



## Nasal temperatures in dairy cows are influenced by positive emotional state

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### HIGHLIGHTS

- First study exploring nasal temperature as a measure of emotional state in cows
- Nasal temperature decreased significantly during what was considered to be a positive experience.
- Positive and negative emotional state may have the same effect on nasal temperature.
- Measuring positive emotions is key to improving animal welfare.

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### ABSTRACT

Understanding how animals express positive emotions is an important area of focus for animal welfare science, yet it is widely neglected. Emotions can be either positive or negative in valence, depending on the rewarding or punishing nature of the stimulus, and they can vary in the degree of arousal or excitement. Previous literature has shown a strong connection between peripheral temperatures and high arousal, negative experiences. Stress, fear and frustration have all been found to cause a drop in peripheral temperature. Little is known however, about whether the experience of positive emotions affects peripheral temperatures. In this study we sought to identify whether the nasal temperature of cows was affected by emotions, and if nasal temperature could be reliably used as a measure of emotional state in cows. We induced a positive, low arousal emotional state by stroking cows in preferred regions, in a similar manner to allogrooming. We performed 350 full focal observations, each comprising three conditions; pre-stroking, stroking, and post-stroking. During each 15 minute focal observation we remotely took the focal cow's nasal temperature six times, twice during each condition.

We analysed the data using the one-way ANOVA repeated measures test and found a significant difference overall ( $F(2, 1.935) = 9.372, p < 0.01$ ). Post-hoc pairwise comparisons indicated that the total mean nasal temperature decreased significantly during the stroking condition ( $25.91\text{ }^{\circ}\text{C}, SD = 1.21$ ), compared with both the pre-stroking ( $26.27\text{ }^{\circ}\text{C}, SD = 1.01, p < 0.01$ ) and post-stroking conditions ( $26.44\text{ }^{\circ}\text{C}, SD = 1.12, p < 0.01$ ). There was no significant difference between the pre-stroking and post-stroking conditions ( $p = 0.14$ ).

We suggest that the cows were in a low state of arousal during the entire focal observation, as no other changes to the cows' environment had been made, and the cows were habituated to both the procedure and the researchers. Furthermore, the stroking stimulus is known to induce a state of relaxation and lower the heart rate of cows. This leads us to conclude that the drop in nasal temperature was indicative of the change in valence, rather than a change in arousal. These findings show that positive emotional state may have the same effect on the peripheral temperatures of mammals as a negative state does. This raises questions regarding the triggers for emotional fever, which is often considered to be associated only with negative states and high arousal. Our results indicate that nasal temperature in cows may prove to be a useful measure of a change in emotional state, but further research is required to validate these findings and to explore the effect of arousal on peripheral temperatures.

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### 1. Introduction

Due to their subjective nature we often believe we cannot measure or understand the emotional lives of non-human animals, hereafter

referred to as animals [7]. Yet, understanding what animals experience is critical for the improvement of animal welfare [22]. In recent years our knowledge of animal emotions has increased dramatically [23], and animal welfare scientists are now recognising the importance of the promotion and experience of positive emotions [15,23,35]. To support this, we need to develop credible and viable measures of emotional states. Such measures must be practical, to allow practitioners to apply

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them quickly and reliably, and incur little to no cost. To date little is known about measuring positive emotional states in cows, although a few studies have found visible eye whites [24,25] and ear postures [21] to be reliable measures of positive emotional state in cattle. In this study we have explored whether the non-invasive measurement of nasal temperatures can be used to measure low arousal, positive emotional state in dairy cows.

### 1.1. Core body temperature

Both physical and psychological stressors are known to cause a short-lived increase in the core body temperature of a number of mammalian species (e.g. sheep; [1], cattle; [14], rats; [18], humans; [32]). This short-lived temperature rise, which is associated with peripheral vasoconstriction, is known as emotional fever [19] and is suggested to be a potential indicator of welfare [1,9]. Furthermore, emotional fever, demonstrated through a conditioned rise in body temperature in response to unpleasant events, is thought to be evidence of the phylogenetic development of emotions [1]. Measuring core body temperature however, is not always practical, as it often requires surgical implants or regular handling. This in turn affects the validity of the measure, and makes it less suitable as a tool in practice. In addition, the animals are often required to be removed from their familiar environments or isolated during the measurement. This is often unrealistic and may also have a stressful effect on the animals' involved [31].

### 1.2. Nasal temperatures

Vasoconstriction, mediated by the sympathetic nervous system (SNS), occurs during the 'fight' or 'flight' response of animals. In order to minimise blood loss from vulnerable areas during injury, blood is diverted to organs such as the brain and muscles which have more urgent metabolic requirements [10]. The aversive stimulus also activates the hypothalamic–pituitary–axis (HPA) and increases concentrations of catecholamines and glucocorticoids; which further impacts heat production and causes heat loss [10]. As the nose is a peripheral, non-essential area, during fight or flight blood is diverted away from it and towards more important organs, resulting in a drop in nasal temperature. Changes in nasal temperature could be a useful measure for animal welfare as they can be measured remotely, quickly, and with little cost. Furthermore, taking temperatures remotely avoids some of the pitfalls associated with manual sampling, such as the handling of animals and the confounding effects of the equipment used [1,19].

In their study, Kuraoka and Nakamura used an infrared thermographic (IRT) system to compare nasal temperatures of rhesus macaques, with the skin conductance responses (SCRs) obtained from a skin conductance amplifier attached to the monkey's hand [11]. The latter is a method traditionally used for determining emotional state, but because SCRs can occur as a result of arm movements, as well as spontaneously during rest periods, the researchers were investigating the reliability of nasal temperature as a potential alternative [11]. They exposed the monkeys to various video clips in different formats, differing in the valence and strength of emotion they elicited. They found that the IRT successfully picked up decreases in nasal skin temperature associated with changes in the emotional state of the animals. The nasal skin temperature decreased significantly following the most aversive stimulus (aggressive threat), regardless of how it was presented (image and sound versus video), whereas there was no significant response to conspecific screams or coos, which represented the lower intensity stimuli, presenting little to no threat to the monkey. The SCRs however, showed no significant differences in response to the stimuli. These results suggest that the changes in nasal temperature were indicative of the valence of the emotional state experienced. The changes in nasal temperature were also considered to be associated with the strength of the emotion experienced [11].

A number of studies have also found that peripheral temperatures in a variety of mammalian species decrease significantly during the experience of stressful stimuli. For example, Lowe et al. found that ear pinna temperature of sheep decreased significantly when the sheep were mustered into pens, moved between pens, socially isolated or subjected to prolonged exercise [12]. In cattle, Stewart et al. found the eye temperature dropped significantly when they were hit, startled, startled and shouted at, or poked with an electrical prod [31]. Research to date has focused primarily on the use of nasal temperatures as a tool for measuring negative states and identifying stressors. As far as we are aware no research to date has considered whether nasal temperatures are indicative of positive emotional state in cattle.

### 1.3. Are nasal temperatures in dairy cows affected by positive emotions?

Emotions are considered to be defined by two fundamental elements; the level of arousal involved, and the emotional valence [16]. The valence of an emotion can either be positive or negative, depending on the rewarding or punishing nature of the stimulus [16]. Whereas the level of arousal can vary from high to low, and describes the degree of excitement the stimulus induces [16]. In this study we have tested whether nasal temperatures change in response to what is considered to be a positive and low arousal emotional state in cows. We recorded the nasal temperature of cows during 15 minute focal observations before, during and after a positive stroking stimulus was applied. We used stroking as a positive stimulus because it has been previously found to reduce both the heart rate of cows [26,33] and their cortisol levels [8] during various stressful procedures. Stroking and gentle handling of dairy cows has also been shown to have positive effects on flight distances and fear of humans [4]. Furthermore, cattle will actively choose to be brushed or stroked by a familiar person [2,34], and will pursue a retreated stroker to initiate another bout of stroking [2].

Previous literature indicates that nasal temperature should decrease in response to negative stimuli, but there is no indication from the literature on whether the experience of positive emotions would have an effect, or in which direction it would be. In this study we sought to determine whether the experience of a low arousal, positive emotional state induced by stroking, had any effect on the nasal temperatures of dairy cows. As there is so little research on nasal temperatures and their relationship with emotional state, and no studies that we know of have explored this in cows, our results provide useful insight into this under explored area of science.

## 2. Materials and methods

### 2.1. Subjects and housing

Data collection was performed between October and December 2013 at Boltons Park Farm, Royal Veterinary College, Hertfordshire, UK. Thirteen randomly selected dairy cows, ranging in age from 2 to 8 years old, and comprising 12 Holsteins and one Friesian, were randomly selected from the commercial dairy herd of 92 cows. None of the focal cows had given birth within the previous 2 months from the start of the study, and none were due to give birth until after the study period. Throughout the study the cows were housed indoors for the winter period, and their standard feeding and handling procedures were maintained. During the study hours of 8 am–5 pm the cows used in the study were kept in two indoor pens adjacent to the main herd.

### 2.2. Habituation period

The cows were fully habituated prior to data collection. The habituation process took 2 weeks, during which time the cows were habituated to the study pens, the five experimenters, the procedure and the equipment, which included a video camera, monopod, clipboard, stopwatch, an infrared thermometer gun, and canvas gloves. The thermometer

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