Timmy's in the well: Empathy and prosocial helping in dogs

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Published online: 23 July 2018
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Abstract

Dogs are thought to evaluate humans' emotional states, and attend more to crying people than to humming people. However, it is unclear whether dogs would go beyond focusing attention on humans in need by providing more substantive help to them. This study used a trapped-other paradigm, modified from use in research on rats, to study prosocial helping in dogs. A human trapped behind a door either cried or hummed, and the dog's behavioral and physiological responses (i.e., door opening and heart rate variability) were recorded. Then, dogs participated in an impossible task to evaluate gaze at the owner as a measure of the strength of their relationship with their owner. Dogs in the distress condition opened at the same frequency, but significantly more quickly, than dogs in the control condition. In the distress condition, the dogs that opened showed lower levels of stress and were able to suppress their own distress response, thus enabling them to open the door more quickly. In the control condition, opening was not related to the dog's stress level and may have instead been motivated by curiosity or a desire for social contact. Results from the impossible task suggest that openers in the distress condition may have a stronger bond with their owner than non-openers, while non-openers in the control condition showed a stronger bond than openers, which may further suggest that the trapped-other paradigm is reflective of empathy.

Keywords Empathy · Prosocial · Heart rate variability

Introduction

Group survival in social organisms is facilitated by prosocial behavior and empathy, traits that improve animals' ability to cooperate and coordinate behavior through perception of each other's emotional states (de Waal, 2008). Empathy is the emotional response that allows an individual to align their feelings with the feelings and experiences of another (Batson, 1998). According to the empathy-altruism hypothesis, empathy leads an individual to take actions to improve someone else's welfare (Batson, 1998).

The relationship between empathy and prosocial helping has been studied in a variety of species, including rats (e.g., Ben-Ami Bartal et al., 2011). Rats have been tested through

various iterations of a trapped-other paradigm, where a rat's reaction to the presence of a physically-restrained conspecific is observed. For instance, rats will press a lever to lower a hanging conspecific to the ground, reducing its distress (Rice & Gainer, 1962). A recent experiment by Ben-Ami Bartal et al. (2011) found that rats would open a plastic restrainer containing their cage-mate rat more frequently than one containing a stuffed rat, and at the same frequency as a chocolate-containing restrainer. However, whether the door opening behavior was motivated by empathy (Ben-Ami Bartal et al., 2011) or rather by a desire for social contact (Silberberg et al., 2014), remains unclear. To better test whether this opening behavior is motivated by empathy, one could manipulate the trapped individual's emotional state, as an empathetically-motivated helper rat would only open the door if the trapped individual were distressed; in the absence of distress, door opening would be better explained by a desire for social contact than empathy. Since this manipulation cannot be made easily in rats, a possible solution is to have humans play the role of the trapped individual because humans can artificially adopt varied emotional states. Then, this paradigm could test for a species' capacity for empathetic responses towards humans.

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An ideal candidate for this cross-species study is the domestic dog. Whether as therapy dogs, emotional support dogs, or in animal-assisted therapy settings, dogs provide emotional comfort to humans in a variety of ways (Fairman & Huebner, 2001; Kaminski, Pellino, & Wish, 2002). Therapy dogs are thought to be highly social and human-oriented, although such traits are not required to receive certification (Fredrickson-MacNamara & Butler, 2010). Even owners of non-therapy dogs believe that their pets perceive and care about their emotional states (Vitulli, 2006). Dogs' reputation for emotional sensitivity could be due to their unique ability to respond to human social cues, which may have developed through inter-species contact over the course of domestication (Hare, Brown, Williamson, & Tomasello, 2002). Additionally, it is likely that ontogenesis also plays a role in the development of empathy in canine behavior. According to the two-stage hypothesis (Udell, Dorey, & Wynne, 2010; Wynne, Udell, & Lord, 2008), dogs develop their emotional sensibilities during the course of ontogenesis through proper social contact, which allows them to learn human social signals (D'Aniello et al., 2017). Due to this evolutionary and ontogenetic relationship, dogs show a remarkable ability to distinguish (e.g., Deputte & Doll, 2011; Morisaki, Takaoka, & Fujita, 2009; Nagasawa, Murai, Mogi, & Kikusui, 2011) and interpret (Merola, Prato-Previde, Lazzaroni, & Marshall-Pescini, 2014) a variety of human emotional states.

In particular, dogs are highly responsive to human crying. For example, both humans and dogs showed behavioral signs of distress and higher stress hormone levels when listening to the sound of babies crying compared to the sounds of babies babbling or white noise (Yong & Ruffman, 2014), and towards crying and whining of both humans and dogs compared to non-emotional sounds (Huber, Barber, Faragó, Müller, & Huber, 2017). One study tested dogs' ability to discriminate and respond to human emotional states by placing individual dogs in a room in their own home with their owner and a stranger (Custance & Mayer, 2012). Each person hummed and cried at separate times, and the dog's approach behaviors toward each person were recorded to investigate response variability as a function of emotion and familiarity. As expected, dogs approached the humans more often if they were crying than if they were humming, supporting the claim that they empathetically respond to human distress. Dogs consistently approached the person who was crying, even if it was the stranger, which suggests that their approaches were motivated by empathy rather than a desire to reduce their personal distress (Custance & Mayer, 2012).

Although dogs' capacity for empathetic emotional responses toward humans is well documented, there is mixed evidence as to whether a dog would go the next step to intentionally act on behalf of a human. Bräuer, Schönefeld, and Call (2013) found that dogs would press a button to open a door for a human. Importantly, the likelihood that dogs

opened the door increased as the human's communication style became more direct, with explicit pointing or reaching behaviors, which appears to indicate that dogs were sensitive to how clearly the human communicated their goal (Bräuer et al., 2013). This demonstrates that dogs can understand that humans have desires when they are communicated, and will provide limited help to assist people in achieving their explicit goals.

Next, there is a question as to whether dogs would assist a human when the need for help is not directly communicated to the dog. In one study, a person simulated a heart attack in the presence of a dog and a passive bystander (Macpherson & Roberts, 2006). Dogs did not seek bystander assistance, but instead wandered around or stayed close to the collapsed owner (Macpherson & Roberts, 2006). However, the dogs also did not appear to understand the nature of the situation, and thus were unlikely to have interpreted it as an emergency (Macpherson & Roberts, 2006). This is especially possible if dogs use external emotional cues to assist in the evaluation of appropriate situational affect, interpreting the passive bystander's lack of distress as people would: as an indicator of a non-emergency situation (Latané & Darley, 1968). Not only did dogs have to evaluate the situation as an emergency despite the bystander's calm affect, but they also had to attempt to solicit assistance from someone who appeared to show no interest in the situation. This methodology likely reduced the help-giving that may otherwise have been seen.

Dogs have been shown to provide help to a fellow dog in a situation where they would not do so for a human (Quervel-Chaumette et al., 2016). Dogs learned to pull a lever to receive a treat, then were given the chance to pull the lever to deliver the treat to an adjacent compartment containing either a fellow dog or a human; they did so only for their conspecific. Humans were not allowed to communicate with the dogs in any way, which may have contributed to the decrease in help for the human compared to the conspecific as this restriction obviously could not have been placed on the dogs. Due to the ambiguity of such results, research using a different help-giving paradigm would be useful to clarify the extent of dogs' help-giving capacities.

To help disentangle empathy from other emotional responses in these paradigms, physiological measurements of distress and arousal could complement behavioral observations. One example is heart rate variability (HRV), a measure of the beat-to-beat fluctuations in heart rate. The distribution of brain regions responsible for physiological changes, such as HRV, in response to emotional and situational cues is known as the central autonomic network and is thought to be primarily responsible for an individual's capacity for emotional regulation (Appelhans & Luecken, 2006; Koval et al., 2013). Emotional regulation is relevant to the study of empathy because empathy can only occur when one is able to regulate their response to an emotionally-salient event. A lack of

empathetic emotional response occurs when an individual reacts to another's distress by feeling personal distress for themselves rather than empathy for the other (Batson & Oleson, 1991). Experiencing distress in response to another's stressful experience is necessary for empathy, but overwhelming distress usually leads to egoism rather than altruism (Eisenberg & Fabes, 1990). This has been demonstrated in children, where strong reactions to distressing situations coupled with a high capacity for emotional regulation leads to more empathetic responses than distress alone (Eisenberg et al., 1996; Eisenberg & Fabes, 1990). To be useful in evaluating empathy, HRV must be a valid emotional marker in dogs. Behavioral observations corroborate that a decrease in HRV is associated with stress in dogs. Dogs show low HRV and increases in appeasement gestures indicative of discomfort during petting by a stranger (Kuhne et al., 2014), and when their owner leaves the room (Katayama et al., 2016). This study sought to further the investigation of dogs' empathetic and prosocial capacities. In particular, we tested the lengths to which dogs will go to help a crying human by placing a moveable barrier between them and their distressed owner. In doing so, we adapted the trapped-other paradigm that had previously only been used in rats (Ben-Ami Bartal et al., 2011). This experiment investigated whether canine empathy can serve as a motivator for helping behaviors. It also tested the validity of a trapped-other paradigm as a measurement of empathy in animals by directly manipulating the emotional state of the trapped human. Humans were instructed to adopt either a distressed (crying) or control (humming) affect; if the opening behavior were solely empathetically motivated, it would only occur if the person trapped behind the door were displaying distress. Additionally, since HRV is related to emotional regulation and stress responses, we measured dogs' HRV to enhance our understanding of how personal distress and emotional suppression contribute to the empathetic response in dogs. Further, because reports in popular press anecdotes often suggest that therapy dogs are a group that might be uniquely empathetic (e.g., Fiegl, 2012), we tested the validity of reports that therapy dogs are more empathetic than non-therapy dogs. The number of dogs who opened, the speed with which they opened, their stress behaviors, and their HRV during the task were recorded.

Following the prosocial helping trial, each dog was also tested using the impossible task paradigm, wherein dogs were given a treat in a container that could not be opened (Ádám Miklósi et al., 2003). Dogs in several different tasks spend more time staring at their owners than at strangers (e.g., Marshall-Pescini, Valsecchi, Petak, Accorsi, & Previde, 2008; Ádám Miklósi et al., 2005; Mongillo, Bono, Regolin, & Marinelli, 2010; Topál, Miklósi, & Csányi, 1997; but see D'Aniello & Scandurra, 2016). Interestingly, a dog's gaze toward a given human appears to be related to the strength of their relationship with that person (Topál et al., 1997; Horn

et al., 2013). In the impossible puzzle task, dogs with extensive cooperative training with their owner stared first at their trainers (D'Aniello et al., 2015) and, in the case of agility dogs, longer at their trainers than a stranger compared to untrained dogs or dogs that were trained for more independent work (Marshall-Pescini, Passalacqua, Barnard, Valsecchi, & Prato-Previde, 2009). Because empathetic responses are more likely to be shown towards familiar individuals with whom one is more strongly bonded (Cialdini et al., 1997), the impossible puzzle task could be used to evaluate the degree to which the strength of a dog's bond with their owner influences their empathetic response to that owner. We anticipated that there would be a negative correlation between opening latency and owner gaze duration in this task.

Method

Subjects

The subjects were 39 (24 male, 15 female; 33 spayed or neutered) household dogs living in the Twin Cities area in Minnesota that were volunteered by their owners. Two dogs (non-therapy dogs) were excluded from analyses because they showed signs of aggression during baseline monitoring, and were thus considered too dangerous to be included further in the experiment. One dog was excluded because it was deaf (therapy dog), and thus was not subjected to the auditory component of the experimental manipulation. One dog in the distress condition was excluded because the owner chose to end the trial before the five-minute trial length had been completed due to the dog's distress (therapy dog). Finally, one dog in the control condition was excluded because its owner did not follow instructions and encouraged the dog to open the door, which led to opening (non-therapy dog). This left 34 dogs (21 male, 13 female; 29 spayed or neutered). The dogs were adults ($M = 6.71$ years old, $SD = 2.62$), ranging from 1.5 to 12 years old. By weight, they ranged from 8 to 160 lbs ($M = 45.57$ lbs, $SD = 29.84$). There were a variety of breeds, although the most common types of dog were mixed breeds ($n = 13$) followed by golden retrievers ($n = 3$; see Table 1 for all breeds by condition). Nearly half of the dogs ($n = 16$) were nationally-certified therapy dogs ($n = 6$ Therapy Dog International; $n = 9$ Pet Partners, $n = 1$ certification type not reported), while the other dogs ($n = 18$) were non-therapy pet dogs. There were no differences between conditions (distress or control) with regard to age or weight, all t s < 1.2 , all p s > 0.24 , or sex, $\chi^2(1, N = 34) = 0.13, p = 0.72$. There were also 34 human participants (32 female, 2 male), the owners that accompanied the dogs during the experiment. The human participants ranged from 19 to 75 years old, with a mean age of 49.56 years old ($SD = 12.23$). Subjects were recruited by word of mouth or from an ad in a daily college-wide email

Table 1 Breeds by condition

Breed	Distress condition	Control condition
American Eskimo	0	1
Australian Shepherd	0	2
Brittany Spaniel	0	1
Cavalier King Charles Spaniel	0	1
Cocker Spaniel	1	0
Collie	1	0
Corgi	2	0
Golden Retriever	2	1
Labrador Retriever	2	0
Large Mixed Breed	5	3
Papillon	0	1
Pug	1	0
Shar-pei	0	1
Shetland Sheepdog	1	0
Shih Tzu	0	1
Siberian Husky	0	1
Small Mixed Breed	1	2
West Highland Terrier	1	0
Whippet	0	1
Wirehaired Pointing Griffon	1	0
Total	18	16

newsletter. All methods were approved by both the Institutional Animal Care and Use Committee and the Institutional Review Board at Macalester College.

Apparatus and materials

A behavioral and demographic survey was used to obtain information about the owner's age, gender, and dog-owning history, and the dog's age, sex, breed, health history, and training. They also completed the C-BARQ behavioral questionnaire to measure general behavioral history of aggression and anxiety (Hsu & Serpell, 2003).

A Polar H7 Heart Rate Monitor was used to record the dog's HRV (Polar Electro, Kempele, Finland). The data from the monitor were transmitted via Bluetooth to an iPhone app (Heart Rate Variability Logger, Marco Altini). The HRV data were analyzed using ARTiFACT software (Kaufmann et al., 2011).

The testing arena was a rectangular room with a small square room adjacent to the main chamber (see Fig. 1). There was a chair in the square room and a small door separating the small room from the main one. The door (96.5 cm wide $\times$ 122 cm tall $\times$ 2.54 cm thick) was made of gray-painted wood with a sheet of clear Plexiglas (55.9 cm $\times$ 106.7 cm) spanning the interior of the door to make a window. This door was attached to the door frame by three magnets positioned

Fig. 1 Schematic representation of the testing arena for the prosocial helping task

vertically along the hinged side of the door. The other side of the door was loosely connected to the other side of the door frame with three weak magnets positioned vertically, such that contact by a dog's nose or paw allowed the door to easily swing open into the small room. Pilot trials of dogs not taking part in the study indicated that dogs of varying sizes could easily open the door.

The impossible task was performed in a small room that was across the hall from the prosocial task testing space. The apparatus was a piece of wood (60.96 cm $\times$ 53.3 cm $\times$ 0.6 cm) covered in white fleece to prevent splinter injuries. The wood had Velcro on the edges of its bottom side that allowed it to be securely attached to the carpeted floor of the room. At the center of the wood plank on the top side, the lid of a glass jar was glued upside-down, such that the jar could be screwed upside-down into its lid and be rendered immovable. This allowed food to be placed onto the lid with the jar screwed over it, such that it was visible but unreachable.

Prosocial helping task

Owners were instructed to restrict their dog's access to food for four hours prior to testing to ensure consistency and motivation in the impossible task (D'Aniello et al., 2015). Dogs and owners were taken to a small classroom where a heart rate monitor was placed on the dog. Veterinary lubricant was applied to the monitor to enable conductivity before it was placed just left of center on the dog's chest, and was held by a band that was wrapped snugly around the dog's rib cage to hold it in place. The connection between the monitor and the app was established, and a 10-min period of baseline heart rate data were collected while the owner completed the behavioral survey in the same room. Once the baseline heart rate data had been recorded, the owner went with one of the experimenters into the testing arena and was instructed on their role in the prosocial helping task while a second experimenter calmly

held the dog's leash. After approximately 2 min of instructions to the owner, the prosocial task began.

The procedure is a modified protocol of trapped-other rat experiments (Ben-Ami Bartal et al., 2011). The dog's owner was seated in the chair in the small square room, and the small door was closed such that they were separated from the main chamber by the door. Dogs were assigned to either the distress or control condition, and only participated in that one condition. This assignment was done by categorizing each dog into one of four groups based on size (small or large to ensure that group differences were not based on physical ability to open the door) and whether the dog was a therapy dog or not. In each of these categories, condition assignment alternated, such that within each of the four groups there were an approximately equal number of dogs assigned to each condition. Each owner received instructions on what vocalizations to make based on their condition assignment. In the control condition, the owner said "Help" in a control tone every 15 s, and hummed "Twinkle Twinkle Little Star" between each vocalization. In the distress condition, the owner said "Help" in a distressed tone at 15-s intervals at approximately the same volume as in the control condition, and made crying sounds between each vocalization. In both conditions, the owner hid their hands from their dogs by placing them under their legs to prevent unintended communication with hand gestures, and maintained their gaze slightly above the dog's eye level to decrease variation in the amount of eye contact between conditions.

To begin the trial, the dog was brought into the room and positioned at the opposite end of the room from their owner and facing toward their owner. The experimenter released the dog's leash and left the room, at which point the trial started. The trial ended if the dog touched the door and detached its magnets from the door frame, thus opening the door. In trials where the dog did not open the door, the experiment was terminated after 5 min. Each dog was allowed to reunite with their owner for a short period of time following the prosocial helping trial, regardless of whether they opened the door. Each trial was video recorded, and the videos were used to calculate opening rate and coded for distress behaviors.

Impossible task

Following the prosocial helping task, the dog's owner left the room with an experimenter and proceeded to the next stage of the experiment while another experimenter stayed with the dog. In the impossible task (Marshall-Pescini et al., 2008), the dog's owner and a stranger each stood on one side behind the testing apparatus, which was positioned in the middle of the room on the floor. The side of the apparatus (left or right) that the owner stood on was counterbalanced across subjects. The owner and stranger both stared diagonally across the room and remained still throughout the experiment. Once

the room was set up, the dog was brought in and held in the back of the room by an experimenter, approximately 0.5 m away from the testing apparatus, such that the dog could see the apparatus and the two people standing behind it.

The main experimenter started by giving the dog a treat to show them that there was an opportunity for food. Then, a treat was placed on the lid at the center of the wood plank, and the dog was released to go get the food. After it had eaten the treat, the dog was retrieved and brought back to its starting position. For the next three treats, the food was placed onto the lid of the jar, and the jar was placed gently on top of the lid such that it could be easily tipped over to retrieve the food underneath. The dog was released to retrieve each piece of food, and if it did not knock over the jar rapidly, the experimenter encouraged the dog to move the jar in order to retrieve the food. Most dogs required at least one trial of encouragement. No dog was allowed to progress to the final trial until it had moved the jar to get to the food underneath three times; this ensured that dogs had started to acquire a jar-moving behavior in order to receive a food reward. In the final trial, the food was placed on the lid and the jar was screwed into place over it. The set-up looked identical to the previous trials but this time the jar could not be moved even if the dog applied force to it. Once the jar was put in place, the dog was released and the two experimenters exited the room, such that the dog was alone in the room with their owner and the stranger. The trial lasted 60 s, during which time videos were recorded for later analyses of gaze direction. After the trial period had passed, the experimenters re-entered the room and removed the jar so that the dog could eat the treat underneath. The heart rate monitor was then removed from the dog, and the owner was debriefed about the purpose of the experiment.

Behavioral ethogram

Dogs were videotaped for the duration of the baseline heart rate recording, and the prosocial helping and impossible task rooms were each videotaped from two different angles. In the prosocial helping room, one angle captured the dog's face when they were facing the door and looking at their owner, and the other captured their movement through the experimental room. The video cameras could not be set up to capture the entire experimental arena, so the amount of time that the dog was visible in the video was also recorded for each trial. Because evaluation of vocalizations required auditory cues from the video, the video coder for the prosocial task was not able to be blind to condition (since the owner's vocalizations were also audible on the video) nor opening (since the length of the video indicated whether the dog opened or not, as all dogs that did not open had 300-s videos while openers had shorter videos). Experimenters blind to the condition and opening status completed the ethogram for the baseline stress and impossible task behavioral coding. In the impossible task,

one camera faced the owner and stranger from the front, and the other was set up to record a side view of the experimental room. Videos of the impossible task were coded to compare gazes toward the owner and stranger as well as task-oriented behaviors such as digging at or attempting to move the jar to get to the food underneath.

Behavioral coding was used to quantify dogs' distress during the baseline and experimental portions of the study. An ethogram was used to code videos for behavioral measures of stress during baseline and testing. Eight variables were recorded: vocalizing (barking or whining that was audible on the video, duration), panting (duration), sniffing the floor (duration), urogenital checkout (sniffing or licking, count), shaking off (count), yawning (count), scratching oneself (count), and flicking the tongue (count) which are all considered typical stress behaviors in dogs (as reviewed by Mariti et al., 2012). The individual totals of stress behaviors (count and duration) were summed to yield a total stress score for each dog. Approximately 25% of videos for behavioral coding for stress and the impossible task were re-coded by a blind coder. In cases, where major discrepancies appeared, coders sat down to reexamine the video to determine where the discrepancies were and came to a joint conclusion. Inter-rater correlations for total stress behaviors during baseline, $r(9) = 0.88$, $p = 0.002$, prosocial task, $r(10) = 0.98$, $p < 0.001$, for the percentage of gaze at the owner $r(10) = 0.92$, $p < 0.001$, were all very high.

Data processing

The C-Barq survey reports averages of scores on several questions to form categories (e.g., owner-directed aggression, stranger-directed fear, etc.). We created a further category for general anxiety. We summed the subcategories of fear of dogs, fear of strangers, non-social fear, touch sensitivity, and separation-related problems under this anxiety measure.

In order to ensure that trial length and differences in visibility in the videos did not confound the behavioral distress measure, stress scores from the ethograms were divided by the total amount of time, in seconds, that the dog was visible in the video to yield a score of stress per second for each dog. The baseline behavioral recording period was 10 min for every dog except for four, for which the videos were truncated due to equipment failure or experimenter error, whereas the testing behavioral recording period was equivalent to the length of the trial (either the latency to opening, or 300 s for dogs that did not open). One dog was excluded from analyses on baseline stress behaviors because their video did not save, and thus stress behaviors could not be analyzed. Videos of the impossible task were coded for the amount of time that the dog spent gazing either at the owner or stranger, or performing task-oriented behaviors. The percentage of gaze directed at the

owner was calculated by dividing the amount of time spent gazing at the owner over the total amount of time the dog spent gazing at either the owner or the stranger.

There were four dogs that were excluded from heart rate analyses because a reliable connection was not able to be established during baseline, or because the reading dropped during the prosocial helping task. Analyses on HRV were performed on a total of 30 dogs (14 in the distress condition, 16 in the control condition). All heart rate data were analyzed using Artifact (Kaufmann et al., 2011). For the baseline sampling, only the most consistent five-minute section of the file was used in analyses. If the entire file was consistent, 180–480 s were used. For the trial phase, the entire file was used unless there was enough inconsistency in a section to deem it unusable, in which case as much of the file as possible was selected. All inter-beat interval data points above 2,000 ms were classified as artefacts and were removed from the sample through cubic spline interpolation prior to analyses using ARTiiFACT software (Craig, Meyers-Manor, Anders, Sütterlin, & Miller, 2017). The VLF band was set at 0.06 Hz, the LF band was set at 0.24 Hz, and the HF band was set at 1.06 Hz, which have been found to be typical for canine heart rate measures (Houle & Billman, 1999). Although the software produces a variety of other HRV measures, including mean HR, SDNN, RMSDD, NN50, VLF, LF, HF, and LF/HF ratio, pNN50 was used to quantify HRV in analyses because it is less sensitive to sample length than the other measures and has been used as a good measure of HRV in dogs (Craig et al., 2017). pNN50 is a measure of the percentage of successive RR intervals that differ from each other by more than 50 ms, and thus a high pNN50 corresponds to high HRV.

Results

For the 34 dogs that completed testing, whether the dog opened and the latency to opening were recorded. If the dog did not open, latency was counted as the length of the trial (300 s). There was no difference between therapy dogs (9 opened, $n = 16$; average latency = 165.19 ± 140.33 s) and non-therapy dogs (7 opened, $n = 18$; average latency = 210.22 ± 119.93 s) in opening frequency, $\chi^2(1, N = 34) = 1.025$, $p = .311$, or latency to opening, with Levene's test for homogeneity of variances significant, $F = 4.99$, $p = .033$, equal variances were not assumed, $t(29.74) = 1.00$, $p = .326$. Because of the lack of significant variation in the pro-social task between the therapy and non-therapy dogs, all subsequent analyses were collapsed across dogs. The age of the dog was examined as a factor in prosocial helping latency, HRV, and owner gaze, but was not predictive so age was not further considered (all $r^2 < 0.10$, $p > 0.05$).

Prosocial helping

Overall, helping occurred in about half of the trials (16 opened, $N = 34$). For dogs that opened, latency to opening ranged from 4 to 298 s ($M = 64.19$, $SD = 75.75$ s). There was no significant difference in opening frequency between the control condition (nine opened, $n = 17$) and distressed condition (seven opened, $n = 17$), $\chi^2(1, N = 34) = 0.472$, $p = 0.492$ (see Fig. 2).

A t -test was used to compare latency to opening between conditions, which did not differ between dogs in the distress condition ($M = 186.12$ s, $SD = 140.73$ s) and dogs in the control condition ($M = 191.94$ s, $SD = 122.46$ s), $t(32) = -0.129$, $p = 0.89$. However, when only dogs that opened were considered to remove the ceiling effects of all non-openers having equivalent latency, there was a significant difference in latency to opening between dogs in the distressed ($M = 23.43$ s, $SD = 17.77$ s) and control conditions ($M = 95.89$ s, $SD = 89.09$ s). Levene's test for homogeneity of variance was significant, $F = 4.84$, $p = .044$, so equal variances were not assumed, $t(8.81) = -2.380$, $p = 0.042$ (see Fig. 3). This result suggests that the speed of dogs' helping behaviors may be dependent on humans' emotional states.

Measures of dogs' emotional states

We used a factorial 2×2 ANOVA to measure whether there were differences in dogs' owner-reported total anxiety between the distressed and control conditions based on opening status. There was a significant interaction between distress condition and opening status on total anxiety, $F(1, 28) = 5.74$, $p = 0.024$. Dogs in the distress condition that did not open ($M = 4.05$, $SD = 2.25$) were higher in owner reported anxiety than dogs that did open ($M = 1.93$, $SD = 1.45$), while dogs in the control condition had more similar owner reported anxiety whether they opened ($M = 2.53$, $SD = 1.31$) or not ($M = 1.73$, $SD = 1.47$). No other main effects or interactions were significant for either anxiety, all F s < 2.0 , p s > 0.10 .

Fig. 2 Percentage of dogs that opened by condition. There was no significant difference in frequency of opening between the distressed and control conditions

Fig. 3 Latency to opening among dogs that opened the door by condition. Dogs opened significantly more quickly in the distress condition than in the control condition. Error bars represent standard error

A three-way mixed factorial ANOVA was used to compare video-coded stress behaviors per second across conditions (control vs. distress), time periods (baseline vs. prosocial task), and whether the dog opened the door. There was a significant interaction between time period and opening, $F(1, 30) = 8.69$, $p = 0.006$. Dogs that opened showed a decrease in stress from baseline ($M = 0.40$, $SD = 0.32$ behaviors/s) to the prosocial task ($M = 0.31$, $SD = 0.26$ behaviors/s), while dogs that did not open were significantly more stressed during the prosocial task ($M = 0.60$, $SD = 0.30$ behaviors/s) than they were during baseline ($M = 0.39$, $SD = 0.32$ behaviors/s; see Fig. 4). All other main effects and interactions were not significant, all F s < 2.5 , p s > 0.10 .

Finally, a three-way ANOVA was used to compare pNN50 variation by condition (control vs. distressed), time period (baseline vs. prosocial task), and whether the dog opened the door. The average pNN50 across both trial phases, during baseline recording and testing, was relatively low ($M = 36.75$, $SD = 18.90\%$) for pet dogs compared to in-home baselines measured in other studies ($Mdn = 79.49$, $IQR = 33.54$;

Fig. 4 Stress behaviors per second by opening and time period. Dogs that opened did not show significantly different stress scores between baseline and the prosocial task, but dogs that did not open were significantly more stressed during the prosocial task than they were during baseline. Error bars represent standard error

Craig et al., 2017). There was a significant difference in pNN50 from the baseline phase to prosocial task phase, $F(1, 26) = 5.68$, $p = .025$, where there was lower HRV (less variability) during the prosocial task ($M = 31.43$, $SD = 17.21\%$) than during baseline ($M = 40.37$, $SD = 18.17\%$). If HRV is a valid measure of stress, this would indicate that dogs were more stressed during the prosocial helping task than they were during the baseline period. This is supported by changes in stress behaviors as well, at least in non-openers. In contrast with the pattern of results found with analyses of stress behaviors, no other comparisons showed significant variation, all F s < 1.5 , p s > 0.10 .

Comparing the correlations between different behavioral and physiological measures of the dogs' state of distress and their opening, we see distinct patterns in dogs based on the distress condition (see all correlation coefficients and p -values in Table 2). As seen in Table 2, dogs in the distress condition show a marginally positive correlation between owner-reported anxiety ($p = .07$) and latency to open and a significant positive correlation between their prosocial stress behaviors and their latency to opening the door. These dogs in the distress condition also show a positive correlation between owner-reported anxiety and prosocial stress behaviors. Finally, distress condition dogs show a negative correlation between their prosocial stress behaviors and their prosocial pNN50 HRV, where an increase in behavioral stress is associated with lowered HRV. These patterns are not present in the control condition (see Table 2, lower half). Dogs in the control condition show positive correlations between baseline and prosocial stress behaviors as well as between baseline and prosocial pNN50 values, suggesting that they have similar stress and HRV between the baseline and prosocial task.

Additionally, they show a negative correlation between baseline HRV and baseline stress behaviors.

Impossible task

On average, dogs spent more time ($M = 2.93$ s, $SD = 3.69$ s) gazing at the owner than at the stranger ($M = 1.31$ s, $SD = 1.13$ s), but even more time ($M = 20.44$ s, $SD = 11.40$ s) engaged in task-oriented behaviors. This corresponds to an average of about two-thirds of total person-oriented gaze directed at the owner ($M = 61.02$, $SD = 32.96\%$) and one-third at the stranger ($M = 36.71$, $SD = 32.99\%$), $t(33) = 2.16$, $p = 0.04$. We ran a two-way ANOVA looking at percent of time gazing at owner between distressed and control conditions by opening status. There was no difference in percentage of gaze toward the owner between the control and distress conditions, $F(1, 30) = 0.122$, $p > .05$. There was also no difference in gaze toward the owner based on opening, $F(1, 30) = 0.831$, $p > .05$. There was, however, a significant interaction between condition and opening, $F(1, 29) = 4.61$, $p = .04$. For dogs in the distressed condition, openers ($M = 81.89\%$, $SD = 18.71$) spent more time gazing at their owners than non-openers ($M = 49.39\%$, $SD = 27.68$). In contrast, the control condition had the reverse pattern with non-openers ($M = 67.96\%$, $SD = 37.55$) gazing at their owners more than openers ($M = 52.32\%$, $SD = 38.56$; see Fig. 5).

Considering all dogs, the amount of time that a dog spent gazing at their owner during the impossible task was not significantly correlated with their latency to opening the door during the prosocial task, $r(33) = -0.26$, $p = 0.14$. When only dogs that opened the door were included, there was a significant negative correlation between latency to opening and

Table 2 Summary of intercorrelations, means, and standard deviations of dog's distress measures and latency to open

	M	SD	1	2	3	4	5
Distress							
1. Latency to Open (s)	186.12	140.73					
2. Owner Reported Anxiety	3.2	2.2	0.48†				
3. Baseline Stress Behaviors	0.35	0.24	0.29	0.44			
4. Prosocial Stress Behaviors	0.50	0.32	0.72***	0.53*	0.31		
5. Baseline pNN50	40.22	19.84	-0.31	0.07	-0.36	-0.37	
6. Prosocial pNN50	31.94	18.71	-0.06	-0.32	-0.24	-0.56*	0.14
Control							
1. Latency to Open (s)	191.94	122.46					
2. Owner Reported Anxiety	2.15	1.41	-0.39				
3. Baseline Stress Behaviors	0.44	0.37	-0.08	-0.03			
4. Prosocial Stress Behaviors	0.42	0.32	0.16	-0.02	0.68**		
5. Baseline pNN50	43.02	20.39	0.15	0.07	-0.50*	-0.25	
6. Prosocial pNN50	30.98	16.39	0.43	-0.1	-0.08	0.11	.67**

† $p < 0.10$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Fig. 5 Percentage of time spent gazing at owner during impossible task by condition and opening status in prosocial task. Dogs that opened in the distressed condition gazed at their owner more than dogs that did not open, whereas dogs in the control condition did not differ in owner-directed gaze whether they opened or not. Error bars represent standard error

gaze at the owner, where dogs that opened more quickly gazed at their owner longer during the impossible task than dogs that opened more slowly, $r(16) = -0.50$, $p = 0.047$.

Discussion

The present experiment found evidence that dogs will provide prosocial help towards humans: almost half of the dogs opened the door. Door opening seems to be a prosocial behavior that dogs will consistently perform (e.g., Bräuer et al., 2013). Analyses beyond opening frequency yield more interesting implications about dogs' empathetic and prosocial behaviors. The speed with which dogs opened indicates that they were sensitive to their owners' emotional states. That dogs were faster to open the door in the distress condition than in the control condition indicates that human distress commanded the dog's attention and perhaps even conferred urgency to the dog's actions, leading them to open more quickly if they opened at all. This study furthered the investigation of empathy as a motivator of prosocial helping in dogs because it added a specific action that needed to be undertaken to provide assistance, as has been done in similar trapped-other paradigms (e.g., Ben-Ami Bartal et al., 2011). Interestingly, therapy dogs were not more likely to open the door for their owner in either condition nor were they faster at opening the door compared to non-therapy dogs. It may be that registered therapy dogs do not in fact possess traits that make them more attentive or responsive to human emotional states given that the therapy dog certification tests involve skills based more on obedience than on human-animal bonding (Fredrickson-MacNamara & Butler, 2010). It might be beneficial for therapy organizations to consider more traits important for therapeutic improvement, such as empathy, in

their testing protocols (Fredrickson-MacNamara & Butler, 2010). It would also be interesting to determine whether service dogs show a different pattern of results given their extensive training in attentiveness to their human companions.

The behavioral measures of dog emotional states also raise the possibility that opening in the prosocial helping task was differentially motivated depending on condition. In the distress condition, dogs that opened were lower stress than dogs that did not open. This is seen in the correlations between latency to open and owner reported anxiety, baseline stress, and prosocial task stress. This pattern may be evidence of a similar emotional regulation mechanism affecting canine helping behaviors as has been seen in children, where help can only be provided by individuals who can sufficiently suppress their own experience of personal distress (Eisenberg et al., 1996; Fabes et al., 1993). Based on this result, it appears that adopting another's emotional state through emotional contagion alone is not sufficient to motivate an empathetic helping response; otherwise, the most stressed dogs could have also opened the door. One must both adopt that emotional state then suppress their own distress, as openers in the distress condition in contrast to non-openers seem to have done, before they are capable of providing help. Consistent with previous research, it appears that a deficit in emotional regulation may have prevented the non-openers from acting empathetically (Eisenberg et al., 1996).

In the control condition, a dog's stress response did not appear to account for their opening behaviors. Dogs were not more stressed during the prosocial task than they were during baseline, and there was no difference in stress level or owner reported anxiety between openers and non-openers. This seems to indicate that a different motivation may have led to the openings in the control condition. One possible alternative is that there were two types of openers in the control condition. High stress openers may have opened because they were stressed due to the novelty of the situation or separation anxiety; they may have been motivated to open the door to get closer to their owner, regardless of their human's emotional state. For a stressed dog, a calm, familiar human could serve as an external source of comfort and emotional regulation (Kuhne et al., 2014). This may explain the marginally significant negative correlation between owner reported anxiety and opening latency. Low stress openers may have opened due to curiosity or a desire to interact with their owner that was not driven by an evaluation of their owner's distress, and these calmer dogs opened more slowly and with less urgency (Silberberg et al., 2014). For both the curious and anxious dogs, egoism rather than empathy is the likely driver of opening in this condition.

There may be an optimal amount of vicarious emotional response that allows for empathetic helping. This follows from longstanding research on the magnitude of a stress response for optimal performance, the Yerkes-Dodson law,

which states that performance is best at a moderate level of emotional arousal and decreases with an increase or decrease from this level of stress (Yerkes & Dodson, 1908). This law may apply to an individual's empathetic help-giving capacity. To a point, increases in distress lead to increases in empathetic responding, such as when humans are more likely to provide help (especially to familiar people) when a situation is perceived as more serious (Cialdini et al., 1997). On the other hand, individuals with prohibitively high emotional responses to another's distress are more likely to egoistically seek a reduction of their own distress than to provide help (Eisenberg & Fabes, 1990; Fabes et al., 1993).

Because closeness of relationships has been important in other measures of empathy (Cialdini et al., 1997), we looked at gaze percentage to the owner as a measure of closeness (Horn et al., 2013) using the impossible task. The difference in gaze to the owner during the impossible task also appears to support the idea that opening in the distress condition may have been motivated by empathy, but not in the control condition. Gaze to owners has typically been higher to the owner than to a stranger in the impossible task (Miklósi et al., 2005; Mongillo et al., 2010; Marshall-Pescini et al., 2008; but see D'Aniello et al., 2015 for contradictory evidence). Empathy is typically strongest for individuals with whom one is most familiar (Cialdini et al., 1997), and it would be expected that dogs that are more strongly bonded to their humans would be better at discerning their emotional state. This would then lead to a heightened likelihood of empathetic behaviors towards them. Among dogs that opened, dogs in the distress condition for the prosocial task gazed significantly more at their owner during the impossible task than dogs in the control condition. This supports the idea that dogs in the distress condition may have opened because they were more closely bonded with their owner, and therefore more likely to be attentive to their owner's emotional state. This did not appear to be the case with openers in the control condition, where non-openers gazed at their owners more than openers. This suggests that in the control condition opening was not controlled by a dog's relationship with their owner. Alternatively, because the impossible task always followed the prosocial task to prevent any effects of learned helplessness (Maier & Seligman, 1976) on the prosocial task, it is possible that the success or failure on the prosocial task was the mediating factor in gaze at the owner during the impossible task. However, the reverse patterns seen in the distressed and control conditions suggest that this cannot be the entire story.

The interpretation of HRV as it relates to emotional regulation and empathy in this study is less clear-cut. Baseline HRV was related to baseline stress measurements for dogs in the control condition. As expected, dogs with higher HRV showed fewer stress behaviors (Katayama et al., 2016). The lack of relationship between baseline and prosocial task HRV in the distress condition highlights the importance of an

individual's trait vs. state emotional regulation capacity. Dogs in the control condition showed more evidence of trait mediated HRV while distress condition dogs showed evidence of state mediated HRV based on the lack of correlation in their HRV baseline to task. This suggests some individuals likely show better regulation capacity in stressful situations allowing them to more readily express empathy (Fabes et al., 1993).

The latency to opening was not predicted by HRV. This is surprising, as previous research on the relationship between empathy and HRV in humans found that children with higher HRV were more likely to show empathetic behaviors because they have better emotional regulation (Fabes et al., 1993). One would expect that dogs that behaved empathetically would have shown higher baseline HRV, as this would serve as a proxy measurement for trait emotional regulation capacity, but this result was not obtained.

The low HRV levels measured here appear to indicate that all dogs were stressed during the baseline and especially the prosocial task, despite the variation in behavioral indices of stress (Craig et al., 2017; Fabes et al., 1993; Katayama et al., 2016; Kuhne et al., 2014). The relatively high overall arousal was likely due to a combination of separation distress, the novelty of the situation, and the unfamiliarity of the testing arena. Future studies should make use of habituation, allowing dogs to become accustomed to the arena prior to the prosocial helping task in order to decrease overall distress and anxiety, as has been done in comparable studies in rats (Ben-Ami Bartal et al., 2011; Silberberg et al., 2014). Alternatively, empathy studies could follow previous research that took place in the home (e.g., Custance & Mayer, 2012), as perhaps the stress of unfamiliar surroundings makes it more difficult for dogs to evaluate humans' emotions, suppress their own distress, and respond prosocially (e.g., Macpherson & Roberts, 2006; Quervel-Chaumette et al., 2016). Running this experiment in the dog's home would allow for a wider range of emotional responses and a decrease in overall anxiety, thereby making room for HRV to vary with the owner's emotional condition.

The HRV results in this study must be interpreted with caution due to constraints on their reliability under certain recording lengths. In fact, both the stress and HRV measures utilized in this study are influenced by recording length, and openers naturally had shorter recordings than non-openers. In particular, HRV measures in this experiment pNN50, are not considered reliable for samples under 20 s (Sütterlin, personal communication). Because the dogs in the distress condition who opened did so on average within about 20 s, their heart rate samples for the trial period should be interpreted with caution.

The presence of empathetic helping behaviors differs from other studies that found no evidence of prosocial behaviors towards humans in a help-requiring situation (Macpherson & Roberts, 2006; Quervel-Chaumette et al., 2016). The wide

variation in the methods of these experiments may be responsible for the discrepancies between their results. Given some of the problems of human communication of intent (Bräuer et al., 2013) that were inherent to these studies, the method of the present study tried to communicate intention by modifying the distress state of the human. These results may underscore the importance of using definitions of empathy that make sense in the context of a domestic dog's normal behavioral repertoire and that the situations are set up so as to clearly demonstrate that help is required.

There are limitations to the claims that can be made about empathy and prosocial helping in dogs from the present study. The size of the sample of this experiment may have contributed to marginal significance in some of the comparisons. Additionally, there was a great degree of variation in the crying and humming abilities of the human participants, where some were significantly more convincing than others. Although fake crying in previous experiments has been found to elicit empathetic responses (Custance & Mayer, 2012), the variability seen in the present sample may have had an influence on dogs' opening behavior. Future studies on helping with this paradigm could use pre-recorded audio clips of human vocalizations to standardize the emotional experience that each dog is exposed to during the trial, although this would require that the voice be unfamiliar for each dog. Another interesting test would be to compare helping toward recordings of human voices and canine vocalizations that are standardized with respect to emotionality. If dogs respond empathetically to crying humans, it is likely that they would respond similarly to distressed dogs, as has been seen in emotional contagion studies (Huber et al., 2017), and the use of pre-recorded distressed or control dog vocalizations would allow for this comparison.

While there is more research to be done, the support for cross-species empathy and prosocial helping found in this experiment is consistent with previous research on non-human primates, who have shown empathy toward humans in certain tasks (Warneken & Tomasello, 2006). In fact, mechanisms resembling rescue behavior are even found in other species such as ants, which indicates that complex social behaviors sometimes have simplistic explanations (Hollis & Nowbahari, 2013). Whether or not dogs were motivated by empathy when they provided help to their owner in a help-requiring situation, they do appear to be capable of responding differentially to humans based on their emotional states (Custance & Mayer, 2012). The extent of this empathetic response and under what conditions it can be elicited deserve further investigation, especially as it can improve understanding of the shared evolutionary history of humans and dogs. Future studies on empathy in animals will allow for a deeper understanding of this social cohesion mechanism, how it evolved, and how it can occur between individuals within one or between multiple species. This study contributes to

the empathy conversation by providing support for empathetically-motivated prosocial helping in dogs. This behavior sometimes appears to be motivated by desire for social contact alone but follows human patterns of empathetic helping in conditions of distress. Dogs are most likely to provide help to a human in need if they are able to focus on the human's need instead of their own personal distress.

Author's Note This research did not receive specific grant funding to support its completion.

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