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Evidence for a synchronization of hormonal states between humans and dogs during competition

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HIGHLIGHTS

- We examined human–dog interactions and hormonal changes during competition.
- Elevations in cortisol levels were associated between dogs and their handlers.
- Male handlers' dogs experienced greater increases in cortisol than females' dogs.
- Handlers' behavior was not associated with changes in dogs' cortisol levels.
- This study provides evidence for coordination of hormonal changes between species.

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ABSTRACT

Social interactions with humans have been shown to influence hormonal processes in dogs, but it is unclear how the hormonal states of humans factor into this relationship. In this study, we explored the associations between changes in the cortisol levels of dogs with humans' hormonal changes, behavior, and perceptions of their performance at an agility competition. A total of 58 dogs and their handlers (44 women, 14 men) provided saliva samples before and after competing. Dogs' saliva samples were later assayed for cortisol and humans' samples for cortisol and testosterone. Following the competition, handler–dog interactions were observed for affiliative and punitive behavior towards their dogs, and handlers completed questionnaires that included personal ratings of their performance. Structural equation modeling revealed that elevations in handlers' cortisol levels were associated with increases in their dogs' cortisol levels. Handlers' affiliative and punitive behaviors towards their dogs following competition were associated with their ratings of their performance, but these variables were unrelated to changes in their own cortisol levels and their dogs', implying their behavior did not mediate the relationship. These findings suggest that changes in the hormonal states were reflected between humans and their dogs, and this relationship was not due to handlers' perceptions of their performance or the behaviors we observed during post-competition social interactions. This study is one of the first to provide evidence for a synchronization of hormonal changes between species.

1. Introduction

Over the past 18–32 thousand years of domestication [45], humans have directly and indirectly selected for certain traits in dogs that have resulted in a unique predisposition for understanding human social behavior [14,27] and an attachment system analogous to what is seen in human infants [34,46]. The last two decades have seen an upsurge of studies investigating dogs' human-directed social behavior, revealing complex, human-like social skills in dogs, including an exceptional ability to follow human visual, auditory, and gestural cues [22,39], a unique sensitivity to humans' attentional [4,20] and emotional states [30,37,47], and perhaps even cross-species empathy [6,24]. Recently, Sümegi et al. [42] reported that stress experienced by owners manifested in their dogs' performance on a cognitive task, indicating that emotional states can be transferred from humans to their dogs. Given that humans' affective states are closely associated with their physiological and behavioral states (e.g., psychological stress causes changes in circulating hormones and behavior, [5]), it stands to reason that dogs' perceptiveness to human behavior could influence their own physiological states, potentially resulting in one that mirrors their humans'. The synchronization of physiological states between species via social interactions is an interesting topic that has received little attention.

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Social interactions have a significant influence on underlying hormonal systems. For instance, social interactions can have opposing effects on the hypothalamic–pituitary–adrenal (HPA) axis (i.e., the neuroendocrine system responsible for producing glucocorticoids and mounting the stress response), both causing stress (e.g., aggressive encounters) and also ameliorating it (e.g., grooming) [8]. The effects of social interaction on the HPA axis are often modulated by other neuroendocrine systems that interact with HPA axis activity (e.g., neuropeptides oxytocin and vasopressin from the hypothalamic–neurohypophysial system: [10,15]; testosterone from the hypothalamic–pituitary–gonadal axis: [26]). These effects are not limited to within-species interactions; social interactions between different species can also influence the hormonal systems of each. Several studies have shown that social interactions with humans influence the hormonal states of dogs. Disciplinary behavior exhibited by humans towards their dogs has been associated with increased cortisol levels [17,19], whereas positive social encounters with humans (e.g., petting, playing, talking, passively interacting) generally produce decreases in cortisol levels in dogs [16,41,48] and elevations in oxytocin [38], β-endorphin, phenyl acetic acid, and dopamine levels [31]. Though the positive physiological effects of interspecific interactions are largely mirrored in humans [28,33], only a few studies up to this point have taken into account both humans' and dogs' hormonal states during their social interactions in the same study [12,31]. In these studies, cortisol levels showed a species-dependent pattern following interactions, increasing or remaining elevated in dogs rather than decreasing as they did in humans.

Few studies up to this point have assessed how changes in human hormones directly relate to changes in the physiological states of dogs. Though some have found support for associations in humans' and dogs' oxytocin levels [13], cross-species correlations between cortisol levels have not been found [9,13]. However, a study of handlers' USA Federal Disaster Canine Teams reported positive correlations between handlers' salivary cortisol following certification testing and their dogs' heart rate and body temperature, suggesting a coordination of dogs' and handlers' physiological states [51]. Further, Jones & Josephs [19] found that following a loss at a dog agility competition, losing male handlers' testosterone levels predicted increases in their dogs' cortisol levels after competing, an effect that was mediated by affiliative and punitive behaviors. The authors suggested that these individuals may have been stressed by their loss and transferred this stress to their dog through their behavior, though they did not assess the cortisol levels of the handlers in that study (but see [26]). Whether hormonal states can be transferred across species warrants further investigation in a broader sample that includes both men and women.

The goal of the present study was to assess whether fluctuations in cortisol levels in humans are reflected in their dogs. We examined this question by observing social interactions and hormonal changes in male and female handlers and their dogs during an agility competition. Agility competitions provide a naturalistic opportunity to study cooperative interactions between humans and dogs in which they must work with one another to be successful. In these competitions, dogs complete an obstacle course as quickly as they can without error, relying on their handler's cues to guide them through. Because these events are generally arousing — physically, socially, and as a sensory experience — and potentially stressful for both dogs and humans, agility competitions provide an interesting, dynamic setting for studying the hormonal changes that underlie human–dog interactions.

Structural equation modeling was used to examine the relationship between human handlers' and their dogs' cortisol levels following competition and evaluate possible mediating behavioral variables. We anticipated that changes in cortisol levels would be associated between handlers and their dogs (i.e., fluctuations in cortisol levels would be reflected between species). In the original model, we examined whether handlers' perceptions of their performance were associated with changes in their cortisol levels, which were mirrored in their dogs due to their behavior immediately following competition. Since previous studies have found that baseline testosterone levels predict differential behavior [19] and changes in cortisol levels [26] during agility competitions, particularly in men, we assessed if handlers' baseline testosterone levels interacted with handlers' performance ratings to predict handlers' cortisol fluctuations. Additionally, an alternative model was run in which we evaluated whether changes in dogs' cortisol levels predicted handlers' perceptions of their performance, which in turn predicted handlers' behavioral and hormonal changes. By evaluating both the predicted model and an alternative model, we were able to assess whether a bi-directional relationship between the variables examined in this study is statistically plausible.

2. Methods

2.1. Participants and setting

Data collection took place from June to November 2013 at dog agility competitions around the Midwest. A total of 58 handler-dog teams agreed to participate. Our human sample consisted of 44 women and 14 men, and varied from 26 to 75 years old ($M_{age} = 51.75$, $SD = 10.56$). The advanced mean age of our sample meant that the majority of the female handlers (74%) were menopausal. Our dog sample was comprised of 25 females and 33 males of various breeds, varying from 15 months to 12 years of age ($M_{age} = 5.40$, $SD = 2.49$). Seven males and two females were not neutered or spayed, whereas all other dogs were altered. All parts of this investigation were approved by the University of Nebraska Medical Center/University of Nebraska at Omaha Institutional Review Board and Institutional Animal Care and Use Committee. Participants were compensated with a bag of dog treats.

2.2. Procedure & measures

2.2.1. Agility competition

Handlers were informed of the study during the morning briefing of the agility trial and were asked to sign up with the researchers if they were interested in participating. We observed one of the handler-dog team's runs and their behaviors following their run. Handlers often ran multiple times throughout the day, so researchers asked them to indicate which run they were most looking forward to and observed that run.

2.2.2. Questionnaire information

Participants were given a questionnaire to complete during their free time that day. The questionnaire included questions about their dog's age, neuter status, rearing history, competitive history, and their training techniques. Three surveys were included within the questionnaire: a personality questionnaire developed for dogs examining four factors: calmness, trainability, sociability, and boldness [21], the Dog Attachment Questionnaire [1], and the Interpersonal Reactivity Index [7]. A separate form obtained the handler's age, sex, how many runs they had completed that day already and how many they had qualified, whether they take corticosteroid or testosterone medications, and women's menstrual history and menopausal status.

2.2.3. Post-competition behavior

Following the observed run, two researchers followed the handler and dog and recorded their post-competition behavior for approximately 5 min or until the dog was put in its crate. Researchers recorded all occurrences of specific affiliative and punitive behaviors the handler exhibited towards their dogs (see Table 1), which were based on those observed in the Jones and Josephs [19] study. Observations were made in real time, as the researchers were concerned that videotaping would discourage participation or that handlers might change their behaviors if they knew they were being videotaped. Therefore, researchers recorded the occurrences with which the handler engaged in specific