



How good is this food? A study on dogs' emotional responses to a potentially pleasant event using infrared thermography



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HIGHLIGHTS

- Dogs' emotional responses to palatable food was studied using infrared thermography.
- Eye temperature and HR increase while receiving treats, no clear pattern of HRV emerges.
- Tail wagging could be a useful indicator of positive emotional state.
- Eye temperature can assess the arousal dimension of dogs' emotions in a positive situation.

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ABSTRACT

Understanding how animals express positive emotions is becoming an interesting and promising area of research in the study of animal emotions and affective experiences.

In the present study, we used infrared thermography in combination with behavioral measures, heart rate (HR) and heart rate variability (HRV), to investigate dogs' emotional responses to a potentially pleasant event: receiving palatable food from the owner.

Nineteen adult pet dogs, 8 females and 11 males, were tested and their eye temperature, HR, HRV and behavior were recorded during a 30-minute test consisting of three 10-minute consecutive phases: Baseline (Phase 1), positive stimulation through the administration of palatable treats (Feeding, Phase 2) and Post-feeding condition following the positive stimulation (Phase 3).

Dogs' eye temperature and mean HR significantly increased during the positive stimulation phase compared with both Baseline and Post-feeding phases. During the positive stimulation with food (Phase 2), dogs engaged in behaviors indicating a positive emotional state and a high arousal, being focused on food treats and increasing tail wagging. However, there was no evidence of an increase in HRV during Phase 2 compared to the Phase 1, with SDNN significantly increasing only in Phase 3, after the positive stimulation occurred.

Overall results point out that IRT may be a useful tool in assessing emotional states in dogs in terms of arousal but fails to discriminate emotional valence, whose interpretation cannot disregard behavioral indexes.

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1. Introduction

Considerable research showed that many animal species besides humans express emotions through a variety of observable signals [1–7]. Emotions can be defined as psychological states occurring when an individual is exposed to specific environmental and/or social stimuli, represent an adaptive interface between the individual and its environment, and guide the selection of appropriate behavioral decisions [8–10]. Psychological research on humans indicates that emotions have a multi-component character and incorporate subjective feelings,

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physiological activation, motor expressions, cognitive appraisals, and behavioral tendencies [8,11,12]. This complexity of emotional states makes their investigation in non-human animals a challenge. According to one of the current approaches to the study of human emotions (*i.e.* the dimensional perspective), emotional states are characterized by at least two main dimensions: arousal (low to high activation) and valence (positive to negative) [13–15]. Recently, this two-dimensional model has been applied to the understanding of the role that emotions play in animal welfare [16,17]. Most studies focused on emotions induced by distress and negative experiences [18–20] but a growing number of researchers pointed out that animal welfare also entails the presence of positive emotional states [21–23]. To understand and assess animal emotions the measurement of positive and negative valence of affective states is therefore important and an objective evaluation needs a combination of behavioral, physiological, and cognitive markers. However, some parameters can be ambivalent and difficult to interpret when considered separately. For example, HR can increase in both positive and negative emotional states, since it reflects arousal rather than valence [21,24,25]. The beat-to-beat variation (heart rate variability – HRV), that reflects changes in the activity of the autonomic nervous system [26], is not differentially influenced by the valence of the test situations such as accessing to popcorn (positive situation) and crossing a black ramp (negative situation) in pigs [27]. Even behavioral measures are not always easy to interpret [15]: lip licking in dogs has previously been explained as a signal of stress [28,29] but has also been related to an increased arousal determined by the reunion with the owner after a long period of separation [30] and some researchers have considered it as an appeasement signal [31]. Self-grooming in dogs can be considered as an index of relaxation and appropriate self-maintenance but can also be associated with an attempt to relieve stress or anxiety [32].

While the literature on positive emotions in farm animals has grown [5,27,33–41], the same topic has received little attention in companion animals [42–47]. Dogs' positive affective states have been investigated in female laboratory beagles tested in four different experimental protocols: Burman and colleagues [42] used the 'cognitive bias test' with a food treat in a bowl; Rehn and colleagues [45] used a separation/reunion to a familiar person paradigm; McGowan and colleagues [43] used a problem solving operant task comparing different rewards: food, human or dog contact; Zupan and colleagues [47] used more/less attractive food/social stimuli testing dog in a runaway motivation test. Kuhne and colleagues [44] evaluated pet dogs' emotional state and behavioral responses to physical human–dog contact by a familiar or unfamiliar person. In a pilot study, Gyax and colleagues [46] conducted a test to assess behavioral and neural indicators (fNIRS) of positive emotional states in dogs using three types of human interactions: verbal, physical or both.

Overall, these studies provided interesting evidence that certain circumstances elicit positive emotional states in dogs that can be measured through behavioral (*e.g.* tail wagging, proximity and contact seeking, gazing, stress signals, and vocalizations [42–47]), physiological (HR and HRV [44,47]), endocrine (oxytocin and cortisol [45]), and neural (hemodynamic [46]) indicators.

The aim of the present study was to introduce another physiological parameter, *i.e.* superficial body temperature, in combination with behavioral, heart rate and heart rate variability measurements, to investigate positive emotions in a sample of pet dogs receiving food treats from their owner. Superficial temperature was measured using infrared thermography (IRT), a remote and non-invasive technique that detects changes in peripheral blood flow. This technique has been recently used to explore physiological correlates of stress and emotions in animals [36,48–56] with only one study on dogs [56], whereas heart rate and heart rate variability are regarded as suitable tools to investigate the role of ANS in the modulation of affect and emotion [17,20,35,55,57,58].

Given that very palatable food is considered a positive reward [15,21,36,38,40,59] and based on the recent evidence by Zupan and

colleagues [47], we hypothesized that a very palatable food treat received from the owner should attract dogs' attention towards her/him, significantly increasing gazing behavior [60] and should also be a source of arousal, determining an increase in HR [47,61,62]. In addition, since HRV reflects the continuous interplay between the two branches of the ANS and it has been suggested that HRV changes are associated to the positive valence of emotional state [34,35,47], we expected that heart rate variability parameters should vary. HRV could increase [63] or decrease [47] and therefore at the present stage of knowledge on dog emotional reaction is difficult to make a more precise hypothesis. Finally, if receiving treats induced in dogs a positive emotional state we should observe an increase in tail wagging [43].

Making predictions on eye temperature changes is difficult, given that the available evidence is relative to a variety of body surface areas, tools and species tested with opposite results (comb in hens: [36]; nose in cows: [41]; eye in dogs: [56]; eye in horses: [54]; nose in macaques: [48,52,64]). However, in dogs eye temperature correlates with core body temperature [56] and thus it is possible that eliciting an attentional state would result in an increase in eye temperature due to a general state of arousal. To test these predictions, dogs' eye temperature, heart rate, heart rate variability and behavior were recorded prior (Phase 1), during (Phase 2) and after (Phase 3) food treats delivery.

2. Materials and methods

2.1. Subjects

The subjects were 19 healthy dogs (8 females, 11 males) of different breeds and body size, whose ages ranged from 2 to 11 years (mean = 6.36 years, SD = 2.72 years). The sample included 13 pure-breed dogs (1 Jack Russell Terrier, 2 Australian Kelpies, 1 Border Collie, 1 Irish Setter, 1 Irish Red and White Setter, 4 Labrador Retrievers, 2 Golden Retrievers, 1 Newfoundland) and 6 mixed-breed dogs (1 miniature size, 2 small size, 3 medium size). All the dogs were kept for companionship, lived within the human household, were accustomed to share daily activities with their owner (*e.g.* travel by car, going to unfamiliar places, encountering unfamiliar humans), and were used to wearing a harness on daily walking.

2.2. Procedure

The study was conducted at the *Canis sapiens* Lab of the University of Milan (Italy). On arrival, the human-dog pairs were escorted to a waiting room where the procedure was briefly described to the owners who were asked to provide their written consent to record behavior and to use the collected data, according to the national Privacy Law 675/96. To apply the heart rate monitor (Polar), the dogs were sheared under the right and left armpits for a surface of approximately 10 cm² each side. Then the Polar was fixed to the dog chest by means of a belt (see data collection paragraph for further details). After this manipulation, dogs were allowed to freely explore the waiting room for an additional period of 5 min to relax and to familiarize with the video camera operator and the infrared thermography technician.

The test took place in an unfamiliar adjacent bare room (3.00 × 5.00 m) equipped with one chair, a carpet and a video camera (Leica Dicomar, Panasonic, Japan) mounted on a tripod. During the test the video camera operator (E.S.C.), the infrared thermography technician (E.H.) and the owner were present. To minimize extraneous noise and disturbance, testing was conducted on weekends over a period of four months. The testing environment was air-conditioned and thus temperature (22 °C) and humidity (40%) remained constant during the procedure [56]. Owners were asked not to feed their dogs for at least 4 h prior testing.

The test procedure consisted of three consecutive phases:

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