

Short communication

Evaluation of Maine Coon cat's behavior during three different management situations

Simona Cannas^{1*}, Silvana Mattiello¹, Monica Battini¹, Sara Irene Ingrassia¹, Delia Cadoni¹, Clara Palestrini¹.

¹Dipartimento di Medicina Veterinaria, Università degli Studi di Milano, Via Celoria 10, 20133, Milano, Italy

***Corresponding author**

Dipartimento di Medicina Veterinaria, Università degli Studi di Milano, Via Celoria 10, 20133, Milano, Italy

Tel : +390250318033

E-mail address: simona.cannas@unimi.it

Abstract

Today, cats are one of the most widespread and beloved companion animals: they share their life with people and are perceived as social partners by their owner. The knowledge and understanding of cat-human communication and of the behavior exhibited in response to different emotions is essential to improve the management of housed cats. The aim of this study is to analyze and compare the behavior of cats in three different situations that can occur in house cats' lives. Ten Maine Coon cats, four males and six females, ranging in age from one to 13 years, belonging to a single private owner and managed under the same conditions, were exposed randomly to three different contexts for five minutes (Waiting for food, Isolation in unknown environment and Brushing). All the situations were video-recorded and subsequently analyzed. Oriented to environment, oriented to food bowl, locomotion, active interactions, yawning, lip licking & swallowing and salivation are behaviors mainly characterizing Waiting for food, while Isolation appears principally characterized by behaviors like hiding, scratching, worried positions and exploration. Withdrawal, passive interactions, aggressive behaviors, facial discomfort and purring are the behaviors that mainly mark out the Brushing. Vocalizations were significantly more frequent during Isolation and Brushing than during Waiting for food, but it is possible that the characteristics of the vocalizations in these two situations are different. Our principal finding is that cats showed different behavioral patterns in the three situations and, in particular, their behavior during Brushing was very different than in the two other situations. It can be hypothesized that these different behavioral responses are due to the different emotional states elicited by each of the three challenging and potentially stressful situations. Further investigation is being carried out in order to better understand cats' behaviors and emotions to improve cats' management in the household.

Keywords: cat behavior, cat management, human-animal relationship

Introduction

Today, cats are one of the most widespread and beloved companion animals: they are ubiquitous, share their life with people and are perceived as social partners by their owner (Karsh and Turner, 1988). Cats became highly adaptable to different habitats and showed signs of neoteny (Budiansky, 2003), but the biological origins of the cat's sociability remain obscure (Bradshaw, 2016a).

There is evidence that besides showing intra-specific communication not present in other solitary felids (Bradshaw and Cameron-Beaumont, 2000), cats establish strict and complex relationships with their owners, showing a great level of adaptability and flexibility to them (Bradshaw, 2016a; Mertens, 1991; Turner, 1991).

Cats recognize their owners' voices distinguishing them from other human voices (Saito and Shinozuka, 2013) and react to unfamiliar and familiar humans differently (Casey and Bradshaw, 2008), even if some researches reported that there is a great variability among cats showing preferences and/or attachment to owner (Podberscek et al., 1991; Potter and Mills, 2015; Vitale and Udell, 2019). Cats' social behavior is very flexible and appears to be influenced by the life experience (Vitale and Udell, 2019).

The cat-owner relationship appears to fulfil the behavioural criteria for an attachment bond (Edwards et al., 2007) and cats showed referential looking towards their owner when exposed to a potentially stressful situation (Merola et al., 2015).

Despite this, cats are considered inscrutable and their relationship with humans is considered weaker than the one with dogs, since dogs appear to their owner more able to feel complex emotions in contrast to cats (Kuroshima et al., 2017; Martens et al., 2016). The presence of a high level of mutual understanding and shared emotions is suggested between humans and dogs (Bekoff, 2006), but not between humans and cats. Furthermore, compared to dogs, cat behavior, welfare and cognition have received less attention in research, so far (Vitale Shreve and Udell, 2017, 2015; Walker et al., 2014).

It is plausible that behavior that originally evolved to facilitate bonds among cats might then have become adapted to improve the relation with humans; the modalities for the interspecific communication are visual, tactile and auditory (Bradshaw, 2016a). Moreover, there are many different cats' behaviors that are learned to communicate with owners in response to human cues and rewards (Bradshaw et al., 2012; Bradshaw, 2016a). So, the great flexibility and adaptability of domestic cats in the interactions with their owners are due to two processes: first, species-typical actions are conformed should be able to acquire different meaning through associative learning,

and second, species-typical signals are changed little in meaning to redress the differences in physical size between humans and cats (Bradshaw, 2016a).

In conclusion, cats are able to modify their species-typical communication signals to facilitate information sharing with the people that they live with (Bradshaw, 2016a), but how this happens and how it affects the cat-human interactions and relationship are still largely unknown.

Since most behavioral studies on cats are conducted in laboratories, shelters or on free-ranging feral cat colonies, we know little about the typical domestic cat behavior (Bernstein and Friedmann, 2014). The typical environment for domestic cats is arguably the household; so it is important to know the behavior of psychologically healthy cats in this environment to improve their management.

The aim of this study is to analyze and compare the behavior of cats in three different situations (Waiting for food; Isolation in unknown environment; Brushing) that can occur in house cats' life and that may represent a challenge for the cat, in order to highlight the adaptation mechanisms to these potentially stressful situations.

Materials and methods

Subjects

Ten Maine Coon cats, three spayed males, one intact male, three spayed and three intact females, ranging in age from one to 13 years, were recruited for the present study. All cats belonged to a single private owner and were housed and managed under the same conditions. The cats lived together since they were born or since the age of 3 months and eight of them were related. All cats were fed *ad libitum* with "Royal Canin Sensible" dry cat food and twice a day with "Cosma Nature" canned cat food (at about 7:00 a.m. and 7:00 p.m.). All cats were brushed monthly since kittenhood in order to maintain healthy fur conditions. All the subjects were used to the pet carrier since kittenhood and entered spontaneously through the front door when it was open. The carrier was made of a durable plastic with a steel-wire front door. All the cats were also used to be transported outside the home by car (inside the pet carrier) about once a year to go to the vet or during holiday.

Experimental context

Each cat was exposed randomly to three different contexts for five minutes:

- Waiting for food: the owner started the normal routine operations that precede food delivery in the home environment, and food was actually delivered five minutes after the start of these routine operations;

- Isolation in unknown environment: the cat was put in its pet carrier and transported by its owner to an unknown environment (a room in a different apartment), at a distance of about five minutes walking from the home environment. At the arrival, the owner opened the pet carrier (the same carrier for all the cats enrolled) and left the cat free to roam in the room (if it wanted) for 30 min to recover from transport. During this 30-minute period, the owner remained with the cat. After that the cat was left alone in the room for five minutes;
- Brushing: the owner brushed the cats in their home environment for five minutes.

The exposure to each experimental context was repeated thrice for each cat, at one-month interval.

Data collection

The behavior of each cat during the three repetitions of the three situations was video-recorded using a Panasonic HDC-SD60 camcorder. During the contexts “Waiting for food” and “Brushing” an operator recorded the situation to obtain the best framing of the animal, whereas during “Isolation” the camera was installed in the room where the cat was left alone and the owner turned on the camera immediately before leaving the room. Each videotape session was subsequently analyzed by two trained observers using Solomon® software with a focal animal continuous recording method (Martin and Bateson, 1993), in order to describe cats’ behaviors and body postures. Twenty-one behavioral categories were identified and recorded as duration of occurrence or frequency (Table 1). Many categories were mutually exclusive (e.g. Aggressive Behavior, Grooming, Exploration) whereas others could be presented at the same time (e.g. Vocalization and Locomotion). In order to assess inter-observer reliability, the two observers independently scored a random sample of 9-videotaped sessions (30% of the videos), for a total duration of 45 min of observation. The reliability was calculated by means of percentage agreement and Spearman’s correlation.

Table 1. Definition and unit (duration or frequency) of each behavioral category (and relative abbreviations)

BEHAVIORAL CATEGORY	DEFINITION	MEASUREMENT UNIT
Active interaction with people - AI	Any behaviour performed when interacting with the owner and or other people including active physical contact, sniffing, rubbing, close visual inspection and gentle oral examination, such as licking.	DURATION
Aggressive behavior - AG	Any aggressive behavior towards the owner, including hissing, scratching, bites and bite attempts.	DURATION

Facial Discomfort - FD	Facial expression showing discomfort like ears flattened and back against the cats head, mydriasis and blinking the eyes while sitting, standing or lying down (the head does not rest on the ground)	DURATION
Exploration -EX	Motor activity directed toward physical parts of the environment (e.g. movement towards an object while looking at it and /or sniffing, gentle oral examination, such as licking, etc.)	DURATION
Grooming - GR	Cleaning the body surface by licking, nibbling, picking, rubbing, scratching, etc., directed towards the animal's body (self-grooming)	DURATION
Hiding - HD	Hiding	DURATION
Locomotion -LO	Walking around without exploring the environment	DURATION
Not Visible - NV	Not visible: the cat goes out from the visual field of the camera (during these periods, activities like vocalizing, scratching, chewing, could be identified and recorded by the sound of the activity)	DURATION
Oriented to the Environment - OE	Sitting, standing or lying down (the head does not rest on the ground) with obvious orientation toward the physical or social environment, including sniffing, close visual inspection, distant visual inspection (vigilance or scanning)	DURATION
Oriented to the Food bowl - OF	Obvious orientation toward the food bowl, including sniffing, close visual inspection, distant visual inspection (vigilance or scanning)	DURATION
Passive Interactions -PI	Sitting, standing or lying down during owner interaction or manipulation (brushing included)	DURATION
Purring - PU	Purring	DURATION
Rubbing- RU	Rubbing on owner or on people	DURATION
Scratching - SC	All active behaviors resulting in physical contact with the cage/door to solicit attention, including scratching the cage/door with the paws, jumping on the cage/door, handling with the forelimbs	DURATION
Twitching tail - TT	Repetitive wagging movements of the tail	DURATION
Vocalizations - VO	Any form of vocalization, including: meowing, moaning, mewing, etc.	DURATION
Withdrawal - WH	Avoiding interaction with the owner by either running, moving away, very clearly turning away or looking away, also during brushing.	DURATION
Worried positions - WP	Positions showing a worried emotion, like a crouching positions (the body is lowered in to a crouched position during movements or in a static way), lowered position of tail close to the body	DURATION
Lip Licking - LL	Part of the tongue is out of the mouth and moved along the upper lip	FREQUENCY
Swallowing & Salivation - SW+SL	Swallowing and/or salivation	FREQUENCY
Yawning - YA	Yawning	FREQUENCY

Table 2. Behavioral categories that are mutually exclusive: categories in the same line are mutually exclusive.

AI, AG, EX, GR, HD, LO, NV, OE, OF, PI, SC, RU, WH	Mutually exclusive
FD	
LL, PU, SW+SL, VO, YA	Mutually exclusive
TT, WP	Mutually exclusive

Statistical analysis

Data were entered into Microsoft Excel (Microsoft Corporation, 2010, Washington, DC, USA), before being analyzed with SPSS statistical package (SPSS Statistic 25, IBM, Armonk, NY, USA). We preliminarily calculated the percentage of overall time engaged in each behavioural category out of the total observation time. In order to describe the duration and frequency for each behavior, a descriptive analysis was initially performed. The percentages were not normally distributed and were then submitted to non-parametric analysis of variance (Mann-Whitney Test) in order to highlight differences between sexes and repetitions and between each couple of situations. A multivariate statistical analysis, Principal Component Analysis (PCA), was used to explore the relationships among variables and their loading on the distribution of the observations, classed according to the three contexts (Waiting for food, Isolation and Brushing).

Results

The agreement between observers was good (always more than 87%, Spearman's $Rho = 0.983$, $p < 0.001$).

Neither univariate nor multivariate analysis pointed out any differences among repetitions and between sexes in the three situations; hence all the data were analyzed together, disregarding the effect of sex and repetition.

The average percentage of time (\pm standard deviation) that cats dedicated to each behavior in each situation is reported in Table 3.

During Waiting for food, cats spent most of their time being oriented to the environment (41.87%) and 13.61% being oriented to the food bowl, whereas during Isolation cats tended to hide (20.76%) and be oriented to the environment (20.27%) for most of the time, and during Brushing they showed principally passive interaction (70.11%), with statistical differences among situations for the above mentioned behaviors. Withdrawal (12.12%) and aggressive behavior (11.87%) were

exhibited only during Brushing. Vocalizations were significantly more frequent during Isolation (3.84%) and Brushing (3.43%) than during Waiting for food (1.23%) (Tab. 3 and Fig. 1). Average frequencies for yawning, lip licking and swallowing & salivation were significantly higher during Waiting for food compared to the other two situations (Fig. 2).

PCA reveals two main components whose Eigen values are greater than 1, which together explained 31.32% of the variation (19.06% and 12.26% of explained variance for PC 1 and PC 2, respectively).

The first component shows positive loadings for the behaviors like oriented to environment, oriented to food bowl, locomotion, rubbing, active interactions and swallowing & salivation, and negative loadings for withdrawal, passive interactions, aggressive behaviors, facial discomfort and purring (Fig. 3). The second component shows positive loadings for yawning, lip licking, facial discomfort, twitching tail, vocalization and grooming, and negative loadings for exploration, hiding, scratching and worried position. The three situations tend to form separate clusters (Fig. 4):

Brushing tends to cluster on the negative side of PC 1, with higher values associated with behaviors such as withdrawal, passive interactions, aggressive behaviors, facial discomfort and purring.

Isolation tends to cluster on the negative side of PC 2, with higher values associated with behaviors like hiding, scratching, worried positions and exploration. Waiting for food tends to spread between PC 1 and PC 2 on the positive side, with higher values associated with behaviors like oriented to environment, oriented to food bowl, locomotion, active interactions, yawning, lip licking and swallowing & salivation.

Discussion

Aim of this study was to analyze and compare the behavior of cats in three different challenging situations (Waiting for food; Isolation in unknown environment; Brushing) that can normally occur in house cats' life, in order to highlight the cat's perception and subsequent behavioral adaptation mechanisms to these potentially stressful situations and consequently improve the management of cats in the household.

The cat's behavior was consistent across situations over the period of months, as shown by the lack of significant differences among the three repetitions: this suggests that an interval of one month between repetitions was sufficient to prevent habituation.

Our principal finding is that cats show different behavioral patterns in the three situations and, in particular, their behavior during Brushing is very different than in the two other situations (Isolation

and Waiting for food). It can be hypothesized that these different behavioral responses are due to the different emotional states elicited by each of the three challenging and potentially stressful situations.

When an animal is faced with a change to its environment, it will perceive such change through various sensory systems and will experience a particular feeling (often referred to as an emotional state or mood) that can be manifested both behaviorally and psychologically (Mills, 2016).

There are many different types of events that a cat may perceive as distressing and they seem to give rise to distinct emotional responses associated with specific emotional systems (Mills, 2016), and therefore to different behavioral reactions.

Withdrawal, passive interactions, aggressive behaviors, facial discomfort and purring are the behaviors that mainly characterize the Brushing. Experiences that are interpreted to be either pleasurable or distressing may also be accompanied by purring vocalizations. Purring may also function as a contact and care-soliciting signal, possibly derived from its presumed function in the neonate. So, while purring is usually interpreted as indicating pleasurable circumstances (Fermo et al., 2019), cats may purr when they are ill or in pain, pointing out a negative valence of this vocalization (Beaver, 2003; Rochlitz, 2009). Brushing cat hair is important to aerate the fur, to remove dead hair and to untie the knots that can cause pruritus and skin tightness. Cats groom themselves to maintain a healthy skin and they need to be habituated being brushed starting from young age. In our sample, behaviors exhibited by cats during brushing suggest that this situation does not elicit positive emotions, in spite of the fact that the owner habituated these subjects to be regularly brushed since kittenhood. In fact, cats can react to brushing in a positive (Bradshaw, 2016a) or in a negative manner (Nicastro and Owren, 2003), not only because of habituation, but also depending on individual predisposition and characteristics. Moreover, it is possible that the owner's brushing style (e.g. rough, too fast), or if the cats were brushed only when they already had knots in their fur, influenced the cats' reaction, leading them to dislike brushing. This behavior could therefore be the result of the specific interaction of this owner with her cats, and may not be generalizable to cats in other households. Nevertheless, it could be recommended to habituate the cat since kittenhood being brushed, but it is important to evaluate the reaction of the single cat to this manipulation, stopping it when cat shows the first signs of distress and eventually to limit it just to the essential need.

Beaver (2003) describes the behavior of adult cats before feeding: pre-meal behaviors are directed at the owners as both vocalizations and directed behaviors. A cat will approach with its tail up; it

may also rub on the owner and any other object. In our results, oriented to environment, oriented to food bowl, locomotion, active interactions, yawning, lip licking & swallowing and salivation are behaviors mainly characterizing Waiting for food. Some of these behaviors indicate an intention of request and interaction to obtain food, and some (such as yawning, lip licking and swallowing & salivation) are related to a condition of stress/anxiety/fear (Carney and Gourkow, 2016; Casey, 2002; Notari, 2009; Palestini, 2009; Palestini et al., 2017). According to some authors, fear has similar signs of distress to those elicited by frustration (Jakovcevic et al., 2013). Frustration appears if a needed resource is unreachable and Waiting for food is therefore potentially related to a state of frustration. In fact, by definition, frustration arises when an individual is unable to access immediately something it wants (Mills, 2016). It is possible that in our results, due to the waiting time, the cats' behavior was held by frustration for the delay in giving food instead of its request. In order to prevent or decrease cat frustration while waiting for food, it can be suggested that cat caretakers should prepare food in a different room or prepare food immediately before serving it. Isolation appears characterized by behaviors like hiding, scratching, worried positions and exploration. For a cat, security appears to arise mainly from confidence and familiarity in its environment and territory. In highly social species such as dogs, security also comes from a dependence on other individuals inside the group and is not clear if this occurs also in adult cats, which naturally lead more solitary lives than dogs (Mills, 2016). Domestic cats' ability to establish social relationships with humans evolved in parallel with their capacity to form long lasting relationships with another cat (Bradshaw, 2016b). During isolation, cats probably experienced distress, and therefore exhibited behaviors that show a state of discomfort and insecurity, principally due to a lack of confidence and familiarity to the environment, but maybe also to the separation from their owner. Separation anxiety is a problem behavior described in cats (Borchelt and Voith, 1996; Erny et al., 2015; Overall, 2013a; Schwartz, 2002) but data regarding its epidemiology are weak as opposed to the dog, where separation anxiety is reported with a high prevalence (Bamberger and Houpt, 2006; Blackwell et al., 2013; Cannas et al., 2018b; Horwitz, 2009; Martínez et al., 2011; Overall et al., 2001; Palestini et al., 2010; Tiira et al., 2016; Yalcin and Batmaz, 2007). A behavioral sign that is probably related to seeking human attention is the emission of vocalizations, that is in fact more frequent in this situation than in the others. The miaow in particular is more common in human-cat interactions than in the intraspecific ones (Rochlitz, 2009). Separation anxiety is one of the diagnosis reported in feline behavioral medicine (Cannas et al., 2018a; Horwitz, 2009; Overall, 2013b) underling a social relationship with humans and suggesting

the presence of affectionate social relationship or bond of cats with owners.

In our results, isolation represents a stressful situation for the cat that could be due to the lack of confidence and familiarity with the environment and to the separation from the owner. This thought encourages pondering over two concepts regarding the welfare of the cat. The first one regards the popular belief that the cat can stay alone at home for many hours without implication for its welfare (Bernstein, 2005). Little is known about how cats are affected by being alone at home (Eriksson et al., 2017). Actually, regardless of the environmental enrichment used to help the cat cope when alone at home for many hours, it is important to wonder if it is ethologically and, from a welfare point of view, correct to keep a cat in a house without sufficient contact and interaction with humans.

The second point to think about regards the separation of cat and owner in a new environment, like a cat boarding facility or a veterinary clinic during routine procedures or hospitalization. It could be interesting to further investigate whether the presence of the owner in certain moments could help the cat to cope in certain stressful situations. For example, in case of hospitalization of the cat, frequent visits may help the cat to cope with the new environment, whereas in case of a cat boarding facility it may be useful to spend some time with the cat before leaving it.

In PCA the two situations, Isolation and Waiting for food, are less separated than Brushing; this may be due to the fact that the emotional states and the resulting behaviors are not mutually exclusive: distress can arise from a blending of activation of different emotional systems (Mills, 2016) and in the same situation two emotional states can cohabit. For example, a cat that is waiting to receive the food bowl from the owner can experience a level of frustration (the denial of access to food) and a level of distress. In our sample cats showed in the same situation different behaviors that are the expression of different emotional states; moreover some of these behaviors and the related emotions are present in both the two situations, Waiting for food and Isolation.

To conclude, in our results Brushing appears really different from the other two situations (Isolation and Waiting for food) in term of behaviors and emotions. Moreover, vocalizations are emitted more frequently during Isolation and Waiting for food, in which we suppose that the underlining emotions are anxiety and attachment-loss. During Waiting for food, cats probably vocalized to seek the attention from the owner, whereas during Isolation this could be an et-epimeletic behavior to obtain the reunion with the owner (Houpt, 2005). We can hypothesize that the characteristics of the vocalizations in the two situations are different. Further investigation is being carried out in order to identify the characteristics of the sounds (in terms of intensity, frequency, duration, etc.) and to

understand if these characteristics are related to specific emotional states and emission contexts.

It is important to highlight that our results arise from cats living in the same household; this could be an advantage for the standardizations of data collection but also a limit for the variability of the possible responses. We are working to enforce the research, increasing the number of subjects coming from different households and different owners.

The results of the present research will provide preliminary information to better understand the cats' behaviors and emotions in some situations and to support the interpretation of vocalization analysis.

Acknowledgements

The authors would like to thank Professor Emanuela Pratoprevide for her support in drafting the project.

The present research was carried out with the financial support of the University of Milan (LINEA2SMATT_2017_AZB).

Conflict of interest statement

The authors of this paper do not have a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

Ethical statement

The present project was approved by the Organism for Animals Welfare of the University of Milan (approval n. OPBA_25_2017). The challenging situations were conceived considering potentially stressful situations that may occur in cats' life and to which cats can usually easily adapt. In order to minimize possible stress reactions, preliminary information on the normal husbandry practices (e.g. brushing or transportation) to which the experimental cats were submitted and on their normal reactions to these practices were collected by interviews to the owners. The information collected did not point out any possibility of excessive reactions of cats in one of the planned situations, and therefore all the cats were included in the trial. No signs of excessive stress were ever recorded in any of the challenging situations, all of which could therefore be completed.

Authorship statement

The idea for the paper was conceived by Simona Cannas, Clara Palestini and Silvana Mattiello. The experiments were designed by Silvana Mattiello, Monica Battini, Simona Cannas and Clara Palestini.

The experiments were performed by Simona Cannas, Sara Irene Ingraffia, Delia Cadoni.

The data were analyzed by Simona Cannas and Silvana Mattiello.

The paper was written by Simona Cannas, Silvana Mattiello and Clara Palestini.

References

- Bamberger, M., Houpt, K.A., 2006. Signalment. *Javma* 229, 1591–1601.
- Beaver, B.V. 2003. *Feline Behavior. A guide for Veterinarians*. Saunders. St. Louis
- Bekoff, M., 2006. *Animal Passions and Beastly Virtues: Reflections on Redecorating Nature*. Temple, Philadelphia.
- Bernstein, P., Friedmann, E., 2014. Social behaviour of domestic cats in the human home. In: Turner, D., Bateson, P. (Eds.), *The Domestic Cat: The Biology of Its Behaviour*. Cambridge, pp. 71–80.
- Blackwell, E.J., Bradshaw, J.W.S., Casey, R.A., 2013. Fear responses to noises in domestic dogs: Prevalence, risk factors and co-occurrence with other fear related behaviour. *Appl. Anim. Behav. Sci.* 145, 15–25.
- Borchelt, PL., Voith, V., 1996. Elimination Behavior Problems in Cats. In: Voith, V., Borchelt, PL (Eds.), *Readings in Companion Animal Behavior*. Veterinary Learning Systems, Trenton, pp. 179–189.
- Bradshaw, J., 2016a. Sociality in cats: A comparative review. *J. Vet. Behav. Clin. Appl. Res.* 11, 113–124.
- Bradshaw, J., 2016b. What is a cat, and why can cats become stressed or distressed. In: Ellis, S., Sparkes, A. (Eds.), *ISFM Guide to Feline Stress and Health. Managing Negative Emotions to Improve Feline Health and Wellbeing*. International Cat Care, Tisbury, Wiltshire, pp. 19–29.
- Bradshaw, J., Cameron-Beaumont, C., 2000. The signaling repertoire of the domestic cat and its undomesticated relatives. In: Turner, D., Bateson, P. (Eds.), *The Domestic Cat: The Biology of Its Behaviour*. Cambridge University Press, Cambridge.
- Bradshaw, J., Casey, R., Brown, S., 2012. *The Behaviour of the Domestic Cat*. CAB International, Wallingford, UK.
- Budiansky, S., 2003. *The Character of Cats: The Origin, Intelligence, Behavior and Stratagems of Felis silvestris catus*. Phoenix, Orion Books Ltd, London.
- Cannas, S., Casavecchia, M., Mazzola, S., Palestini, C., 2018a. Characteristics of cats submitted to behavioral examination: A retrospective study. *Veterinaria* 32.
- Cannas, S., Talamonti, Z., Mazzola, S., Minero, M., Picciolini, A., Palestini, C., 2018b. Factors associated with dog behavioral problems referred to a behavior clinic. *J. Vet. Behav.* 24.
- Carney, H., Gourkow, N., 2016. Impact of stress and distress on cat behavior and body language. In: Ellis, S., Sparkes, A. (Eds.), *ISFM Guide to Feline Stress and Health. Managing Negative*

- Emotions to Improve Feline Health and Wellbeing. International Cat Care, Tisbury, Wiltshire, pp. 31–39.
- Casey, R., 2002. Fear and stress in companion animals. In: Horwitz, D., Mills, D., Heath, S. (Eds.), *BSAVA Manual of Canine and Feline Behavioural Medicine*. British Small Animal Veterinary Association, Gloucester, pp. 144–153.
- Casey, R.A., Bradshaw, J.W.S., 2008. The effects of additional socialisation for kittens in a rescue centre on their behaviour and suitability as a pet. *Appl. Anim. Behav. Sci.* 114, 196–205.
- Edwards, C., Heiblum, M., Tejeda, A., Galindo, F., 2007. Experimental evaluation of attachment behaviors in owned cats. *J. Vet. Behav. Clin. Appl. Res.* 2, 119–125.
- Erny, D., De Angelis, A.L.H., Jaitin, D., Wieghofer, P., Staszewski, O., David, E., Keren-Shaul, H., Mahlakoiv, T., Jakobshagen, K., Buch, T., Schwierzeck, V., Utermöhlen, O., Chun, E., Garrett, W.S., McCoy, K.D., Diefenbach, A., Staeheli, P., Stecher, B., Amit, I., Prinz, M., 2015. Host microbiota constantly control maturation and function of microglia in the CNS. *Nat. Neurosci.* 18, 965–977.
- Fermo, J.L., Schnaider, M.A., Pescatori Silva, A.H., Forte Maiolino Molento, C., 2019. Only When It Feels Good: Specific Cat Vocalizations Other Than Meowing. *Animals*, 9 (11), 878; <https://doi.org/10.3390/ani9110878> (registering DOI)
- Horwitz, D.F., 2009. Separation-related problems in dogs and cats. In: Horwitz, D., Mills, D. (Eds.), *BSAVA Manual of Canine and Feline Behavioural Medicine*. British Small Animal Veterinary Association, Gloucester, pp. 146–158.
- Houpt, K., 2005. *Domestic Animal Behavior*, 4th ed. Wiley-Blackwell.
- Jakovcevic, A., Elgier, A., Mustaca, A., Bentosela, M., 2013. Frustration behaviors in domestic dogs. *J. Appl. Anim. Welf. Sci.* 16, 19–34.
- Karsh, E., Turner, D., 1988. The human–cat relationship. In: Turner, D., Bateson, P. (Eds.), *The Domestic Cat: The Biology of Its Behaviour*. Cambridge University Press, Cambridge, pp. 159–177.
- Kuroshima, H., Hori, Y., Arahori, M., Takagi, S., Fujita, K., Chijiwa, H., 2017. Owners’ view of their pets’ emotions, intellect, and mutual relationship: Cats and dogs compared. *Behav. Processes* 141, 316–321.
- Martens, P., Enders-Slegers, M.J., Walker, J.K., 2016. The emotional lives of companion animals: Attachment and subjective claims by owners of cats and dogs. *Anthrozoos* 29, 73–88.
- Martin, P., Bateson, P., 1993. *Measuring Behaviour: An Introductory Guide*, 2nd ed. Cambridge

University Press, Cambridge.

- Martínez, Á.G., Santamarina Pernas, G., Diéguez Casalta, F.J., Suárez Rey, M.L., De la Cruz Palomino, L.F., 2011. Risk factors associated with behavioral problems in dogs. *J. Vet. Behav. Clin. Appl. Res.* 6, 225–231.
- Merola, I., Lazzaroni, M., Marshall-Pescini, S., Prato-Previde, E., 2015. Social referencing and cat–human communication. *Anim. Cogn.* 18, 639–648.
- Mertens, C., 1991. Human-cat relationship in the home setting. *Anthrozoos* 4, 214–231.
- Mills, D., 2016. What are stress and distress, and what emotions are involved? In: Ellis, S., Sparkes, A. (Eds.), *ISFM Guide to Feline Stress and Health. Managing Negative Emotions to Improve Feline Health and Wellbeing*. International Cat Care, Tisbury, Wiltshire, pp. 7–18.
- Nicastro, N., Owren, M.J., 2003. Classification of Domestic Cat (*Felis catus*) Vocalizations by Naive and Experienced Human Listeners. *J. Comp. Psychol.* 117, 44–52.
- Notari, L., 2009. Stress in veterinary behavioural medicine. In: Horwitz, D., Mills, D. (Eds.), *BSAVA Manual of Canine and Feline Behavioural Medicine*. British Small Animal Veterinary Association, Gloucester, pp. 136–145.
- Overall, K., 2013a. *Manual of clinical behavioral medicine for dogs and cats*. Elsevier, St. Louis, MO.
- Overall, K., 2013b. *Manual of Canine and Feline Behavioral Medicine*. Elsevier Inc, St. Louis, MO.
- Overall, K.L., Dunham, A.E., Frank, D., 2001. Frequency of nonspecific clinical signs in dogs with separation anxiety, thunderstorm phobia, and noise phobia, alone or in combination. *J. Am. Vet. Med. Assoc.* 219,(4), 467–473.
- Palestrini, C., 2009. Situational Sensitivities. In: Horwitz, D., Mills, D. (Eds.), *BSAVA Manual of Canine and Feline Behavioural Medicine*. British Small Animal Veterinary Association, Gloucester, pp. 169–181.
- Palestrini, C., Calcaterra, V., Cannas, S., Talamonti, Z., Papotti, F., Buttram, D., Pelizzo, G., 2017. Stress level evaluation in a dog during animal-assisted therapy in pediatric surgery. *J. Vet. Behav.* 17.
- Palestrini, C., Minero, M., Cannas, S., Rossi, E., Frank, D., 2010. Video analysis of dogs with separation-related behaviors. *Appl. Anim. Behav. Sci.* 124.
- Podberscek, A., Blackshaw, J., Beattie, A., 1991. The behavior of laboratory colony cats and their reactions to a familiar and unfamiliar person. *Appl. Anim. Behav. Sci.* 31, 119–130.
- Potter, A., Mills, D.S., 2015. Domestic cats (*Felis silvestris catus*) do not show signs of secure

- attachment to their owners. PLoS One 10, 1–17.
- Rochlitz, I., 2009. Basic requirements for good behavioural health and welfare in cats. In: Horwitz, D., Mills, D. (Eds.), BSAVA Manual of Canine and Feline Behavioural Medicine. British Small Animal Veterinary Association, Gloucester, pp. 35–48.
- Saito, A., Shinozuka, K., 2013. Vocal recognition of owners by domestic cats (*Felis catus*). Anim. Cogn. 16, 685–690.
- Schwartz, S., 2002. Separation anxiety syndrome in cats: 136 cases (1991–2000). Javma 7, 1028–1033.
- Tiira, K., Sulkama, S., Lohi, H., 2016. Prevalence, comorbidity, and behavioral variation in canine anxiety. J. Vet. Behav. Clin. Appl. Res. 16, 36–44.
- Turner, D., 1991. The ethology of the human–cat relationship. Schweiz Arch Tierheilk 133, 63–70.
- Vitale, K.R., Udell, M.A.R., 2019. The quality of being sociable: The influence of human attentional state, population, and human familiarity on domestic cat sociability. Behav. Processes 158, 11–17.
- Vitale Shreve, K.R., Udell, M.A.R., 2015. What’s inside your cat’s head? A review of cat (*Felis silvestris catus*) cognition research past, present and future. Anim. Cogn. 18, 1195–1206.
- Vitale Shreve, K.R., Udell, M.A.R., 2017. Stress, security, and scent: The influence of chemical signals on the social lives of domestic cats and implications for applied settings. Appl. Anim. Behav. Sci. 187, 69–76.
- Walker, J.K., Waran, N.K., Phillips, C.J.C., 2014. The effect of conspecific removal on the behaviour and physiology of pair-housed shelter dogs. Appl. Anim. Behav. Sci. 158, 46–56.
- Yalcin, E., Batmaz, H., 2007. Signalment Factors, Comorbidity in Behavior Diagnoses in Dogs in Bursa Region, Turkey (2000 - 2004). Acta Vet. Brno 76, 445–450.

Table 3. Means percentage (\pm Standard Deviation) of overall time engaged in each behavioral category in the three situations (different superscripts in the same row indicate significant differences: a, b, c = $P < 0.05$; A, B, C = $P < 0.01$).

SITUATIONS						
BEHAVIORAL CATEGORY	Waiting for food		Isolation		Brushing	
	Mean	SD	Mean	SD	Mean	SD
Exploration	3.28 ^A	10.87	13.24 ^B	12.70	0 ^C	0
Locomotion	16.16 ^A	12.16	4.74 ^B	10.13	0.17 ^C	0.54
Hiding	0.04 ^A	0.21	20.76 ^B	37.24	0.18 ^A	0.84
Withdrawal	0.82 ^A	2.01	0 ^B	0	12.12 ^C	9.23
Active Interactions	4.65 ^A	9.21	0 ^B	0	0.20 ^{BC}	0.63
Passive Interactions	2.33 ^A	5.73	0 ^B	0	70.11 ^C	15.64
Oriented to Environment	41.87 ^A	21.56	20.27 ^B	16.49	1.35 ^C	3.91
Oriented to Food bowl	13.61 ^A	12.29	0 ^B	0	0 ^B	0
Aggressive behavior	0 ^A	0	0 ^A	0	11.87 ^B	11.45
Twitching Tail	3.16 ^A	5.83	0 ^B	0	2.63 ^A	4.47
Vocalizations	1.23 ^A	2.46	3.84 ^{AB}	9.81	3.43 ^B	5.78
Purring	0	0	0	0	0.44	1.56
Grooming	0.75 ^a	2.60	0 ^b	0	0.86 ^{ab}	4.02
Scratching	0.16	0.63	1.08 ^a	2.88	0 ^b	0
Rubbing	2.03 ^A	4.92	0.06 ^B	0.32	0 ^B	0
Facial Discomfort	0.08	0.43	0 ^a	0	0.49 ^b	1.54
Worried Positions	1.05 ^a	2.87	1.24 ^A	3.08	0 ^{bB}	0

Figures caption

Figure 1. Means percentage (\pm Standard Deviation) of overall time engaged in the most representative behavioral category in the three situations (different superscripts indicate significant differences: a, b, c = $P < 0.05$; A, B, C = $P < 0.01$).

Figure 2. Average frequencies (\pm Standard Deviation) of behaviors shown by cats during the three situations: Waiting for food, Isolation and Brushing.

Figure 3. Loadings plot of the behavioral variables on the first (PC 1) and second (PC 2) principal components. EX, exploration; LO, locomotion; HD, hiding; WD, withdrawal; AI, Active interactions; PI, passive interactions; OE, oriented to environment; OF, oriented to food bowl; AG, aggressive behaviors; TT, twitching tail; VO, vocalizations, PU, purring; GR, grooming; SC, scratching; RU, rubbing; LL, Lip Licking; YA, Yawning; SW+SL, Swallowing & Salivation; FD, facial discomfort; WP, worried positions.

Figure 4. Score plot of cats on the first (PC 1) and second (PC 2) principal components, classed according to the three situations: Waiting for food, Isolation and Brushing.