Evaluation of mediating and moderating effects on the relationship between owners' and dogs' anxiety: A tool to understand a complex problem

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ABSTRACT

Anxiety tends to aggregate in families, and families increasingly include companion animals, such as dogs. Based on previous research pointing to a 'personality fit' between humans and their companion dogs, this study explored the potential association between owners' trait anxiety and dogs' fear and anxiety-related behavior problems, while also testing for mediating and moderating factors. Two hypotheses previously proposed in the literature were here tested: that dogs may respond to their owners' anxiety directly through emotional contagion, or that owners' anxiety may affect dogs' indirectly via (a) owners' over-protectiveness - thereby restricting the dog's ability to familiarize itself with novel situations - or (b) their use of coercive dog-training methods. A cross-sectional approach was followed with use of an on-line questionnaire designed to measure owners' trait anxiety and dogs' fear and anxiety-related behavior problems, as well as owners' protective behavior, and dogs' emotional reactions to their owners' emotions (i.e., 'empathic trait'). Data were obtained from 1,172 self-identified dog owners. Results showed a significant positive correlation between owners' trait anxiety and the severity of their dogs' fear and anxiety-related behavior. No evidence was found for mediation of this relationship by owners' protective behavior or their use of coercive training methods. However, the results showed a marginally significant moderation effect above a particular score in dogs' 'empathic trait'. This study suggests that owners' trait anxiety is associated, to some extent, with the occurrence of dogs' fear and anxiety related behavior problems. The extent to which dogs exhibit an 'empathic trait' may explain the strength of this association.

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Introduction

Fear and anxiety are among the most fundamental emotions needed to survive or cope in potentially dangerous or harmful situations, in both humans and animals (Bateson, 2011). As highlighted in Tiira et al. (2016), fear is considered to be brief in duration, stimulated by specific stimuli, and usually results in active defense (fight or flight), whereas anxiety may be prolonged, does not necessarily have a specific focus, and is associated with anticipation of possible threats or harms in the future, particularly the near future. When dysfunctional, both fear and anxiety can become pathological. Indeed, fear- and anxiety-related disorders are among the most common behavior disorders in humans (Kessler et al., 2005). These disorders are also among the most common behavioral problems observed in domestic dogs (Overall et al., 2006; Sherman and Mills, 2008; Tiira et al., 2016).

Evidence shows that behavior problems related to fear and anxiety can lead to deleterious effects on canine health and lifespan

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(Dreschel, 2010; Mills et al., 2014). Moreover, they have also been shown to have negative effects on dog owners' well-being (Bradley and Bennett, 2015; Campbell et al., 2016). Understanding the factors that may contribute to the development of fear and anxiety-based problems in dogs is of major clinical relevance, both from the dogs' and the owners' perspectives (Mills et al., 2014; Dodman et al., 2018).

Recently, a growing interest in the veterinary literature has focused on the association between humans' personality traits (defined as behavioral predispositions that reflect a reliable behavioral responsiveness of a given individual across time and circumstances (Weger and Sandi, 2018)), and behavior problems in dogs (Jagoe and Serpell, 1996; Podberscek and Serpell, 1997; Turcsán et al., 2012; Konok et al., 2015; Dodman et al., 2018). For example, Dodman et al. (2018), using a convenience sample of 1,564 dog owners and an online battery of questionnaires, detected a number of significant associations between the presence and severity of dogs' behavior problems and owner personality traits. Notably, these authors showed that owners scoring high on neuroticism (i.e., owners who see themselves as anxious and easily upset) reported more fear and anxiety-related behaviors in their dogs, such as fear of strangers and separation-related urination.

The mechanism underlying the potential influence of owners' personality on their dogs' behavior problems has yet to be clearly identified. Based on studies showing an association between owners' use of positive punishment and/or confrontational or aversive methods of behavioral control and behavior problems in dogs (Rooney and Cowan, 2011), Dodman et al. (2018) hypothesized that the relationship between owner personality and the behavior of companion dogs might be mediated by the quality or style of the owner's interactions with the dog, particularly in the context of training. Their results provided little evidence in support of this hypothesis, suggesting that any potential influence of an owners' personality on his/her dog's behavior occurs via mechanisms other than training. For example, some dogs showing fear and anxiety-related behaviors might be responding 'empathically' (i.e., directly) to their owners' anxiety, or indirectly as a consequence of the owners' overprotectiveness, resulting in the dogs being inadequately socialized (Dodman et al. 2018).

According to most theoretical models, empathy encompasses three components: emotional contagion (i.e., the sharing of emotional states with others), the ability to recognize emotions in oneself and others, and the ability to take the perspective of another person (Pearson and de Waal, 2002; Derntl and Regenbogen, 2014). Studies show that dogs are sensitive to their owners' emotional states (Nagasawa et al., 2011; Albuquerque et al., 2016; Barber et al., 2016; Huber et al., 2017) and that emotional contagion between owners and dogs is possible (Silva and De Sousa, 2011; Custance and Mayer, 2012; Sümegi et al., 2014; Huber et al., 2017). Sundman et al. (2019) used measures of hair cortisol concentration (HCC) to demonstrate long-term synchronization in physiological stress levels between dogs and their owners. Dogs' HCC was unrelated to their own personality or overall levels of physical activity or training, but it was influenced by their owners' personality characteristics, suggesting that dogs mirror the stress levels of their owners (Sundman et al., 2019).

In human research there is some evidence that individuals with high trait anxiety may show hyper-responsiveness to moderately threatening or ambiguous, stimuli, and a negative affective bias in attention that facilitates the detection of threats and aversiveness (Hu & Dolcos, 2017; Weger & Sandi, 2018). There are data suggesting that anxious parents engage in more over-controlling parenting practices ('helicopter parents') and that this parental behavior increases child anxiety (Rapee, 1997; Chorpita and Barlow, 1998; Ginsburg and Schlossberg, 2002; Gouze et al., 2017; Ginsburg et al.,

2018). Given the documented similarities between child-directed and dog-directed parenting styles (Van Herwijnen et al., 2018), it is plausible that dog owners with high trait anxiety may be more protective and controlling of their dogs and limit their ability to familiarize with novel stimuli, thereby leading to dogs' fear and anxiety-related behavior problems.

In this work, we sought to explore the association between trait anxiety in owners and dogs' fear- and anxiety-related behavior problems (as reported by their owners). We further aimed to test the direct and indirect paths linking owners' trait anxiety to their dogs' behavior, as proposed by Dodman et al. (2018). Specifically, we tested i) a moderation model in which dogs' reactivity to their owners' emotions determines the strength of this link, and ii) a mediation model in which owners' trait anxiety causes anxiety in their dogs via overprotective behaviors and/or the use of coercive training methods. While the latter association was not supported by the findings of Dodman et al. (2018), we decided to include it here for the purposes of comparison and replication.

Materials and Methods

Recruiting participants

Participants in this study were Portuguese dog owners who completed an anonymous online questionnaire, hosted in a digital platform (Google forms) and advertised on social media platforms (Facebook and Instagram) from December 2018 to March 2019.

By clicking on the link to the questionnaire, subjects were led to an informed consent web page presenting a description of the study, referring to participants' anonymity in the sample and assuring them of using data only for scientific purposes. Inclusion criteria for study participation were also highlighted here: participants should be aged ≥ 18 years; live with the same dog for at least one year; and be the main guardian of that dog. Importantly to notice here, studies show that in both humans and animals, empathy is biased toward individuals who are more similar, familiar, or socially close (de Waal, 2002). Thus, the criterion "living with the same dog for at least one year", aimed at increase chances of capturing any potential effect of dogs' empathic trait.

Once subjects reached the bottom of this page, they were given the option of continuing on to the study questionnaire by clicking on an icon at the bottom of the page that read, "I fulfill all inclusion criteria for study participation and I consent to participate." Otherwise, subjects could decline to participate.

Procedure and study questionnaire

This study questionnaire included owner characterization (age, gender and trait anxiety) and identification of the number of dogs in the household. When participants owned more than one dog, they were asked to answer all subsequent questions relating to the dog to whom they perceived themselves to be more emotionally attached. The emphasis on strong emotional attachments aimed to increase the likelihood of including dog-owner dyads that were more responsive to each other's emotions, actions, and personality characteristics.

Dogs were characterized with respect to age, gender, neuter status, and breed. Owners were asked to complete a series of questions designed to measure: i) dogs' fear and anxiety related behavior problems, ii) owners' use of coercive training methods, iii) owners' protective behavior towards their dogs, and iv) dogs' emotional reactivity to their owners' emotions.

The questions and response options of the questionnaire can be found in Supplementary Materials.

Owners' trait anxiety

Owners' trait anxiety was assessed using the STAI-Trait Inventory, a widely used questionnaire to assess the stable propensity to experience anxiety and the tendency to perceive stressful situations as threatening (Spielberger et al., 1970). This questionnaire consists of 20 items rated on a 4-point Likert scale with total scores ranging between 20 and 80 (the higher the score, the more the individual is anxious).

Dogs' fear and anxiety related behavior problems

Dogs' fear and anxiety related behavior problems were assessed using 18 items from the C-BARQ questionnaire (Hsu and Serpell, 2003) (see Questionnaire in Supplementary Materials). The C-BARQ questionnaire is commonly used to assess the prevalence and severity of behavior problems in dogs using a series of 5-point Likert scales. A single fear and anxiety subscale was created by combining items from four factors in the C-BARQ (stranger-directed fear, dog-directed fear, non-social fear, and touch sensitivity; following Canejo-Teixeira et al. (2018)). The fear and anxiety score was calculated as the average of all of the item scores for these four factors combined (the higher the score, the higher the severity of dogs' fear and anxiety-related behavior problems reported by the owner). Cronbach's alpha for the combined items was 0.911, suggesting that this group of items could be used reliably to measure a single fear/anxiety construct in this population of dogs.

Owners' use of coercive training methods

Owners' use of coercive training methods was assessed using the Attitude to Training (ATT) scale developed by Dodman et al. (2018). This scale score is derived as the average of the ordinal rating scale responses to 8 items asking owners how often (on a 7-point Likert scale) they use a number of different techniques whenever they need to control or discipline their dog.

Owners' protective behavior towards their dogs

Owners' protective behavior towards their dogs was assessed using an original 15-item scale: the Dog Owner Protectiveness Scale (DOPS). To develop this scale, and given existing evidence for an analogy between human-child and owner-dog bonding (Walsh, 2009; Stoeckel et al., 2014), we adapted a measure of parental protective behaviors towards children age 2 to 10 years to the owner-dog relationship (the Parent Protection Scale (PPS; Thomasgard et al., 1995). The PPS consists of 25 items representing four facets of protective behavior: supervision, separation problems, dependence, and control. Items that could be adapted to situations dog owners encounter when raising their dogs were retained. Face validity of the selected items was appraised by a panel of experts (5 veterinarians and 5 researchers working in the field of human-animal bond) who were asked to review the items for format, clarity, and usefulness to assess owners' protective behavior toward their dogs. Modifications were made according to the panel's recommendations, when these were deemed to be important by the entire group of expert panelists. Two iterations of this process were required before items were subjected to further psychometric testing. A total of 18 items were pre-tested on six dog owners (3 females, 3 males; aged 41 ± 6 years) to detect possible ambiguities in the wording of questions. All items were measured on 4-point Likert scales, rating the likelihood of scenarios occurring as never (score 0), sometimes (1), most of the time (2), and always (3). After rephrasing some of the items, the DOPS was administered to a sample of 250 dog owners (147 females, 103 males; aged 39 ± 13 years) and an exploratory Principal Component Analysis (PCA) was performed on the resulting data. Any items exhibiting poor fit were eliminated. Poor fit was defined as any item that had a low communality score (< 0.40), did not load on any factor within a given section (< 0.40), or showed cross-loading on 2 factors (i.e., > 0.40 on more than 1 factor). Internal reliability analyses (Cronbach's alpha) were also used to select the final items to be retained. As a result, the final DOPS scale consisted of a total of 15 items.

Dogs' emotional reactivity to their owners' emotions

Dogs' emotional reactivity to their owners' emotions was assessed using a sub-scale from the Dog Emotional Reactivity Survey (Szánthó et al., 2017), labeled the Dog's Reactivity to the Owner's Emotions (DROE) scale. This sub-scale was adapted from a parental questionnaire developed by Rieffe et al. (2010), who measured empathy-related behavior in young children. The sub-scale consists of 7 items, rated on 4-point Likert scales, asking owners about their experiences with their dogs in emotionally loaded situations (e.g., My dog is frightened if I am afraid of something). The higher the score, the higher the dogs' emotional reactivity to the owner.

Data analysis

Basic data screening activities were performed prior to any analysis to ensure the accuracy and legibility of data entry and assess the normality of continuous variables. The data were also inspected for outliers (defined as values greater than 3.5 standard deviation units from the sample mean for a given variable). Univariate outlier analysis using box plots indicated the absence of univariate outliers for all the continuous variables. Internal consistency of all the scales (STAI: State-Trait Anxiety Inventory -Trait, ATT: Attitude to Training, DOPS: Dog Owner Protectiveness Scale, DROE: Dog Emotional Reactivity to the Owners' Emotions, and C-BARQ: Canine Behavioral Assessment and Research Questionnaire) was assessed using Cronbach's alpha coefficient. Descriptive statistics were used to describe the sample in this study. Bivariate correlations were conducted among the measures of primary interest: STAI-Trait scores, C-BARQ scores, DOPS scores, ATT scores, and DROE scores. Demographic variables were examined for their associations with the C-BARQ scores so as to identify potential covariates to be controlled for in the subsequent mediation and moderation analyses. All analyses were conducted using Statistical Package for Social Sciences (SPSS) for Windows version 22 (IBM Statistics) and statistical significance at an alpha level of 0.05 was used.

Mediation analysis

To test whether owners' trait anxiety has indirect effects on their dogs' fear and anxiety via the use of coercive training methods and/or protective behaviors, a parallel multiple mediation analysis was conducted using the Model 4 for mediation embedded in the PROCESS macro written for SPSS (Hayes, 2012). This method uses non-parametric bootstrapping analyses to split the relation between a predefined independent variable and an outcome variable into a direct effect and one or several indirect effects linking the independent variable to the outcome variable via one or several mediators operating in parallel (while controlling for covariates). In this study, owners' trait anxiety (STAI-Trait scores) was set as the independent variable affecting two mediator variables (owners' use of coercive training methods (ATT scores) and owners' protective behavior toward their dogs (DOPS scores)). Dogs' fear and anxiety-related behavior problems (C-BARQ scores) was set as the outcome variable affected by the two mediators. One

Table 1
Demographic characterization of the participants (N = 1172) and characteristics of their dogs.

	%	Median	Range
Owner gender	86.3 (female)		
Owner age		32	18-79
Dog gender	51.0 (female)		
Dog age		5	1-18
Dog neutered status	48.1 (spayed/neutered)		
Dog breed			
- purebred	43.1		
- crossbred	15.1		
- unknown/mixed breed	41.8		
N° of dogs in the household		1	1-14

Figure 1. Association between owners' trait anxiety (STAIT-Trait) and dogs' fear and anxiety related behavior problems (C-BARQ), and the mediating effects of owners' protection behavior towards their dogs (DOPS) and use of coercive training methods (ATT). Model statistics for the total effect model: $R^2 = 0.051$, $F(3, 1167) = 20.89$, $P < .001$. For the mediated model: $R^2 = .076$, $F(5, 1165) = 19.17$, $P < .001$. Unstandardized path coefficients marked with an asterisk identify 95% bootstrap confidence intervals which do not include zero and significant level ($P < 0.001$).

thousand bootstrap samples were used to assess 95% confidence intervals (CI) of the estimated effects. Evidence for mediation was obtained if the 95% confidence intervals for the indirect effects via the tested mediators excluded zero (Hayes, 2012).

Moderation analysis

To examine the potential moderating effect of dogs' emotional reactivity towards their owners' emotions on the observed association between dogs' fear and anxiety related behavior problems and owners' trait anxiety, a moderation analysis was conducted also using PROCESS macro for SPSS (Model 1; Hayes, 2012). Within this method, all continuous variables are mean centered prior to analysis. An interaction term is then created by multiplying the centered predictor variable by the moderator variable. The macro performs a series of OLS regression analyses to determine whether the interaction term increases the proportion of variance explained in the outcome variable (while controlling for covariates). It also provides estimates of the effects of the predictor variable at different values of the moderator variable. In this study, STAI-Trait scores were modelled as the predictor variable, C-BARQ scores as the outcome variable, and DROE scores as the moderator variable. Evidence for moderation was obtained if the addition of the interaction term significantly accounted for an increase in R^2 (Hayes, 2012).
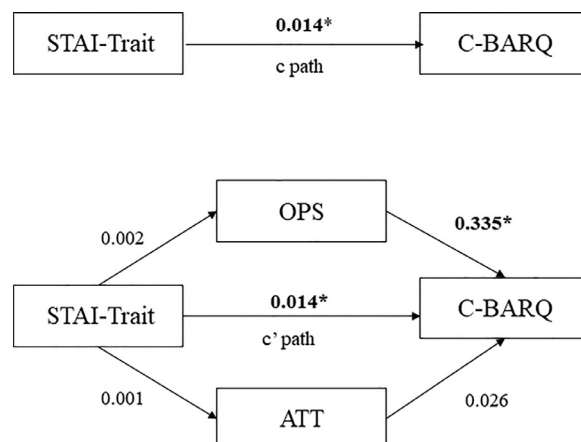
Results

Descriptive statistics, correlations and covariates

The demographic characteristics of the dog owners who completed the online questionnaire (N=1,172) are shown in Table 1. Data obtained for the respondents' dogs are also shown. Non-normally distributed variables are expressed as medians and ranges, and categorical variables are expressed as percentages.

Descriptive statistics and correlations among the measures of interest are presented in Table 2. Cronbach's alpha values for each scale used are also shown in Table 2. As expected, owners' trait anxiety (i.e., STAI-Trait scores) was found to be significantly (positively) correlated with dogs' fear and anxiety related behavior problems (i.e., C-BARQ scores). STAIT-Trait scores were also positively correlated with owners' attitudes to training (i.e., ATT scores) and owners' protective behavior toward their dogs (i.e., DOPS scores), although not significantly. ATT scores and DOPS were positively correlated with C-BARQ scores, but the correlation was only significant for DOPS scores. No significant correlation was found between ATT scores and any of the other study variables.

C-BARQ fear-anxiety scores did not differ significantly across dog gender or breed, nor were they associated with owner's age, dog's age or number of dogs in the household. C-BARQ fear-anxiety scores, however, differed significantly between neutered and non-

neutered dogs (Mann-Whitney test: $P < 0.01$). The median C-BARQ score of neutered dogs was 1.22 (range: 0-1.34), while the median C-BARQ score for non-neutered dogs was 1.05 (range: 0-3.67). Significant differences were also observed between male and female owners (Mann-Whitney test: $P < 0.01$). The median C-BARQ score for female owners was 1.22 (range: 0-3.67), and the median C-BARQ score for male owners was 1.00 (range: 0-3.11). These two variables (dog neuter status and owner gender) were entered as covariates in subsequent mediation and moderation analyses.

Mediation analysis

Results of the mediation analysis are shown in Figure 1. The total effect of owners' trait anxiety on dogs' fear and anxiety related behavior problems showed that a one unit increase in owners' trait anxiety related to an average 0.014 unit rise in dogs' fear and anxiety related behavior problems (95% CI [0.010, 0.019]).

The total indirect effect of owners' trait anxiety on dogs' fear and anxiety related behavior problems was 0.0005 (95% CI [-0.001, 0,0013], from which the indirect effect through owners use of coercive dog training was 0.0000 (95% CI [-0.0002, 0,0002] and through owners' protection behavior was 0.0005 (95% CI [-0.001, 0,0012]. Confidence intervals included zero suggesting no significant indirect effect.

When a ratio of indirect to total effect was performed, a value of 0.036 (3.6%) was obtained, providing evidence for a direct effect.

Moderation analysis

The hypothesized moderation model explained 20.3% of the total variance in C-BARQ scores (as a measure of dogs' fear and anxiety related behavior problems) ($R^2 = 0.203$, $F(6,1165) = 49.42$, $P < 0.001$). Results showed a marginally significant increase in R^2 as a function of the interaction term (R^2 change = 0.026, $F(1,1165) = 3.74$, $P = 0.053$; Table 3).

The Johnson-Neymann (JN) technique (Bauer & Curran, 2005; Hayes and Matthes, 2009) was used to characterize a potential moderator effect. The JN technique identifies points of transition along the continuum of the moderator between a statistically significant and nonsignificant effect of the independent variable. These points of transition define regions of significance: the range

Table 2

Medians, ranges, and Spearman correlation coefficients for all variables of interest in this study. Cronbach's alpha coefficients are also shown (in parentheses and on diagonal).

	Median	Range	C-BARQ	STAI-Trait	ATT	DOPS	DROE
C-BARQ	*1.21*	*0-3.67*	*(0.911)*				
STAI-Trait	*37*	*20-74*	*0.185**	*(0.930)*			
ATT	*0.86*	*0-3.14*	*0.020*	*0.010*	*(0.741)*		
DOPS	*1.7*	*0.5-3.0*	*0.377**	*0.079*	*0.028*	*(0.800)*	
DROE	*23*	*7-40*	*0.333**	*-0.005*	*-0.018*	*0.062*	*(0.715)*

* *P* < 0.01

Table 3

Results of the regression analysis testing the moderation model.

	B	SE	T	P	LLCI	ULCI
Constant	0.800	0.095	8.423	< 0.001	0.614	0.986
STAI-Trait	0.014	0.003	6.832	< 0.001	0.009	0.078
DROE	0.055	0.004	13.514	< 0.001	0.047	0.063
STAI-Trait x DROE	0.001	0.000	1.934	0.053	0.000	0.002
DOPS	0.022	0.004	5.950	< 0.001	0.015	0.030
Owners gender	-0.073	0.059	-1.229	0.219	-0.190	0.044
Dogs neuter status	-0.149	0.041	-3.675	<0.001	-0.229	-0.070

or ranges of the moderator where the independent variable is significantly related to the dependent variable and where it is not. The results of the JN analysis showed that the hypothesized effect of owner's trait anxiety on dogs' fear and anxiety transitioned in significance at a particular level of dogs' emotional reactivity to their owners' emotions: DROE score of 15.46 (b = 0.0076, P = 0.05, 95% CI [0.000, 0.0153]. At the highest recorded DROE score (40), a one unit increase in STAI-Trait scores relates significantly to an average 0.027 unit rise in C-BARQ scores (95% CI [0.0133 to 0.0413]).

Discussion

In line with previous studies pointing to a 'personality fit' between owners and their companion dogs (Podberscek and Serpell, 1997; Turcsán et al., 2012; Dodman et al., 2018), results obtained showed that owners scoring higher on trait anxiety (as measured by the STAI-Trait scale) reported higher fear and anxiety-related behavior problems in their dogs (as assessed by the C-BARQ). Interestingly, this result parallels observations in human research showing that anxiety aggregates in families (Schreier et al., 2008) and reinforces a broader concept of "family" that includes companion animals (Walsh, 2009).

Our results replicated previous findings (Dodman et al., 2018) that owners' use of coercive methods of training (as measured by the ATT scale) was not significantly associated with owners' reports of fear and anxiety-related behavior in their dogs. However, a significant association was detected between fear and anxiety-related behavior in dogs and owners' protective behavior (as measured by the DOPS). The higher the owners scored on the DOPS, the higher the intensity of fear and anxiety-related behavior displayed by their dogs. The positive association between owners' trait anxiety and protective behavior towards their dogs was also significant. These associations seemingly support the Dodman et al. (2018) suggestion that more anxious owners may be more protective of their dogs, which may lead to the development of dogs' fear and anxiety-related behavior problems. However, when a mediation analysis was performed, no evidence for an indirect effect via owners' protective behavior was found. Instead, owners' protective behaviors towards their dogs was significantly associated with fear and anxiety-related behavior in dogs, independent of owners' trait anxiety. The importance of examining dog owners "parenting" styles as a pathway for improving dog welfare (Van Her-

wijnen et al., 2018) is therefore corroborated by the observations of this study and calls for further attention. It is important to acknowledge, however, that the observed association between owners' protective behavior and their dogs fear and anxiety could also have resulted from owners adjusting their protectiveness according to their perception of the dogs' fearfulness. The vulnerability of their dogs, as perceived by the owners, might be worth exploring in future studies. In human research, it has been shown that children raised in an environment characterized by the combination of high perceived vulnerability and parental overprotectiveness may have very different outcomes owing to the disproportionate number and severity of stressors for both the child and the parents (Thomasgard and Metz, 1999). It would be interesting to know if a similar pattern of results would emerge in the context of dog-owner relationships.

Results from both the mediation and moderation analyses seem to support Dodman et al.'s (2018) alternative hypothesis that dogs respond to their owners' anxiety directly. Indeed, the mediation analysis revealed that almost 100% of the total effect of owners' trait anxiety on dogs' fear and anxiety was a direct effect. In addition, the moderation analysis pointed to a conditional effect of owners' trait anxiety on dogs' fear- and anxiety-related behaviors: i.e., above a particular threshold in dogs' emotional reactivity to their owners' emotions, the higher the dogs' 'empathic trait,' the stronger the association between owners' trait anxiety and dogs' behavior problems. This observation appears also to be in line with Sundman et al.'s observation of long-term stress level synchronization between dogs and their owners (Sundman et al., 2019).

Our study has limitations inherent to its methodology. First, we need to acknowledge that a relatively short questionnaire was used here (with the intention of increasing response rate (Beebe et al., 2010)), thus leaving out potentially relevant information. Information regarding the owner such as number of people in the household, housing conditions (e.g., apartment vs. house; or city center vs rural) was not obtained. Also information related to the dog, such as breed, origin, age at adoption time, time with the owner, health condition (such as underlying disease may affect behavior), behavioral history, clinical confirmation of the dog's 'problem'. Owners' ability to reliably assess their pets' behavior could be a further limitation of the current study. Previous work suggests that the internal consistency and both inter-rater and test-retest reliabilities of the C-BARQ fear/anxiety subscales fall within the accept-

able range (Duffy & Serpell, 2008; Duffy & Serpell, 2012; Jacuba et al., 2013), and numerous studies have confirmed their construct and predictive validity (e.g., Hsu & Serpell, 2003; DeMeester et al., 2008; Kato et al., 2012; Wormald et al., 2017; Clay et al., 2020). Reliability estimates for the DROE scale, however, were relatively low and its validity is unknown (Szánthó et al., 2017). Further research is therefore needed to confirm the DROE's ability to measure dog empathy accurately. Finally, those completing the questionnaire were self-selected and not a random sample of dog owners. Future research aimed at further exploring the results obtained here might consider assessing such variables.

The observational and cross-sectional nature of the methodology employed does not allow for conclusive considerations to be made on causality, a limitation of all associational studies. For example, more anxious owners may have chosen dogs with fearful/anxious traits. Also, one could argue that behavior problems in dogs may lead to anxiety in the owners and not vice versa. Indeed, and even though psychological traits tend to remain relatively stable and consistent throughout life, this study does not allow to establish a causality direction from owners' anxiety to dogs' anxiety rather than vice versa. As pointed out, the lack of information on the duration of behavioral problems in the dogs as well as the duration of ownership of the dog, prevents from assuming unidirectionality in the observed association between owners' trait anxiety and dogs' behavioral problems.

It is also important to highlight the low R^2 observed here, suggesting that the effect of some other important variable (or variables) was not captured by the tested models and needs consideration in future studies. Among these variables, future studies could consider exploring the dogs' genetic predisposition for behavioral problems, level of dogs' social exposure during maturation, and the occurrence of common stressful factors for both the dog and its owners. Also, it is worth noting that a dog may react more to an owner's *state* of anxiety (i.e., a transient reaction to an adverse situation) compared to his or her trait anxiety (i.e., a stable personality attribute) since an owner with high trait anxiety will not necessarily be experiencing a state of anxiety at all times. It may be important, therefore, for future observational studies to consider additional proxies of the actual anxiety levels experienced by owners. In line with this, the use of trait anxiety as the focal predictor in this study may help to explain the relatively small effects observed.

All data in this study was obtained from indirect, owner-reported assessments. Thus, one cannot entirely discard the possibility that the current findings merely reflect consistent biases in how anxious people evaluate their dogs' behavior. It seems implausible, however, that any biases or confounding effects could lead to the pattern of results obtained here, and most notably the moderation effect.

It is also worth noting that almost 90% of the participants in this study were women. Although gender differences have been identified for some aspects relating to human-animal interaction (Amiot and Bastian, 2015), this does not seem to be the case for certain aspects linked to the intimacy domain of the human-animal bond (e.g. self-disclosure; Evans-Wilday et al., 2018) and may thus not have affected our results substantially.

Conclusion

Our study provides evidence suggesting that owners' trait anxiety contributes to their dogs' fear- and anxiety-related behavior to some degree. In addition, this study improves our understanding of the path linking owners' trait anxiety and dogs' fear and anxiety related behavior problems. Specifically, the results suggest that dogs' 'empathic trait' (i.e., emotional reactivity to owners' emo-

tions), above a particular threshold, may explain the strength of the observed association between owners' and dogs' anxiety.

From a clinical perspective, the results of this study emphasize the importance of the dog-owner dyad when addressing behavior problems in dogs. An implication of such an approach is that identifying dogs' fear and anxiety-related behavior may also draw attention to particular psychological conditions in the owners. Interestingly, this is also the approach associated with the One Health concept which embraces collaborative efforts of multiple disciplines working together to attain optimal health for people, animals, and the environment (Gibbs, 2014). Dogs are increasingly involved in human emotional contexts and are trained to support people with physical and psychological disorders. Further studies are crucial if these animals' needs are to be met, as well as our obligations to them (Glenk et al., 2014; Pirrone et al., 2017; Carvalho et al., 2019). Moreover, it might prove valuable for such studies to be combined with experimental approaches adapting methods used in human research, such as the one by Waters et al. (2017), exploring physiological resonance of affective states in mother-child dyads. These authors demonstrated how acute parental psychological stress may be taken up by their infants and also what can be done to exacerbate or attenuate affect transmission. Such results have important implications for chronically stressed families and warrant extension to such populations. Similarly, in veterinary research, it seems of utmost importance to further explore the potential implications of owners' psychological traits (and disorders) on the welfare of both companion *and* assistance dogs.

Ethical statement

The procedure followed in this study did not involve treatments or interventions in the life of respondents or their dogs. The questionnaire was not repeated, meaning it did not interfere significantly with normal daily life and did not include questions that were psychologically stressful. Also, the filling of the questionnaire was anonymous and so this study does not violate respondents' privacy. This exempts the study from approval of higher ethics committees (according to the guidelines of our institutional review board (Comissão de Ética CHUP/ICBAS).

Conflict of Interest

The authors declare no conflict of interest.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jveb.2021.03.004.

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