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Measuring positive emotions in cows: Do visible eye whites tell us anything?

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HIGHLIGHTS

- Explored whether visible eye whites indicate a positive emotional state in cows
- Behaviours associated with emotional state were also recorded.
- Percentage of visible eye white dropped during a positive emotional state.
- Measures of positive emotions are key to ensuring good animal welfare.

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ABSTRACT

Insight into the emotional lives of animals is of utmost importance to the welfare of the billions of animals in our care, yet little is known about how to measure these states. Scientific understanding of how to measure and interpret positive emotional states is particularly lacking, although recent years have seen a notable increase in such studies. This study explored whether the percentage of visible eye whites is a valid measure of a low arousal, positive emotional state in dairy cows (*Bos taurus*), by using stroking as the positive stimulus. Thirteen dairy cows were studied over a period of two months, and a total of 372 full 15 minute focal observations were performed. Each focal observation comprised three 5 minute phases: pre-stroking (baseline), stroking (stimulus), and post-stroking (post-stimulus), and the focal cow's behaviours were recorded throughout each observation, and the focal eye was filmed for later analysis. Following data collection we calculated the percentage of visible eye white at nine pre-determined measurement points throughout each focal observation.

The eye white data were analysed using the one-way repeated measures ANOVA test. The percentage of visible eye white dropped during stroking compared with during both the pre-stroking and post-stroking phases (ANOVA: $F_{1.242,\ 14.9} = 4.32$, $P = 0.025$). The behaviours were analysed using Friedman's ANOVA and Wilcoxon's signed-rank test. Behaviours known to be associated with positive emotions in cows were performed during the stroking phase of the focal observation, supporting the use of stroking as a stimulus to induce a positive, low arousal emotional state.

This study has explored the potential of visible eye whites as a measure of positive emotions and arousal, and our results support previous studies which suggest that eye whites may serve as a dynamic measure of emotion and arousal.

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1. Introduction

As in humans, positive experiences and emotions are an important element of a non-human animal's life [1]. More research is needed to better understand the emotional lives of the animals in our care and to improve their welfare [4]. To date, most research into animal welfare has focussed on negative experiences and emotions [11]. There is however a collective understanding that knowledge of positive emotions is essential to ensure that animals have a good life, one which is rich with positive experiences and emotions [8,12,23]. In this study we have sought to address the need for valid measures of positive emotions by exploring the suitability of visible eye white percentage in dairy cows as a measure of low arousal, positive emotional state.

Emotions are typically considered to be short-lasting and occur in direct response to an event or stimulus [1]. The elicited emotion can either be positive or negative in valence, depending on the nature of the stimulus [7]. If for example, an animal is exposed to an unpleasant experience, this is likely to result in a negatively valenced emotional state, such as fear. Another component of emotions is the degree of associated arousal, which can vary from high to low. The emotion

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'frustration' for example, refers to a negative, high arousal emotional state, whereas the emotional state 'relaxed' refers to a positive, low arousal emotional state [7].

1.1. Visible eye whites

The visible percentage of eye whites in cows has been assessed as an indication of emotional state in a number of studies and has been found to be associated with a strong emotional response in dairy cows [13–15]. The percentage of visible eye white increases when the cow's upper eye lid is lifted, and the muscle responsible for this is controlled by the sympathetic postganglionic axons [16]. Sandem and Janczak [16] suggest therefore, that the sympathetic nervous system may be involved in the response of visible eye whites to emotion inducing stimuli. In order to explore this, they performed a number of studies using stimuli which would activate the sympathetic nervous system [13,14,17].

In one study, Sandem et al. [13] looked at visible eye whites in three groups of cows: one control group and two groups of hungry cows who were either given food (fed), or prevented from accessing visible food (food-frustrated). They expected the food-frustrated cows to show an increase in visible eye white in response to the negative stimulus. Furthermore, they expected the fed cows to show a decrease in eye white, and perform the 'consummatory face', commonly seen when cows eat, ruminate, or rest. This typically involves the eyes being closed or half-closed, and Sandem et al. [13] suggest that it may indicate a positive emotional state. Sandem et al. [13] did find a significant increase in visible eye whites in the food-frustrated cows, compared with the fed cows, throughout the 6 minute observation period. The percentage was also significantly higher than that of the control cows after 2 min. Whereas the fed cows showed a quick decrease in visible eye white once the food was introduced, the eye white percentage was then significantly lower than that of the control cows after 1 min of observations. They also found that only the food-frustrated cows performed aggressive behaviours, tongue rolling, head shaking and vocalisations. This led the authors to suggest that both the eye whites and behaviours reflected the same underlying emotion [13].

Visible eye whites have also been shown to increase in response to a positive, high arousal stimulus [15]. Cows were conditioned to anticipate the delivery of concentrated feed within 10 min of a stockman entering the barn. The authors considered this anticipatory phase to be positive, as the delivery of concentrates is one of the most positive events for a tethered cow. The cow's visible eye whites increased significantly during the first minute after the stockman entered, and then remained non-significantly high until the feed was provided. Once they could consume the feed, the percentage of visible eye whites decreased, and after 40 s to 2 min, they were significantly lower than the baseline levels [15]. The fact that the visible eye whites increased in response to what is considered to be a high arousal, positive emotional experience: positive anticipation [15], as well as in response to high arousal, negative states such as fear and frustration [13,17], suggests that arousal has a marked effect on visible eye whites, in that levels of high arousal result in increased visible eye white. Furthermore, visible eye whites have been shown to decrease only in response to low arousal stimuli, dropping below baseline levels during a low arousal, positive emotional state [13,15]. If the baseline levels were assumed to be indicative of a low arousal state, then the drop in visible eye white below these levels suggests that valence may also have an effect on visible eye whites, and that eye whites could offer an insight into the valence of the cow's emotional state.

In our study we have sought to build upon the existing work in this field and further explore whether eye whites are indicative of emotional valence in dairy cows. We emulated allogrooming by stroking habituated dairy cows. Stroking has been shown to be a positive experience for cows in a number of studies [9,10,19,20,22]. Stroking cows on preferred regions has also helped them to cope with husbandry procedures, reducing their fear, heart rate, and cortisol levels [2,5,18,21]. We therefore suggest that according to Mendl et al.'s framework of affective states, stroking is a low arousal stimulus which elicits the positive core affects 'relaxed' and 'calm' [7].

1.2. Aims

As previous studies have always involved a shift in arousal from high to low, we attempted to maintain a low arousal level prior to the stroking stimulus so that the change in arousal was minimal. By doing this we aim to determine whether the changes in visible eye white found in Sandem et al.'s work were the result of the more substantial change in arousal from high to low, or whether visible whites do indeed indicate emotional valence in dairy cows. We hypothesise that in response to the positive, low arousal state induced by stroking, the percentage of visible eye white will decrease, compared with both the pre-stroking and post-stroking phases.

2. Methods

2.1. Ethics

The experiment was performed in compliance with both the journal's and the Royal Veterinary College's ethical guidelines.

2.2. Subjects and housing

During this study we used 13 randomly selected dairy cows from a commercial herd of 92 cows. The cows, 12 Holstein's and one Friesian, ranged from 2 to 8 years of age and were based at Bolton's Park Farm, Royal Veterinary College, Hertfordshire, UK. Data collection took place between October and December, 2013. Throughout the study the cows were housed in a loose-house barn for the winter and were maintained under standard feeding and handling procedures. The 13 cows were kept overnight with the main herd, and then separated each morning following milking into two indoor pens adjacent to the main herd. There were typically five cows in one pen and eight in the other, and each group remained stable and were not mixed.

2.3. Habituation

Prior to the start of data collection we fully habituated the cows to each of the five experimenters (only three were ever present at one time), the procedure and to the equipment, namely a video camera (Sony HDRXR160EB Handycam), monopod, clipboard, canvas gloves, and a stopwatch. This procedure is described in Proctor and Carder [9,10]. To ensure that the cows always viewed the strokers positively, we ensured that the cows had no prior experience of the strokers and that all of their interactions throughout the study period were positive (e.g. no shouting, hitting, etc.).

2.4. Experimental procedure

We used focal sampling to perform 372 full focal observations. Each focal cow was used for an average of 28.61 times ($SD = 2.72$) throughout the study period of October to December, 2013. These were conducted randomly across the course of each day and over a period of 10 weeks. We also stroked each cow equally on their left and right side to control for effects of lateralisation. Following a complete focal observation, the focal cow would be left for a minimum of 45 min prior to their participation in another focal observation. Following an aborted focal observation, the focal cow would be left for a minimum of 2 h.

Each of the focal observations were composed of three 5 minute phases: pre-stroking (baseline) (0–4:59 min), stroking (stimulus) (5:00–09:59 min), and post-stroking (post-stimulus) (10:00–15:00 min). Prior to the start of the focal observation the cow and the

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