The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK

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# Animals' emotions: studies in sheep using appraisal theories

I Veissier*, A Boissy, L Désiré and L Greiveldinger

INRA, UR1213 Herbivores, F-63122 Saint-Genès-Champanelle, France
* Contact for correspondence and requests for reprints isabelle.veissier@clermont.inra.fr

## Abstract

*Animal welfare concerns stem from recognition of the fact that animals can experience emotions such as pain or joy. Nevertheless, discussion of animal emotions is often considered anthropomorphic, and there is a clear need to use explanatory frameworks to understand animals' emotions. We borrowed appraisal theories developed in cognitive psychology to study sheep emotions. Emotions are viewed as the result of how an individual evaluates a triggering situation, following a sequence of checks, including the relevance of the situation (its suddenness, familiarity, predictability, and intrinsic pleasantness), its implications for the individual (including consistency with the individual's expectations), the potential for control, and both internal and external standards. We assumed that if the outcome of checks has an impact on the animal's emotional responses, then animals do not only show emotional responses but also feel emotions. We showed that sheep use similar checks to those used by humans to evaluate their environment, ie suddenness, familiarity, predictability, consistency with expectations, and control. Furthermore, this evaluation affects their emotional responses (behavioural responses, such as startle, ear postures, and cardiac activity). It is concluded that sheep are able to experience emotions such as fear, anger, rage, despair, boredom, disgust and happiness because they use the same checks involved in such emotions as humans. For instance, despair is triggered by situations which are evaluated as sudden, unfamiliar, unpredictable, discrepant from expectations, and uncontrollable, whereas boredom results from an overly predictable environment, and all these checks have been found to affect emotional responses in sheep. These results have implications for animal welfare: although a completely invariable and totally predictable environment should be avoided to prevent boredom, sudden events should probably be minimised, the animals should be offered the possibility to control their environment, and care should be taken to ensure a degree of predictability concerning the various events.*

**Keywords**: *animal welfare, appraisal theories, ear postures, emotion, heart rate, sheep*

## Introduction

Animal welfare concerns stem from recognition of the fact that animals are sentient beings able to experience emotions such as fear, pain, joy, contentment, etc. The reference to animal sentience is explicit in the Amsterdam treaty of the European Union (European Union 1997), which stipulates that measures shall be applied "to ensure improved protection and respect for the welfare of animals as sentient beings". The European Convention for the Protection of farm animals also states that "No animal shall be provided with food or liquid in a manner (…) which may cause unnecessary suffering or injury" (Council of Europe 1976). Furthermore, animal emotions form the core of many scientific definitions of animal welfare (Duncan 1993; Dawkins 2006; Veissier & Boissy 2007). Hence, identifying the range of emotions animals are capable of experiencing appears crucial to the design of measures ensuring their welfare.

The word 'emotion' comes from the Latin 'emovere', to remove or shake, and 'movere', to move. An emotion can be roughly defined as something that moves one's body and mind. Emotions are more often defined by their components: the internal-psychological component (what one feels), the neurophysiological component (how the body responds, eg by stress responses), and the behavioural component (what one shows to others, eg facial expressions and movements). Emotions differ from sensations, which are only physical consequences (eg heat), and from feelings, which designate only internal states with no reference to external reactions. It is generally agreed that animals have emotional responses (neurophysiological responses, such as increased heart rate and changes in heart-rate variability reflecting the balance between the sympathetic and parasympathetic branches of the autonomic nervous system [Després *et al* 2003] or release of corticosteroids in blood; behavioural responses such as startle or attempts to escape a situation) but the issue of whether animals feel emotions (psychological component) remains controversial (discussed by Duncan 2006).

## Frameworks to study emotions

Emotions in animals were first described by Darwin in *The Expression of Emotions in Man and Animals* (1872), where he described emotions as stereotyped facial expressions and

bodily postures in specific contexts. Darwin observed similarities between human and non-human animal expressions, in line with the theory of continuity between species. His work on animals' emotions was criticised for approximately 100 years and labelled as anthropomorphic (Grassé 1977; Jacobs 1998). Animals' emotions were considered as falling outside of the realm of science and therefore not to be studied scientifically. Darwin's book was re-edited in 2001, and now seems to be the time to reconsider animals' emotions as a scientific topic. However, discussion of animals' emotions is still often considered anthropomorphic.

On the one hand, anthropomorphism carries the risk of misinterpreting animals' responses. For instance, we may think that a pig wallowing in mud is happy (hence the expression 'happy as a pig in mud') whereas the pig is actually suffering from over-heating. This makes it dangerous ground to naïvely and anthropomorphically project ourselves directly onto animals. On the other hand, as argued by de Waal (1999), the danger lies not only in anthropomorphism but also in 'anthropodenial'. Animals and humans do share common characteristics, and anthropomorphism may help us investigate the human-like characteristics of animals as well as the animal-like characteristics of humans. This led Wynne (2004) to conclude that "Progress will surely be most rapid when we adopt explanatory frameworks that are concrete and unambiguous". Appraisal theories developed in cognitive psychology to understand human emotions appear to provide a strong candidate framework (Désiré *et al* 2002). Human emotions are viewed as the result of how an individual evaluates a triggering situation, beginning with an evaluation of the situation *per se* and followed by the possible responses to that situation (Arnold 1945; Lazarus *et al* 1970; Scherer 2001). Several authors have listed items on which the evaluation is based. Scherer (2001), for instance, asserted that the evaluation is operated following a sequence of checks grouped into four classes:

• The relevance of the situation, including the check for novelty (suddenness, familiarity and predictability of a situation), the check for intrinsic pleasantness, and the check for the relevance of the situation for the individual's own goals;

• The implications of the situation for the individual, including the check of the probability of the consequences expected from that situation, and the check of consistency with the individual's expectations;

• The coping potential, including the check for coping possibilities (offered by the environment, ie controllability) and abilities (within the individual);

• The 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 standards (are there responses which are preferable or compulsory according to the social group one belongs to?)

These checks do not necessarily need high cognitive processes. Some of them are fairly automatic and subconscious, especially within the first check of relevance, while others are more complex (Kappas 2006). Each check operates at several different levels according to the intensity of the cognitive processes required: a sensorimotor level that involves automatic processes, a schematic level requiring the individual to memorise emotional experiences and involving conditioned responses, and a conceptual level that is voluntarily and consciously activated (eg comparison between the real-world situation and conscious plans or self-representation) (Leventhal & Scherer 1987). Within the check of relevance, the check of suddenness seems to require only sensorimotor processes while familiarity and predictability require schematic processes. Assessing a situation in terms of expectations and controllability requires schematic processes, while the check of normative significance is likely to require conceptual processes.

The outcome of the checks is responsible for the psychological component of an emotion, which in turn affects physiological and behavioural responses. Typical emotions such as fear, anger or happiness are linked to the outcome of the evaluation. Table 1 reports the links between several different human emotions and the evaluations that triggered them. For instance, fear is experienced by an individual when he/she is exposed to an unpleasant event which is sudden, unfamiliar, could not be predicted, and not consistent with his/her expectations (ie the event does not match what he/she was prepared for); rage (ie 'hot anger' as opposed to 'cold anger') 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. The internal component, ie the feeling, may well be essential to emotions, but it does not imply that the individual is conscious of his/her own emotions. It can be assumed that there is a gradient of emotional responses, from the mere expression of rather automatic responses to the experience of emotional feelings and the consciousness of self-emotional experiences, depending on the level of the cognitive processes used to appraise the situation: simple checks are likely to lead to automatic responses (eg startle responses when confronted with a very sudden event), checks requiring schematic processes are likely to lead to proper emotional experiences (ie felt by the individual, as reported verbally by people), with checks requiring conceptual processes leading to more conscious emotions.

Other appraisal theories either place emphasis on the nature of the checks (Smith & Kirby 2001) or on the levels of cognitive processes (Philippot *et al* 2004), or present slightly different descriptions of checks (Frijda 1986; Roseman 1991). The results presented in this paper will be discussed in the context of the appraisal theory developed by Scherer's team (2001), as this theory appears to encompass the other appraisal theories, and similar interpretations would thus be obtained with other frameworks.

There are a number of literature reports showing that animals respond to the suddenness of a situation, its novelty, predictability, correspondence to expectations, or controllability (reviewed by Désiré *et al* 2002). Mammals appear able



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**Table 1 Humans' emotions in relation to the outcome of their evaluation of a triggering situation (from Sander *et al* 2005).**

| Emotion | Fear | Anger | Despair | Rage | Boredom | Happiness | Pride | Shame | Disgust |
|---|---|---|---|---|---|---|---|---|---|
| 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 | | | Low | | High | | | Very low |
| Consistency with expectations | Low | | Very low | Low | High | High | | | |
| Control | Open | High | Very low | High | Medium | | | | |
| Social norms | | Low | | | | | High | Low | |

to use all these checks. However, whether they distinguish these various checks and how the outcomes of checks affect their emotional responses remains to be clarified. For instance, it was demonstrated back in the 1970s that the predictability and controllability of aversive events can reduce their negative impacts in the long term (ie reduced rate of gastric ulcers in rodents following exposure to electric shocks) (Weiss 1972). However, whether this effect is due to different emotional responses immediately after the aversive event remains unclear. A comprehensive study based on similar paradigms applied to the same species would greatly help our understanding of how exactly the animal evaluates its environment and responds to it emotionally.

Our research group has transposed the framework proposed by appraisal theories in order to study animals' emotions (Désiré *et al* 2004, 2006; Greiveldinger *et al* 2007, 2009). We postulated that if the outcome of checks that require some cognitive processes has an impact on emotional responses, then the animal not only has emotional responses (which in that case could not be seen as mere automatic responses) but also feels emotions. We used sheep as models because they have moderate cognitive abilities (Nicol 1996), and we assumed that if such animals are able to use similar checks to humans, then most of the other animals reared on farms or used by humans for other purposes would also use these same checks. We essentially investigated whether sheep could feel emotions. We exposed sheep to situations designed so as to make one check more prominent. This check could require only automatic processes (here, the check of suddenness) or schematic processes (familiarity, predictability, consistency with expectations, controllability), in which case its use by the animals would support evidence of the existence of emotional feelings. We also initiated some work on the influence of social norms, the way the animals perceive dominance relationships with their social partners being assimilated to norms. This kind of check is supposed to require a conceptual information process and could thus lead to conscious emotions. Nevertheless, the discussion presented in this paper is focused on the existence of *emotional* feelings in sheep, and does not extend to *conscious* feelings.

We accustomed sheep to being separated from their peers in an experimental chamber where they received highly palatable foods. The sheep were then exposed to various events while they were eating. For instance, sheep exposed to a very sudden event were compared to sheep for which the same event was introduced more gradually; sheep that could control a situation were compared to sheep that could not; and so on. We monitored physiological responses (heart rate and heart-rate variability) and behavioural responses (ear postures, movements). The relevance of each check for sheep will be presented in the next section, where we report the results from some of the experiments we have carried out.

## The relevance of checks for sheep emotions

Each section below starts by describing the various checks used by humans according to the framework proposed by Scherer or his collaborators (Scherer 2001; Sander *et al* 2005). We then explain how we tested the relevance of checks to sheep before going on to analyse how such checks affect sheep's emotional responses.

### Novelty of a situation

When facing an event, the first thing evaluated by the individual is the novelty of that event. Novelty comprises three features: the suddenness of the event (ie does the event occur abruptly?), its familiarity (ie does the event match with something the individual already knows), and its predictability (ie what was the probability of this event occurring, and/or does it occur regularly?)

We exposed sheep to events that were presented abruptly or gradually, were familiar vs unfamiliar, and were predictable vs unpredictable. While the sheep were eating, we manoeuvred a piece of textile behind the trough. This object fell rapidly (88 cm $s^{-1}$) in front of half the animals and fell slowly (6 cm $s^{-1}$) in front of the other half (Désiré *et al* 2004, 2006). In addition, the object was familiar for some animals and new for the others. The sheep showed startle responses and asymmetric ear postures when the object fell rapidly and they looked more often at the object with their ears oriented forward when the object was unfamiliar. In addition, different physiological responses to suddenness and unfamiliarity were observed: when the object fell



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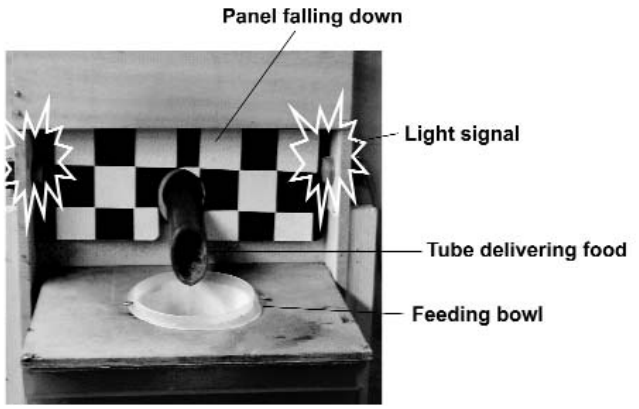
**Figure 1**




Experimental set-up for studying the impact of novelty. The sheep were trained to eat in the feeding bowl. An object (in this case a large panel with white and blue squares) was then made to fall either rapidly or slowly above the feeding bowl. For some sheep, the fall of the object was cued by a light signal.

rapidly, there was a high but transient increase in heart rate whereas sheep reacted to unfamiliarity with increased heart-rate variability. We again exposed sheep to a rapidly falling object, in this case a wooden panel, and we trained some sheep to predict the occurrence of the object fall event via a light signal (Figure 1) (Greiveldinger *et al* 2007). The sheep that benefited from this conditioning reacted less to the fall of the object, ie startle responses were less frequent and the heart rate increase was limited. Therefore, sheep are sensitive to the suddenness, unfamiliarity and predictability of their environment, and these aspects do affect their emotional responses.

## Discrepancy from expectations

Individuals form expectations about their environment. They expect some events to occur and they also expect these events to have specific consequences. For instance, if a person knows certain colleagues well, he/she expects these people to behave in accordance with what they usually do. Similarly, if a person knows a certain food, then he/she expects this food to have a specific flavour or texture. If the colleagues behave in a constant manner or if the food has the same properties as usual, then the situation will be fully consistent with the individual's expectations. However, this is not always the case: the colleague may have experienced a very difficult situation affecting his/her mood, or the food being eaten, despite having a similar appearance, may taste different from usual. In these cases, there is a discrepancy between what the individual expects and the actual situation.

To test whether sheep can form expectations about their environment, we trained them to perform an operant task (to cross a beam with their muzzle) to get a large food reward or a small food reward, and then we shifted the amount of reward (from large to small and vice versa) for half the animals (Greiveldinger *et al* 2006). Sheep were particularly sensitive to the decrease in the size of the reward: compared to sheep that had always been trained with a small reward, those that were shifted from a large to a small reward seemed disturbed, adopting an asymmetric ear posture at the time of the reward delivery and walking around the chamber, while their heart rate increased and heart-rate variability decreased (suggesting a lower parasympathetic tone, which is indicative of stress (Porges 1995; Després *et al* 2003). Sheep responses to an increase in the reward were far less marked and were observed only when it occurred after a previous decrease in reward. In this case, the number of operant responses performed by the sheep decreased, but there was no change in emotional responses (heart rate, ear postures). Sheep can thus form expectations about their environment. A discrepancy from their expectations has an effect on their emotional responses if an actual situation is less attractive than the expected situation.

## Control potential

The potential for control evaluated by an individual corresponds to the extent to which this individual perceives that he/she is able to influence the event to which he/she is exposed and/or act on the consequences of this event.

To test whether sheep were sensitive to their potential to control a situation, we gave them intermittent access to food: from time-to-time during a session, an air blower was turned on above the trough (Greiveldinger *et al* 2009). Half the sheep were trained to cross an infra-red beam to terminate the air blow and resume access to food (Figure 2). The other sheep were yoked to the previous sheep and thus received exactly the same access to the food but without controlling the air disturbance. Again, the two treatments elicited different behavioural and physiological responses: when the sheep were eating, their ears were horizontal and pointed downward, whereas immediately after the air blow started, the ears were oriented forward in sheep that could control the event and backward in those that could not. In addition, for the entire duration of the session, the sheep that could not control the event bleated four times as frequently as the sheep that could control it, and their heart rate was higher. Therefore, a disturbing situation has distinct consequences on emotional responses of a sheep depending on whether or not the disturbance can be controlled.

## Social norms

When facing a triggering event, an individual also evaluates whether the responses available to him/her are compatible with the norms of the social group to which he/she belongs (ie is a given response desirable or compulsory?)

To transpose this check to animals, we used the spontaneous dominance hierarchy of sheep. A dominance relationship is established when aggressive encounters or the mere presence of an emitter animal trigger submissive postures or avoidance patterns in a receiver animal (Bouissou *et al* 2001). This emitter thus dominates the receiver. It is likely that animals know their position relative to the other animals in their group. For instance, a subordinate animal may



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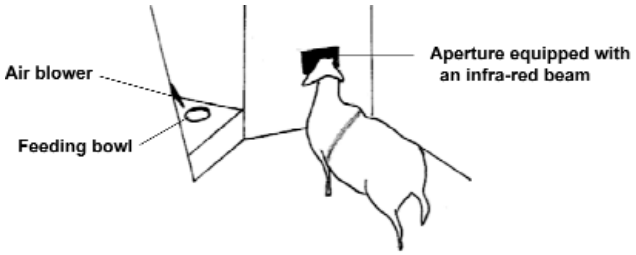
display submissive postures or avoidance even without aggression from the dominant animal, but may display aggressive behaviour toward a third animal it dominates. We thus assumed that dominance relationships act as external norms, reflecting how the animal adjusts its behaviour in accordance with the social identity of its group partners.

We thus checked the hypothesis that the same disturbing event may not have the same impact on a target animal accompanied by another animal that it dominates vs that it is dominated by. Forty-eight sheep were accommodated together. Prior to testing, the dominance relationships were analysed between each pair of animals via food competition tests (Erhard *et al* 2004). Briefly, two animals chosen at random were introduced into a chamber where a highly palatable food (concentrates) was placed in a small trough that only enabled one animal to feed at a time. An animal was considered to dominate its paired counterpart when it spent at least five times more time eating than its counterpart over two test sessions. Triads of animals were then composed of a target sheep, a sheep that the target dominates, and a sheep dominating the target. The target sheep was then tested in the same experimental chamber as the one used to test predictability, but was accompanied by either its dominant or its subordinated counterpart. We observed startle responses and a transient increase in heart rate immediately following the fall of the object behind the trough, as in the first experiment when the fall of the object could not be predicted. However, there were also subtle differences between the two conditions: when accompanied with a dominant animal, the target animal under test often looked at the accompanying animal and the increase in heart rate was more marked, whereas it walked back further from the trough when accompanied by a subordinate. Therefore, the emotional responses of a sheep to a disturbing situation vary according to the dominance relations with the partners around, with more internal reactions when the sheep is dominated by its partner and more overt reactions when it dominates the partner.

## Implications for sheep emotions

These studies confirmed that sheep evaluate events in their environment according to their suddenness, familiarity, predictability, and the consistency of these events with their own expectations and the control they have over the event. In addition, the way the animals evaluate their dominance-subordination relationships with others, similarly to social standards, also plays a role. In humans, emotions derive from the outcome of these checks, leading to specific responses and internal feelings (Rosemand & Evdokas 2004). We found that the behavioural and cardiac responses of sheep (ear postures, startle, agitation, orientation, heart rate, and heart-rate variability) also vary according to the outcome of these checks. The fact that, in humans, similar responses resulting from the outcome of checks are tightly linked to the internal psychological component of emotions, ie the internal feeling, and these checks are used by sheep and modify their emotional responses, support the existence of emotions in sheep. Sheep emotional responses are not only modified by a simple check like that of suddenness but also by checks that require a schematic process of appraisal (familiarity, predictability, consistency with expectations, controllability). Hence, we assume that sheep do not only display emotional responses but can also experience the 'feeling' component of emotions. Nevertheless, whether sheep are conscious of their emotions remains open to speculation. The fact that their relationship towards other sheep accompanying them when they face triggering situations affects their responses would add support to the assumption of conscious feelings in sheep, but our results on this point are not very clear-cut (we found only subtle variations between sheep accompanied by a dominant vs a subordinate animal) and need further confirmation. Furthermore, specific paradigms should be used to test whether sheep can remember their emotions. According to the framework used by Sander *et al* (2005), sheep appear to have the potential to feel at least the following emotions:

**Figure 2**




Experimental set-up for studying the impact of the controllability of an event. Sheep were trained to eat in a feeding bowl. From time-to-time during a session, an air blower was turned on, blowing into the feeding bowl and preventing the sheep from eating. Some sheep could terminate the airflow by nosing into an aperture; and cutting an infra-red beam. Their yoked counterparts received the same air blowing condition but could not control it.

•Anger, since they are sensitive to suddenness, unpredictability, controllability, and social norms;

• Rage, since they are sensitive to suddenness, unfamiliarity, unpredictability, discrepancy from expectations, controllability, and social norms;

• Despair, since they are sensitive to suddenness, unfamiliarity, unpredictability, discrepancy from expectations, and controllability;

• Boredom, since they are sensitive to suddenness, unfamiliarity, unpredictability, discrepancy from expectations, and controllability.

Our team has not yet been able to robustly analyse how the pleasantness of an event affects the emotional responses of sheep. However, other teams have successfully conducted choice tests on sheep (Dumont *et al* 1995; Rushen 1990). It is clear that sheep have preferences for certain foods or certain partners, including human beings (Tallet *et al*



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2005), and that they actively avoid (so probably dislike) specific situations, such as being handled roughly. Therefore, it is reasonable to believe that sheep can experience fear which is triggered by suddenness, unfamiliarity, unpredictability, unpleasantness, and discrepancy from expectations. It is also reasonable to believe that sheep can experience disgust, which is triggered by unfamiliarity, unpredictability and unpleasantness, as well as happiness, which is triggered by suddenness, unpredictability, pleasantness and discrepancy from expectations.

In humans, emotional responses are specific to the emotional feeling. For instance, competing athletes facing the same situation (a win or a defeat) exhibit the same facial expressions, regardless of whether they are sighted or blind (ie cannot have seen this expression exhibited by others) (Matsumoto & Willingham 2009). Sheep showed startle responses and a transient heart rate increase when confronted with sudden events, while their ears were pointed backward when they lacked control over a disturbing situation. Such responses might thus be specific to fear and anger. However, we have tested too few situations involving one or several more salient checks to be able to draw firm conclusions on emotional signatures in sheep.

To conclude that sheep can feel certain emotions, we first postulated that if the outcome of the checks has an impact on responses, then the animal not only displays emotional responses but also feels emotions (see above). This postulate is still open to debate, as it can be argued that the analogy of cognitive treatments and emotional responses between animals and humans is not enough to prove that an animal's cognitive processing of a situation they are exposed to results in similar mental states as in humans (see *Discussion* in Volpato *et al* 2007). Nevertheless, the present findings broadly support the idea that animals possess intuitive understanding, according to which it would make no sense to deny mental states to non-human animals (Bekoff 2008). Another body of findings that would add support to the existence of emotions in animals could be brought by functional imagery. Several authors have studied the links between emotions and brain activity in humans. For instance, the fronto-temporal areas are activated by joy, sadness and disgust (Esslen *et al* 2004; Delplanque *et al* 2005). Similar activations may be observed in animals, at least those that, like vertebrates, present homologous brains. Nevertheless, although this sort of finding could provide further evidence for the existence of emotions in animals, it would not offer any sceptical mind with final proof. We strongly believe that it is getting harder and harder not to accept the existence of emotions in non-human animals, even if these emotions are not as sophisticated as those of humans.

Most of the results presented in this paper were obtained in situations that were rather aversive to animals, except when we enlarged a reward to make it higher than expected. According to Fraser and Duncan (1998), different evolutionary processes seem to have selected negative vs positive emotions: negative emotions are supposed to have evolved in 'need situations', such as a threat to survival or reproductive success, whereas positive emotions are supposed to have evolved in 'opportunity situations' where the action resulting from the positive emotional state enhances but is not essential to individual fitness. This may be the reason why positive emotions have more between-animal variability and are more difficult to highlight than negative emotions. Further research is needed into the positive side of the emotional scale to get an overall view of animal welfare.

We have not explored all the possible aspects of the appraisal theories. The use of checks such as the relevance of a situation for the animal's goals, the probability of consequences of a situation, an animal's perceived abilities to engage in control, or even the role of internal standards (if any exist) have not yet been investigated, but we believe that sophisticated conditioning paradigms could make these investigations possible.

All of our experiments have been conducted in sheep. Several recent studies confirm that pigs are sensitive to the predictability of aversive events, which affects their vocal responses (Duepjan *et al* 2008), and to the variability of food rewards (De Jonge *et al* 2008). These findings suggest that the checks of predictability and discrepancy from expectations are also valid in other contexts and other species than the sheep tested in our research group. A comparison between species from different phyla using a similar rationale would certainly provide critical insight into the kind of emotions they can feel, and this would in turn help to refine regulations adopted to ensure animal welfare.

In conclusion, by using the framework of appraisal theories, the experiments reported in this paper give support to the hypothesis that non-human animals do experience emotions. Sheep seem able to experience a wide range of emotions, including fear, anger, rage, despair, boredom, disgust, and happiness.

## Animal welfare implications

Although the findings reported in this paper were obtained in artificial experimental situations, they have nevertheless produced generic knowledge that can easily be transposed to the actual living conditions of animals, including farm animals. For instance, sudden noises or movements can occur in any farm environment, and animals that are offered new foods, mixed with new animals, or moved to a new barn face unfamiliar situations. These situations are all known to affect animal behaviour. Cows, for instance, are very sensitive to shouting and dislike novel situations (Rushen *et al* 1999; Herskin *et al* 2004). Predictability also appears to be an important characteristic of farming environments. It is common practice to feed or milk animals at the same time(s) every day. If this regularity is broken for any reason, it can be expected to disturb the animals. For instance, it is well known to veterinarians that pigs can develop gastric ulcers when feeding is delayed or when the usual signals of feeding (noise in pipes) are not followed by food delivery. Similarly, calves that receive their milk at regular times during the day seem disturbed when feeding is delayed (Johannesson & Ladewig 2000). There has been a longstanding practice of tying large farm animals when they



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are housed indoors (eg as is the case with cows in winter), which means the animals had little control over their environment. More possibilities for control are offered by more modern systems, such as loose housing and automatic feeding systems where the animals need to go and operate a device to get their food. Similarly, there are facilities running milking robots that enable cows to decide to go to milking. This level of control appears beneficial to the animals: pigs given control over food delivery show enhanced healing abilities (Ernst *et al* 2006).

There have also been studies describing the long-term effects of the predictability and controllability of aversive events. In both humans and non-human animals, unpredictability can enhance negative emotional experiences, such as fear (Adkin *et al* 2006; Armfield 2006; Carlsson *et al* 2006) and induce negative cognitive bias whereby neutral situations are more likely to be perceived as negative (Harding *et al* 2004). This may lead to wide-reaching disorders such as anxiety (Zvolensky *et al* 2000), depression (Anisman & Matheson 2005) or neurosis (Mineka & Kihlstrom 1978). Similarly, repeated uncontrollability can induce chronic stress, as suggested by rats unable to control the termination of an electric shock, which develop more gastric ulcers than their yoked counterparts able to terminate the shock (Weiss 1972; Milde *et al* 2005). Similarly, restriction in movements, which can be viewed as largely limiting the control the animal can exert, is known to facilitate stereotypies and apathy in sows, which suggest low welfare (Broom 1987; Terlouw *et al* 1991). The uncontrollability of positive events like food delivery may also have negative consequences, leading for instance to hypoalgesia in mice (Tazi *et al* 1987) or learned helplessness in hens (Haskell *et al* 2004), both of which are signs attributed to chronic stress. Our findings suggest that the mechanism underlying such long-term effects may be the repetition of negative (short-term) emotions.

Findings such as these led Bassett and Buchanan-Smith (2007) to recommend that the environment given to animals should be predictable and controllable, allowing anticipation to develop fully. However, an overly predictable environment may result in boredom (Van Rooijen 1984; Wemelsfelder 1993). Therefore, initiatives to ensure animal welfare need to find a balance between complete unpredictability vs complete predictability of the environment, while a degree of control always seems beneficial.

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