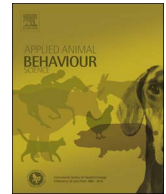




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Face-based perception of emotions in dairy goats

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ABSTRACT

Faces of conspecifics convey information about identity, but also gaze, and attentional or emotional state. As a cognitive process, face-based emotion recognition can be subject to judgement bias. In this study we investigated whether dairy goats ($n = 32$) would show different responses to 2-D images of faces of familiar conspecifics displaying positive or negative emotional states. We also examined the possible use of images of faces as stimuli in cognitive bias studies. The faces of four subjects were photographed in a positive and a negative situation. Three types of images of ambiguous facial expressions were then created using morphing software (75% positive, 50% positive, and 25% positive). In a test-pen, each goat was exposed for 3 s to each type of image, obtained from the same goat. All goats were shown non-morphed faces first, before being shown the three types of morphed faces, balanced for order. Finally, the first non-morphed face was shown again. Spontaneous behavioural reactions including ear postures (forward, backward and asymmetrical) and interactions with the screen (time spent looking or touching) were recorded during the 3 s. Results were analysed using REML with repeated measurements. Goats spent more time with their ears forward when the negative was shown compared to the positive ($F_{4,121.3} = 2.51$, $P = 0.018$), indicating greater interest in negative faces. Identity of the photographed goat influenced the time spent with the ears forward ($F_{2,57.4} = 7.01$, $P = 0.002$). We conclude that goats react differently to images of faces displaying different emotional states and that they seem to perceive the emotional valence expressed in these images. Response to morphed faces was not necessarily intermediate to response to negative and positive faces, and not on a continuum. Further study is thus needed to clarify the potential use of faces in cognitive bias studies.

1. Introduction

It is now generally accepted both in the scientific community and by policy makers that animals are sentient beings, capable of experiencing emotions (de Vere and Kuczaj, 2016). Being able to assess emotional states in farm animals is crucial to improving their welfare. Emotions are defined as short-term internal psychological states induced by stimuli. According to Dantzer (2002) an emotional state has behavioural (e.g. running away from a frightening stimulus), physiological component (e.g. increase of heart-rate) and subjective (e.g. 'I feel frightened') components. Evidence of behavioural and physiological components of emotions has been shown repeatedly in animals (Désiré et al., 2002). The subjective dimension of emotions is of course difficult to evaluate in animals, since there can be no use of language for self-report as in psychology. However the development of methodologies such as judgement bias or attention bias tests in animals can give the

researcher an indirect access to the subjective dimension of emotions in animals (Roelofs et al., 2016). An emotion can also be characterised by a combination of its valence, i.e. positive vs. negative, and its arousal, i.e. low or high. For example, fear has a negative valence and a high level of arousal (Mendl et al., 2010).

Although the function of emotion is not primarily for communication, the outward expression of an emotional state involves changes in posture, vocalisations, odours and facial expressions, which can be perceived and used as indicators of emotional state by other animals (Siniscalchi et al., 2013; Terlouw et al., 1998). Since conspecifics can perceive one another's emotions, understanding how emotions are identified and how they can spread within a social group could have a major impact on improving the welfare of farmed species that are reared in groups. This study was a step in that direction and focused on face-based emotion recognition in goats. The fact that the facial expressions of humans and nonhuman mammals have a lot in common

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was suggested first by Darwin (1872). For social species, faces are a major source of information (Little et al., 2011); features that allow the identification of the individual, but also the direction of gaze, attentional state and emotional state are conveyed through the face (Adolphs, 2002). Face perception, and more specifically the processing of emotions, has been widely studied in sheep, which can discriminate between calm and stressed faces of conspecifics and humans in 2-D images (Tate et al., 2006).

As small ruminants, goats are closely related to sheep. We therefore hypothesised that face-based perception of emotions in goats would be as developed as in sheep. Since goats display behavioural expressions that differ between situations of positive and negative valence (Briefer et al., 2015), we wished to determine if those displays would impact the goats' faces sufficiently so that a difference could be perceived by conspecifics. We therefore tested whether goats would react differently to 2-D images of faces of familiar conspecifics displaying positive or negative emotional states. The images used were obtained by filming goats during two types of interactions with a human handler. We also hypothesised that goats would display behaviours indicating negative valence when looking at negative faces, and positive valence when looking at positive ones.

Recent studies demonstrated that the emotional state of an animal can influence cognitive processes, such as learning, attention or judgement (Mendl et al., 2009). Judgement bias tests have been used in farm animals to assess emotional states, especially after manipulation of the environment to induce positive or negative emotional states or as a tool to assess the impact of husbandry practices (reviewed by Baciadonna and McElligott, 2015). Animals in a negative emotional state show pessimistic judgements (i.e., react in a similar way to negative and ambiguous stimuli) while those in a positive emotional state make optimistic judgements about ambiguous stimuli (i.e., react in a similar way to positive and ambiguous stimuli). Face-based perception of emotion is a cognitive process (Martin et al., 2012) and as such is potentially subject to this judgement bias. To test if images of faces could be used as cognitive bias stimuli, we produced three types of ambiguous faces ranging in valence from negative, using morphing software. For these images to be usable in cognitive bias studies, goats have to show distinct spontaneous reactions to images of goat faces taken in positive or negative situations. Furthermore goats have to show gradual intermediate responses to the morphed faces to comply with the cognitive bias response pattern.

Finally, since goats were exposed repeatedly and without reinforcement to the same type of stimuli, we wanted to test their level of attention after five exposures, and thus included a final test session that was a repeat of the first.

2. Methods

2.1. Ethical note

All experimental procedures were approved by the Animal Welfare Advisory Board of the research unit (INRA) and complied with the GRICE (Groupe de réflexion interprofessionnel sur les comités d'éthique appliquée à l'expérimentation animale) recommendations.

2.2. Animals and management

The experimental work took place between April and May 2015 at the INRA experimental farm at Thiverval-Grignon, France. 32 lactating Saanen ($n = 17$) and Alpine ($n = 15$) goats aged 18 months were used in this experiment. The animals had been removed from their dams after birth and artificially reared in mixed-breed groups. They were all familiar with each other, having lived in the same group for at least six months prior to the trial.

The 32 goats were tested in two groups of 16, balanced for breed (Group 1: 8 Alpine and 8 Saanen; Group 2: 7 Alpine and 9 Saanen) and

weight (Group 1: 55.3 ± 6.5 kg; Group 2: 53.7 ± 5.2 kg). For the duration of the study, goats from both groups were housed together in the same straw pen that was set within the main farm building. Morning milking took place between 07.30 and 09.30, and afternoon milking between 15.30 and 17.30. The goats were fed a total mixed ration twice a day ad libitum. Goats had unlimited access to water.

For each group the tests were completed in four days. Two days separated the trials for Group 1 and Group 2.

2.3. Images of faces

Amongst the 32 goats, two Saanen and two Alpine were selected to be filmed to produce images of faces. The choice of the filmed animals, hereafter referred to as Photo Goats, was based on their individual reactions to humans. Since the positive situation consisted of a positive interaction with an experimenter, the first two goats of each breed to approach the experimenter of their own volition in the home pen were selected to be the Photo Goats. To produce the images, each Photo Goat was placed into two different situations that were likely to elicit a positive and a negative emotional state respectively. Rewarding stimuli are thought to elicit positive emotional states, while fitness-threatening stimuli (predator, pain, stress) elicit negative emotional states (Mendl et al., 2010). Behavioural observations were used in conjunction with this framework to determine the valence of the situation the goats were placed in.

Photo Goat faces were filmed with a HD camera (HDR-XR155, Sony, Japan). Frames with a full clear frontal view of the face were extracted from those short video clips. The faces were then digitally cut from the frames and placed against a neutral beige background (RGB model: R = 217, G = 202, B = 126) to create the images used in the tests (Fig. 1).

2.3.1. Positive situation

The Photo Goats were groomed by a familiar experimenter in the home pen. Pleasant grooming consisted of gentle scratching of the neck and shoulder areas for approximately 5 min. Grooming of this sort has been shown to be a gentle interaction in cattle (Schmied et al., 2008) and to induce a positive judgement bias in goats (Baciadonna et al., 2016). Since the Photo Goats had been chosen based on the fact that they voluntarily approached humans, habituation was not necessary. During grooming the Photo Goats did not move away and after grooming they repeatedly sought attention from the experimenter. These observations supported the idea that grooming was pleasurable and thus rewarding and induced an emotional state of low arousal and positive valence (Coulon et al., 2015). Goats had their ears lowered and turned down during almost the entire grooming session, and pictures of the animal displaying this ear posture were extracted from the videos. These images are hereafter named the positive images (Fig. 1).

2.3.2. Negative situation

Each Photo Goat was isolated in a weigh-crate, located within the main building, thus allowing continued auditory and olfactory contact with other goats. The negative stimulus was produced by an experimenter who applied an ice block to the udder for a maximum of 30 s, or until a negative reaction from the goat (e.g. stamping, sharp head movements, trying to leave the crate) was observed. The obvious thermal discomfort induced by the application of the ice pack made Ice a fitness-threatening situation. This is highlighted by attempts made by the Photo Goat to escape the source of discomfort and the situation was thus considered to have induced a negative state of high arousal. As soon as a good quality video was captured the goat was brought back to the group. All Photo Goats displayed a negative reaction and avoidance behaviours when the ice block was applied, which suggests that it did elicit an emotional state of high arousal and negative valence.

Pictures from the first reaction of the goat to the ice block were extracted from the films, when the animal raised its head, with the tip

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