Prosocial Rescue Behavior in Pet Dogs

by

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ABSTRACT

Domestic dogs have assisted humans for millennia. However, the extent to which these helpful behaviors are prosocially motivated remains unclear. To assess the propensity of pet dogs to spontaneously and actively rescue distressed humans, this study tested whether sixty pet dogs would release their seemingly trapped owners from a large box. To examine the causal mechanisms that shaped this behavior, the readiness of each dog to open the box was tested in three conditions: 1) the owner sat in the box and called for help ("Distress" test), 2) an experimenter placed high-value food rewards in the box ("Food" test), and 3) the owner sat in the box and calmly read aloud ("Reading" test).

Dogs were as likely to release their distressed owner as to retrieve treats from inside the box, indicating that rescuing an owner may be a highly rewarding action for dogs. After accounting for ability, dogs released the owner more often when the owner called for help than when the owner read aloud calmly. In addition, opening latencies decreased with test number in the Distress test but not the Reading test. Thus, rescuing the owner could not be attributed solely to social facilitation, stimulus enhancement, or social contact-seeking behavior.

Dogs displayed more stress behaviors in the Distress test than in the Reading test, and stress scores decreased with test number in the Reading test but not in the Distress test. This evidence of emotional contagion supports the hypothesis that rescuing the distressed owner was an empathetically-motivated prosocial behavior. Success in the Food task and previous (in-home) experience opening objects were both strong predictors of releasing the owner. Thus, prosocial behavior tests for dogs should control for physical ability and previous experience.

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Prosocial behaviors occur when individuals voluntarily act to benefit one or more individuals other than themselves (Batson and Powell, 1998). Although most authors describe prosocial behaviors in terms of costs and benefits (e.g., West et al. 2006), some definitions require that the prosocial actor demonstrate concern for the receiver and thus, an understanding of the receiver's emotional state (de Waal 2008; Burkart et al. 2007). However, the extent to which empathy and sympathy shape prosociality in non-human animals remains unclear (Batson et al., 1987, Panksepp & Panksepp, 2013).

Warneken and Tomasello (2009) distinguished four types of prosocial behavior: comforting (Zahn-Waxler et al., 1992), sharing (Hay et al., 1991), informing (Liszkowski et al., 2006) and instrumental helping. Studies on instrumental helping in non-human animals can be designed such that demonstrations of helping require or indicate that donors take the perspective of recipients. Thus, helping paradigms offer a potentially valuable means of investigating the intrinsic motivations that drive prosocial behavior.

Prosocial helping paradigms have typically employed an 'out-of-reach task' in which potential donor individuals can choose to retrieve and transfer an item to a recipient individual, for whom this item is otherwise out of reach (e.g., Drayton and Santos, 2014). The current study adopted an alternative test for helping that has been used to successfully demonstrate prosocial rescue behavior in rats and ants (e.g., Ben-Ami Bartal et al., 2016; Nowbahari et al., 2009). In this paradigm, a potential rescuer is free to move about a testing arena while a conspecific in the same arena is either trapped inside a restrainer apparatus that can only be opened from the outside (rats), or partially buried in sand and tied down by a nylon thread (ants).

As in previous tests of prosociality, rescue behavior in the trapped-other test may result from social facilitation and stimulus enhancement rather than emotional contagion (Vasconcelos et al., 2012). Rescuing in this paradigm may also be attributed to social-contact seeking behavior and may depend upon the proximity of rescuers to the restrainer apparatus (Hollis and Nowbahari, 2013; Marshall-Pescini et al., 2016). However, studies manipulating the affectual state of the trapped individual may be able to detect empathetically-motivated prosocial behavior by controlling for stimulus enhancement, social facilitation, and social contact-seeking behavior (Sanford et al., 2018).

Prosocial behaviors are generally regarded as widespread among species (Dugatkin, 1997; Nowbarhari et al., 2009). Dolphins and elephants are known to support or lift sick companions (Caldwell and Caldwell 1966; Hamilton-Douglas et al. 2006), *Formica* ants dig away sand to rescue conspecifics trapped in ant lion pits, and diverse taxa exhibit allomaternal care (Isler and van Schaik, 2012). Although prosociality has been experimentally demonstrated in corvids, parrots, canids, rodents, and social insects (see Marshall-Pescini et al., 2016), research on prosociality in non-human animals has primarily focused on primates (Decety et al., 2016; Cronin, 2012). However, some of the most commonly proposed evolutionary drivers are relatively uncommon in primates compared to other taxa (Marshall-Pescini et al., 2016). Thus, a broader phylogenetic framework is needed to clarify the evolutionary origins of prosocial behavior (Silk, 2008; Kujala, 2017).

Canids may serve as a valuable taxon for such investigations given that a number of canid species are highly social and may cooperate in territory defense, group hunting, and allomaternal care (Moehlman, 1986; 1989). Studies on domestic dogs in particular, might afford a unique perspective on the mechanisms shaping the evolution of prosocial behavior as domestication and selective breeding may have favored hypersocial tendencies in dogs (vonHoldt et al., 2017). Dogs have also been presented as a viable model for the evolution of human social cognition (Miklósi et al., 2007). Furthermore, pet, shelter, and free-ranging dogs differ greatly in their experiences with humans and overall social ecology. Therefore, intraspecific comparisons of dogs may yield insight into the relative importance of environment and rearing on the expression of prosocial behaviors (Udell and Wynne, 2008). Finally, as almost all dogs share some component of their ecological niche with humans and millions form intimate associations with their owners (Topál et al., 2005), studies focusing on dogs also provide a rare opportunity to examine prosociality in a naturalistic, interspecific context (Quervel-Chaumette et al., 2016).

Previous work has established that dogs are sensitive to human attentional states (Call et al., 2003, Udell et al., 2011), respond discriminately to human visual and auditory emotional signals (see Kujala, 2017, for review) and provide emotional comfort to humans (Kaminski et al., 2002). In addition, physiological and behavioral data suggest that dogs and owners synchronize their emotions (Silva et al. 2012, Romero et al. 2013). Thus, dogs stand as an ideal focal species for research on empathetically-motivated prosocial rescue.

For thousands of years, dogs have been trained to assist humans with tasks ranging from herding and guarding livestock to opening doors for the mobility impaired. Yet, the extent to which dogs understand the consequence of these helpful behaviors, as well as their underlying motivations for performing these actions, remain unclear (Bräuer et al., 2013).

To assess the propensity of pet dogs to spontaneously and actively rescue their owners, we tested whether dogs would move a piece of foam-board restraining their seemingly distressed owner inside of a cage (the "restrainer apparatus"). In addition, to examine the relative contributions of stimulus enhancement, desire for social contact, and empathetic concern in motivating rescue behavior in this paradigm, we tested whether each dog would display the same propensity for opening the door when the owner calmly read aloud from within the restrainer apparatus. In a third test, we placed high-value food rewards in the apparatus to determine whether the dog was capable of moving the restrainer door when sufficiently motivated.

To further examine the role of previous experience and ability in determining whether the dog opened the apparatus, we conducted a short survey after the dog completed the tests. To examine the possibility of emotional contagion, we also compared across test conditions the number of stress behaviors exhibited by the dog. To account for the staged nature of the rescue scenario, we rated the sincerity of the owner's distress vocalization and analyzed whether the owner's convincingness affected the dog's performance. Finally, to assess whether dogs attempted to solicit assistance for their owner, we recorded the latency of the dog to approach the doorway through which the experimenter exited the room, as well as the frequency with which the dog returned to this location during each test.

METHOD

Sixty-seven pet dogs (*Canis lupus* familiaris) of diverse and mixed breeds were volunteered by their owners to participate. There were no predetermined criteria for study subjects (Appendix A). Seven dogs were excluded from analyses: two dogs would not leave the room with the experimenter, one owner did not follow the script, one dog's leash unraveled and accidentally opened the door, one dog opened the apparatus before the owner started vocalizing, and in one case the video cameras malfunctioned. To prevent satiation, all dogs were fasted in the four hours proceeding the experiment.

As diagramed in Figure 1, the 9.45m x 4.78m testing room was divided into a northern and a southern section measuring 4.71m x 4.78m and 3.81m x 4.78m, respectively. The rescue apparatus was centered in the northern section of the room in line with a camera mounted above a door leading to an adjacent office. A table and a chair facing the southeast corner of the room sat next to a set of doors on the east wall, which lead to an adjacent hallway. A water bowl and tray were centered along the west wall and a tripod-mounted camera stood in the southwest corner of the room.

The restrainer apparatus was constructed using acrylic-coated peg board supported by a 0.8 x 0.8 x 1.0m metal dog kennel with the front face removed. The sides of the apparatus were angled from 1.36m in width at the bottom to 1.13m at the top to allow the restrainer door, an aluminum tape-coated foam board, to rest against and seal the front opening of the apparatus. The door was wider than the apparatus and weighed only 670g, so that it could be easily moved by dogs of all sizes. A 12cm$_2$ hole was cut into the top of the restrainer apparatus to allow food to be dropped inside without opening the restrainer door. To increase visibility into the apparatus while still preventing physical contact, five rows of horizontal slits (2cm x 20cm) were cut into each side of the apparatus and the door spaced 10-cm apart vertically and horizontally.

Procedure

Upon entering the testing space, each dog was allowed to freely explore the room while the experimenter (E) reviewed the protocol with the owner. To ensure that the dog was comfortable with handling and with leaving the room, E then led the dog out of the testing room and down the adjacent hallway. Upon returning, E instructed the owner to guide the dog around the perimeter of the testing room and restrainer apparatus. After demonstrating to the dog that the restrainer door could be moved by lightly tapping or pushing, E directed the owner to a chair facing the wall in the far corner and then exited the room. Each dog was given at least three additional minutes to fully acclimate to the testing room and restrainer apparatus while the owner sat silently reading, ignoring the dog. After the acclimation period was completed, E lead the dog out of the testing room and down the hallway. This allowed an assistant to enter from an adjacent office, unseen by the dog, to prepare the testing room and owner for the upcoming test.

The dog was then given a series of three tests – the primary test for prosocial rescue behavior (Distress), a social facilitation control test (Reading), and an assessment for task ability (Food). Ten dogs were randomly assigned to each of the six possible orders of the three tests. To rule out the possibility that random assignment did not adequately control for physical differences among test subjects, separate linear models were used to test the regression of test order (DFR, DRF, FDR, FRD, RDF and RFD) on the age, height and weight of the dog. Likewise, a general linear model was used to test the regression of test order on the sex of the dog.

Once the testing room and owner were prepared, E returned with the dog and announced the beginning of the Distress test. E then released the dog and exited into the hallway, leaving the dog alone with the owner in the testing room. For the duration of the test, E observed through an observation window in the hallway door.

Once the hallway door was fully closed, the owner tapped the bottom of the restrainer apparatus four times before vocalizing her distress using only the words 'help' or 'help me.' In advance of the test, the owner was instructed to convey distress as genuinely as possible while maintaining a consistent volume and even pace. The dog was given up to two minutes to release the owner from the apparatus by dislodging the restrainer door. If the dog rescued the owner, the owner ceased distress vocalizations and immediately began to pet and praise the dog for up to 30 seconds. If the dog did not rescue the owner, E announced the end of the test and the owner ceased vocalizations. After the test, E led the dog out of the room and down the hallway.

In the Reading test, the owner read aloud from a magazine while conveying a calm and relaxed state. In advance of the test, the owner was instructed to match the volume and pace of his narration to his distress vocalizations so that only his tone differed between the two tests. In all other regards, the Reading and Distress tests were conducted identically.

To assess the ability of the dog to move the restrainer door and access the inside of the apparatus, food was placed inside the apparatus for the third task. The owner did not participate in the Food test but remained in the testing room to prevent the dog from becoming distressed by the owner's absence. To minimize distractions, the owner sat in the same chair used during habituation and again faced the wall while ignoring the dog.

Before E returned with the dog to begin the test, the assistant set out a plate with food rewards on a table near the hallway entrance. These rewards consisted of four pieces of the dog's normal dry kibble bundled with a $1cm^3$ piece of hot dog. In addition, the assistant placed two identical trays on the floor - one outside of the apparatus (demonstration tray) and the other inside the apparatus.

Once the assistant was quietly situated in the adjacent office, E returned with the dog. Upon re-entering the testing room, E collected a food reward from the table, led the dog to the demonstration tray, and dropped the food reward into the tray. After allowing the dog to retrieve the food, E repeated this demonstration with a second food reward. These demonstrations provided confirmation that each dog was sufficiently motivated by food and permitted the formation of an association between the actions of E, the sound of treats hitting the tray, and the consequent reward.

In the test, E dropped a food reward inside the apparatus, released the dog, and exited into the hallway. The dog was then allowed up to two minutes to open the apparatus before E ended the test. If the dog successfully opened the apparatus and retrieved the treats, the dog was permitted an additional 30s to cease exploratory behaviors. E then re-entered the testing space and announced the end of the test before leading the dog out into the hallway.

Following the conclusion of the third test, the owner was given a short survey on the previous experience and behavior of the dog relevant to the experiment.

Analysis

Opening the apparatus in all three tests was defined by the same criteria - contact between the apparatus and any part of the dog other than the tail which resulted in the restrainer door moving away from the apparatus. In addition to the binary outcome of whether the dog opened the apparatus, the latency (in seconds) of the dog to open the apparatus was also recorded. A latency of 120 seconds (the maximum length of the test) was assigned to tests in which the dog did not open the apparatus. Latencies were natural log-transformed to reduce skew and kurtosis.

In three Reading, two Rescue and one Food test, the dog nudged the restrainer door but did not enter the apparatus. These tests were allowed to continue until the dog entered the apparatus or two minutes elapsed. However, in all analyses the same criteria for opening and latency were applied to these tests.

To assess the level of stress and activity of the dog, a composite stress score was generated using four positive behavioral indicators (running, barking, whining, and sniffing the apparatus) and one negative indicator (laying down). The occurrence of each behavior was treated as a binary outcome and all behaviors were weighted equally such that the composite score increased by an absolute value of one for each additional behavior exhibited by the dog. Thus, composite scores ranged from negative one for an inactive and unstressed dog to positive four for a very stressed and active dog.

To assess whether dogs that failed to open the apparatus sought out the experimenter for assistance, the latency of the dog to approach the hallway and the frequency of this behavior during the test were recorded. A rectangular surface of the floor extending 0.5 meters from the hallway doors was used to delineate an area near the hallway. Hallway approaches were tallied each time the dog contacted this area with any part of the body other than the tail. If the dog was near the hallway when the test began but moved to vacate the hallway area within the first second of the test, the event was not scored as a hallway approach. If, however, the dog did not begin to walk out of the hallway area within three seconds, the event was scored as an approach and a latency of 0.001 seconds was assigned to the test. If the dog did not approach the hallway during the test, a latency of 120 seconds was assigned.

All measurements were recorded from video recordings using the event-logging software, BORIS (Friard and Gamba, 2016) by coders who were blind to the nature of the study. Coders were trained to 100% agreement using six randomly selected tests. For each measurement, one coder scored all tests and at least half of the data were scored by a second coder. For all tests, the coders agreed on whether the dog opened the apparatus and all opening latencies were consistent to within 0.1 seconds. For stress scores, hallway approaches and hallway latencies, any discrepancies were reconciled by a third coder.

To assess whether the convincingness of the owner's distress affected the performance of the dog, audio recordings of the owner's distress vocalizations were rated on a scale of perceived sincerity from one to six. To provide a consistent metric of sincerity, all distress vocalizations were rated by one coder. Up to three intervals per test were rated to produce an average vocalization score. When the duration of the test was at least 30 seconds, the first, middle, and last ten seconds of the test were rated. When the duration of the test was between 20 and 30 seconds, the first and last 10 seconds of the test were rated. When the duration of the test was less than 20 seconds, playback of the entire test was given a single rating.

The survey of the dog's previous exposure to relevant scenarios consisted of four yes-or-no questions: (1) Has your dog ever seen you in genuine emotional or physical distress? (2) Has your dog ever heard you say "help" or “help me”? (3) Has your dog ever played hide-and-seek? (4) Has your dog ever opened boxes, bins, cabinets, doggy gates, garbage cans or other objects?

Data were analyzed in R version 3.4.1. Models were tested using the package "lme4" (Bates et al., 2015) and post-hoc comparisons were conducted using the package "multcomp" (Hothorn et al., 2008). To analyze repeated measures, mixed effects models were constructed with study subject treated as a random intercept and all remaining predictors treated as fixed effects. Fixed effects models were used to analyze non-repeated measures.

To analyze continuous outcomes and discrete numerical outcomes with a sufficient number of levels, linear regression analyses were conducted using linear models (LMs) and linear mixed models (LMMs). P-values were then obtained using Wald tests. To analyze binomial outcomes, logistic regression analyses were conducted using generalized linear models (GLMs) and generalized linear mixed models (GLMMs). P-values were then obtained from likelihood ratio tests (LRTs) of nested models. Specifically, the difference between the full model and the null model without the effect of interest was tested using the Chi square distribution.

To test the assumptions of each model, residual plots were inspected to confirm linearity, Levene's tests were conducted to confirm homoscedasticity, and standard normal quantile plots were inspected to confirm that residuals were normally distributed. Model assumptions were met in all analyses described herein.

RESULTS

Of the 60 dogs tested, 20 rescued the owner in the primary Distress test, 19 successfully retrieved treats from the apparatus in the Food control task, and 16 released the owner from the apparatus in the Reading test. To test whether releasing the owner from the apparatus in the Distress test could be attributed to social-contact seeking behavior, the frequency of opening in the Distress and Reading tests were compared using a logistic regression analysis. A general linear mixed model (GLMM) was constructed with opening modeled as a binomial outcome, study subjects treated as a random intercept, and test condition treated as a fixed-effect with two levels (Distress and Reading). To test for effects of repeated testing, test number was included in the model as a fixed effect with three levels (first, second, and third test). To account for the ability of the dog to open the apparatus, the outcome of the food control task was also incorporated into the model of rescuing the owner as a fixed-effect predictor with two levels (failure and success).

Dogs that successfully retrieved food from the apparatus during the Food test were significantly more likely to release the owner in the Distress and Reading tests ($\bar{x}$ = .76, *SE* = .07) than were dogs that failed to retrieve the food ($\bar{x}$ = .09, *SE* = .03), $X^2(1, N = 60) = 36.35$, $p < .0001$ (Fig. 2). After accounting for task ability, dogs released the owner from the apparatus more often in the Distress test ($\bar{x}_{F+} = .84 \pm .08$, $\bar{x}_{F-} = .33 \pm .06$,) than in the Reading test ($\bar{x}_{F+} = .68 \pm .11$, $\bar{x}_{F-} = .27 \pm .06$), $X^2(1, N = 60) = 8.67$; $p < .01$ (Fig. 2). Test number did not predict whether the dog released the owner, $X^2(2, N = 60) = 1.80$, $p > .05$. The effect of test subject was significant $X^2(1, N = 60) = 31.46$, $p < .0001$.

To assess whether dogs freed the owner faster in the Distress test than in the Reading test, a linear regression analysis of latency to open the apparatus was conducted using a linear mixed model (LMM). A latency of 120 seconds (the length of the test) was assigned to tests in which the dog did not open the apparatus. Latency data were natural log-transformed to reduce skew and kurtosis. To control for task ability, only dogs that demonstrated the capacity to open the apparatus in the Food control task were included in the analysis. To assess whether potential learning and desensitization effects differed among conditions, test number and the interaction between test number and condition were included in the model as fixed effect predictors. Study subject was treated as a random effect.

The main effect of test number was significant, $X_2(2, N = 19) = 9.62$, $p < .01$. The main effect of test condition was not significant but dogs tended to open the apparatus more quickly in the Distress test than in the Reading test, $X_2(1, N = 19) = 3.60$, $p < .10$. However, the interaction between test condition and number was significant, $X_2(2, N = 19) = 8.83$, $p < .05$ (Fig. 3). Specifically, latency to release the owner decreased with test number in the Distress test but not in the Reading test.

To assess the role of previous experience in predicting whether the dog rescued the owner, a logistic regression analysis of opening in the Distress test was conducted using a GLM in which each of the four survey responses was treated as a binary, fixed-effect predictor. Whether the dog previously played hide-and-seek, $X_2(1, N = 60) = 0.84$, $p > .05$, or heard the word “help”, $X_2(1, N = 60) = 1.52$, $p > .05$, did not predict whether the dog rescued the owner. Dogs that had previously seen the owner in genuine distress tended to open the apparatus less frequently but this effect was not significant, $X_2(1, N =$

60) = 2.83, $p < .1$. However, when the owner reported that the dog had experience opening objects, the dog was four times more likely to open the apparatus, $X^2(1, N = 60) = 7.50$, $p < .01$ (Fig. 4).

To test the hypothesis that the distress expressed by the owner increased the level of activity and stress displayed by the dog, a linear regression analysis of composite stress scores was conducted using an LMM. To test for acclimation and sensitization across repeated tests, and to assess whether these effects differed among conditions, coefficients for test number and the interaction between test number and condition were included in the model. Subject intercepts were included in the model as a random effect. Linear hypotheses were then specified to compare the Distress test to the Reading test and the Distress test to the Food test. P-values for these pairwise comparisons were adjusted using the “single-step” method which accounted for the joint normal distribution of each linear function.

The main effect of test condition was significant, $X^2(2, N = 60) = 15.74$, $p < .001$. Dogs were more active and displayed more stress behaviors in the Distress test ($\bar{x} = 1.89$, $SE = .12$) than in either the Reading test ($\bar{x} = 1.47$, $SE = .13$) $z = 2.82$, $p < .01$, or the Food task ($\bar{x} = 1.32$, $SE = .13$) $z = 3.83$, $p < .01$ (Fig. 5). The main effect of test number was not significant, $X^2 (2, N = 60) = 0.87$, $p > .05$. However, there was a significant interaction between test number and condition, $X^2 (2, N = 60) = 12.68$, $p < .01$, whereby stress score decreased with test number in the Reading test but not in the Distress or Food test (Fig. 6). The effect of study subject was significant, $X^2 (1, N = 60) = 15.52$, $p < .0001$.

To assess whether dogs that failed to open the apparatus sought out the experimenter for assistance, the frequency with which the dog approached the hallway and the latency of the dog to first approach the hallway were analyzed using linear regressions. Separate LMMs were constructed for hallway frequency (Fig. 7) and latency (Fig. 8) in which test number and condition were treated as a fixed-effect predictors and study subjects was treated as a random intercept. Pairwise comparisons among test conditions were then conducted using Tukey post-hoc tests.

Test condition significantly predicted hallway approach frequency, $X_2(2, N = 48) = 39.95$, $p < .0001$, and latency, $X_2(2, N = 48) = 27.12$, $p < .0001$. Dogs took significantly longer to approach the hallway in the Distress test ($\bar{x} = 78.67$, $SE = 5.91$) than in the Reading test ($\bar{x} = 78.67$, $SE = 5.91$), $z = 2.80$, $p < .05$, but approach frequency in the Distress ($\bar{x} = .98$, $SE = .18$) and Reading ($\bar{x} = 1.20$, $SE = .18$) tests did not significantly differ ($z = .75$, $p > .05$). Hallway approach frequency was greater in the Food test ($\bar{x} = 2.49$, $SE = .33$) than in either the Distress test, $z = 5.80$, $p < .0001$, or the Reading test, $z = 5.14$, $p < .0001$. Likewise, hallway approach latency was shorter in the Food test ($\bar{x} = 36.33$, $SE = 6.37$) than in either the Distress test, $z = -5.20$, $p < .001$, or the Reading test, $z = -2.51$, $p < .05$. Test number did not predict hallway approach frequency, $X_2(2, N = 48) = 2.38$, $p > .05$, or latency, $X_2(2, N = 48) = 2.34$, $p > .05$. The effect of study subject was significant, $X_2(2, N = 48) = 6.59$, $p < .05$.

To assess whether the convincingness of the owner's distress vocalizations affected the performance of dogs in the primary Distress test, a GLM and an LMM were used to test the regressions of vocalization score on opening frequency and opening latency, respectively. Vocalization score did not significantly predict opening frequency, $X2(1, N = 60) = .37$, $p > .05$, or latency, $X2(1, N = 60) = .29$, $p > .05$.

To assess whether study subject covariates were adequately controlled through random assignment of test order (DFR, DRF, FDR, FRD, RDF and RFD), separate linear models were used to test the regression of test order on the age, height and weight of the dog. Likewise, a GLM was used to test the regression of test order on the sex of the dog. Test order did not predict sex, $X^2(5, N = 60) = 6.71$, $p > .05$, age, $F(5, N = 60) = 2.19$, $p > .05$, height $F(5, N = 60) = .25$, $p > .05$, or weight, $F(5, N = 60) = .1$, $p > .05$.

DISCUSSION

Our findings indicate that dogs readily rescue their trapped owners. Both in the first test and across all test orders, approximately one third of the dogs released the owner in the Distress test. However, a much larger proportion of dogs may have been motivated to rescue the owner. Warneken & Tomasello (2009) posited that instrumental helping behaviors incorporate a motivational component as well as a cognitive component in which the donor both recognizes the recipient’s goal and understands how to fulfill that goal. However, previous studies have demonstrated that dogs may have difficulties understanding the intentions and goals of humans in instrumental helping paradigms (Kaminski et al., 2011, Bräuer et al., 2013). Thus, dogs that did not rescue the owner in our Distress test may not have met the cognitive demands of the task.

Feuerbacher and Wynne (2014) demonstrated that food is a highly salient reward, even more so than vocal praise or petting. In the present study, all dogs retrieved the treats immediately in both pre-test demonstrations further indicating that these treats served as salient rewards. Thus, the finding that dogs were as likely to release their distressed owner (n = 20) as to retrieve treats from inside the box (n = 19) indicates that rescuing an owner may be a highly rewarding action for dogs. Moreover, 84% of the dogs that demonstrated an ability to open the apparatus in the Food test rescued the owner in the Distress test.

The finding that dogs opened more often when the owner called for help than when the owner read aloud calmly supports our hypothesis that opening in the Distress test could not be attributed solely to social facilitation, stimulus enhancement, or social contact-seeking behavior. In addition, opening latencies decreased with test number in the Distress test but not the Reading test indicating that previous exposures to the paradigm only improved performance when the dog was motivated by the owner's Distress. Moreover, in the Reading control, dogs tended open more slowly in each successive test suggesting that dogs acclimated to being separated from a calm, but not a distressed owner.

Analyses of the owners' distress vocalizations suggests that the staged nature of the rescue scenario did not undermine this study. Given that the sincerity scores of the owners did not predict whether the dog rescued, variation in the acting abilities of the owners did not introduce a confound. This finding aligns with previous indications that dogs do not perceive the insincerity of contrived affective states and will respond to feigned crying, anger, and happiness (for review, see Albuquerque et al., 2016; Kujala, 2017). Moreover, in three experiments explicitly designed to test whether dogs detect human deception, Petter et al. (2009) found no indications that dogs understand human intentionality. Nonetheless, studies on the prevalence of spontaneous rescue behavior among dogs in genuine emergency situations may provide further insight into the importance of distress sincerity in tests for prosocial rescue behavior.

The finding that dogs displayed more stress behaviors in the Distress test than in the Reading test indicates that the distressed state of the owner was transmitted to the dog. Given that dogs were more likely to open in the Distress test, this evidence of emotional contagion may indicate that dogs were empathetically-motivated to rescue their owners. Furthermore, the finding that stress scores decreased with test number in the Reading test but not in the Distress test indicates that dogs experienced different forms of stress in these scenarios. We hypothesize that stress behaviors displayed in the Reading test were caused by the dog's physical separation from the owner while stress behaviors displayed in the Distress test was also a product of emotional contagion between the owner and dog. Thus, dogs acclimated to being separated from the owner but the transmission of the distressed affectual state continued to produce rapid opening in the second and third tests.

Although it is possible that dogs were empathetically motivated to rescue their owner, our findings do not confirm that this behavior was intentional or consciously altruistic. Moreover, emotional contagion during the Distress test may have increased the dog's desire for, or the reinforcing strength of, social contact with the owner. Hollis and Nowbahari (2013) argue that, to qualify as rescue behavior, an action must not inherently reward or benefit the rescuer. Therefore, future studies should aim to reduce the potential for immediate egoistic reinforcement. An effective approach may require redesigning the apparatus such that successful rescue of the owner does not result in social contact between the dog and owner (e.g., Ben-Ami Bartal et al., 2011). However, in such a paradigm, dogs may still rescue the owner to reduce their own stress rather than to reduce the distress of the owner. Moreover, it is not clear that conscious, intentional helping or any form of prosocial behavior can be altruistic in a psychological sense given that such behavior must be reinforcing to the actor in order to be maintained (Cialdini et al., 1987; Moen, 2016; but see Batson et al., 1981). Notwithstanding these considerations, our findings indicate that emotional contagion of a distressed state increased the likelihood that the dog rescued the owner - a behavior that imposed a cost to the dog, and that instrumentally benefited the owner.

The present study did not find any indications that dogs attempted to solicit assistance from the experimenter for their owners. This aligns with the outcome of a study by Macpherson and Roberts (2006), which was explicitly designed to test for help-seeking behavior in dogs. Macpherson and Roberts found that dogs did not seek help from a human bystander when their owner feigned a heart attack or pulled a bookcase down onto themselves. However, dogs were more attentive towards the owner in these staged emergency scenarios than in a control condition. Thus, approaching the bystander, like approaching the hallway in our study, may have been negatively correlated with concern for the owner. We suggest that future studies on rescue behavior in pet dogs should focus on instrumental helping rather than help-soliciting behavior.

This study provides strong evidence that physical ability and previous experience heavily constrain the performance of dogs in prosocial behavior tests. Indeed, dogs that demonstrated the ability to open the apparatus in the Food test were eight times more likely to release the owner in either the Distress or Reading tests. Likewise, when the owner reported that the dog had previously opened objects such as garbage cans, cabinets, dog gates, or containers, the dog was four times more likely to open the apparatus. In addition, the significant effect of test number on opening latency indicates that even a single exposure to the paradigm altered the tendencies of dogs to open the apparatus.

Study designs that do not sufficiently control for individual variation in understanding the contingencies of a prosocial task may lead to misidentification of prosocial behavior (Bräuer, 2015; Marshall-Pescini et al. 2016). Although accounting for performance in the food test helped to control for task ability, our findings indicate that repeated measures were still necessary to control for individual variation among study subjects. Indeed, the random effect of study subject was by far the strongest predictor of opening frequency and latency, stress and activity, and assistance solicitation. Moreover, an average of eighteen dogs opened the apparatus in each of the three successive tests, yet only twenty-four dogs ever opened. Thus, an independent-samples analogue of our study would largely reflect the test condition assignments of these twenty-four dogs rather than any underlying differences in the test conditions.

To our knowledge, these findings provide the first evidence that dogs prosocially help humans. Kaminski et al. (2011) tested whether dogs used gaze alternation to direct a human towards a hidden object with which the human had previously interacted. Their findings suggested that dogs concentrated on objects that they wanted for themselves rather than the object desired by the human. Quervel-Chaumette et al. (2015, 2016) demonstrated that dogs preferentially donated food to familiar dogs but not to humans, regardless of the human’s identity. Bräuer et al. (2013) found that dogs pushed a button to open a door separating the dog’s owner from a desired object but only when the owner pointed directly to the button or attempted to communicate with the dog in a naturalistic manner. However, it is unlikely that this behavior constituted prosocial helping given that the owner directed the dog's attention towards the mechanism rather the goal (Marshall-Pescini et al., 2016). Additionally, the owner's vocalizations and actions were not controlled in the Natural test condition. Thus, the observed increase in button pushing in these test conditions relative to the control conditions may be more parsimoniously attributed to stimulus enhancement and increased arousal (Bräuer, 2015; Quervel-Chaumette et al., 2016).

Using an independent-samples design, Sanford et al. (2018) deployed a modified trapped-other paradigm to test for indications that dogs prosocially rescue their owners. In the experimental condition, the owner pretended to cry and in the control condition, the owner hummed. The owner and dog began the test in separate rooms separated by a short door with a viewing window. The number of dogs that opened the door, the latency of the dog to open the door, the stress behaviors expressed by the dogs, and the heart rate variability of the dogs did not significantly differ between the experimental and control conditions. Thus, social facilitation, stimulus enhancement, and social contact-seeking behavior may explain opening in this study. Furthermore, success in this paradigm required only that the dog walk to the owner by pushing through the door. However, the owner was not trapped in a restrainer apparatus and the dog did not release the owner by walking through the door. Thus, it was not clear how a successful dog rescued, or provided instrumental assistance to the owner.

Relative to rats, dogs appear to possess a strong propensity for rescue behavior. Approximately 17% of the rats tested by Ben-Ami Bartal et al. (2011) rescued within the first hour of their first trial. Moreover, none of the forty-six rats tested by Tomek et al. (2019) opened the restrainer door within the first two minutes of their first trial. However, as with dogs, task ability may heavily constrain rescue behavior in rats. Indeed, when trained to open the apparatus in advance of testing, all rats released their trapped cage-mate within the first few trials (Blystad et al., 2019). Therefore, future studies in which dogs are trained to open the apparatus prior to testing are needed to facilitate further interspecific comparisons.

Rescuing an owner may have been more rewarding for dogs than freeing a cage-mate was for rats. Using a simultaneous choice paradigm, Ben-Ami Bartal et al. (2011) showed that rats may find the act of rescuing their cage-mates to be nearly as rewarding as retrieving food treats, and may choose to share food after rescuing cage mates. However, Blystad et al. (2019) found that rats waited longer to open the restrainer apparatus and did so less frequently for a trapped cage-mate than for food. In contrast, dogs were as likely to rescue their owner as to retrieve treats.

Our ability to manipulate the affectual state of the owner, provided more stringent controls for stimulus enhancement and social facilitation than were possible in previous studies on rats. Although Ben-Ami Bartal et al. (2011) demonstrated that the presence of another rat, a toy rat within the restrainer apparatus, and the apparatus itself could not account for observed rescue behavior, the second rat could not be placed in the apparatus in these control conditions. Thus, the degree of stimulus enhancement and potential forms of social facilitation present in the testing scenario were not fully controlled.

Likewise, the Reading test allowed us to control for social-contact seeking behavior, an obstacle that has not been fully resolved in rat rescue studies. Although Ben-Ami Bartal et al. (2011) demonstrated that rats continued to rescue when social contact was prevented, opening in this control condition may have been a residual response that was not extinguished after the original testing scenario (Sapolsky, 2016; Vasconcelos et al., 2012). Indeed, in a follow up study Silberberg et al. (2014) found that rats took significantly longer to free trapped cage-mates when social contact was prevented. Furthermore, modifications to the apparatus that rendered successful rescue impossible did not extinguish attempts to open the restrainer, indicating that desire for social contact may still motivate rescue behavior when social contact is prevented.

The transmission of the owner's distressed affectual state to the dog in the rescue scenario mirrors previous evidence of empathetic concern in rats. Specifically, free rats made more alarm calls when their cage-mate was restrained than when the apparatus was empty or contained a toy rat (Ben-Ami Bartal et al., 2011). In addition, anxiolytic treatment impaired rescue behavior in rats indicating that this behavior was motivated by an affective state of anxiety elicited by the distress of the trapped conspecific (Ben-Ami Bartal et al., 2016).

The present study demonstrated that dogs rescue their owners without explicit training and further indicated that dogs capable of completing the required rescue task have a much higher propensity to display prosocial rescue behavior. However, further studies are needed to determine the rescue propensity of dogs that have been trained in advance to perform the required behaviors. Moreover, the extent to which explicit training renders future rescue behavior a pre-conditioned response as opposed to a prosocial behavior resulting from empathetic concern remains unclear. Thus, further research may help to better understand the behavior of working dogs trained in search-and-rescue and related fields.

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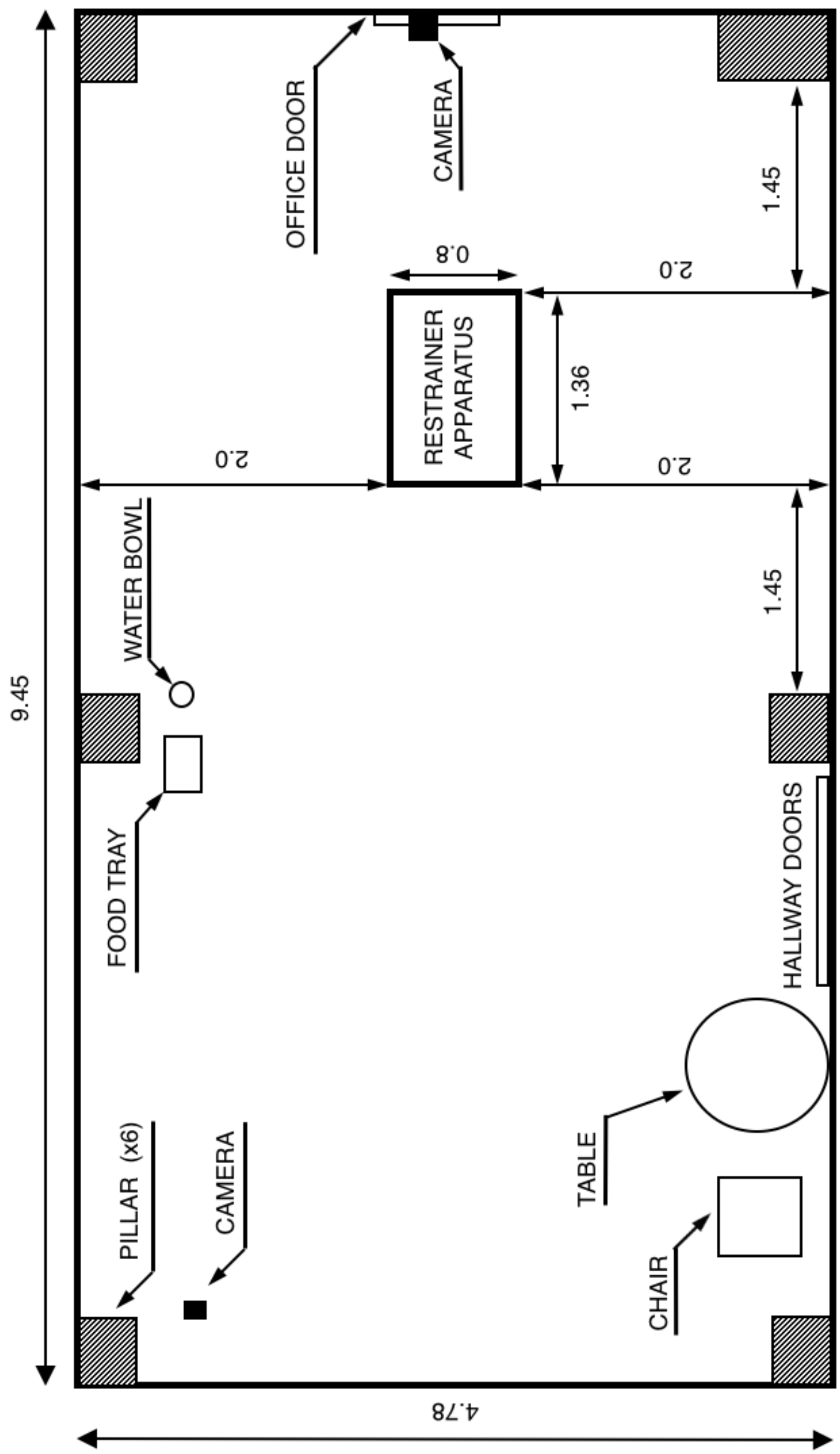

Figure 1. Schematic of the experimental setup. Dimensions are in meters.

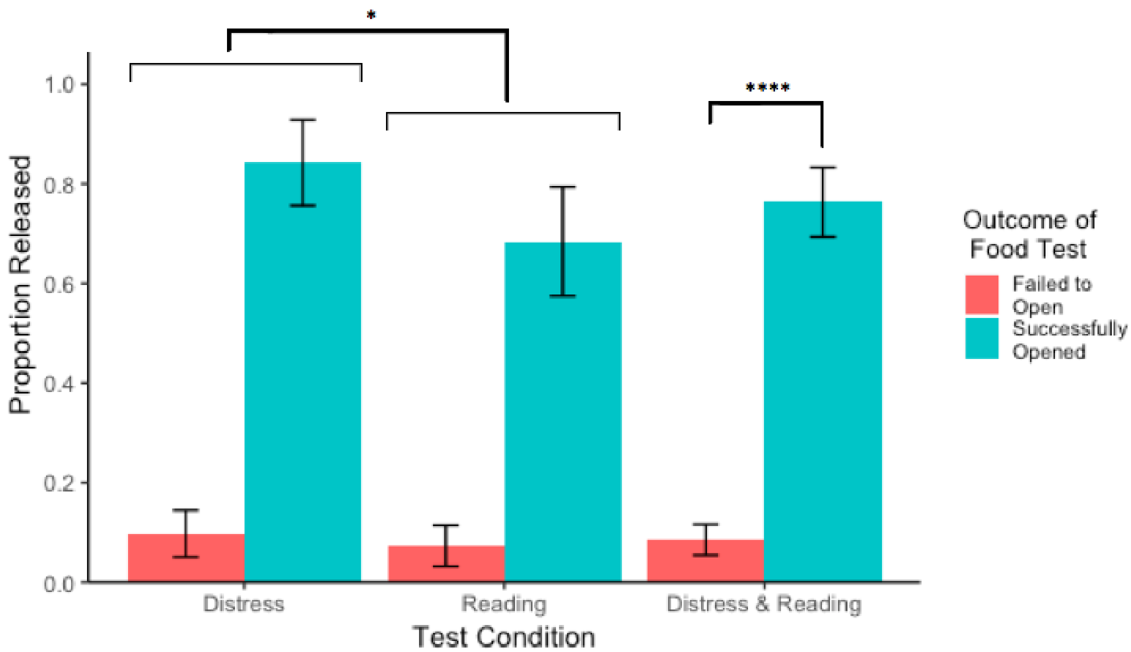

Figure 2. Proportion of owners released by test condition and outcome of Food test.

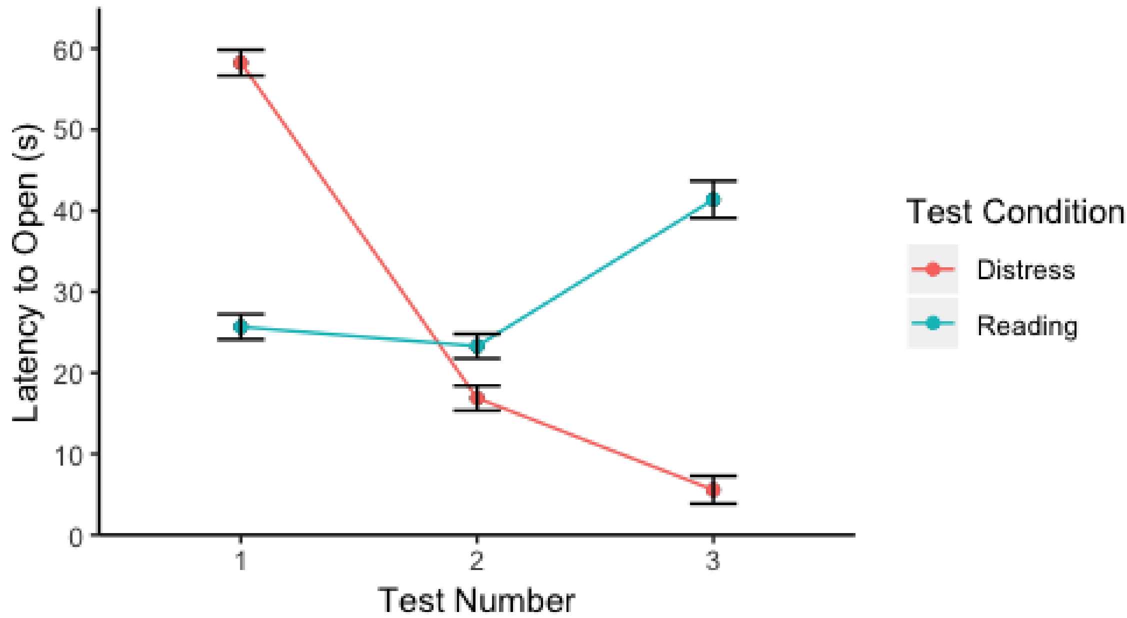

Figure 3. Latency to release the owner by test condition and number (among dogs that successfully opened in the Food test).

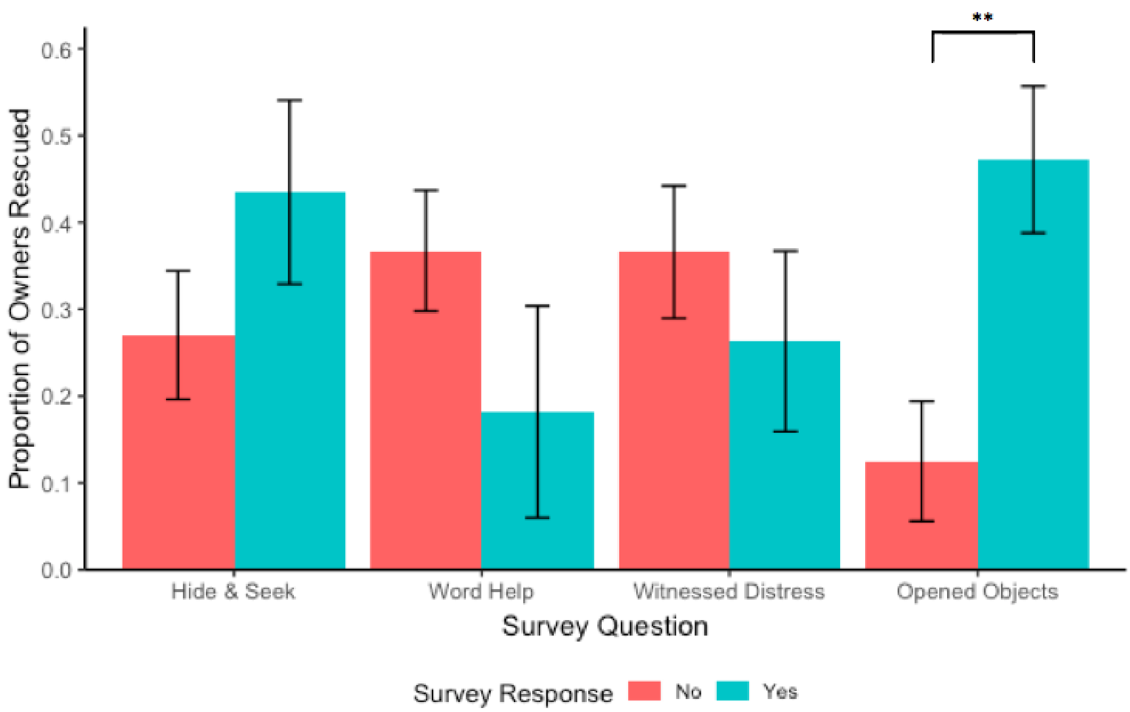

Figure 4. Proportion of owners rescued by survey response.

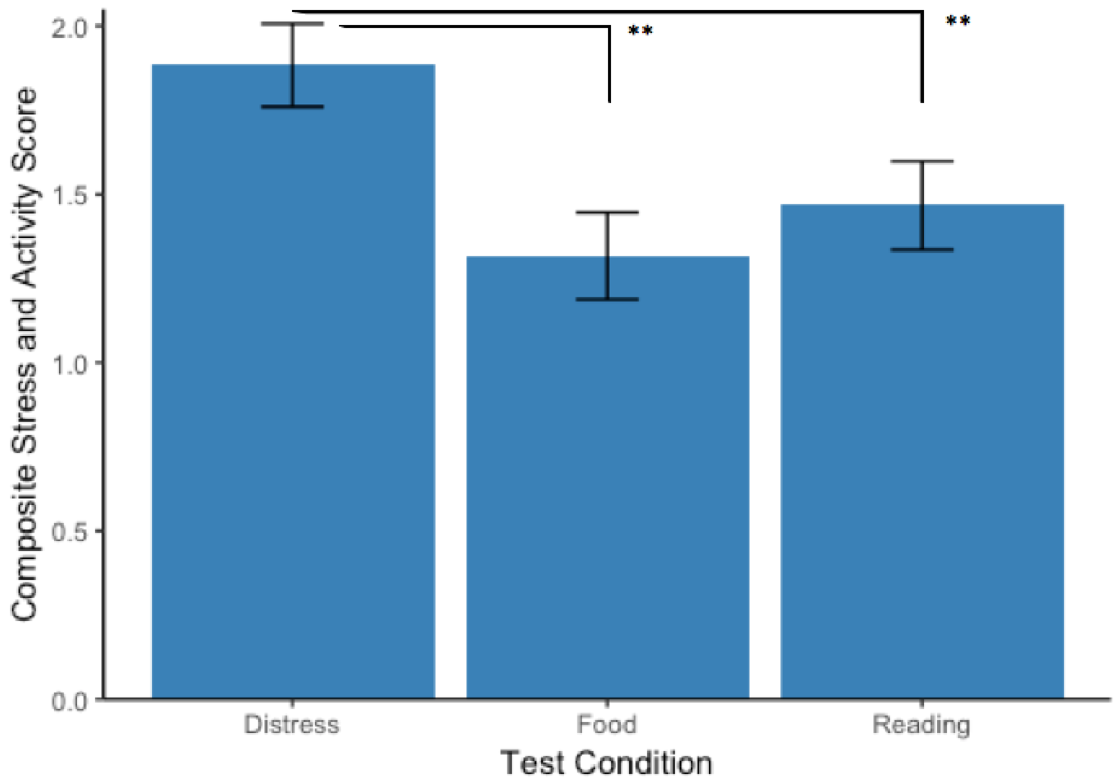

Figure 5. Stress and activity level by test condition.

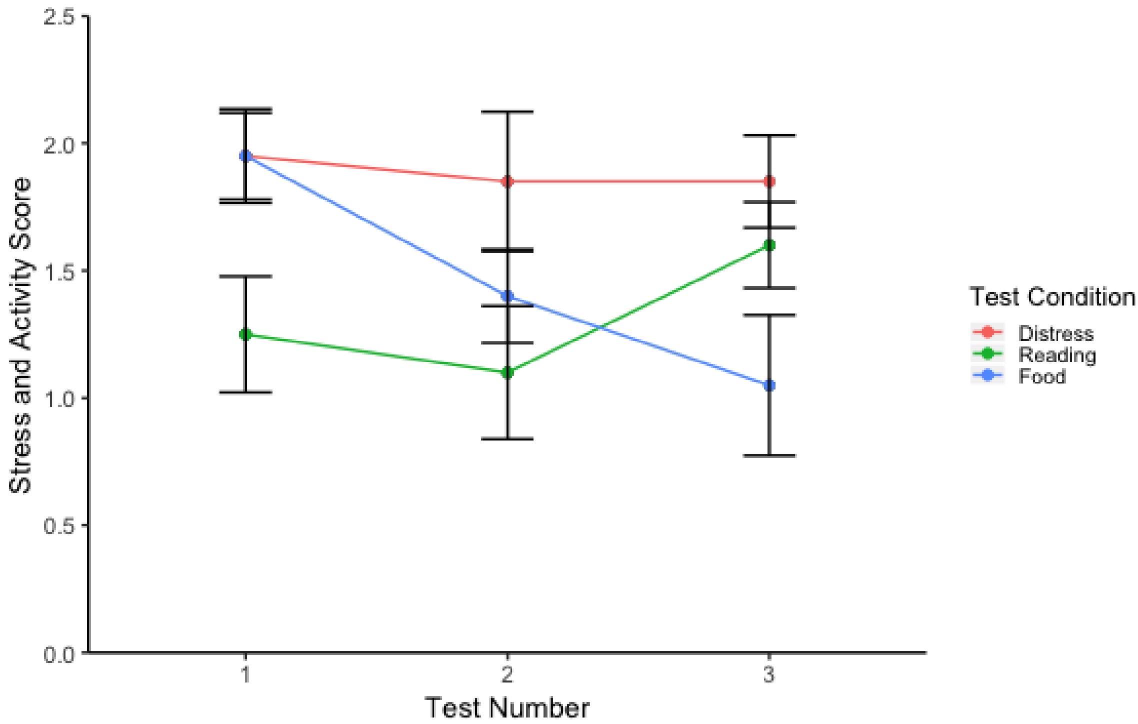

Figure 6. Stress and activity score by test number and condition.

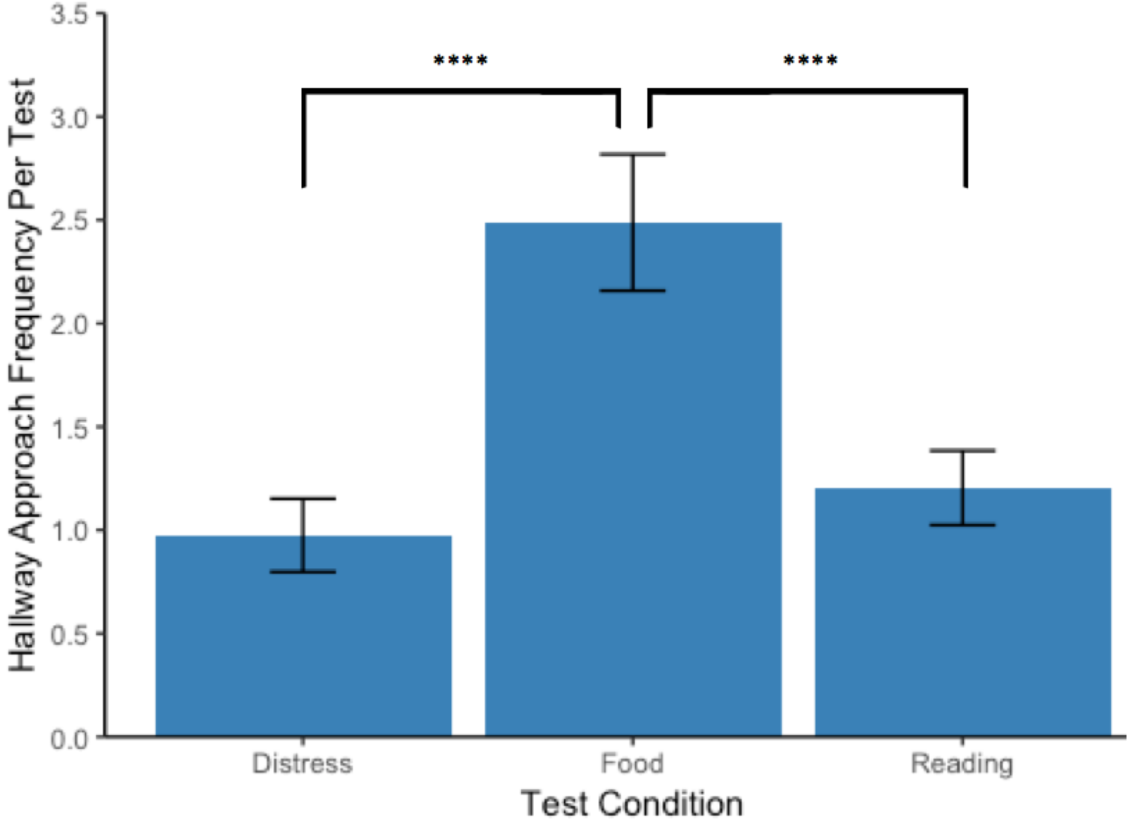

Figure 7. Hallway approach frequency by test condition.

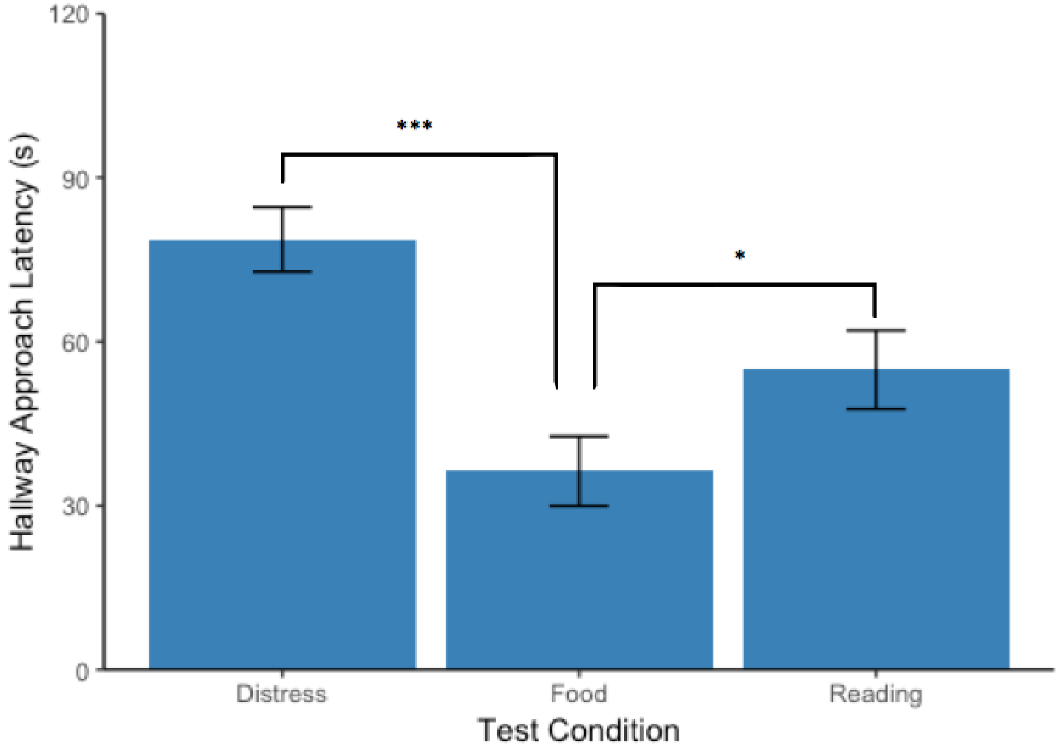

Figure 8. Latency to approach hallway by test condition.

APPENDIX A

STUDY SUBJECT COVARIATES & TEST ORDER ASSIGNMENTS

Name	Order	Sex	Age(m)	Height(m)	Weight(kg)	Breed
Mango*	N/A	F	49	N/A	N/A	Mixed
Mongo*	N/A	M	46	0.69	28.21	Mixed
Oakley*	N/A	M	65	0.66	33.11	Mixed
Ziggy	FDR	M	119	0.76	38.74	Labrador Retriever
Tesla	DRF	F	72	0.81	31.57	Mixed
Qyette	DRF	M	84	0.69	20.77	Australian Shepherd
Zazu*	N/A	M	65	0.88	29.48	Mixed
Max	RDF	M	138	0.79	32.66	Mixed
Lucy	RDF	F	119	0.79	34.56	Mixed
Mia	FDR	F	38	0.69	20.23	Mixed
Tibbie	FDR	M	96	0.43	5.67	Tibetan Spaniel
Max	DFR	M	78	0.86	28.67	Mixed
Bella	DRF	F	102	0.74	18.64	Queensland Heeler
Asher*	N/A	M	91	0.71	12.34	Australian Shepherd
Louie	RFD	M	39	0.42	7.48	Mixed
Rexy	RFD	M	38	0.67	21.32	Mixed
Odie	DFR	M	61	0.65	15.79	Australian Shepherd
Wynne	DFR	M	18	0.71	30.66	Labrador Retriever
Phlash	FRD	M	105	0.70	17.51	Australian Shepherd
Tess	FDR	F	30	0.83	26.04	Rhodesian Ridgeback

Piggy	FRD	F	132	0.69	24.40	Mixed
Manny	RFD	M	97	0.51	13.52	Mixed
Baby	FRD	F	18	0.77	16.60	Australian Shepherd
Stella	FRD	F	30	0.77	24.77	Mixed
Moose	DFR	M	30	0.58	9.62	Mixed
Penny	FDR	F	17	0.71	18.33	Mixed
Winston	RDF	M	72	0.48	10.89	Mixed
Calder	DFR	M	48	0.80	27.40	Mixed
Uzi	RFD	F	15	0.41	5.99	Jack Russel
Bullett	RFD	M	129	0.46	6.71	Jack Russel
Ak	RFD	F	92	0.52	11.25	Mixed
Moses	DFR	M	99	0.00	46.27	Akita
Kip	DRF	M	47	0.69	20.41	Border Collie
Olive	FDR	F	60	0.84	22.04	Standard Poodle
Fulana	FRD	F	75	0.64	18.42	Mixed
Jasmine	DRF	F	26	0.76	25.22	Flat Coat Retriever
Nay Nay	DRF	F	132	0.69	25.49	Golden Retriever
Mori	FDR	F	53	0.43	6.89	Welsh Terrier
Milo*	N/A	M	101	0.50	8.26	Jack Russel
Basquiat	RDF	M	131	0.85	30.66	Mixed
Henry	DFR	M	68	0.79	39.28	Labradoodle
Chip	FDR	M	59	0.76	26.40	Mixed

Eloise	RDF	F	109	0.76	36.74	German Shepherd
Kukkula	FRD	F	67	0.79	35.47	Mixed
Greta	DFR	F	18	0.41	8.44	Swedish Vallhund
Kiba	RDF	M	93	0.46	10.98	Corgi
Daisy	RDF	F	70	0.46	19.87	Corgi
Auberon	RFD	M	61	0.86	23.50	Standard Poodle
Oso	FDR	M	36	0.74	32.30	Mixed
Ticket	FRD	F	32	0.72	21.41	Golden Retriever
Cody	DRF	M	116	0.85	45.99	Labrador Retriever
Leo	DRF	M	65	0.97	47.99	Mixed
Kira	DFR	F	47	0.64	26.85	Mixed
Puddy	RFD	M	80	0.94	64.14	Mixed
Zelda	RFD	F	39	1.05	65.14	Great Dane
Izzi	FDR	F	80	0.77	22.14	Samoyed
Barkley	FRD	M	49	0.71	22.04	Mixed
Almond*	N/A	M	48	0.44	8.71	Mixed
Quest	RDF	F	29	0.67	21.86	Labrador Retriever
Quantico	RDF	M	29	0.74	29.48	Labrador Retriever
Vail	FRD	F	21	0.66	24.49	Labrador Retriever
Scout	FRD	F	18	0.57	16.51	Mixed
Dana	DRF	F	97	0.39	8.26	Mixed
Billy	DRF	M	144	0.42	6.89	Mixed

Mason	DFR	M	68	0.47	7.17	Dachshund
Rosie	RFD	F	24	0.64	18.27	Mixed
Ozzy	RDF	M	96	0.58	21.32	Mixed

* Dogs that were excluded from analyses

Note. Order refers to the order of tests presented to the dog (D = Distress, F = Food, R = Reading).

*Seven dogs were excluded due to handling limitations, video or apparatus malfunctions, or owners going off script in the Distress test

APPENDIX B

INSTITUTIONAL ANIMAL CARE AND USE COMITTEE APPROVAL

Institutional Animal Care and Use Committee (IACUC)
Office of Research Integrity and Assurance
Arizona State University
660 South Mill Avenue, Suite 312
Tempe, Arizona 85287-6111
Phone: (480) 965-6788 *FAX:* (480) 965-7772

Animal Protocol Review

ASU Protocol Number:	**18-1620R**
Protocol Title:	**Prosocial Rescue in Dogs**
Principal Investigator:	**Clive Wynne**
Date of Action:	**1/2/2018**

The animal protocol review was considered by the Committee and the following decisions were made:

The protocol was approved.

If you have not already done so, documentation of Level III Training (i.e., procedure-specific training) will need to be provided to the IACUC office before participants can perform procedures independently. For more information on Level III requirements see https://researchintegrity.asu.edu/training/animals/levelthree.

Total # of Animals:	**60**	
Species:	**Dogs**	**Pain Category: C**

Protocol Approval Period: **1/2/2018 – 1/1/2018**

Sponsor:	**N/A**
ASU Proposal/Award #:	**N/A**
Title:	**N/A**

Signature: [signature] for C.Shalley
IACUC Chair or ***Designee***

Date: 1/8/2018

Cc: IACUC Office
IACUC Chair