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RECEIVED 21 July 2026
REVISED 11 September 2026
ACCEPTED 18 September 2026
PUBLISHED 05 October 2026

CITATION

Otzelberger KA, Romero T and Meyers-Manor JE (2026) Let's get it together: the relationship between different measures of empathy in dogs.
Front. Ethol. 5:1944284.
doi: 10.3389/fetho.2026.1944284

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Let's get it together: the relationship between different measures of empathy in dogs

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The lives of humans and dogs are greatly intertwined, making it crucial to understand how human emotions impact companion animals. While previous work found dogs respond greatly to humans and emotions through different metrics, including heart rate variability (HRV), person-oriented behaviors, a cognitive bias task (CBT), and owner-reported empathy surveys, little work has compared these measures of emotional responsiveness. We examined relationships between the aforementioned measures while dogs were presented with human emotions by their owner and a stranger. We hypothesized that these metrics would highly correlate if all measured empathy-related responses. We found the most person-oriented behaviors for expressions of negative emotions (i.e., crying), followed by positive ones (i.e., laughing), and similar physiological responses to previous research. Survey results suggested that dogs with higher empathy scores showed more person-oriented behaviors while their owner cried and had marginally greater attachment scores. However, dogs did not show any evidence of pessimism based on the emotional state they were exposed to in the CBT. Lastly, dogs who displayed more person-oriented behaviors showed greater physiological stress (i.e., low HRV) when the stranger cried or owner laughed. Our findings suggest that dogs respond to human emotions, which is reflected through physiological measures, and owners can predict their dog's emotional responsiveness. Additionally, dogs with greater attachment are viewed as more empathetic by their owners, and orient to and interact with humans when they show distress. However, dogs may not feel that emotional state, or the CBT may not be an effective method of evaluating those short-term states.

KEYWORDS

canine (dog), cognitive bias task (CBT), correlating measures, empathy, heart rate variability (HRV)

1 Introduction

Empathy, the ability to experience and respond to the emotional states of others (Eisenberg and Fabes, 1990; de Waal, 2008), has become an important topic in animal research. Understanding the extent to which animals have the capacity for empathy, and the circumstances under which it is expressed, not only provides insights into the evolution of human empathy but also has important implications for animal welfare, management, and legislation. One species that has attracted significant attention is the domestic dog (*Canis lupus familiaris*), due to its evolutionary history alongside humans (Miklósi et al., 2004;

Galibert et al., 2011; Horn et al., 2011), which is thought to have shaped its socio-cognitive skills (Hare et al., 2002; Hare and Tomasello, 2005; Lazzaroni et al., 2020). Thus, numerous studies (reviewed below) have examined the human-dog relationship to assess the presence and expression of empathy in dogs, using a range of measures, including contagious yawning, behavioral responses, physiological indicators, and owner-reported surveys.

Contagious yawning, or yawning after seeing or hearing another individual yawning, is a prevalent phenomenon among social animals (e.g., Anderson et al., 2004; Paukner and Anderson, 2005; Mancini and Palagi, 2009; Norscia and Palagi, 2011; Romero et al., 2014; Ake and Kutsukake, 2023). While contagious yawning is not in itself an empathy reaction, it has been used as a proxy for the presence of empathy since its occurrence has been connected with capacity for empathy in humans' behavior (Senju et al., 2007; Franzen et al., 2018) and brain circuitry (Platek et al., 2005; Haker et al., 2012). Supporting the hypothesis that it is linked to empathy, contagious yawning, as well as empathy responses (as reviewed in Preston and de Waal, 2002), occurs more frequently between socially bonded individuals (Norscia and Palagi, 2011). Similarly, dogs have been shown to yawn more frequently after seeing their human companions yawning than when watching an unfamiliar one (Joly-Mascheroni et al., 2008; Madsen and Persson, 2012; Romero et al., 2013), suggesting that dogs may also show this building block of empathy (but see Neilands et al., 2020).

Other studies examining empathy in dogs have used more direct tests of empathy by looking at dogs' behavioral reactions when placed into emotion-laden situations. This experimental approach, extensively used in developmental psychology (e.g., Eisenberg and Fabes, 1990), provides valuable insights into empathy because it allows us to measure animals' responses to individuals' emotional states, therefore capturing potential expressions of empathy. For instance, when dogs observe a human, either the owner or a stranger, showing an acted negative emotion (i.e., crying), dogs tend to respond with more person-oriented behaviors (e.g., engage or contact the person) than when the person is showing a neutral (e.g., humming), or acted positive emotion (i.e., or laughing) (Custance and Mayer, 2012; Meyers-Manor and Botten, 2020; but see Bräuer et al., 2024 for counter evidence with genuine emotion). Similarly, dogs have been shown to respond faster to their trapped owners who appeared to be in distress, as compared to when their trapped owners were humming or reading and not showing any signs of distress (Sanford et al., 2018; Bourg et al., 2020; Carballo et al., 2020). This rescue behavior did not, however, extend to trapped strangers pretending to be in distress (Rivera and Meyers-Manor, 2024). These findings suggest that dogs are able to distinguish and react differently to human emotions, specifically negative emotions, and tend to respond with contact seeking to those emotional expressions. In some settings (e.g., laboratory rescue behavior), this behavior appears to be stronger for the owner than a stranger (Sanford et al., 2018; Rivera and Meyers-Manor, 2024), whereas in home settings where the owner is present alongside the stranger, empathetic response appears to be more equal between strangers and owners (Custance and Mayer, 2012; Meyers-Manor and Botten, 2020).

In addition to behavioral measures, many studies have also recorded physiological changes as additional measures when evaluating empathy-related responses. Empathy not only involves understanding and responding to another individual's emotional state, but also sharing the state of others (de Waal, 2008). Physiological measures can capture these internal processes and provide objective indicators while animals either observe emotional stimuli or interact with others. Heart rate (HR) and heart rate variability (HRV) can inform about the stress levels in animals by giving a measure of autonomic nervous system activity, with lower HRV generally reflecting greater sympathetic nervous system activity and increased levels of stress (Appelhans and Luecken, 2006). In dogs, HRV has been used to assess their emotional states (e.g., Kuhne et al., 2014; Katayama et al., 2016; Craig et al., 2017) and reactions to others in distress (Sanford et al., 2018; Meyers-Manor and Botten, 2020; Rivera and Meyers-Manor, 2024). For instance, dogs showed lower HRV and higher HR when they observed their trapped owner crying (Sanford et al., 2018; Carballo et al., 2020) or when responding to strangers crying (Meyers-Manor and Botten, 2020), suggesting that dogs are sensitive to humans in distress and react physiologically.

In addition to behavioral and physiological measures, some researchers have attempted to evaluate empathy in dogs using owner-reported surveys. Questionnaires are a common method to measure empathy in humans (e.g. (Baron-Cohen and Wheelwright, 2004)), and have also been used to assess several traits in dogs (Hsu and Serpell, 2003; Kubinyi et al., 2015). Szánthó et al. (2017) created the Dog Emotional Reactivity Survey, which contained measures of both the dogs and the owners' empathy, as well as their relationships. In particular, the two most relevant sub-scales in the Dog Emotional Reactivity Survey are the Dog's Reactivity to the Owner's Emotion and the Dog's Reactivity to Other Dogs' Behaviour (Szánthó et al., 2017). Although these scales showed good internal consistency and reliability, they have not been evaluated for their validity and therefore their ability to accurately measure empathy in dogs remains untested.

While many studies have evaluated dogs' responses to human emotional states and behaviors to investigate dogs' empathy capacity, no study has assessed the emotional state of the animal as a result of observing humans in distress. Additionally, some researchers have argued that none of these measures demonstrate that the dogs actually react empathetically to the distress of humans during these tests (for review, see Adriaense et al., 2020, Adriaense et al., 2020, Adriaense et al., 2020, Adriaense et al., 2020). One measure that has been used to assess the emotional states of animals is a cognitive bias task (CBT). A CBT assesses the emotional state of an animal as animals respond to ambiguous stimuli (as reviewed in Adriaense et al., 2020). A positive location is trained with reinforcement, while a negative location lacks this preferred reinforcement. An ambiguous location is then introduced, and the latency to reach this new location indicates the internal state of the animal, such that a latency comparable to that of a positive location indicates a more positive internal state, while a latency similar to that of a negative location indicates a more negative one.

Previous work on rats (Burman et al., 2008) and zoo animals (as reviewed in Clegg, 2018) has used CBT to assess how enrichment

affects well-being, with results suggesting that animals housed with enrichment respond to the CBT in a more positive way. In dogs, CBTs have been used to assess if their well-being is impacted by their environment, revealing that dogs housed in a shelter have a more negative affective state in comparison to pet dogs (Burani et al., 2020). In addition, fluoxetine, a medication used to treat separation anxiety in dogs, has been found to have positive effects on CBT in dogs who have been treated over several weeks (Karagiannis et al., 2015). Enrichment activities such as olfactory enrichment using essential oils or nose work likewise improved optimistic responses in the CBT (Uccheddu et al., 2018; Duranton and Horowitz, 2019). These findings indicate that CBTs can detect differences that correspond to the well-being of animals.

The results of the above studies suggest that CBTs may measure the internal states of dogs, however they are typically done to assess long-term changes and not in response to short-term actions. One study, however, used CBT to assess the short-term affective states of dogs in response to human odors (Parr-Cortes et al., 2024), with CBT results suggesting that dogs have a more negative affective state after exposure to the odor of a stressed human. The findings suggest that short exposure to human emotions may impact the well-being of dogs, and that CBT may be suitable to assess these states.

Overall, the current literature shows that while dogs have shown awareness and responsiveness to human emotions, it is still unclear whether these different measures of awareness and responsiveness relate to one another, and therefore whether they reflect the same underlying construct: empathy skills. Clarifying this is crucial to accurately defining and measuring empathy-related abilities in dogs. Furthermore, it will improve our understanding of dog empathy and help determine whether emotional awareness and responsiveness represent a unified ability of distinct components of socio-emotional cognition. The present study attempted to understand how human emotions, both positive and negative, may impact dogs' affective states and associated responses as measured through behavior (contagious yawning and person-oriented behavior), physiology (heart rate variability), and a cognitive bias task, all of which have been previously used independently to assess empathy-related responses or emotional states in dogs. Survey responses from owners were also correlated with the behavioral and physiological measures. We hypothesized that if empathy was accurately being measured, then these various empathy measures would highly correlate. We also hypothesized that exposure to negative human emotions would result in slower latencies during the CBT, which would reflect a negative emotional state, suggesting empathetic responding.

2 Materials and methods

2.1 Participants

A total of 35 dogs and their owners volunteered to participate in this study. Of the 35 dogs, there were 15 males ($n = 12$ neutered, $n = 3$ not neutered) and 20 females ($n = 18$ neutered, $n = 2$ not neutered). Dogs ranged between the ages of 1 and 12 years old ($M = 5.53$, $SD = 3.09$). There were 12 mixed-breed dogs, 6 Golden

Retrievers, 7 Labrador Retrievers, 2 English Cocker Spaniels, and 8 other pure-bred dogs of varying breeds (Australian Shepherd, Cavalier King Charles Spaniel, Weimaraner, Dalmatian, Dachshund, Rough Coated Collie, French Bulldog, Border Collie). The owners ranged from 29 to 79 years of age ($M = 52.15$, $SD = 13.55$). There were 20 female owners (57.1%) and 12 male owners (34.3%); three owners declined to give their gender. Participants were recruited from the Ripon College community through email. All participation was voluntary and took place in a lab setting at Ripon College (WI, USA). There was no incentive or compensation for participants. All ethical approvals were received from both human and animal ethical boards (IACUC approval: https://2023.01.Manor; IRB approval: 2022-23.026).

2.2 Materials

A Polar H9 heart rate monitor was used to measure and record the dogs' heart rate and heart rate variability throughout the entirety of the study. The heart rate monitor was strapped to the chest of the dog, and water-based lubricant was used to ensure connection and clear readings of heart rate. Data from the heart rate monitor was recorded on an iPad using HRV Logger App (A.S.M.A B.V.) via Bluetooth. This data was then downloaded and analyzed using Kubios software (v. 4.1.1, Kubios Oy, Kuopio, Finland).

A timer was used to record latency during the cognitive bias task, and was used during the experimental emotional presentations to ensure equal amounts of exposure to emotions. Recordings of the CBT were done using a Canon Vixia camcorder, and a GoPro Hero 10 camera was used to record the experimental room where emotional presentations occurred. Metal bowls were used during the CBT for dogs to retrieve a treat. A variety of treats were available, and a preferred treat was used for the training and test trials. If a dog had a food allergy, the owner was asked to bring treats that were safe for their dog. Metal bowls were washed after each dog that was tested. Water was available *ad libitum*.

2.2.1 Owner-reported behavioral surveys

Dog owners completed two surveys on a laptop (Dell PC). The first survey completed was the Canine Behavioural Assessment and Research Questionnaire (C-BARQ), which was developed and validated by Hsu and Serpell (2003). Only the subsections of Total Aggression, Total Fear, and Total Attachment were analyzed for this experiment. The second survey completed was the Dog Emotional Reactivity Survey (Szánthó et al., 2017), which includes questions about a dog's responses to both human and dog emotions. In the current study, only the Dog's Reactivity to Owner's Emotion Scale (DROE) portion of this survey was analyzed, as this portion assesses dog empathic responses toward people (Szánthó et al., 2017), and only behavior toward people was measured in the current study.

2.3 Procedure

All dogs completed CBT, human emotion, and contagious yawning tests. The study was split into two visits, approximately one week apart (range of 6–10 days). In the first visit, dogs were

trained on the CBT (see below), exposed to the baseline condition of the human emotion test (see below for the description of the conditions), with a follow-up CBT, and then exposed to one of the two experimental emotion conditions, once again followed by a CBT post-test. Owners completed the surveys during the first visit as well. During the second visit, dogs were retrained on the CBT, exposed to the baseline condition of the human emotion test with a follow-up CBT, and then exposed to the emotion they had not previously been exposed to, once again followed by a CBT post-test. The second visit concluded with a contagious yawning test. Heart rate variability data were recorded throughout all parts of both visits.

When the dogs and owners entered the room, the owners completed the informed consent and the dogs were fitted with heart rate monitors before any training or experimentation. Cameras and heart rate were started before any training or experimentation.

2.3.1 Cognitive bias task

Dogs entered the experimental room (9.57 m x 5.74 m) and were given a five-minute habituation period to reduce stress after the handling for applying the heart monitor and for exploring the room prior to any training or test trials (this period is consistent with similar previous studies, e.g. (Carballo et al., 2020; Meyers-Manor and Botten, 2020)). Owners and experimenters were instructed not to interact with the dog unless the dog approached them.

The owner was present in the room, sitting in a chair while filling out the behavioral surveys. There were also three to four experimenters present, running the video cameras, baiting food bowls, and holding the dog during trials. After the habituation period had ended, the dogs were given a free food trial where they were presented with a treat in a metal bowl that was placed on the ground. If the dog ate the treat, training of the CBT began. If the dog did not eat the treat, alternative treats were presented until a preferred treat was identified. If the dog refused all treats, training of the CBT was discontinued. Training of the CBT also did not continue if the dog expressed increased stress behaviors, including avoidance behaviors, repeated self-directed behaviors (e.g., self-scratching, lip licking, shaking/trembling; Beerda et al., 1997).

Dogs were held at a designated start location at the end of the room by an experimenter, with the start position marked with a tape line. A camera was positioned behind the start line to record the dog's responses during the trial. While the dog was being held by its leash at this start location, a second experimenter walked to the opposite end of the room, where there was a table with metal bowls and treats that were out of reach of the dog. For positive trials, the experimenter would place a treat into the bowl (i.e., food baiting), whereas for negative trials, the experimenter performed the same actions but did not bait the bowl (sham baiting). The experimenter then placed the bowl four meters away from the left or the right of the starting location and four meters away from each other (see Figure 1). For half of the dogs, the bowl containing the treat (Positive location- P), was placed to the right, while for the other half of the dogs, the positive location was located to the left.

The other location always had an empty bowl placed there and served as a negative (N) location.

After placing the bowl at the designated location, the experimenter called the dog's name and made eye contact to ensure that the dog attended to the bowl placement. The experimenter then returned to the start location, and the experimenter holding the dog's leash released the dog. A timer was started immediately after the dog's leash had been dropped to record the latency for the dog to contact the bowl. Dogs were allowed up to 30 seconds to contact the bowl. If they failed to contact the bowl within this time, the dog's leash was picked up, the dog was returned to the start location for the next trial, and a latency of 30 seconds was recorded.

The training of the CBT began with a P trial, followed by an N trial, and then repeated. Trials then alternated randomly with no more than two P or N trials presented in a row. Dogs completed at least 15 trials but continued until the last three P trials had a faster latency than the last three N trials (Mendl et al., 2010).

2.3.2 Stimuli exposure

Once the CBT training had been successfully completed, the dog was then walked by their owner and an experimenter to a room down the hall. This room (6.05 m x 5.45 m) was set up with two chairs facing each other, where both the owner and an unfamiliar experimenter (separate from the CBT experimenter) sat. A GoPro camera, set up in the front of the room, was recording the trials. The methods for emotional stimuli presentation were taken directly from Custance and Mayer (2012) and replicated in Meyers-Manor and Botten, 2020. Once the owner and the experimenter sat in the chairs, they had a conversation for two minutes to allow both the dog and the owner to habituate to the room. After the two minutes had passed, either the owner or the experimenter read from a book out loud for 20 seconds. The owner and experimenter were asked to read with a pace and volume that was as natural as possible. After 20 seconds of reading, the owner and experimenter resumed their conversation for one minute. Once the one minute had passed, the second person read from a book out loud for 20 seconds. During this entire session, both the owner and experimenter were instructed to completely ignore the dog, avoiding any physical or eye contact. At the end of the session, the dog and owner walked back with an experimenter to the CBT testing room.

When the dog returned to the CBT room, they were led to the start location, and a P and N trial were conducted following the same procedure as in the training session. The order of these trials was counterbalanced for all dogs. After the dog had received one P and one N trial, an ambiguous location was introduced. The ambiguous location (M) was located four meters away from the start location and was two meters from both the P and N locations, placed directly in the middle of those locations (see Figure 1). The M trial was completed with the same procedure as the P and N trials, however the M location never actually had a treat in the bowl. Once this trial had been completed, another P and N trial was completed. A total of five trials (2P 1M 2N) were completed for the CBT test, and latency to each location was recorded during each trial. As in previous tests, people present in the room were asked not to have any interactions with the dog during the test trials.

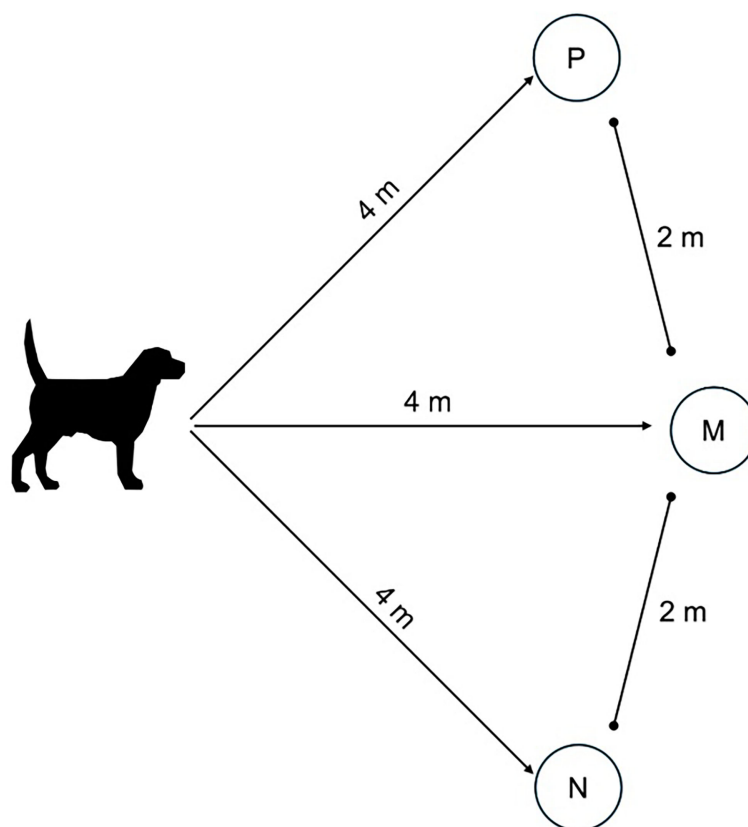


FIGURE 1

Room set-up for cognitive bias task. The circles indicate the position of the bowls (P, positive; N, negative; M, ambiguous middle).

Following this second CBT test, owners and their dogs walked with an experimenter back to the human emotion experiment room. Following the same procedure as in the reading condition, the owner and experimenter took turns presenting either the negative emotion (crying) or the positive emotion (laughing), instead of reading. Both model order (i.e., owner or experimenter) and the type of emotion presented (positive vs. negative emotion) were randomly allocated to counterbalance conditions of who began the emotion and which emotion was presented across dogs, but only one emotion was presented during each session. While the emotion was being presented, the owner and experimenter were instructed not to interact with the dog in any way, as well as to keep their face uncovered as much as possible to ensure that the dog could clearly hear and see what was being expressed. Owners were also encouraged to cry and laugh as naturally as possible (Custance and Mayer, 2012; Meyers-Manor and Botten, 2020). Person-oriented behaviors were recorded throughout the entirety of the emotion and reading presentations for later coding (see below).

After exposure to one of the emotions, the dog and their owner walked with an experimenter back to the CBT room. The procedure was the same as the CBT test following reading with a single ambiguous trial, 2P, and 2N trials. Once dogs completed the CBT test a second time, they were finished for the day. Dogs were expected to return to the lab approximately one week after their first session so the remainder of the experiment could be completed. This was to prevent fatigue, as the total time for each session was approximately one hour.

2.3.3 CBT retraining and second emotion presentation

When one week had passed, dogs and their owners returned to complete the remainder of the experiment. Dogs were first retrained on the CBT. The retraining of the CBT had the same procedure as the initial training trials; however, the minimum number of trials was reduced from 15 to 6. Dogs were considered to be retrained if they completed the last 3 P trials with a faster latency than their last 3 N trials.

Following retraining, dogs (and their owners) participated in the same tests, in the same order, and following the same procedures as in the previous session, with the exception that the emotion presented was the one not presented during the first session. That is, if during the first session the owner and experimenter expressed laughter, they now expressed crying and vice versa.

2.3.4 Contagious yawning

The final test of the study was a contagious yawning test. In the same room where the emotion testing was conducted, an experimenter sat in a chair in the middle of the room, while the owner sat in another chair at one side of the room. Once again, it was expected that anyone in the room would ignore the dog during testing except when trials were presented by the experimenter. When testing began, the experimenter called the dog's name to get the dog's attention and then yawned with vocalization. This was repeated for

a total of three minutes with approximately 10 seconds between each yawn. Once this time had passed, the dog and its owner were done with the study. All yawns by the dog were video recorded.

2.3.5 Behavioral coding and physiological processing

Video recordings of the emotional stimuli and contagious yawning tests were coded by an experimenter who was not present in the room at the time of the experiment. Dogs were coded for person-oriented behaviors (Custance and Mayer, 2012; Meyers-Manor and Botten, 2020) during each emotional condition. Person-oriented behaviors included any actions where the dog looked at, contacted, approached, or vocalized at a person in the room. Person-oriented behaviors were recorded using scan sampling at each second of the 20-second emotion conditions. Two coders completed interrater reliability coding for 20% of all videos. Interrater reliability was 88% agreement on all person-oriented behaviors. Additionally, the tone of the first approach was also recorded for each condition, which included alert, playful, submissive, and calm (Custance and Mayer, 2012; Meyers-Manor and Botten, 2020). The coders had 86% agreement on tone. Any disagreements were arbitrated by a third coder.

Heart rate variability was processed using Kubios Processing. All artifacts were detected and smoothed using cubic spline interpolation. To make HRV comparisons similar to other studies, pNN50 was used as the measure of variability in this study (Sanford et al., 2018; Meyers-Manor and Botten, 2020; Rivera and Meyers-Manor, 2024). It represents the proportion of successive intervals that differ by more than 50 msec.

2.3.6 Data analysis

All statistical analyses were performed using SPSS (version 31 and 32). Of the 35 dogs, 26 successfully completed the cognitive bias task. Dogs that failed to complete the CBT either presented with too many stress behaviors or could not achieve three positive trials faster than three negative trials during the single 45-minute initial training session. Data from these dogs were excluded from any CBT analyses but were included in other parts of the experiment.

Some HRV data were incomplete or could not be collected from some dogs during the emotional stimuli presentations due to problems with connectivity, typically due to too much fur or deep chested breeds. For the first reading session, there were 22 complete HRV readings, 24 complete recordings for the second reading session, 18 for the crying condition, and 22 complete recordings for the laughing condition. Tests for normality of data were conducted using Shapiro-Wilk and all data was normally distributed except for two measures of HRV for the reading owners and laughing owners.

A 2x4x2 (Who x Emotions x Whom) completely repeated measures analysis of variance (ANOVA) was run to analyze total person-oriented behaviors based on who was expressing the emotion: owner and stranger (i.e., experimenter), the emotions (two reading sessions, crying, and laughing), and whom the person-oriented behaviors were directed toward. Although two measures of

HRV were not normally distributed, modeling suggests that ANOVAs are appropriate to use and robust to violations of normality (Schmider et al., 2010). Thus a 2x4 (Who x Emotions) repeated measures ANOVA was also completed to compare HRV during each emotion condition by who was the individual expressing the emotion. The latency from the CBT was analyzed using a single-factor within-subjects ANOVA, which compared the latency of the CBT after each emotion was presented to the dogs.

In addition, a series of Pearson correlations was completed to evaluate if owners' perceptions of their dog's behavior matched what the dogs did during emotional stimuli presentations, which was measured using the total score from the Dog's Reaction to Owner's Emotion (DROE) portion of the empathy survey. These were compared to the CBARQ (attachment, fear, and aggression), person-oriented behaviors in each condition by person doing the emotion, HRV (pNN50) by condition and person, and CBT latency for each ambiguous trial by emotion. Because the data was non-normally distributed for the first reading owner trial and for the owner laughing trial, Spearman's rho correlations were used for those two measures.

Of the 35 dogs, only 4 dogs yawned when exposed to the experimenter's yawns, so further analyses were not performed. If a greater proportion of dogs had yawned, dogs would have been grouped into "yawners" and "non-yawners", and behaviors would have been further analyzed with other variables.

3 Results

A 2x4x2 completely repeated measures ANOVA was used to identify if person-oriented behaviors were affected by who was presenting the emotion, the emotion being presented, as well as the direction of the person-oriented behaviors. There was not a significant main effect of the identity of the person presenting the emotion on person-oriented behaviors, $F(1, 34) = .001$, $p = .977$, $partial-eta\ squared = .000$. There was also no significant main effect of direction on person-oriented behaviors, $F(1, 34) = 1.896$, $p = .177$, $partial-eta\ squared = .053$. However, there was a significant main effect of emotion on person-oriented behaviors, $F(3, 102) = 35.07$, $p < .001$, $partial-eta\ squared = .508$ (see Figure 2).

Bonferroni follow-ups revealed there to be no significant difference in person-oriented behaviors between the first ($M = .721$, $SE = .178$) and second ($M = 1.100$, $SE = .250$) reading sessions, $p = 1.00$. However, there were significantly more person-oriented behaviors during crying ($M = 5.236$, $SE = .487$) compared to the first or second reading session, p 's $< .001$. Similarly, there were significantly more person-oriented behaviors during laughing ($M = 3.029$, $SE = .488$) than during the first, $p < .001$, or second reading session, $p = .004$. There were also more person-oriented behaviors during crying compared to laughing, $p = .002$, but there was not a significant interaction of who was expressing the emotion and the type of emotion presented, $F(3, 102) = .229$, $p = .876$, $partial-eta\ squared = .007$.

When analyzing the interaction between who did the emotion and the direction of person-oriented behavior, we found a

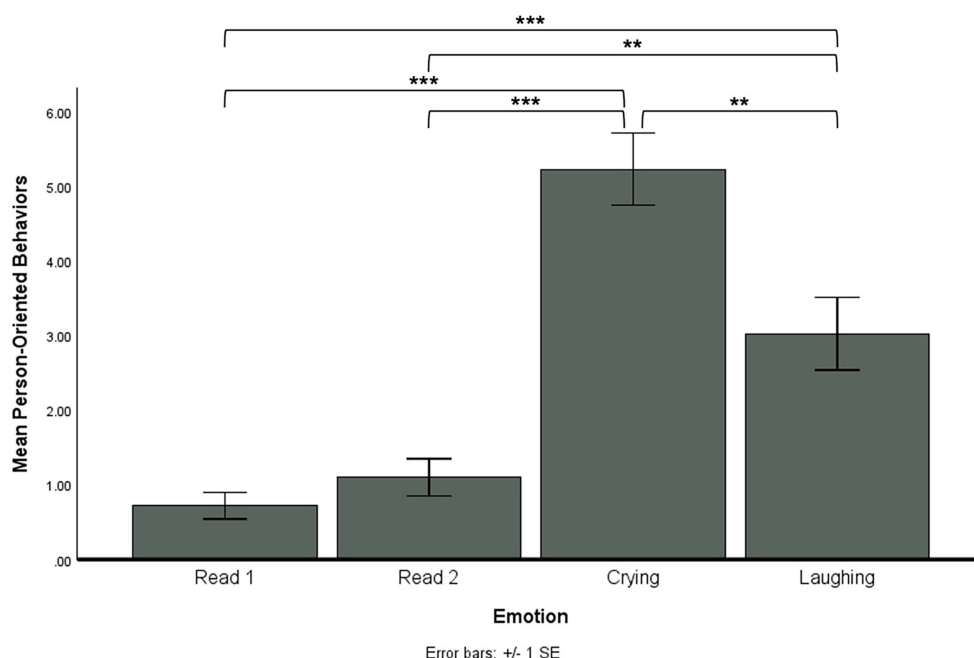


FIGURE 2

Mean person-oriented behaviors by emotional condition. Error bars represent standard error of the mean. ** $p < .01$, *** $p < .001$.

significant effect, $F(1,34) = 76.998$, $p < .001$, *partial-eta squared* = .694. While the owner expressed emotions, dogs showed more person-oriented behaviors to the owner ($M = 4.357$, $SE = .499$) than to the stranger ($M = .693$, $SE = .134$), $p < .001$. Similarly, while the stranger was expressing the emotion, there were more person-oriented behaviors directed towards the stranger ($M = 3.90$, $SE = .415$) than to the owner ($M = 1.136$, $SE = .415$), $p < .001$.

There was also a significant three-way interaction of who presented the emotion, the emotion presented, and the direction of the person-oriented behavior, $F(3,102) = 37.226$, $p < .001$, *partial-eta squared* = .523. Bonferroni pairwise comparisons revealed that there were more person-oriented behaviors toward the owner while the owner cried, as well as more person-oriented behaviors toward the stranger when the stranger cried, p 's $< .001$. This same pattern was observed for laughter but with fewer person-oriented behaviors overall, p 's $< .001$. No other differences were significant. Means and standard errors are represented in Table 1.

The tone of the first approach was also recorded for each dog. Given that there were four emotional displays coded, we ran a non-central binomial test with a probability of 0.25 for both the crying and laughing conditions (Custance and Mayer, 2012; Meyers-Manor and Botten, 2020). There were 35 submissive approaches out of the 44 total approaches during crying conditions. Likewise, there were 17 submissive approaches out of the 24 total approaches during laughing conditions. The 35 submissive approaches in the crying condition ($p < .001$) and the 17 submissive approaches in the laughing condition ($p < .001$) were significantly higher than expected by chance.

A 2x4 completely repeated measures ANOVA on HRV revealed no significant main effect of who was expressing the emotion, $F(1, 10) = 1.913$, $p = .197$, *partial-eta squared* = .161, as well as no significant effect of emotion on HRV, $F(1, 10) = 1.861$, $p = .158$,

partial-eta squared = .042. The interaction between who was expressing the emotion and the emotion was also not statistically significant, $F(3,30) = .440$, $p = .725$, *partial-eta squared* = .042.

Dogs on average took 20.23 trials ($SD = 5.02$) to reach criterion in the CBT. In retraining, dogs took on average 11.57 trials ($SD = 6.24$). A single factor within subjects ANOVA revealed a no significant main effect of emotion on latency to the middle location during the CBT, $F(3, 75) = .315$, $p = .815$, $p = .815$, *partial-eta squared* = .012. Means and standard deviations are represented in Figure 3.

TABLE 1 Interaction of person expressing x emotion x direction of person-oriented behavior.

Person expressing emotion	Direction of person-oriented behavior		<i>p</i>
	Owner (<i>M</i> ± <i>SE</i>)	Stranger (<i>M</i> ± <i>SE</i>)	
Owner			
Read 1	.743 ± .341	.943 ± .350	0.614
Read 2	1.543 ± .466	.800 ± .335	0.227
Cry	9.686 ± 1.135	.657 ± .224	<.001
Laugh	5.457 ± 1.119	.371 ± .174	<.001
Stranger			
Read 1	.571 ± .214	.629 ± .281	0.858
Read 2	1.486 ± .563	.571 ± .222	0.133
Cry	1.543 ± .473	9.057 ± 1.067	<.001
Laugh	.943 ± .350	5.343 ± 1.026	<.001

Significant values are bold.

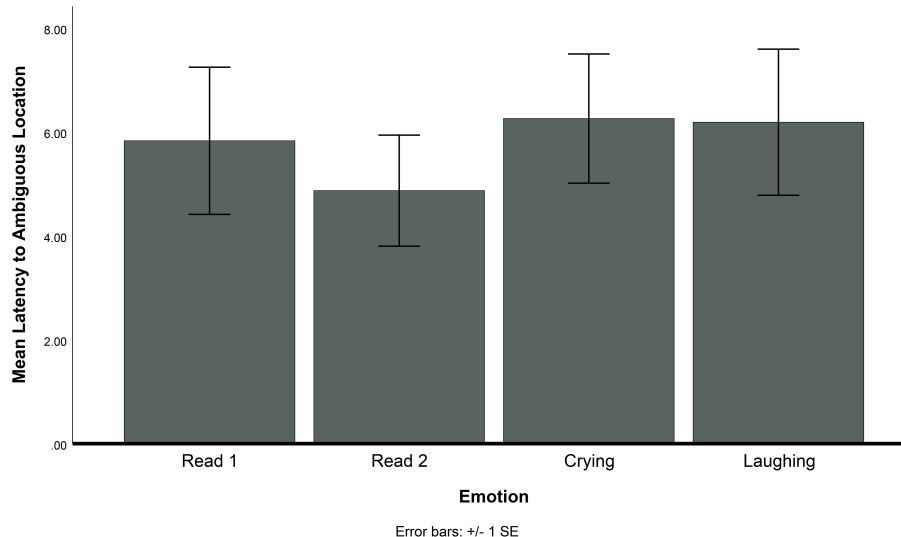


FIGURE 3
Mean latency to ambiguous location in CBT trials. Error bars represent standard error of the mean.

A series of Pearson's correlations (and Spearman's for the non-normal variables) was run to identify relationships between person-oriented behaviors, HRV, the CBARQ subsections, and the DROE portion of the empathy survey. It was found that dogs in the stranger-crying condition with more person-oriented behaviors toward the stranger had a lower HRV while the stranger was crying, $r(20) = -.598$, $p = .003$. Interestingly, a similar relationship was found for the owner-laughing condition with lower HRV predicting more person-oriented behaviors toward the owner, $\rho(23) = -.510$, $p = .009$. Dogs who had a higher score on the DROE had more person-oriented behaviors toward their owner while they were crying, $r(33) = .489$, $p = .003$. This relationship did not hold for the DROE and person-oriented behaviors toward the stranger while crying, $r(33) = .039$, $p = .824$. The DROE also marginally correlated with attachment scores on the CBARQ with higher DROE positively correlated with attachment scores, $r(33) = .319$, $p = .062$. No other significant correlations were found between the CBARQ subsections (Aggression, Fear, Attachment) and any other measures, all r 's $< .30$, p 's $> .10$.

4 Discussion

As in past studies (Custance and Mayer, 2012; Meyers-Manor and Botten, 2020), the present study found that dogs showed more person-oriented behaviors during the crying condition than during the laughing condition or during the baseline conditions of reading. However, the CBT did not show a significant difference in latencies after exposure to different human emotions, and the majority of subjects did not yawn contagiously when a stranger acted out a yawn. There was evidence, however, to support that owners were able to accurately report their dog's empathetic-like behaviors toward themselves in their survey responses as this matched how the dogs responded in the emotional stimuli.

Our findings suggest that dogs are aware of human emotions and show more empathetic-like behaviors when humans appear to be in distress. These findings were consistent with those of Custance and Mayer (2012), as well as Meyers-Manor and Botten (2020), who both found that dogs show more person-oriented behaviors while people were crying than when they were humming, laughing, or talking. Our research further extends these findings by replicating them in a laboratory setting rather than in the dog's home, as in previous research. One limitation of this study is that, like most other previous research on empathy, the emotions presented were artificial, which may have led the dogs to respond differently than they would have had the individuals expressed true emotions. In fact, research using emotion induction found that dogs made very little response to their owners, regardless of whether they were in the crying or neutral condition (Bräuer et al., 2024) (Bräuer et al., 2024). It may be of value to look at how dogs may respond to more natural emotion and to look at other emotions, such as anger, fear, or surprise.

Like Meyers-Manor and Botten (2020), the present study found that dogs showed decreased HRV with higher person-oriented behaviors only in the stranger crying condition. One additional correlation appeared in the present data, with higher person-oriented behaviors in the owner laughing condition, with lower HRV in the dogs, suggesting that dogs respond with contact seeking when under mild stress. However, it is not clear why the stranger crying and the owner laughing are the only to show this relationship, but it is intriguing that the HRV did not differ overall by condition, nor did the person-oriented behavior vary between the stranger and owner. These finding of no difference between HRV or person-oriented behaviors were consistent with the finding of Meyers-Manor and Botten (2020). While it is possible that the correlations found with HRV represent Type I errors, the similarity of the results in the stranger crying condition to Meyers-Manor and Botten (2020) lends support for at least that result. Throughout the current study, we measured HRV; however, there was a lot of

incomplete data due to fur length and poorly fitting straps (e.g., toy breeds). Attempts were made to ensure that the monitors were reading properly, but some of these attempts were unsuccessful, resulting in a reduced sample size of HRV data that may have prevented detection of true effects (Type II error). It is possible that there were unknown consistent differences in the dogs that were not able to be measured that could have affected the results (e.g., toy breeds or fluffier breeds). However, it should be noted that in all correlational comparisons, a minimum of 20 of the 35 dogs were included. Furthermore, the fact that these results are very similar to Meyers-Manor and Botten (2020) does lend more support to our findings. To help resolve some of the problems faced, we think that it may be beneficial for future studies to include an additional biological measure of stress, such as saliva cortisol (Dreschel and Granger, 2009). The collection of saliva from dogs would allow researchers to not solely rely on heart monitors working or fitting on all of the dogs.

Although dogs are sensitive and respond to the emotional states of humans, our results do not suggest that dogs' emotional states mimic human emotions themselves as a result of exposure. Emotional contagion and state matching are characteristics of empathy in humans and other mammals (Preston and de Waal, 2002; Batson, 2009). For instance, prairie voles match the fear response, anxiety-related behaviors, and corticosterone increase of stressed cagemates, suggesting an empathy mechanism (Burkett et al., 2016). In contrast, the lack of difference in the CBT results in our study does not provide evidence of a more positive or negative state following exposure to the human positive or negative emotional conditions. However, the lack of emotional state matching is not in line with the person-oriented behavioral responses (but see Bräuer et al., 2024). Hence, it is possible that the CBT may measure only prolonged changes in emotional states rather than transitory ones. In fact, most studies have performed CBT on more trait (Mendl et al., 2010; Karagiannis et al., 2015) or long-term state (Karagiannis et al., 2015; Burani et al., 2020) based conditions, and only a few studies have used shorter-term changes in emotional states from olfactory exposures (Parr-Cortes et al., 2024). In both of those short-term changes, the olfactory exposure occurred during the CBT test. In the present study, there was a short delay between the emotional presentation and the CBT test. This delay may have been sufficient to erase any mild emotional changes that occurred during the testing. This procedural limitation may help explain our null results. Additionally, Parr-Cortes et al. (2024) used three intermediate bowls for their CBT and only found significant differences in the NN bowl (closer to the N). Thus, it is also possible that subtle changes may be more apparent at these more biased intermediate bowls. Future studies should include intermediate biased bowls to test for these more subtle changes. It would also be useful to devise a methodology in which the emotional states could be presented concurrently with the CBT test to ensure the emotional states are properly evaluated by the CBT.

The present study did not find contagious yawning, with very few dogs ($N = 4$) yawning when presented with acted yawns from strangers. This is in contrast to Joly-Mascheroni et al. (2008); Joly-Mascheroni et al. (2008) and Romero et al. (2013); Romero et al. (2013), who found approximately 72% and ~30% of dogs yawning contagiously toward a stranger, respectively (see also Neilands et al.,

2020), for strong evidence that contagious yawning is present in dogs). Although we followed the same protocol as those studies, including the use of a stranger for the demonstration, it may be that the other parts of the study, prior to the contagious yawning, may have influenced the rates of contagious yawning. Alternatively, it could be that other procedural differences limited our success in triggering contagious yawning in our subject dogs. It is likely that we could have increased rates of contagious yawning if we had used the owner for the yawning stimulus instead of the experimenter given that some studies have found higher rates in owners (Madsen and Persson, 2012; Romero et al., 2013). Unfortunately, due to the limited number of dogs showing contagious yawning, we could not assess the proposed link with empathy or the other measures. We believe that having a familiar person yawn, such as the owner, would increase the rate of yawning in dogs. It could be interesting to compare rates of yawning in familiar and unfamiliar people to correlate more directly with the person-oriented behaviors to the owner and stranger during the emotional stimuli.

Comparing responses on the DROE portion of the survey (Szánthó et al., 2017), we found that there is validity in owner-reported empathy at least toward the owner. There was a moderate correlation between the owner-reported empathy of the dog toward the owner and the number of person-oriented behaviors that the dog showed to the owner during crying. This finding suggests that people recognize how their dogs typically respond to them when they are in distress. However, there was no correlation with person-oriented behaviors toward the stranger and the responses on the survey about how the dog responds to the owner, suggesting that this observation about the dog's empathy is limited to themselves. Our results represent a preliminary validation of the Dog Emotional Reactivity Survey. By comparing the survey to behavioral data, we can better understand which aspects of the survey are the most useful in studying dog empathy. Dogs' empathetic responses to other dogs (DRDB subsection) should be evaluated for validity by comparing behavior toward other dogs in future research.

Although the findings of the current study are of great interest, we must acknowledge its limitations. As in many previous studies, the emotions presented by strangers and owners were artificial, potentially altering how dogs would respond to more realistic emotions. There was much incomplete HRV data during the emotional presentations due to problems with heart rate monitors, as well as a short delay between emotional presentations and the CBT testing room, making it possible to have missed the effects the emotional presentations had on both physiological and behavioral responses. Lastly, during the yawning portion we had a stranger yawn which could explain our reduced contagious yawning, as some previous studies with more successful contagious yawning used familiar people.

The current study is one of the first to directly compare multiple empathy measures in dogs, including person-oriented behaviors, CBT, HRV, owner-reported empathy, and contagious yawning. Overall, our findings provide further evidence that dogs are capable of recognizing and distinguishing between different human emotional expressions, as well as responding to human distress with increased person-oriented behaviors. Our results also suggest that dogs may be more sensitive and responsive to negative rather than positive human emotions, possibly reflecting the greater salience of distress cues (Custance and Mayer, 2012; Quervel-Chaumette et al., 2016; Sanford et al., 2018; Meyers-

Manor and Botten, 2020). In contrast, CBT did not appear to effectively capture the short-term changes in affective state of dogs, but rather it may be better suited to assess longer-term affective states of animals or may require testing only concurrently with emotional stimuli. Integrating these complementary approaches and measures will be essential to develop a more comprehensive understanding of empathy in dogs and its implications for welfare and human-dog bonds.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: Open Science Framework <https://osf.io/qhkzg/overview>.

Ethics statement

The studies involving humans were approved by Ripon College Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. The animal studies were approved by Ripon College Institutional Animal Care and Use Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent was obtained from the owners for the participation of their animals in this.

Author contributions

KO: Conceptualization, Data curation, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. TR: Conceptualization, Investigation, Methodology, Validation, Writing – review & editing. JM-M: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Funding

The author(s) declared that financial support was not received for this work and/or its publication.

Acknowledgments

We would like to thank Calysta Kurz, Jacoby Cefalu, Paige Nickel and Jake Hargrave for their help in running all participants and in their contributions for the design of this experiment.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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