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Detection of owner-perceived emotional eating in companion dogs. A regression modeling approach.

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ABSTRACT

Background

Emotional eating has been largely demonstrated in humans and laboratory rodents, but a recent survey conducted by the authors revealed that dog owners have also detected this phenomenon in their pets. However, due to the lack of diagnostic tools, veterinarians and researchers might encounter serious difficulties in detecting emotional eating in clinical settings. The present study aimed to explore different variables associated with owner perceived-emotional eating in companion dogs with the ultimate goal of designing a tool that could facilitate its detection.

Methods

The mentioned survey included information on feeding habits, eating behaviour, temperament and emotional state of the dogs, as well as a specific question for assessing the owners' perception on emotional eating. From these data, a stochastic model based on binary logistic regression was used to design a regression model.

Results and Conclusion

The final model (r2=0.179, p<0.001) included a constant and 9 variables and, of these, 5 did act as risk factors whereas the rest were considered as protective factors, in line with a congruent clinical perception.

These variables could make up an easy-to-respond 9-item checklist to be answered by dog owners that could help veterinarians identify those companion dogs susceptible to emotional eating.

KEYWORDS: dog, behaviour, emotional eating, emotions, predictive model, owners.

INTRODUCTION

A relationship between negative emotional states or stress and changes in the eating behaviour has been largely demonstrated in both humans and laboratory animals, and it is referred to as “emotional or stress-induced eating”.(1-4) In humans, the cause of emotional eating is considered to be multifactorial, including genetic, sociocultural and psychological influences, some of them related to the early feeding experiences.(5) To date, there are no clinical studies aimed at identifying causes for emotional eating in canine species, but the French literature has defined bulimia in dogs as an increased food intake due to an emotional disorder, with a link to states of either permanent anxiety or chronic depression.(6)

Emotional eating has important implications in obesity in both humans and laboratory rodents,(2, 7-9) and it would make sense to think that it could be also a contributing cause for obesity in pet dogs. This means that emotional eating, obesity and canine welfare may be closely related in various ways, as pointed out by McMillan.(10) First, it has been proposed that emotional stress should be included among the possible causes of obesity in a dog, and consequently, obesity should be considered as a warning signal for compromised canine welfare, not only for the physical limitations but also for the potential emotional underlying cause.(10) Second, if these emotionally affected animals go under food restriction due to obesity, they may be deprived of a way to cope with a negative emotional state, and this would have consequences in both accomplishment of diet programs and the dog’s welfare.(10) Beyond obesity implications, emotional eating in companion animals by itself is an interesting phenomenon to be investigated in relation with the way of coping with stress in dogs, especially in those suffering from behaviour problems. In fact, a recent study conducted by the authors observed changes in the ghrelin and cortisol response to the administration of palatable food in dogs

showing different chronic stress related problems such as separation anxiety and owners-directed aggression. In particular, the study suggested a parallel meal-induced decrease in both cortisol and ghrelin in dogs with separation anxiety, but not in dogs with social conflict aggression directed to the owners, pointing towards a failure to suppress ghrelin (and cortisol) after intake in the latter.(11)

In the area of animal health, epidemiology brings us useful information to establish prevention and control measures. The use of theoretical models in epidemiology can be a practical tool for disease research where experimentation and field observations are very complex due to the existence of multiple factors related to animal welfare, time, money, etc.(12) In particular, mathematical modelling allows the study of complex phenomena such as psychological concepts and risk factors for psychopathologies.(13) In this sense, emotional eating in dogs could be investigated by using this methodology.

Emotional eating, a relatively novel concept in veterinary behaviour medicine, needs a better characterization and useful tools to make its detection easier and more accurate. While emotional eating has not been empirically demonstrated in companion dogs, a previous study by the authors showed that the 82.7% of the surveyed owners perceived that their dog showed emotional eating at some level of intensity. In this study, the fact of showing emotional eating was associated to different issues related to feeding habits, eating behaviour and emotional state of the studied dogs, as it is explained hereafter. For instance, a high score for emotional eating was associated with feeding the dog "exclusively with home-made food", "once a day", and "giving extras as a reward for obedience", as well as with a dog being "dependent" and "unhappy", and "not eating during the absence of the owner". On the other hand, "being a calm dog" and not showing "fear (to other dogs)" or "aggression problems" was associated with the absence of emotional eating.(14) The present study was aimed to explore different

variables associated with owner perceived-emotional eating in companion dogs by means of a regression model with the ultimate purpose of designing a tool that facilitate the detection of this phenomenon at the clinical setting.

MATERIALS AND METHODS

The study was approved by the regional Ethical Committee of Clinical Research of Aragón (CEICA). This committee did not require the inclusion of an informed consent in the survey, as no personal data were collected.

Recruiting data

Prior to the development of the model, a data analysis was performed based on a previous questionnaire conducted in 1099 dog owners.(14)

The questionnaire was published online in Spanish using commercially available software (Google questionnaires, Google, USA) from December 2015 to January 2016 and was distributed via social media and via e-mail to clients attending the Behavioural Service of the Veterinary Hospital of the University of Zaragoza as well as in an online social network (Facebook).

The questionnaire included 43 questions grouped into four main sections: (a) General information (breed, age, sex, reproductive status, body condition, medical problems and treatments, duration of walks and exercise intensity); (b) Feeding habits (type of food, patterns of feeding and administration of extras); (c) Eating behaviour and related problems (time to finish the meal, voracity, changes in eating behavior in the absence of owners, signs of aggression related to food protection and other eating-related problems); and (d) Temperament (shyness, nervousness, dependency and affection) and emotional state (quality of life and happiness, and behavioral problems such as

nervousness -in the sense of excitability-, separation-related problems, fear of social stimuli and noises, and aggression toward other dogs or humans). The questionnaire included a specific question for assessing the perception of owners on emotional eating in their dogs followed by a concise explanation: “To what extent is your dog´s eating behaviour related to his/her emotional state? Rate from 0 to 4 to what extent the way your dog eats (more or less quantity, more or less voracious…) is related to changes in his/her emotional state (sad, nervous, scared, stressed…), where 0 means “Not related at all” and 4 means “Closely related”. From this questionnaire, several variables were obtained in order to design the mathematical model.

Development of the regression model

A stochastic model based on logistic regression was used as it provides insight into the relationship between a qualitative dependent variable and one or more explanatory independent variables or covariates.(13) This model allows estimating the probability of the outcome using equation 1 (see below), considering one or more independent variables (x1, x2…xn).

$$(y)=e\beta 0+\beta 1\cdot x1+\cdots+\beta n\cdot xn/(1+e\beta 0+\beta 1\cdot x1+\cdots+\beta n\cdot xn) \text{ (Eq. 1)}$$

Using the coefficients β of the model, it is possible to estimate the odds ratios (OR) corresponding to the independent variables. The OR represents the odds that an outcome will occur given a particular exposure. If the OR is higher than 1, it means that there is a higher odd of property B happening with exposure to property A, and the variable is considered to be associated with the outcome (risk factor), whereas an OR lower than 1 is considered to be a protective factor.

The regression model was developed twice. In the first approach, variables were introduced as they were, dichotomic or not. In the second approach, non-dichotomic dependent and independent variables of the model were transformed into dichotomic

142 ones, with the aim of simplifying the model and a binary logistic regression model was
143 developed. The collinearity between the different variables was checked by means of a
144 chi-square test, and independence between variables was confirmed.

145 All statistical analyses and the development of the logistic regression model were
146 carried out with IBM SPSS 19.0 for Windows, and alpha error (p) was set at 0.05.

147

148 **RESULTS**

149 To design the regression model, "emotional eating" was defined as the outcome
150 (dependent variable), with possible answers from 0 to 4. The rest of variables, defined
151 as the independent ones, were introduced in the model as they were initially questioned
152 (mainly in scales from 0 to 4). The independent variables introduced in the first step of
153 the model are included in Table 1.

154 Table 1. Variables introduced in the first step of the model.

Variables	Type
General information	
• Age	Continuous
• Gender	Binary
• Reproductive status	Binary
• Diagnosed illness	Binary
• Pharmacological treatment	Binary
• Knowledge about ideal weight	Binary
• Body condition score	Ordinal
• Daily walk	Continuous
• Intensity of daily exercise	Ordinal
Feeding habits	
• Homecooked/Commercial food/Both	Categorical
• Wet/Dry food/Both	Categorical
• Pattern of administration	Binary
• Frequency of administration	Ordinal
• Extra food	Binary
• Type of extra food	Categorical
• Frequency of extra food	Ordinal
• Situations of extra food	Categorical
Eating behaviour and related problems	
• Voracity with habitual food	Ordinal
• Voracity with palatable food	Ordinal
• Time for finishing the ration	Continuous

• Changes in eating behaviour in the absence of owners	Categorical
• Food protection aggression	Binary
• Food stealing	Ordinal
• Pica	Ordinal
• Emotional eating	Ordinal
Temperament and emotional state	
• Shyness	Ordinal
• Excitability	Ordinal
• Dependency	Ordinal
• Affection	Ordinal
• Behaviour problems	Binary
• Professional help	Categorical
• Excitability with toys	Ordinal
• Excitability with food	Ordinal
• Excitability at the greetings	Ordinal
• Excitability during walks	Ordinal
• Separation anxiety	Ordinal
• Fear to noises	Ordinal
• Fear to people	Ordinal
• Fear to dogs	Ordinal
• Aggression towards familiar people	Ordinal
• Aggression towards unknown people	Ordinal
• Aggression towards dogs	Ordinal
• Happiness	Ordinal
• Quality of life	Ordinal

According to this first model approach, the backwards stepwise method finally included 9 statistically significant variables (r^2=0.198, p<0.001) with a 10.7% of lost cases (Table 2).

Table 2. Variables included in the first regression model.

Variables	**β**	***p***	**OR**	**LCI**	**UCI**
Constant	1.679	0.298	5.362		
Treats at the owner's discretion (1)	-0.522	0.004	0.593	0.416	0.847
Changes in eating behaviour in the absence of owners (0 -Ref-)		0.001	1.000		
(1)	0.406	0.308	1.501	0.688	3.275
(2)	-0.669	0.047	0.512	0.265	0.991
(3)	-0.865	0.147	0.421	0.131	1.355
(4)	-0.962	0.313	0.382	0.059	2.480
Shyness (0 -Ref-)		0.035	1.000		
(1)	0.418	0.161	1.519	0.846	2.728

(2)	0.078	0.766	1.081	0.648	1.801
(3)	0.8	0.006	2.226	1.264	3.921
(4)	0.159	0.607	1.172	0.639	2.151
Consulting a veterinarian specialist in behaviour medicine (1)	-0.597	0.012	0.551	0.345	0.878
Excitability with food (0 -Ref-)		<0.001	1.000		
(1)	1.026	<0.001	2.791	1.636	4.759
(2)	1.179	<0.001	3.250	1.911	5.526
(3)	1.137	<0.001	3.117	1.776	5.471
(4)	0.815	0.012	2.260	1.193	4.281
Excitability during walks (0 -Ref-)		<0.001	1.000		
(1)	1.385	<0.001	3.996	2.013	7.931
(2)	1.51	<0.001	4.528	2.387	8.587
(3)	1.406	<0.001	4.080	2.079	8.008
(4)	1.65	<0.001	5.208	2.372	11.435
Aggression (1)	0.543	0.003	1.722	1.196	2.478
Happiness (1)	-2.306	0.043	0.100	0.011	0.932
Quality of life (0 -Ref-)		0.005	1.000		
(1)	-3.979	0.067	0.019	0.000	1.325
(2)	0.427	0.707	1.532	0.166	14.112
(3)	-0.141	0.9	0.869	0.096	7.843

Ref: reference value; LCI: lower confidence interval; UCI: upper confidence interval.

In a second approach, both the dependent and independent variables of the model were transformed into dichotomic and the same process of model development was repeated. To this end, variables were recoded according to clinical criteria, as follows:

- Emotional eating (dependent variable): 0 score was maintained as 0 (no emotional eating) and 1, 2, 3 and 4 scores were recoded into 1 (any level of emotional eating).

- Changes in the eating behaviour in the absence of the owners: dogs that ate less or even nothing in the absence of the owner were recoded into 0, and dogs that ate the same, more or only in the absence of the owner were recoded into 1.
- Shyness: 0, 1 and 2 scores were recoded into 0 (meaning average to bold temperament) and 3 and 4 scores were recoded into 1 (meaning shy temperament).
- Excitability with food: 0 score was maintained as 0 (not showing excitability with food) and 1, 2, 3 and 4 scores were recoded into 1 (showing some level of excitability with food).
- Excitability during walks: 0 score was maintained as 0 (not showing excitability during walks) and 1, 2, 3 and 4 scores were recoded into 1 (showing some level of excitability during walks).
- Quality of life: very bad, bad and good scores were recoded into 0 (meaning not optimal) and very good was recoded into 1 (meaning optimal).

Table 3 summarizes the recoding process from non-dichotomic into dichotomic variables.

Table 3. Recodification process of the variables from non-dichotomic into dichotomic ones.

Variable	**Non dichotomic variable**		**Dichotomic variable**		**Criteria for recoding**
	Score	**n**	**Value**	**n**	
Emotional eating	0-Not related at all	205	0	205	The detection of affected individuals at risk from an "all or nothing" approach.
	1	159	1	932	
	2	306			
	3	284			
	4-Closely related	183			
Changes in the eating behavior in the absence of the owners	Never eating without owners	114	0	351	The inhibition of food intake in the absence of the owner as a sign of separation anxiety.
	Eating less without owners	237			
	Eating the same with/without owners	746	1	786	

	Eating more without owners	32			
	Only eating without owners	8			
Shyness	0-Nothing at all	209	0	713	The predisposition to fear/anxiety related problems in individuals with shy temperament.
	1-Below average	190			
	2-On average	314			
	3-Above average	274	1	424	
	4-Very high level	150			
Excitability with food	0-Not at all	163	0	163	The predisposition to food-related behavior problems (e.g., resource guarding) in individuals that get excited during feeding.
	1	272	1	974	
	2	318			
	3	242			
	4-A lot	142			
Excitability during walks	0-Not at all	73	0	73	The predisposition to walk-related behavior problems (e.g., reactivity toward other dogs, runners or noises) in individuals that get excited outdoors.
	1	219	1	1064	
	2	403			
	3	301			
	4-A lot	141			
Quality of life	Very bad	7	0	435	A perceived quality of life other than optimal (i.e. very good) may not warrant the proper meeting of dog´s mental and physical needs.
	Bad	5			
	Good	423			
	Very good	702	1	702	

This second approach improved the regression model, as the level of significance of the variables was higher (i.e., *p* was lower*)* and only a 7.4% of cases were lost. The final model (r^2=0.179, p<0.001) also included 9 variables and a constant (Table 4). In this case, however, "happiness" was not significant and so, it was removed, but then "diagnosed illness" was included in the new model.

Table 4. Variables included in the final regression model.

Variables		**β**	***p***	**OR**	**LCI**	**UCI**
Constant		0.190	0.644	1.209		
Diagnosed illness	(0 -Ref-)					
	(1)	0.518	0.038	1.679	1.086	2.769
Treats at the owner's discretion	(0 -Ref-)					
	(1)	-0.512	0.004	0.599	0.419	0.827

Changes in eating behaviour in the absence of owners	(0 -Ref-)					
	(1)	-0.962	<0.001	0.532	0.319	0.769
Shyness	(0 -Ref-)					
	(1)	0.451	0.016	1.754	1.226	2.469
Consulting a veterinarian specialist in behaviour medicine	(0 -Ref-)					
	(1)	-0.632	0.006	0.382	0.257	0.590
Excitability with food	(0 -Ref-)					
	(1)	1.061	<0.001	1.569	1.098	2.264
Excitability during walks	(0 -Ref-)			Ref		
	(1)	1.392	<0.001	2.890	1.906	4.435
Aggression	(0 -Ref-)					
	(1)	0.562	0.002	4.022	2.238	7.048
Quality of life	(0 -Ref-)					
	(1)	-0.536	0.006	0.585	0.388	0.822

LCI: lower confidence interval; UCI: upper confidence interval.

DISCUSSION

The aim of the present study was to design a regression model to detect variables associated with the owner perception of emotional eating in dogs based on data from a previously published larger questionnaire.(14)

Predictive models in veterinary science usually obtain higher r^2 than that obtained in this study (r^2=0.179). Nevertheless, it is important to mention that models based on people's opinion are frequently rated with lower values for r^2. For instance, in those models aimed at predicting human behaviour, it is entirely expected that r2 values are much lower than 50%. The results obtained in this work can be therefore considered as a proper rate according the source of information (i.e. dog owners' opinion), even if it is quite low. Furthermore, the variables included in this model can be also considered appropriate since they can be well understood and properly assessed by the owners. Interestingly, a part of the variables did act as risk factors (i.e. those that make more

likely to develop emotional eating) whereas others might be considered as protective factors (i.e. those that make less likely to develop emotional eating). Taking into account the multifactorial etiology of emotional eating in humans, these factors may help to identify possible causes for emotional eating in dogs. In particular, risk factor variables were being diagnosed with an illness, being shy and excitable with food and during walks and showing aggression problems. On the other hand, eating in the absence of owners, giving treats at the owner's discretion, consulting to the veterinarian specialist when behaviour problems occur as well as having an optimal quality of life, were considered as protective factors. Both risk and protective factors were reasonable and congruent with clinical perception as discussed below, even if they should be explored in deep to be better understood in relation to emotional eating.

Painful conditions and limitations of the mobility, drugs administration or variations in the diet as a consequence of an illness are some of the situations that modify the dog's life and can mean stress or emotional concerns for the animal.(15, 16) This might affect eating behaviour, as previously observed in other species,(10) but also influence the owner's perception by increasing the dogs monitoring as a consequence of an increased awareness about the animal health. Indeed, in a previous study by the authors, the fact of the dogs suffering from a medical disease was related to a high owner perception of emotional eating.(14) In this sense, it is probable that owners of diseased dogs do not consider their quality of life as optimal (very good), in contrast to owners of healthy dogs. This statement, however, contrasts with the study by Wojciechowska and colleagues(17) that did not find differences in the quality of life scores given by the owners of sick and healthy dogs.

Behaviour problems, especially when long-lasting, are considered an important welfare concern.(18-21) In fact, some forms of aggression, separation anxiety and phobias are

usually classified as anxiety-related problems.(22) Dogs suffering from these problems may be predisposed to show emotional eating, as it occurs in human and laboratory animals, even this has to be further explored.(10) According to the present work, showing aggression problems might increase the risk for emotional eating detection, and this may be explained by the state of chronic stress linked to these problems. In fact, a previous study has reported higher plasma cortisol levels in dogs showing aggression problems, especially toward the owners, than in non-aggressive dogs. (23) Moreover, another recent study by the authors showed that dogs displaying owners-directed aggression showed a failure to suppress ghrelin levels after the intake of food and, consequently, to decrease cortisol,(11) similarly to that observed in so called "emotional eaters" in humans.(24)

Excitability with food and during walks, which could be commonly considered as unruly behaviours, might however underlie a more serious problem such as lack of self-control and hyperexcitability,(22, 25) and this condition may also predispose to emotional eating. Eating (or not to change eating behaviour) during the absence of the owner, on the opposite, was considered as a protective factor and it might indirectly suggest the absence of separation anxiety problems.(26)

Interestingly, the fact of visiting a specialist in behaviour medicine was also a protective factor, suggesting that behaviour treatment might effectively achieve an alleviation of anxiety signs and reduce stress consequences, either by means of pharmacological and non-pharmacological (i.e. behaviour therapy) interventions,(22, 25, 27) and this might turn into a decreased perception of emotional eating in treated dogs.

Finally, a temperament trait, shyness, emerged as a risk factor for perceived-emotional eating. It is possible that being a shy dog may predispose the individual to develop behaviour problems such as fears.(28) Indeed, in the previous study by the authors, not

being fearful or aggressive toward social stimuli was related with the absence of emotional eating.(14)

Giving the dog treats without any particular reason, just when the owner wants to, appeared paradoxically as a protective factor in the regression model. Thus, the fact of administering food without a specific criterion (for instance, as a reward for obedience training) may be considered as a lack of consistence during dogs handling and training. In this line, providing structure and consistency in the household through enhanced communication and predictable social interactions around resources has been previously considered to substantially reduce conflict and anxiety and, therefore, stress.(29) However, other possible arguments may explain this practice of administering treats at the owner's discretion, including making regular food more attractive but also expressing affection toward their dogs.(30, 31) In this sense, treats have been recognized as an integral component in the relationship between dogs and owners.(32) Kienzle and colleagues(33) already noted that owners of obese dogs tended to interpret their dogs' needs as a request for food, and feeding was considered for the owners as a handy and agreeable form of communication and interaction with the dog. Considering this, it is possible that those owners that give dogs treats for no apparent reason, *just* to express affection and communicate with their dogs, consider their dogs "happy" and therefore less likely to suffer from emotional eating.

All of the previous results suggest that the perception of emotional eating in dogs may be more easily detected when paying attention to a number of specific situations, here converted into variables, with some of them acting as risk factors and the others as protective factors. Detecting these factors may help veterinarians identify those companion dogs more susceptible to emotional eating and therefore to start-up the appropriate treatment measures. But, conversely, the detection of emotional eating in

278 dogs may also be useful to alert on an animal suffering from an undetected illness or
279 experiencing stress or a lack of welfare due to behaviour problems, such as being shy,
280 excitable or aggressive.

281 During mathematical model development, it is important to obtain a balance between
282 simplicity and realism. If the model is designed in a way that accurately represents the
283 real existence of a condition and all its possible influencing factors, the result can be so
284 multifaceted that it is impossible to find all the parameters contained in it, or the
285 algorithm is not efficient enough to perform the computations in a reasonable time. In
286 contrast, if the model is too simple, it may represent a scenario far away from reality.
287 The most difficult point is the determination of the function of the model, and the most
288 important aspect necessary to make this possible is to properly identify the factors or
289 variables that will be considered. Another difficulty during model development is to
290 dispose of sufficient and detailed data to validate the model.(34) In the present study,
291 these objectives were achieved, obtaining a model with 9 variables that may help detect
292 perceived-emotional eating in dogs. Even the first version of the model showed a
293 slightly higher r^2 value than the second one, the latter was established as the most
294 appropriate as it made the model simpler.

295 The present study has a number of limitations, especially with respect to the inherent
296 subjectivity of respondents when answering a survey. Although each question was
297 carefully formulated, and some were accompanied by an explanation, it is possible that
298 some owners did not fully understand some questions. In addition, the r^2 value, although
299 within the normal values expected for models based on people's opinion, could be
300 raised by increasing the number of participants.

301 The present study shows that there are a number of variables related to emotional eating
302 in dogs according to their owners' opinion. These variables could be turned into an

easy-to-respond 9 items check-list to be answer by dog owners that could help veterinarians identify those companion dogs more susceptible to emotional eating. Moreover, these results provide a first-line tool for researchers to deep in the study of emotional eating in dogs. Nevertheless, future studies should be carried out to show the accuracy of the regression model in detecting this phenomenon in canine species.

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CONFLICT OF INTEREST STATEMENT:

The authors declare that no conflicts of interest exist in any financial, personal or other relationships with other people or organizations within the years of beginning the submitted work that could inappropriately influence, or be perceived to influence, the work.

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