welfare Quality assessment system, criteria, and indicators (Welfare Quality, 2009)

Welfare criteria	Indicators in dairy cows
Absence of prolonged hunger	Body condition score
Absence of prolonged thirst	Water supply
Comfort around resting	Behavior around resting Cleanliness scores
Thermal comfort	No measure available at present
Ease of movement	Presence of tethering Access to outdoor loafing area and/or pasture
Absence of injuries	Lameness Integument alterations
Absence of disease	Respiratory, enteric and reproductive disorders, mortality
Absence of pain induced by management procedures	Dehorning and tail docking practices
Expression of social behavior	Aggressive behaviors
Expression of other behaviors	Access to pasture
Good human–animal relationship	Avoidance distance at feeding place
Positive emotional state	Qualitative behavior assessment

Figure 5. In Welfare Quality, the body condition score is used to assess whether cows may have suffered from hunger for a prolonged time. The cow on the right is considered too lean. Also the proportion of the year when cattle are at pasture is used to assess the possibility to express a wide range of behavior (© K. Leach).

tions leading to discomfort, injury, or disease; poor handling leading to fear of humans; repeated social mixing; and lack of water). The internal states of hunger, discomfort, fear, malaise due to a disease, and so on, are not directly measurable, making it necessary to look at the effects these factors can have not on the mind, but on the body of the animals. Some effects are directly due to the physical components of the causal factor (e.g., leanness in the case of poor feeding or a visible injury or clinical sign of a disease in the case of poor health) whereas other effects reflect how the animal may feel about its situation (e.g., a flight response when a human approaches the animal even though that human is not forcing the animal to flee).

Welfare is a multidimensional concept: there are many factors that affect welfare, and specific indices of poor welfare will depend on the causal factors. Assessing welfare implies taking multiple aspects into account, and thus entails using a series of indicators rather than just one. Based on a large scientific consortium, the Welfare Quality project proposed 12 welfare criteria that need to be met to ensure animal welfare (Botreau et al., 2007). This list is supposed to be exhaustive. In experimental conditions, sophisticated measures may be run to determine cardiac activity, blood level of stress hormones, long-lasting and detailed behavioral observations. These methods are not adequate for welfare assessment in commercial conditions.

Many welfare assessment systems to be used in commercial settings rely on the presence of certain resources on the farm (e.g., amount of food and housing type) and on the management of that farm. These aspects constitute risk factors for the welfare of animals. However, interactions between risk factors are unable to form solid predictions on their effects on animals. By contrast, the Welfare Quality assessment tool relies as much as possible on animal-based indicators, taken on the farm or at slaughter, which are assumed to be closely linked to the internal welfare state of animals (Table 3 and Figure 5 and 6; Welfare Quality, 2009). These indicators are probably not as precise as what can be used in experiments; however, they appear more sensitive than those based on resources or management (Mollenhorst et al., 2005). Although originally designed to cover hens, broilers, cattle, and pigs, Welfare Quality principles are now applied to other species ranging from horses and sheep to minks and foxes.

Scientific studies can provide information on welfare criteria that may be valid and reliable indicators for assessing them. When it comes to producing an overall evaluation of the welfare provided by a given farm or system, the various components need to be balanced. For instance the health of animals may be better in a given system A compared with B while B may offer more behavioral opportunities (see for instance calves in individual crates vs. in group pens), and system C may reduce the prevalence of welfare problems in general while maintaining some animals in very poor conditions. This leads to ethical dilemmas, such as "is health more important than behavior?" (the answer to which might differ, e.g., between vets and ethologists) or "shall we consider the average welfare state in a group of animals or give the priority to the animals in the worst conditions?" and science alone cannot solve these dilemmas. A clear debate on these issues is necessary, and the construction of an overall assessment must be made explicit so that anyone can see whether it matches his or her ethical reasoning (Veissier et al., 2011).

Where Next?

Major causes of poor welfare in farm animals can be insufficient provision of food (especially in reproductive poultry and sows, where it leads to chronic hunger and abnormal behaviors such as stereotypies; Terlouw et al., 1991; Savory and Lariviere, 2000); uncomfortable housing leading to poor resting (e.g., poor cubicle design in cattle; Veissier et al., 2004), overcrowding, boredom (due to barren environment), or respiratory diseases due to insufficient ventilation; poor health status often linked to highly intensive production resulting from genetic selection for productivity (e.g., rapid growth in broilers resulting in leg disorders, ruminal acidosis due to high-energy diets in ruminants, and greater sensitivity to mastitis in high-milk-producing cows; EFSA Panel on Animal Health and Welfare,

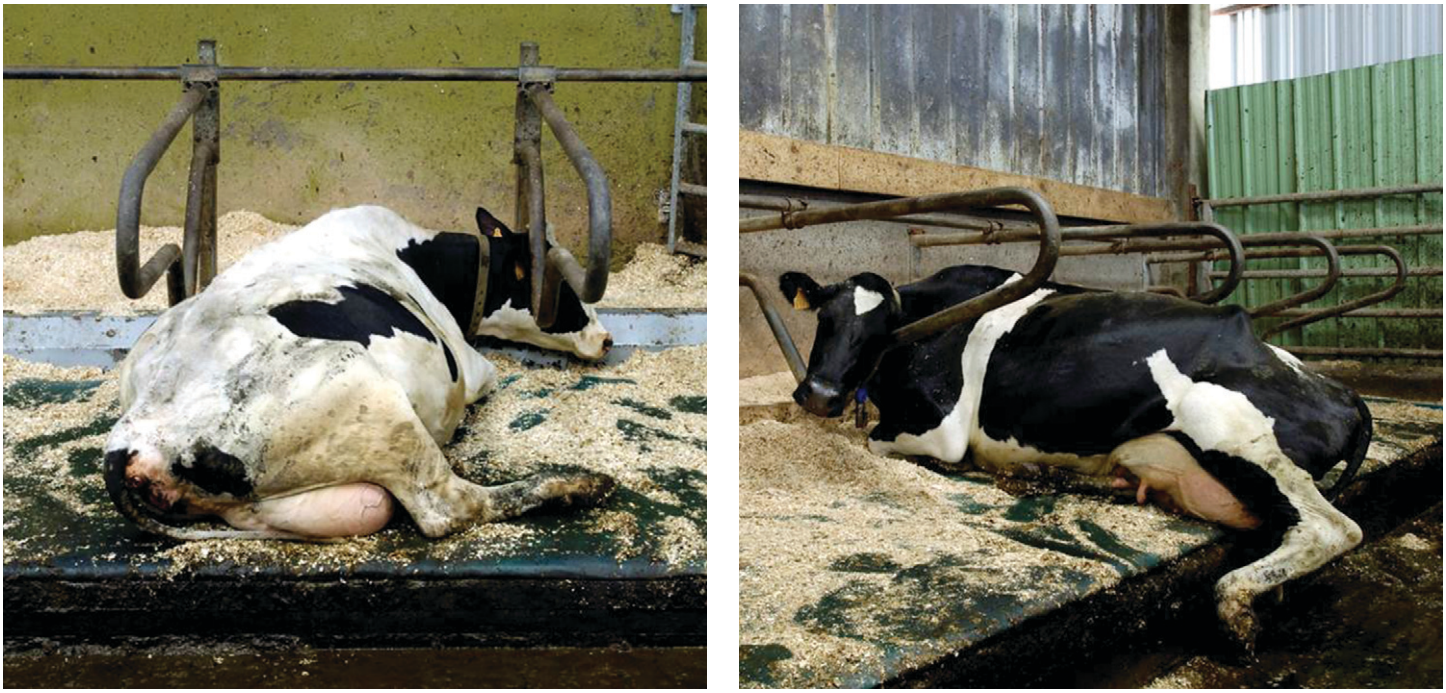


Figure 6. Cubicles offer an adequate lying area as far as they are properly designed. In Welfare Quality, the proportion of cows lying completely in the lying area (**left side**) and that of cows lying outside or partly outside the lying area (**right side**) are taken into account to assess the comfort of the lying area (© Jérôme Chabanne).

2009); and pain due to management procedures such as castration or dehorning, especially when performed without pain-relievers (Stafford and Mellor, 2005). Rough handling from humans and repeated social mixing are also likely to result in altered immune functions or altered HPA axis function, both of which suggest stress and are linked to overt behaviors of animals that try to avoid further contacts (Hemsworth and Barnett, 1991; Mormède et al., 1990).

Good welfare should include not only the absence of negative emotions (i.e., suffering), but also the presence of positive emotions. It is likely that negative emotions correspond to "need situations" where an action is needed from the animal facing a threat to survival or reproductive success, whereas positive emotions correspond to "opportunity situations" where the pleasure conferred by being able to perform a behavior or enjoy a resource motivates the animal (Fraser and Duncan, 1998). Expression of species-specific behavior, which animals are motivated to express, and therefore access to the resources allowing such behavior are probably important aspects eliciting positive emotions. Pigs spend a significant part of their time budget manipulating substrates (e.g., wood shavings and straw), and this is likely to improve their welfare (De Leeuw and Ekkel, 2004); and cows scratch their body on objects and highly appreciate mechanical brushes (DeVries et al., 2007).

These risk factors for poor vs. good welfare probably interact with each other. For instance, social instability may increase the effect of pathogens present in the environment, with a higher probability of clinical disease and more pronounced sickness behavior. Such an interaction has been observed in beef bulls, where social regrouping at the beginning of fattening may induce chronic stress and make the animals more susceptible to stressors encountered at slaughter (Mounier et al., 2006). However, as things stand, we still have little knowledge on the interactions between risk factors of poor welfare.

We have seen in this paper that the animal itself has a key role in constructing its welfare. The level of welfare depends not only on the actual environment in which the animal is reared but also on the animal itself, especially its temperament and the interactions between its past experience and its temperament. At present, there is a clear need for a better understanding of the interactions between risk factors as well as between these factors and animals' temperament in order to predict the level of possible welfare in a given farm environment and to propose ways to improve it.

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