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CICLO XXXI

Secondary emotions in non-primate animals: experimental assessment of jealous behavior in pet dogs (*Canis familiaris*)

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ODA AL PERRO (Pablo Neruda)

El perro me pregunta
y no respondo.
Salta, corre en el campo y me
pregunta
sin hablar
y sus ojos
son dos preguntas húmedas,
dos llamas
líquidas que me interrogan
y no respondo,
no respondo porque
no sé, no puedo nada.
A campo pleno vamos
hombre y perro.
Brillan las hojas como
si alguien
las hubiera besado
una por una,
suben del suelo
todas las naranjas
a establecer
pequeños planetarios
en árboles redondos
como la noche, y verdes,
y perro y hombre vamos
oliendo el mundo, sacudiendo el
trébol,
por el campo de Chile,
entre los dedos claros de
septiembre.
El perro se detiene,
persigue las abejas,
salta el agua intranquila,
escucha lejanísimos ladridos,
orina en una piedra
y me trae la punta de su hocico,
a mí, como un regalo.
Es su frescura tierna,
la comunicación de su ternura,
y allí me preguntó
con sus dos ojos,
por qué es de día,
por qué vendrá la noche,
por qué la primavera
no trajo en su canasta nada
para perros errantes,
sino flores inútiles,
flores, flores y flores.
Y así pregunta
el perro
y no respondo.
Vamos
hombre y perro reunidos
por la mañana verde,
por la incitante soledad vacía
en que sólo nosotros
existimos,
esta unidad de perro con rocío
y el poeta del bosque,
porque no existe el pájaro
escondido,
ni la secreta flor,
sino trino y aroma
para dos compañeros,
para dos cazadores
compañeros:
un mundo humedecido
por las destilaciones de la
noche,
un túnel verde y luego
una pradera,
una ráfaga de aire anaranjado,
el susurro de las raíces,
la vida caminando,
respirando, creciendo,
y la antigua amistad,
la dicha
de ser perro y ser hombre
convertida
en un solo animal
que camina moviendo
seis patas
y una cola
con rocío.

ABSTRACT

Jealousy is a secondary emotion with clear adaptive functions in maintaining and protecting social relationships and bonds. In the human psychological literature, it has been defined as a context-dependent emotion that requires a social triangle and arises when one individual perceives that an intruder is threatening an important relationship. It is crucial for fitness in humans, appearing early in infancy in absence of sexual interest and before the maturation of self-consciousness, suggesting the possibility that it could be found in other species. Dogs are suitable subjects to investigate jealousy since they are highly social animals, engage in cooperative and affiliative interactions with humans, form an infant-like attachment bond with owners, discriminate human emotions, draw information from third party interactions and perceive when they receive an unfair treatment. While dog owners ascribe different emotions to their pets, including jealousy, experimental research is very limited.

This topic was deepened using different research approaches.

1. Italian owners were surveyed to assess their opinion regarding the existence of primary and secondary emotions in dogs. In particular, the aim was to collect information about jealousy. From the answers of 1572 participants, an overall certainty emerged: according to them dogs experience jealousy, mostly when owners pay attention to other dogs, and react trying to interfere with the ongoing interaction and seeking for attention.
2. Readapting a procedure devised for human babies, we exposed 2 groups of 36 dogs each to a situation in which the owner and a stranger ignored them while directing attention towards a book, a novel object and a fake dog (furry: group 1; plastic: group 2). Findings from both groups did not prove that dogs' reactions were driven by jealousy. First, it was unclear if fake dogs were perceived as real rivals, although dogs looked at and interacted with them at high levels. Then, dogs did not show protest, stress, attention seeking, aggression, behaviors usually considered peculiar of jealous reactions. Lastly, dogs did not behave differentially between the caregiver and the unfamiliar person, when they were manipulating the fake dog.

3. Adjusting a procedure used with human siblings, we exposed 21 dog dyads living together to a realistic jealousy-evoking situation in which their owners at first ignored both dogs, while reading a magazine (Control episode, C) and then petted and praised one of the dogs while ignoring the other, and vice versa (Experimental episodes, E). During the Control episode (C) and the Experimental episodes (E) several differences emerged, although only “monitoring the owner" resulted significantly higher in experimental episodes. Behaviors showed a great individual variability, likely due to hierarchies between dogs and styles of attachment between dogs and owners.
4. 25 dogs were tested using the eye tracker method. We showed them 8 videos showing different situations (petting/veterinary check) and subjects (owner/stranger; real dog/fake dog on wheels), in order to find what is more attractive for dogs, during a social interaction, between the person who is interacting with the potential rival, the rival itself or the kind of interaction. Duration of fixations was analysed for each possible target: no difference in the time spent gazing the owner or the unfamiliar person when appeared as first person on the screen emerged, and dogs gazed for a significantly longer time the areas of interaction and the paws/wheels, regardless of the type of the ongoing interaction, the kind of dog present and the identity of the person involved.

Altogether these findings do not allow to reject the hypothesis that dogs can experience jealousy, instead they underline the methodological problems emerging in the study of animals’ emotions. Setting up experimental procedures suitable to draw information from dogs’ internal state and emotional experience is still extremely hard.

ABSTRACT {Italian version}

La gelosia è un'emozione secondaria con chiare funzioni adattative nel mantenere e proteggere legami e relazioni sociali. In psicologia, è definita un'emozione contesto-dipendente che richiede un triangolo sociale e sorge quando un individuo percepisce che un intruso sta minacciando una sua relazione importante. Fondamentale per la fitness negli esseri umani, emerge durante l'infanzia in tempi precoci, in assenza di motivazioni sessuali e prima della maturazione dell'autocoscienza, suggerendo la possibilità che possa essere ritrovata anche in altre specie. I cani sono soggetti adatti allo studio della gelosia per diverse ragioni: sono spiccatamente sociali, si impegnano in interazioni cooperative e affiliative con l'uomo, formano col proprietario un legame di attaccamento simile a quello esistente tra madre e bambino nell'uomo, discriminano le emozioni umane, traggono informazioni da interazioni di terzi e percepiscono quando ricevono un trattamento ingiusto. Nonostante i proprietari di cani attribuiscano diverse emozioni ai loro animali domestici, inclusa la gelosia, la ricerca sperimentale in questo campo è tuttora molto limitata.
Questo argomento è stato approfondito utilizzando diversi approcci di ricerca.

1. Proprietari italiani sono stati intervistati per valutare la loro opinione sull'esistenza nel cane delle emozioni primarie e secondarie. In particolare, l'obiettivo era raccogliere informazioni sulla gelosia. Dalle risposte di 1572 partecipanti è emersa una generale certezza: secondo loro i cani sperimentano la gelosia, soprattutto quando i proprietari prestano attenzione ad altri cani, e reagiscono cercando di interferire con l'interazione in corso e richiamando l'attenzione del proprietario.
2. Riadattando una procedura concepita per i bambini, abbiamo esposto 2 gruppi di 36 cani ciascuno ad una situazione in cui il proprietario e un estraneo li ignoravano mentre dirigevano le loro attenzioni verso un libro, un oggetto nuovo e un cane finto (di peluche: gruppo 1; di plastica: gruppo 2). I risultati di entrambi gli studi non hanno dimostrato che le reazioni dei cani siano state guidate dalla gelosia. Innanzitutto, non è chiaro se i cani finti siano stati percepiti come veri rivali, sebbene i cani li abbiano guardati e abbiano interagito con loro a livelli elevati. Inoltre, i cani non hanno mostrato aggressività, segnali di protesta, di stress e non hanno richiamato l'attenzione, comportamenti

solitamente considerati peculiari nelle reazioni di gelosia. Infine, i cani non si sono comportati in modo diverso tra la figura di attaccamento e la persona sconosciuta, quando questi stavano manipolando il cane finto.

3. Adeguando una procedura usata negli esperimenti con infanti figli degli stessi genitori ed allevati assieme, abbiamo esposto 21 diadi di cani che vivevano insieme ad una situazione realistica di evocazione della gelosia, in cui i loro proprietari in un primo momento ignoravano simultaneamente entrambi i cani leggendo una rivista (episodio di Controllo, C) e successivamente accarezzavano e lodavano solo uno dei due cani ignorando l'altro e viceversa (episodi Sperimentali, E). Durante l'episodio di controllo (C) e gli episodi sperimentali (E) sono emerse varie differenze, sebbene solo il monitoraggio del proprietario sia risultato significativamente più alto negli episodi sperimentali. I comportamenti hanno mostrato una grande variabilità individuale, probabilmente dovuta alle gerarchie esistenti tra i cani e agli stili di attaccamento tra i cani e i proprietari.
4. 25 cani sono stati testati usando la metodologia dell'eye-tracker. Abbiamo presentato loro 8 video che mostravano diverse situazioni (coccole/controllo veterinario) e diversi soggetti (proprietario/estraneo, cane reale/cane finto su ruote), per trovare ciò che è più attraente per i cani, durante un'interazione sociale, tra la persona che interagisce con il potenziale rivale, il rivale stesso o il tipo di interazione in atto. È stata analizzata la durata delle fissazioni dello sguardo per ogni possibile target: nessuna differenza è emersa nel tempo trascorso guardando il proprietario o la persona sconosciuta quando essi sono apparsi per primi sullo schermo e i cani hanno osservato per una quantità significativamente maggiore di tempo l'area dell'interazione e l'area delle zampe/ruote, indipendentemente dal tipo di interazione in corso, dal tipo di cane presente e dall'identità della persona coinvolta.

Complessivamente queste scoperte non consentono di rifiutare l'ipotesi che i cani possano sperimentare la gelosia, invece sottolineano i problemi metodologici emergenti nello studio delle emozioni degli animali. Stabilire procedure sperimentali atte a trarre informazioni dallo stato interiore dei cani e dalla loro esperienza emotiva è ancora estremamente difficile.

1. GENERAL INTRODUCTION

1.1. EARLY RESEARCHES ON EMOTIONS

Research on emotions dates back in 19th century with very important scientists involved. Charles Darwin for first theorised the existence of internal states, he called “emotions” (from Latin word “*emovere*”, literally “to move out”), universally recognisable because of inherited expressions, similar in all populations in the world and detectable in some animal reactions to the environment [1872].

The core of emotions was initially theorised by William James [1884], who argued that the affective experience is a consequent of a bodily change. In his opinion, the emotional brain processes are just ordinary sensorial brain processes variously combined. Therefore, an “exciting fact” stimulates one or more sense organs and the cortex gets the information through afferent nerves (Perception). Efferent nerves reach muscles and viscera inducing alterations (Bodily changes), which are reported to the cortex by other afferent impulses: the feeling originated from those alterations is the “emotion” itself. Carl Lange in the same period [1885] exposed a similar theory on origin of emotions, according to him "we owe all the emotional side of our mental life, our joys and sorrows, our happy and unhappy hours, to our vasomotor system” (i.e. the circulatory system).

The James-Lange theory [1922] was strongly criticized by Cannon, following recent studies demonstrating that separating the viscera from the central nervous system in dogs and cats did not affect their emotional responses when stimulated [Sherrington, 1900; Cannon et al., 1927]. Moreover, Cannon took into account that many non-emotional states cause the same bodily alterations mentioned by James and Lange, and if artificially elicited, they do not produce the related emotions; also viscera involved are not as sensitive as claimed and their alterations are too slow to induce an affective reaction. He proposed an alternative theory on origin of emotions, since the latest research had highlighted the importance of thalamus for the affective responses both in animals and in human beings. Research had unveiled that in absence of the control mediated by the cortex, all emotional responses were excessive and unconscious, while in absence of the thalamic control, they disappeared. Cannon proposed that after an external stimulation the cortex receives impulses and suddenly stimulates the thalamic processes to act in a specific combination, depending on the emotional response activated, innerving both viscera ab muscles and

afferent paths to the cortex. In this view, the cortex modulates the individual responses, acting on the thalamus, which represents a discharging station [Cannon, 1927; Bard, 1928].

Following this branch of research, few years later James W. Papez pointed out that the hypothalamus, the anterior thalamic nuclei, the gyrus cinguli, the hippocampus and their interconnections constituted a subcortical circuit, responsible for the control of the emotional expression [1937]. Paul D. Mc Lean reconceptualised this perspective, coining the definition of “limbic system”. In his view, the human brain could be divided into three main parts, the “reptilian brain” the most ancient, involved in the most primitive behaviors, the “neomammalian brain”, the most recent, responsible of all the highest cognitive processes and the “paleomammalian brain” or “limbic system”, the portion involved in the expression of emotions. It included the septum, the amygdala, the hypothalamus, the hippocampal complex and the cingulate cortex [1952].

Therefore, emotive reactions seemed to be governed by different neural structures, but only Joseph LeDoux defined the circuits involved and their tasks. He found that, after the perception of an emotional trigger, two separate neural paths originate from the thalamus, one directly connecting the thalamus with the amygdala, the other one reaches the neocortex and then go back to the amygdala. Emotions were recognized as an automatic response to the environment, under the control of the thalamus-amygdala circuit, in charge to activate a fight-or-flight response, but modulated by the neocortex, able to evaluate the stimulus, in order to calibrate reactions based on previous experiences [1998].

The existence of complex neural circuits engaged in the emotional states inspired researchers to analyse phylogenetic aspects of emotions. The pioneer of this field is Jaak Panksepp who carried out research on emotions through comparative experiments. His work unveiled that after activation of specific neural circuits in comparable brain areas, different mammals (rats, cats and primates) react with seven similar emotive reactions: rage, fear, lust, care, panic, grief, play [1998].

1.2. PRIMARY EMOTIONS

Nowadays, in literature it is widely accepted the existence of two kinds of emotions, basic (or primary) and complex (or secondary). Basic emotions are innate [Panksepp, 1998, 2005] and, according to Ekman, entail some unique external (i.e. facial expressions) and internal (i.e. physiology responses) features that make them “discrete”. Namely, a basic emotion can be distinguished easily from another, and has evolved through adaptation to the environment, to deal with fundamental life tasks. Moreover, he proposed that basic emotions, to be distinguished from one another or from other affective phenomena, should have nine characteristics: distinctive universal signals, presence in other primates, distinctive physiology, distinctive universals in antecedent events, coherence among emotional response, quick onset, brief duration, automatic appraisal, and unbidden occurrence [1992].

In this perspective, six emotions fulfil these criteria: anger, fear, sadness, enjoyment, disgust and surprise. Other scientists argued about which emotions should be included or not in this list and a general overlap persists, although nomenclature could be slightly different [Plutchik, 1980; Izard & Dougherty, 1982, Ekman, 1992].

The association of facial expressions to specific emotions in members of different literate cultures was examined by Ekman and Friesen in 1969, by showing pictures of faces to College-educated subjects of Brazil, USA, Chile, Argentina and Japan, in order to assess if the provenience culture would have conditioned answers. Although results were coherent, this study was not enough to affirm that emotions and related facial expressions were universal.

For this reason, Ekman and Friesen carried out a cross-cultural study involving members of the Fore linguistic-cultural group of the South East Highlands of New Guinea. They told subjects a story, showing them a set of three pictures of three different facial expressions. After that, subjects were asked to choose the most appropriate expression to the story. Results were coherent and almost exactly the same of those gathered with the same experiment with members of a most Westernized population, giving support to the hypothesis that basic emotions are universal [Ekman & Friesen, 1971]. Each basic emotion actives a determined pattern of mimic muscles, called “action units” (AUS) and illustrated

by the facial action coding system (FACS), giving as result a certain facial expression identifiable by any human population in the world [Ekman & Friesen, 1978].

1.3. SECONDARY EMOTIONS

While primary emotions are shared by human beings and other mammals [Panksepp, 1998], there is still a great debate around secondary (or complex) emotions.

Primary emotions are instinctive and they do not vanish if the cortical connections are interrupted [LeDoux, 1998], on the other hand secondary emotions need a cortical control, they are shown after a conscious analysis of the situation. Indeed, a damage in the prefrontal lobe of the brain causes a reduced capacity to keep reasoning and to experience complex emotions [Damasio, 1994; Lewis et al., 2008]. Each of secondary emotions seems to be the result of a combination of various basic emotions and vocal and bodily signals, previous experiences and conscious analysis of the situation, in this perspective, secondary emotions appear to be too elaborate to be experienced by non-human animals [Lewis et al., 2008].

Moreover, studies on children indicate that some secondary emotions emerge in specific moments during the growth. Embarrassment, empathy, and envy appear after the development of the self-consciousness and self-recognition (second year of life) and for this reason are defined “self-conscious emotions” [Lewis et al., 1989; 2008; Bischof-Köhler, 1991]. Pride, shame, and guilt are called “self-evaluate emotions” [Lewis, 1992; Lewis et al., 2008] since they are shown after the child is able to compare his/her behavior with a standard (third year of life).

However, according to Buck, there was a biological connection between all the “affects”, namely “subjectively experienced feelings and desires”. In his view, “cognitive” (e.g., curiosity, surprise), “moral” and “social affects” (e.g., pride, guilt, shame, pity, jealousy) share the same physiological bases, the “biological affects”, which seem conditioned by a “primary motivational-emotional systems” acting on a brain system including different structures (e.g. subcortical and paleo cortical brain) and based on neurochemical information [Buck, 1999].

Since there is a biological base for secondary emotions shared by phylogenetically distant animals, it is likely that at least some of these complex emotions can be found not

only in humans and primates, but also in other mammals [Panksepp, 1998, 2010a, 2010b, 2011].

1.4. JEALOUSY

1.4.1. Definition and general features

Jealousy can be evoked when a social intruder threatens an affective relationship, so the context is fundamental. In humans, the individual should believe that his/her beloved is engaged in a parallel affective interaction with a third part. Consequent expressions fall in the sphere of other emotions, in particular sadness, fear and anger and the individual acts in order to regain his/her beloved's interest [Hart, 2010; Dillon, 2013].

Even though jealousy is considered a derived emotion, there is still lack of information, since research in this field has been limited [Panksepp, 2010b]. However, it represents a paradox in the classification of emotions. According to Ekman and Plutchik a primary emotion has specific features (universal signals, presence in other non-human animals, rapid onset, brief duration, etc. [Plutchik, 1980; Ekman, 1994]) and of course jealousy does not fulfil these criteria, e.g. it does not produce a "jealousy face" and/or its expression is long-lasting. On the other hand, Plutchik and the modern evolutionary psychology believe that a basic emotion has emerged to solve an adaptive dilemma, to guarantee the survival: therefore, it should be considered an evolutionary adaptation [Plutchik, 1980; Nesse, 1990; Tooby & Cosmides, 2008; Tracy, 2014].

Nobody could deny that echolocation and language are evolutionary adaptations fundamental for the fitness in, respectively, bats and humans, but they are extremely specific [Pinker & Bloom, 1990]. For the same reason, Buss is fully convinced that jealousy, although less widespread than anger, fear, happiness, etc. cannot be left out from the primary emotions list, since sexual jealousy is essential for the reproductive success, the key for the survival of a species. The reproductive success of an individual is subject to the risk of infidelity, especially for men, therefore a jealous attitude can prevent the promiscuity of the partner, while for women, jealousy represents the best strategy to avoid that the partner loses interest in the offspring [Dillon, 2013; Buss, 2014].

1.4.2. Jealousy in children

Differently from the classic definition of secondary emotions (the need of self-consciousness, dated at the second year of age), in children the earliest proofs of jealous behaviors towards their mother/father emerge in preverbal children around the sixth month of age. This is not surprising, children rely on their parents for all that concern their survival, not only for physiological needs (sustenance, safety, protection, hygiene, etc.) but also for their psychological needs (affect, allegiance, stimulation, etc [Dillon, 2013]).

Since jealousy entails an interpretation of the ongoing situation, it is likely that those jealous expressions found in infancy are a sort of primordial form of jealousy and that it becomes more complex with the growth [Panksepp, 2010b; Dillon, 2013]. However, reactions found in children, when exposed to a jealousy-evoking situation, are consistent with those reported for adolescents and adults: they can vocally protest, stare at the mother/father, act to interrupt the ongoing interaction, react aggressively or imitate the intruder [Hart, 2010; Dillon, 2013].

Research on jealousy in children followed two main currents: the first one had the aim to elicit jealous behavior in children when the mother attended a faux rival, the second one focused on the already existing triangle between two siblings and their mother.

1.4.2.1. Experiments with faux rivals

Jealousy in children was investigated at first using a non-naturalistic approach, in which a doll represented the rival. This approach could include the presence of a stranger, as a control, or not.

The experimental paradigm used by Hart and colleagues in 1998 entailed four episodes in which the mother and an unknown woman manipulated and talked affectively to two kinds of object: a storybook and a child-like doll which were alternatively on the mother's and on the stranger's laps (Figure 1).

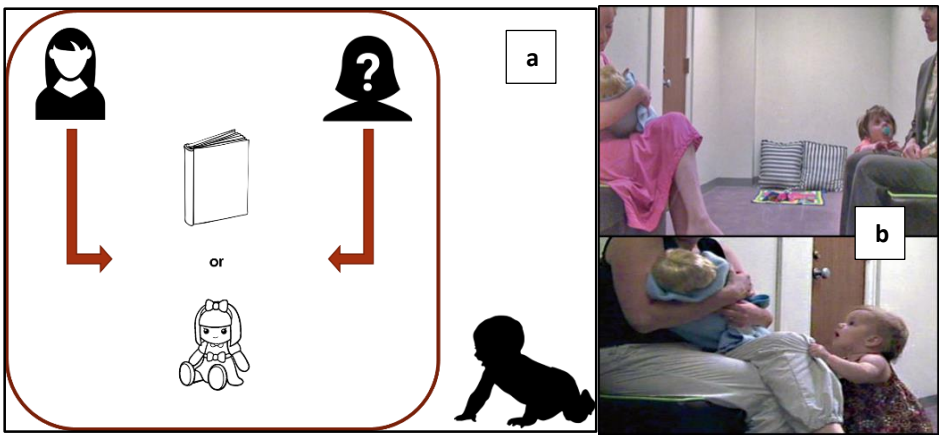

Figure 1 a: Experimental procedure to study jealousy in infants with faux rivals. b: Pictures from Hart & Behrens, 2013.

Experimental children showed higher levels of stress and protests in the episodes in which the mother had the doll on her laps. Although the driving motivation their reactions could be the desire to play with the doll, behaviors registered were overall coherent with a jealous reaction, since children tried to regain their mother interest, using vocal protest, proximity seeking, direct touch and gazing.

In addition, children reactions to the lack of attention from their mothers in favour of a rival were found associated with many variables, like maternal interaction style and attachment security [Hart and Behrens, 2013].

However, one of the most interesting results, obtained by this kind of procedure with faux rival is that, when put in a jealousy-eliciting situation, also 6-months infants show distress and protests. This challenges one of the cornerstone of the theory on secondary emotions in general and on jealousy in particular, the need of self-consciousness, since this complex cognitive capability emerges only when children are two years old [Hart & Carrington, 2002, 2004; Mize et al., 2014].

1.4.2.2. Experiments with siblings

Children rely to their parents for all what concerns their survival, so a new born child represents a great risk for an older sibling, and also the older one represents a risk for the infant. Indeed, it has been reported that the risk of mortality in infants is higher when the older is less than two years old [CDC, 2000], but in general a second child in family force parents to redistribute their cares to both siblings, and the older could react negatively [Volling et al., 2010].

In addition, it is worth highlighting that the emotion of jealousy strongly depends on the context: an individual must perceive the risk of the loss of a valuable relationship, caused by a third part. Although previous cited experiments with child-like dolls brought very interesting results on children, according to Volling and colleagues there are other conditions that must be satisfied, to elicit a real jealous reaction: the dyadic relationships. The existence of a social triangle is not enough, research should take into account also three relationships: jealous individual-beloved one, beloved one-rival, jealous individual-rival [2002].

There is also a great difficulty in interpretation of findings from experiment in which the jealousy is elicited with faux rival, it is not certain which is the motivation driving children, jealousy or playful intent?

To test jealousy in a more natural way, another procedure was devised, and it involved two siblings and their mother/father. In this paradigm, the parent ignored alternatively one of the two children in favour of the other one, and vice versa (Figure 2). It emerged that reactions showed by children depended by their age, temperament, capability of emotional understanding and coping with the situation and their kind of attachment bond with the parent [Teti & Ablard, 1989; Miller et al., 2000; Volling et al.,2002].

Figure 2 a: Experimental procedure to study jealousy in siblings. b: Picture from Hart, 2012.

In 2010 Volling and colleagues analysed behaviors shown by children during a jealousy-evoking situation, when the mother positively interacted with one sibling ignoring the other one, and it emerged that children could opt for three main strategies to cope with the situation. There were children who tried to physically interfere with the ongoing interaction, touching the parent or trying to interrupt the interaction, others who kept the

proximity with the parent, seeking for comfort, and others who remained distant and tried to reach vocally for their parent's attention.

1.5. *Canis lupus familiaris*

Humans and dogs have shared the same ecological niche for centuries. Initially, less aggressive and less fearful individuals of dogs' ancestor moved close to humans' villages to consume humans' food waste and humans, thanks to the presence of these animals in their villages, felt protected by other dangerous species. Over time, this self-domestication produced both morphologic and behavioral changes in dogs, which conserved paedomorphic features, and the relationship between the two species got stronger, as long as the dogs became dependent from humans for all what concerns their survival and humans incorporated dogs in all fields of their lives. Humans selected dogs' individuals for their behavioral and physical features, bringing to the present existence of more than 400 different dogs' breeds (Marshall-Pescini & Kaminski, 2014).

Pet dogs represent a suitable subject to investigate the existence of social emotions in non-primate animals for many reasons. They share high levels of sociality with wolves, forming stable populations with conspecifics, and a strong inequity response, since pet dogs dislike attending a conspecific being rewarded without performing the requested task [Bonanni & Cafazzo, 2014; Essler et al., 2017], and because of their characteristic co-evolutionary history with humans, they developed also special social cognitive skills in the relationship with us.

Initially, researchers speculated that owners could represent a leader for their pet dogs, similar to alpha-individuals in wolf societies [Miklosi 2007], but more recently it has been theorised that there could be analogies in cognition and behavior between dogs and children, bringing the idea that owners and their pet dogs could form an infant-like bond. The evidence that owners (more often women) interact with dogs using the "motherese", a peculiar speech that mothers use with their babies, supports this perspective [Hirsh-Pasek & Treiman, 1982; Mitchell, 2001; Burnham et al., 2002; Prato-Previde et al. 2006].

Bowlby [1958] used the term "attachment" to describe the relationship between human infants and their caregivers (usually parents, but not necessarily) first, highlighting that the role of the parents in children's lives goes beyond the mere action of feeding (as already found in goslings and macaques [Lorenz, 1952; Harlow & Zimmermann, 1959]).

Ainsworth asserted that when a child forms an attachment bond, it involves a specific reference figure, embodies emotional features and behaviors finalized in guaranteeing proximity and attention [Ainsworth, 1989]. Thanks to the Strange Situation Test, Ainsworth and colleagues could discriminate between four different kinds of attachment bond: secure, avoidant, ambivalent and disorganised [Ainsworth et al., 1978].

The Strange Situation was readapted to investigate the relationship between adult dogs and owners and findings supported the hypothesis that their affective bond is functionally comparable to that existing between mother and child in humans. Dogs reacted similarly to children when separated to their reference figure (vocalizing, protesting, and searching for him/her), and when reunited greeted more him/her compared to an unfamiliar person [Prato-Previde & Valsecchi, 2014].

Not only dogs developed an infant-like bond with owners, but also they are able to reach information from third-party human interactions, showing preference to cooperative people, compared to non-cooperative [Marshall-Pescini et al., 2011]. Moreover, nonetheless the capability of perceive others' emotions is widely spread in nature, because it is fundamental for social species to evaluate conspecifics' intentions, dogs are the only one able to discriminate between human positive and negative facial expressions [Albuquerque et al., 2016].

Furthermore, it is worth noting that pet dogs are entirely dependent to their owners for all their needs, both physical and psychological, and owner's family can be considered an ecological niche for dogs: losing the relationship with the owner could run a great risk for dog's survival. It is likely that in the building of the relationship between human and dog, this last one had developed strategies to avoid the lack of attention from the human. In this perspective, expressing a primordial form of jealousy towards the owner could represent the solution.

1.5.1. Jealousy in pet dogs

In 2014, in order to investigate the existence of the emotion of jealousy in dogs, Harris and Prouvost readapted the paradigm used to investigate jealous reactions toward faux rivals in children, without the presence of an unfamiliar person.

Differently from studies on human babies, this study was conducted in a familiar environment for the dogs (i.e. their homes). The owners were asked to manipulate and talk affectionately to an object, while ignoring their dog and after that to put on the floor the object letting the dog free to interact with it. Harris and Prouvost chose to use three different objects for this experiment: a stuffed dog, which barked and wagged the tail, a jack 'o lantern pumpkin and a sonorous book (Figure 3).

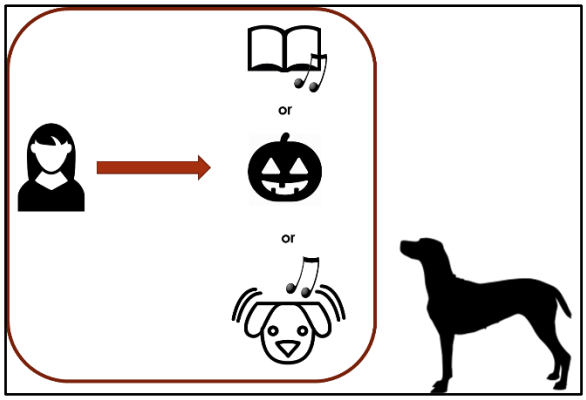

Figure 3 Experimental procedure to study jealousy in dogs used by Harris & Prouvost, 2014.

Researchers found that dogs reacted negatively (e.g. snapping the object and getting between the owner and the object) when the owners interacted positively with the stuffed dog compared to the non-social object, the book, and the pumpkin (Figure 4). However, data on dogs' interest/attention towards owners were not found significantly different between the stuffed dog condition and the jack 'o lantern condition, leaving the doubt that experimental dogs did not perceive the stuffed dog as a real conspecific, and in more detail a rival, but that their reactions could be driven by different reasons, e.g. playful or hunting intent. It should be highlighted that Harris and Prouvost, probably in order to increase dogs' interest towards objects, used in the paradigm a sonorous and moving stuffed dog, producing complexity in the interpretation of their results.

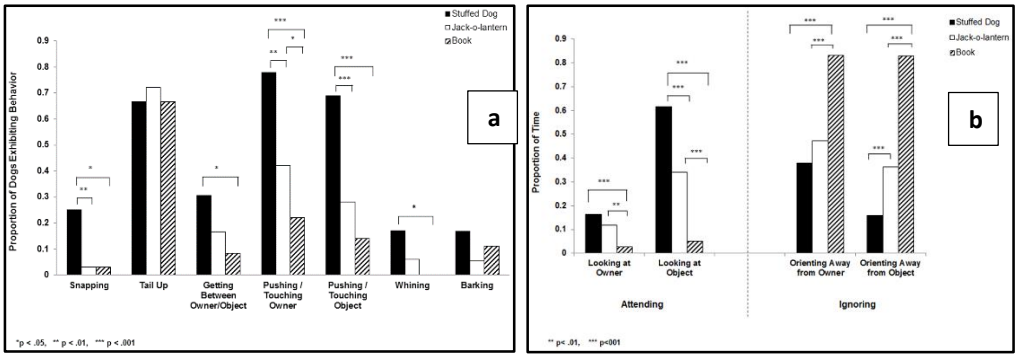

Figure 4 a: Comparisons of the proportion of dogs exhibiting each type of behavior in each of the three experimental conditions. b: Proportion of time dogs spent attending to and orienting away from their owner and the object in each of the three experimental conditions [Harris & Prouvost, 2014].

1.6. AIMS OF THE PRESENT STUDY

The overview on secondary emotions in non-primate animals needs to be in-depth, and in this perspective, dogs are a useful animal model. They are easy to find, there are low risks for injuries in case of negative reactions and the affective bond between dog and owner allows testing interspecific social emotions, driving owners behaviors, in order to elicit dogs' behavioral responses.

This PhD project has been structured in order to investigate the subject step-by-step. The first aim was to collect opinions by Italian owners on dogs' emotions, in particular on jealousy, both to make a comparison with data from Morris and colleagues [2008] and also to device following experiments with more awareness. People were asked to give a description of which situations could provoke jealous reactions in their dogs and to make a list of behaviors observed.

Subsequently, it has been considered necessary to replicate Harris and Prouvost's experiment [2014], with some changes in humans and objects involved. The main uncertainty originating from their results was if dogs reacted to the stuffed dog because it was weird and attractive for its features (i.e. it barked a wagged the tail), therefore the test was replicated using motionless and silent objects. Also, since jealousy is a social strategy to protect a valuable relationship, an unfamiliar person was included in the test, she was asked to behave exactly the same as the owner and dogs' reaction towards the two people were evaluated, expecting that the stranger person did not elicit any jealous behavior.

The following step was to device a new paradigm to evaluate the existence of the emotion of jealousy in a natural context. Readapting the experiment used to assess jealousy in human siblings, dogs' dyads were tested. The aim was to verify if in a real triadic context, attending to a positive interaction between the owner and the companion dog could elicit strategies to regain owner's interest and disrupt the ongoing interaction. According to the definition of jealousy, it should emerge only when the lack of attention is in favour of a rival, not when it is per se.

Experiments devised to assess the existence of jealousy in dog entail situations in which a dog attends its owner affectively interacting with a potential rival. The trigger of interest in these tests is the interaction itself, but what is really attracting during an interaction remains mysterious. The final step of this project was to evaluate what drives dogs' interest during a social interaction. Employing the technique of Eye-tracking, a sample of dogs was tested at the Clever Dog Lab (Messerli Research Institute, VetMedUni) in Vienna. They were exposed to a stimulus set of different videos and fixation gaze data were collected and analysed.

2. OVERVIEW QUESTIONNAIRE

2.1 ABSTRACT

Pet owners frequently explain behaviors they observe in their animals as an emotional reaction, although they do not have knowledge in ethology. To collect information and opinions about the existence of jealousy in dogs from Italian owners, a survey was spread online. A general certainty emerged and according to participants, the most triggering situation is attending the owner interacting with another dog. Reactions are finalized in regaining owner's attentions and in disrupting the ongoing interaction.

This first approach allowed to device the experimental part of this project with more awareness.

2.2. INTRODUCTION

The debate around the existence of secondary emotions in non-primate animals is far to be solved. A group of researchers strongly defends the theory that this kind of emotions needs complex cognitive capabilities emerging only at a certain point of ontogenesis in primates [Premack, 1988; Tangney & Fischer, 1995 Hart & Karmel, 1996; Povinelli, 1996; Lewis, 2002]. On the other hand, animals living in packs experience social interactions, hierarchies, affective bonds and alliances and in this perspective it hard to imagine how it could be possible without social emotions, e.g. pride/arrogance and envy/jealousy: social dynamics need modulation [Buck, 1999; Morris et al., 2008].

However, most of pets' and dogs' owners declare without uncertainties to be able to describe the emotional states experienced by their pets. The issue is more complex when people have notions of ethology/neurosciences, but it is frequent to hear people saying "He knows he should not do this!" or "I know what she is going to do!" or "He is jealous of my partner!", supplying to their declarations more or less convincing evidences.

Morris and colleagues [2008] devised a survey directed to pets' owners, in order to evaluate their opinions on animal emotional life: 907 owners, 337 of which were dogs' owners filled out the questionnaire. The only criterion to be included in the study was that the owner should had lived with that pet for at least two years. Owners were asked to answer to questions like ''is your animal ever surprised? Yes/No. If yes, how confident are you about your decision?'' (on a scale from 1 ''not at all confident'' to 5 ''very confident'').

Participants appeared very confident about the existence of primary emotions (except for disgust) in pet animals, while they were less certain for secondary emotions. Within the secondary emotions, owners were more confident about the existence of jealousy and empathy (self- conscious emotions) in their pets, compared with shame, guilt and pride (self-conscious evaluative emotions).

However, the main finding was that 81% of dogs' owner and 79% of horses' owners reported the existence of the emotion of jealousy in their pets. This was so surprising that in in their second study Morris and colleagues focused only on jealousy interviewing 40

dog's owners. They were asked if their dogs showed jealousy and, if yes, to describe when it happened and in which manner.

In total, 39 owners out of 40 answered yes to the first question. In addition, they reported that dogs seemed to react in a jealous manner when they were paying attention to a person, to another animal o to a toy. Behaviors reported as "jealous reactions" were a lot, the most cited was the physical attempt to throw out the rival (e.g. sitting between the caregiver and the rival), but owners reported also vocal protests and aggressive behaviors. Results were coherent with human descriptions of jealous reactions in human siblings [Volling, 2010].

Giving these results, the first aim of this project was to outline the opinion of Italian dogs' owners about these topics. A survey was devised to collect information from owners about the existence of primary and secondary emotions in dogs, trigger situations and descriptions of reactions observed.

2.3. METHODS

The questionnaire was spread online through mailing lists and social networks and it had been available for two months. People were included in the sample if they fulfilled two criterions: they had to fill the questionnaire giving information about alive dogs, to avoid misrepresented information and they had no more than three dogs at the moment of the survey, to avoid the risk to include in the sample opinions from people who do not live in close contact with their dogs.

The overview questionnaire was made of two main parts: the first one ("Some initial information") consisted of general questions about the person (age, sex, etc.), his/her previous experiences with dogs (attendance to training courses, ethological knowledge, etc.) and about the family unit (number of children, number of owned dogs, etc.). The second part of the survey ("Let's talk about Your dog" & "Opinions and Experiences") was made of questions focused on the dog. People owning more than one dog was asked to fill this last part for each dog. Owners were asked to answer to the questions in a rank from 0 (absolutely not) to 5 (absolutely yes) and to give examples of the situations during which they observed the behaviors cited.

For example:

- *"Do you think your dog is able to experience empathy?"*
  (absolutely not) 0 - 1- 2 - 3 - 4 - 5 (absolutely yes)
- *"In which situation? You can give more than an answer, if necessary."*
  When I am sad - When I am happy - When I am suffering - When a family member is sad - When a family member is happy - When a family member is suffering - When another dog seems sad - When another dog seems happy - When another dog seems suffering - Never
- *"Give a brief description of the situations in which your dog showed empathy and how it occurred."*

The survey was organized not to drive people attention to the main purpose of this study, that was aimed to assess their opinion on dogs' jealousy (see Supplementary Materials).

2.4. RESULTS AND DISCUSSION

After two months online, 1642 replies were collected, 70 of them were discarded due to incomplete or unclear answers. Following analysis were carried out on 1572 replies: 1066 from owners with only one single dog, 357 from owners with two dogs and 149 from owners with three dogs. Information were collected for a total of 2227 dogs.

Overall, owners interviewed seemed to be rather confident regarding their own dogs' emotions (see Table 1). They asserted to be sure (score >3) that all the emotions cited are experienced by their pet dogs, only for anger they gave a slightly lower score, but it is probably due to the anthropic meaning of the term "anger".

Table 1 Mean scores and SD of owners' opinions regarding the existence of Anger, Fear, Surprise, Happiness, Sadness, Empathy, Jealousy and Guilty in pet dogs.

N	Anger	Fear	Surprise	Happiness	Sadness	Empathy	Jealousy	Guilty
Valid	2173	2172	2172	2168	2164	2167	2162	2166
Missing	54	55	55	59	63	60	65	61
Mean	3,03	4,33	4,23	4,86	4,36	4,32	**3,98**	3,2405
Standard Dev.	1,469	1,024	,963	,430	,989	1,010	1,212	1,47178

Confirming data from Morris et al. [2008] jealousy is generally identified as an emotion experienced by dogs and concerning jealousy-evoking situations 1702 owners claimed that positive interactions with other dogs (e.g. petting or playing) triggered jealous behaviors in their dogs. Most common reactions seemed to be vocal and physical requests of attention (1282 out of 1702) and physical disruptions of the ongoing interaction (863 out of 1702), while aggressive reactions (i.e. growls and attempts to bite the rival) were rare (202 out of 1702).

This first step of the projects gave precious information and the experimental part proceeded devising jealousy-evoking situations, potential rivals and ethograms, not only on basis of existing literature but also on basis of owners' declarations collected in the survey.

3. PET DOGS' BEHAVIOR WHEN THE OWNER AND AN UNFAMILIAR PERSON ATTEND TO A FAUX RIVAL

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3.1. ABSTRACT

While dog owners ascribe different emotions to their pets, including jealousy, research on secondary emotions in nonhuman animals is very limited and, so far, only one study has investigated jealousy in dogs (*Canis familiaris*). This work explores jealousy in dogs one step further. We conducted two studies adapting a procedure devised to assess jealousy in human infants. In each study 36 adult dogs were exposed to a situation in which their owner and a stranger ignored them while directing positive attention towards three different objects: a book, a puppet and a fake dog (Study 1: furry; Study 2: plastic). Overall, the results of both studies do not provide evidence that the behavioral responses of our dogs were triggered by jealousy: we did not find a clear indication that the fake dogs were perceived as real social rivals, neither the furry nor the plastic one. Indeed, dogs exhibited a higher interest (i.e. look at, interact with) towards the fake dogs, but differences in the behavior towards the fake dog and the puppet only emerged in Study 2. In addition, many of the behaviors (protest, stress, attention seeking, aggression) that are considered distinctive features of jealousy were not expressed or were expressed to a limited extent, revealing that dogs did not actively try to regain their owner's attention or interfere with the interaction between the owner and the faux rival. Finally, a differentiated response towards the attachment figure (the owner) and the unfamiliar person (the stranger) did not emerge. Differently from what reported in human infants, dogs' behavior towards the attachment figure and the stranger interacting with the potential competitor (in this case, the fake dog) did not significantly differ: in both studies dogs paid attention to the owner and the stranger manipulating the fake dog to the same extent. In conclusion, we do not exclude that dogs could possess a rudimentary form of jealousy, but we suggest that research on this topic should require the use of a real social interloper (conspecific or human) and more naturalistic procedures.

3.2. INTRODUCTION

Scientists generally agree that some emotions ("primary" or "basic") have a long evolutionary history and can be found across a wide range of vertebrate species, due to their fundamental adaptive value [Ekman, 1992; Izard, 1992; Buck, 1999; Panksepp, 2010a, 2010b, 2011; Panksepp & Watt, 2011]. Conversely, the presence of "secondary" or "complex" emotions in nonhuman species is a lively debated topic. Many researchers still assume that these emotions require elaborate cognitive abilities and emerge relatively late in human development. It is also believed that they imply self and interpersonal awareness, which is generally considered a uniquely human characteristic [Lewis, 2008]. Nevertheless, the perspective on secondary emotions is changing as evidences deriving from developmental and cross-species studies suggest that at least some secondary emotions, due to their fundamental role in regulating social life, are present in other species. In addition, this view is supported by the presence of specific cortical structures and psychological infrastructures in at least some mammals [Buck, 1999; Draghi-Lorenz, Reddy, Costall, 2001; Harris, 2004; Panksepp, 1998; de Waal, 2011; Kujala, 2017].

Jealousy is a secondary emotion that appears to have a clear, strong adaptive value in maintaining and protecting social relationships and bonds (i.e. sibling-parent, sexual, friendship), enhancing the individual's fitness [Harris, 2004; Panksepp, 2010a, 2010b; Dillon, 2013]. In the human psychological literature jealousy has been defined as a context-dependent social emotion that requires a social triangle and arises when one individual perceives that an intruder is threatening an important relationship. It is generally expressed by observable negative affective responses (e.g. fear, anger, sadness) and accompanied by overt behaviors directed at restoring the relationship by reducing the threat represented by the interloper and regaining attention and care from a significant social partner [Dillon, 2013; Hart, 2010]. It has been proposed that jealousy could also occur outside conscious awareness [Harris, 2004; Massar et al., 2009], without the need of cortically mediated cognition [Panksepp, 2010b] and in the absence of complex interpretations of the meaning of the social interaction [Hobson, 2010]. Thus, at least a primordial form of jealousy could arise in other animals in specific situations where a significant relationship is threatened. The best evidence that jealousy could have a primordial form derives from the literature on human infants, which shows that jealousy can be exhibited within the first two years of

life in specific social situations (see [Hart, 2010, 2015] for reviews).There are several studies indicating that human infants aged from six to twelve months exhibited more protest behaviors, negative vocalizations and proximity seeking (approach and gaze) when their mother was holding an infant-like doll compared with when she held a book and when a stranger held the doll [Hart et al., 1998; Hart & Carrington, 2002; Mize et al., 2014]. Taken together, these studies suggest that infants are sensitive to the loss of maternal attention, distinguish between social and non-social objects and do not show an undifferentiated general response to any person or object, but react to potential threats to the relationship with the attachment figure. Thus, jealousy could initially have evolved as a behavioral/ emotional strategy to protect material and affective resources within the parent-offspring relationship [Hart, 2016]. The fact that jealousy can be recognizable in cognitively immature infants also suggests that this secondary emotion could occur with various degrees of complexity across social species, rather than being an all-or-none phenomenon, suddenly appearing in humans during the 2nd year of life or later. In addition, the adaptive function of jealousy in human infants has important theoretical implications since many nonhuman animals, particularly those living in social groups, could face situations that in principle would evoke jealousy in humans [Forbes, 2010]. Comparative studies are needed to better understand the evolutionary emergence and the functions of jealousy and its relation with cognitive abilities.

The domestic dog (*Canis lupus familiaris*) has proved to be an interesting and promising animal model to investigate the evolution of social cognition and in the last 20 years researchers showed that dogs have quite sophisticated socio-cognitive abilities that in some cases parallel those reported for human infants [Hare & Tomasello, 2005; Adachi et al., 2007; Lakatos et al. 2009; Topàl et al.; 2009; Marshall-Pescini et al. 2013, 2014; Merola et al, 2012a; Chijiiwa et al., 2015]. Moreover, a growing body of research is shedding light on their emotional life (Kujala, 2017 for a review), suggesting that, besides primary emotions, dogs could also experience, at least to some extent, more complex emotional states, such as empathic-like responses [Custance & Mayer, 2012; Quervel-Chaumette et al., 2016] and inequity aversion [Range et al., 2009; Brucks et al., 2016; Essler et al., 2017]. Recently, Harris & Prouvost [2014] suggested that dogs could express jealousy when their owner directs his/her attention to a potential rival, providing some support to people's

belief that animals, especially dogs, show jealousy when attention and affection are given to another person or animal [Morris et al., 2008, 2012; Martens et al. 2016]. Indeed, dogs are suitable subjects for investigating the existence of jealousy as they: 1. form stable groups and differentiate social relationships with conspecifics [Bonanni & Cafazzo, 2014; Trisko et al., 2016]; 2. establish a strong relationship with their owner, characterized by dependency for physical and psychological resources, which is functionally comparable to an infantile attachment [Prato Previde & Valsecchi, 2014]; 3. Discriminate human emotions [Merola et al., 2013; Muèller et al., 2015; Albuquerque et al., 2016], are sensitive to others' attentional states [Gàcsi et al. 2004; Schwab & Huber, 2006; Mongillo et al.; 2010] and to unfair treatment [Range et al., 2009; Brucks et al., 2016; Essler et al. 2017]. Hence, comparing dogs and infants, using the same type of procedures and analyses, may help to unravel proximate and ultimate causes of emotional behaviors.

Adapting a paradigm from human infant studies, Harris and Prouvost [2014] tested dogs at their homes in three different conditions in which their owner ignored them while affectionately interacting with different objects. In the jealousy condition owners petted and sweetly talked to a realistic-looking stuffed dog that barked and wagged its tail; in the second condition, they directed the same behavior to a jack-o-lantern pail; in the third condition, owners were instructed to read aloud a book which played melodies. At the end of each condition, the owner put the object down within the dog's reach and walked away. It emerged that a significantly higher percentage of dogs showed behaviors that the authors considered indicative of jealousy (pushing/touching the owner and the object, getting between the owner and the object, snapping and whining) when the owner was manipulating the stuffed dog compared to both the jack-o-lantern and the book. These findings represent an interesting starting point to assess jealousy in dogs. However, some methodological issues suggest caution in drawing conclusions: for example, the authors recorded the number of subjects expressing a certain behavior in each condition, but this only provides partial information on the phenomenon, since the robustness of the behavioral response (e.g. duration) is neglected. When they estimated the amount of time (percentage of point samples) spent by dogs attending to the owner (i.e. looking at the owner), no difference emerged between the stuffed dog and the novel object (jack o' lantern) conditions. Conversely, dogs directed a significantly higher attention (i.e. looking)

to the animated stuffed dog compared to both the jack-o-lantern and the book. These results could be due to different emotional/motivational states rather than jealousy: as many pet dogs are familiar with furry and squeaking toys and are used to play with them, it cannot be excluded that they considered the stuffed dog just a toy to play with. Last but not least, in our opinion, since the function of jealousy is to protect a valuable relationship from an intruder, in order to provide more conclusive evidence, it would be important to compare the dogs' behavior towards the owner (the attachment figure) and towards an unfamiliar person giving attention to a potential rival. Human infants differentiate among potential rivals (e.g. a book vs. a realistic doll) and also react in different ways when their mother rather than an unfamiliar adult gives positive attention to a potential rival [Hart, 2015].

The current work explores jealousy in dogs one step further, pursuing two goals: 1. clarify whether dogs can really be deceived by a fake dog, considering it a social rival rather than a toy; 2. evaluate whether the identity of the humans involved plays a role in triggering jealousy behaviors.

The dogs were presented with two types of fake dogs differing in appearance and size (Study 1: furry stuffed dog; Study 2: plastic dog), a novel object (a puppet) that did not appear like a conspecific but had some potentially appealing features for a dog (big eyes and soft fabric), and a picture book (a familiar and non-social object). The latter was used as a control stimulus to ascertain to what extent dogs would react to the mere loss of people's attention. The identity of the handler of the potential rivals was controlled introducing an unfamiliar person in the testing situation, as done by Hart and colleagues [Hart et al., 1998] with human infants. Thus, in our testing situation, both the owner and an unfamiliar person interacted with the three different objects, directing positive attention and affection towards them. Assuming that our experimental subjects could be deceived by the fake dogs and therefore be driven to jealousy, we expected they would: 1. sniff the ano-genital region of the fake dog, a behavioral pattern that dogs exhibit during social interactions with conspecifics for individual recognition [Harris & Prouvost, 2014]; 2. show some aggression towards the fake dog to prevent the rival to interfere with the relationship with the owner [Volling et al., 2002; Harris & Prouvost, 2014]; 3. show higher levels of attention/interaction, vocalizations and stress signals in the fake dog condition

compared to the puppet condition to gain their owner attention and to disrupt the interaction [Hart et al., 1998; Harris & Prouvost, 2014]; 4. show attention/interaction, vocalizations and stress signals only when their owner gave affection to the fake dog, since dogs are not affectionately bonded with the stranger [Hart et al., 1998]; 5. show a limited behavioral response in the book condition, since the book is just a familiar and non-social object [Hart et al., 1998; Harris & Prouvost, 2014].

3.3. MATERIAL AND METHODS

3.3.1 Experimental setting and stimuli

Testing took place in two different locations: one at the Canis sapiens Lab of the Università degli Studi di Milano and the other one at the Dipartimento di Scienze Chimiche, della Vita e della Sostenibilità Ambientale of the Università degli Studi di Parma. Testing rooms were not identical but both measured approximately 4.5 x 3.5 m and were equipped with two chairs (one for the stranger and one for the owner) facing each other at a distance of 120 cm, a soft plastic carpet between them, a water bowl and a small table with a computer positioned on it. The computer was used to guide and standardize the owner's and the stranger's actions throughout the procedure: a PowerPoint presentation provided written instructions at predetermined fixed intervals. An HD video camera was placed on a wall in a corner of the room to record the test.

Three different objects were used during the test: a fake dog, a soft puppet and a picture book. In Study 1 the fake dog was a furry Yorkshire terrier (length 32 cm, height at the withers 18 cm, Figure 5A); in Study 2 the fake dog was a plastic Fox terrier (length 50 cm, height at the withers 30 cm, Figure 5B). In both studies the puppet was a soft hand-made bag with a light grey fleece and two 'eyes' fixed on it (40 x 37 cm, Figure 5C). The objects were all static and did not emit sounds.

Two different female researchers (one in Milano and the other in Parma) played the role of the stranger.

3.3.2. Experimental design

To test our hypotheses, in both studies we set up a 3 (object type: fake dog, puppet, book) x 2 (object handler: owner, stranger) within-subjects design. Thus, each dog had the opportunity to observe and interact with both the owner and the stranger manipulating the three objects.

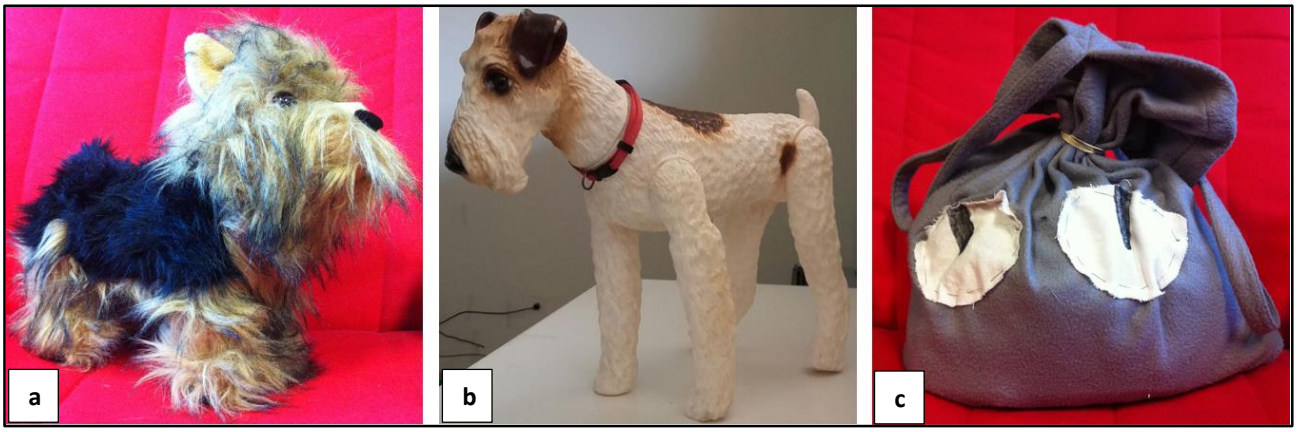

Figure 5 The three objects used in study 1 and 2. a: Furry fake dog; b: Plastic fake dog; c: Puppet.

An a priori power analysis (G*Power 3.1.9.2) for our experimental design (3x2 within-subject) setting alfa = .05, power = .90, an expected medium effect size f = .25, correlation between measures r = .5 and sphericity close to 1 (epsilon = .9), indicated a minimum sample size of 25 subjects.

3.3.3. Ethical statement.

All procedures were performed in full accordance with Italian legal regulations (National Directive n. 26/14--Directive 2010/63/UE) and the guidelines for the treatments of animals in behavioral research and teaching of the Association for the Study of Animal Behavior (ASAB). The protocol was approved by the Ethical Committee for the Use of Animals (PROT.N. 105/OPBA/2016) of the Università degli Studi di Parma. A written consent to video-record and use data in an anonymous form was obtained by the owners prior to testing.

3.3.4. Subjects

Study 1. Thirty-six healthy adult dogs (15 males, 21 females; 20 pure breed, 16 mixed breed), ranging in age from 1 to 13 years (mean = 5.24 years, SD = 2.74;), and their owners participated in the study. Dog-owner dyads were recruited both by personal contact and from advertisement distributed within the Università di Milano.

Dogs' inclusion criteria were: being kept exclusively for companionship, living within the human household for at least 1 year, being accustomed to encounter human strangers, being at least 1- year old. Dog-owner dyads were randomly allocated to the different testing sequences and thus we tested 6 dogs for each sequence.

Study 2. Thirty-six healthy adult dogs (17 males, 19 females; 19 pure breed, 17 mixed breed), ranging in age from 1 to 10 years (mean = 4.74 years, SD = 2.5), and their owners participated in the study. Dog-owner dyads were recruited both by personal contact and from advertisement distributed within the Università di Parma.

Inclusion criteria were the same as in Study 1. Dog-owner dyads were randomly allocated to the different testing sequences and thus we tested 6 dogs for each sequence.

3.3.5. Procedure

Researchers met the owner-dog dyads outside the Departments and escorted them to a waiting room were the owner signed a consent form and filled up a questionnaire with information about the dog (age, breed, education and lifestyle). Next, the owner and the dog entered the testing room and the experimenter (a researcher different from the stranger) explained the test procedure to the owner, while the dog was free to explore the room for approximately 10 minutes. The experimenter then left the room. The test started with a 1-min familiarization phase during which the owner initially walked around the room paying attention to some wall posters and then sat on the owner's chair and interacted with his/her dog. The procedure comprised three experimental episodes, each consisting of two 1-min phases during which the owner and the stranger (a researcher unfamiliar to the dog) were both in the room and ignored the dog. In each experimental episode the owner and the stranger alternately handled one of the objects for 1 minute (book, puppet, fake dog) while talking to each other in a friendly manner. For sake of simplicity, the 6 phases will be hereinafter indicated as follows:

FDOW: the fake dog (FD) is handled by the owner (OW);

FDSTR: the fake dog is handled by the stranger (STR);

BOW: the book (B) is handled by the owner;

BSTR: the book is handled by the stranger;

POW: the puppet (P) is handled by the owner;

PSTR: the puppet is handled by the stranger.

These 3 episodes were separated by 1-min intervals identical to the familiarization phase: these intervals aimed at avoiding, or at least reducing, any potential carryover effects from the previous. The order in which the objects were presented during the test and who manipulated them first (i.e. owner or stranger) were partially counterbalanced to avoid order effects on dogs' behavioral responses. Thus, each dog was exposed to a given sequence of phases and the following six combinations were selected:

1. BSTR-BOW, FDSTR-FDOW, PSTR-POW;

2. BOW-BSTR, FDOW-FDSTR, POW-PSTR;

3. FDSTR-FDOW, PSTR-POW, BSTR-BOW;

4. FDOW-FDSTR, POW-PSTR, BOW-BSTR;

5. PSTR-POW, BTSR-BOW, FDSTR-FDOW;

6. POW-PSTR, BOW-BSTR, FDOW-FDSTR.

At the beginning of each episode, the stranger entered the room holding one of the objects. In combinations 1, 3 and 5, upon entering, she sat on the stranger's chair, manipulating the object that was kept on her lap, and engaged in an affectionate conversation about the object with the owner. In sequences 2, 4, and 6 the stranger, upon entering the room, gave the object to the owner, who manipulated it first keeping it on his/her lap. After 1 minute the object was transferred to the other person, who held it on his/her lap and handled it appropriately, while still conversing The dog was ignored by both the owner and the stranger for the two minutes. At the end of each episode, the stranger left the room, taking the object with her.

3.3.6. Data collection and analyses

The test was video recorded and analysed using Solomon Coder beta® 15.01.13 (ELTE TTK, Hungary). Behaviors were recorded continuously in terms of duration and

frequency of their occurrence according to the ethogram reported in Table 2. The ethogram was developed considering both the literature on human infants [Hart & Carrington, 2002; Mize et al. 2014] and dogs [Harris & Prouvost, 2014; Prato Previde & Valsecchi, 2014] and was refined after a preliminary analysis of the videos to include other potentially interesting behaviors. The ethogram included behaviors directed towards the owner/stranger, the objects and environment and stress related behaviors. Inter-observer agreement was assessed by means of independent parallel coding of a random sample of 16 dogs out of 72 (8 dogs for each experiment; 22.22% of the total number of dogs). The agreement was assessed by Spearman correlation and it was good for all behaviors (Rho ranging from 0.7 to 0.979; Table 2).

Since there was a small variability in the length of each phase, due to owners' differences in readiness to follow the instructions, durations and frequencies were respectively transformed in percentages of the total time and of total occurrences and used as dependent variables in the statistical analysis.

For both studies, the effects of dog's sex and age, order of the objects presentation (FD-P-B vs. B-FD-P vs. P-B-FD) and order of handlers (OW first vs. STR first) on dogs' behaviors were evaluated by means of preliminary ANOVAs. No significant effects of any variable emerged.

Repeated measures GLM ANOVAs with object (3 levels: book, fake dog, puppet) and handler identity (2 levels: owner, stranger) as factors, and behaviors as dependent variables were carried out using the Greenhouse-Geisser correction when sphericity assumption was violated.

Table 2 Ethogram used in study 1 and 2 and interobserver agreement.

Category	Pattern	Description	Agreement
[a]**Object Directed Behaviors**	**Chew/bite**	The dog chews or bites the object	Rho = 0.809
	Interaction with Object	The dog interacts with the object without ambiguity. This pattern includes behaviors such as touching (with the paws or the muzzle), pushing and sniffing.	Rho = 0.753
	Look at Object	The dog looks at the object.	Rho = 0.868
	Social Investigation	The dog clearly smells the ano-genital area, the muzzle, or the ears of the fake dog.	Rho = 0.832
[a]**Person Directed Behaviors**	**Attention to Owner**	The dog is oriented with the head and the body towards the owner and can gaze at him/her face.	Rho = 0.858
	Attention to Stranger	The dog is oriented with the head and the body towards the stranger, and can gaze at her face.	Rho = 0.874
	Interaction with Owner	The dog actively interacts with the owner. This pattern includes behaviors such as being in contact, touching (with the paws or the muzzle), sniffing and jumping on.	Rho = 0.833
	Interaction with Stranger	The dog actively interacts with the stranger. This pattern includes behaviors such as being in contact, touching (with the paws or the muzzle), sniffing and jumping on.	Rho = 0.979
[a]**Enviroment Directed Behaviors**	**Explore Room**	The dog explores the room. This pattern includes walking around and careful visual/olfactory exploration.	Rho = 0.929
	Orientation to Door	The dog is oriented with the head and the body towards the door, gazing at it.	Rho = 0.762
[b]**Stress Related Behaviors**	**Stress Signals**	Nose-lip licking, shaking, yawning, scratching, stretching, rolling, chewing, raising paw.	Rho = 0.874
[b]**Vocal Behavior**	**Vocalizations**	This pattern includes whining and barking.	Rho = 0.937

[a]behaviors recorded as duration and transformed into percentage of the total time for purpose of statistical analysis

[b]behaviors recorded as frequency and transformed into percentage of total occurrences for purpose of statistical analysis

Pairwise post-hoc tests with Bonferroni's correction were carried out for significant main and interaction effects. All the statistical analyses were carried out with IBM SPSS Statistics 24.

3.4. RESULTS

Data and results of statistical analysis of Studies 1 and 2 are reported in Tables 3, 4, 5, 6 and in Figures 6, 7 and 8. In Tables 3 and 5 mean ± SD of each behavior (duration or frequency) are detailed and in Tables 4 and 6 statistical values of the GLM ANOVAs are reported.

Table 3 (Study 1) Mean percentage± SD of time spent for each behavior across the experimental phases.

Phase	Interaction with Object	Look at Object	Social investigation	Attention to Owner	Attention to Stranger	Interaction with Owner	Interaction with Stranger	Explore Room	Orientation to Door	Stress
BOW	.75 ±2.06	1.09 ±2.82	-	18.68 ±21.99	13.33 ±17.24	1.399 ±4.23	1.54 ±7.03	30.45 ±25.21	3.84 ±8.84	2.39 ±3.10
FDOW	6.83 ±7.95	14.80 ±13.95	5.96 ±7.22	33.06 ±20.60	5.84 ±9.53	1.63 ±3.13	1.39 ±3.86	10.14 ±17.9	2.10 ±6.07	2.44 ±2.85
POW	4.81 ±9.69	4.85 ±5.77	-	28.89 ±23.75	4.91 ±7.57	.75 ±3.37	1.12 ±2.71	26.43 ±25.57	3.72 ±11.59	2.58 ±2.59
BSTR	0.02 ±.08	.71 ±1.81	-	19.89 ±27.07	17.52 ±21.74	1.39 ±4.04	.91 ±3.26	30.55 ±28.42	4.75 ±12.79	2.11 ±2.15
FDSTR	1.92 ±3.76	12.88 ±17.77	3.49 ±5.51	9.52 ±16.31	31.13 ±24.02	4.05 ±15.50	1.53 ±2.77	16.29 ±16	1.44 ±3.47	2.28 ±3.09
PSTR	1.11 ±2.74	1.49 ±2.29	-	12.88 ±19.27	22.46 ±23.77	4.27± 13.79	1.55 ±3.48	23.18 ±21.37	3.32 ±8.79	2.39 ±2.72

BOW: the book is handled by the owner; FDOW: the fake dog is handled by the owner; POW: the puppet is handled by the owner; BSTR: the book is handled by the stranger; FDSTR: the fake dog is handled by the stranger; PSTR: the puppet is handled by the stranger.

Table 4 (Study 1) Statistical values of the GLM ANOVA for main and interaction effects.

Effects	Interaction with Object	Look at Object	Social Investigation	Attention to Owner	Attention to Stranger	Interaction with Owner	Interaction with Stranger	Explore Room	Orientation to Door	Stress
Object	$F_{[1.6,58.45]}$= 9.27	$F_{[1.13,39.6]}$= 35.02	-	$F_{[1.59,55.65]}$= .22	$F_{[1.49,52.21]}$= 1.56	$F_{[1.385,48.491]}$= 1.22	$F_{[1.557,54.501]}$= .05	$F_{[2,70]}$= 9.37	$F_{[1.59,55.79]}$= 1.03	$F_{[2,705]}$= .15
	p= .000	p= .000		p= .75	p= .22	p= .219	p= .911	p= .000	p= .36	p= .857
	η_{par}^2= .21	η_{par}^2= .50		η_{par}^2= .006	η_{par}^2= .04	η_{par}^2= .034	η_{par}^2= .002	η_{par}^2= .21	η_{par}^2= .03	η_{par}^2= .004
Handler	$F_{[1,35]}$= 15.03	$F_{[1,35]}$= 1.78	$F_{[1,35]}$= 2.93	$F_{[1,35]}$= 19.78	$F_{[1,35]}$= 32.58	$F_{[1,35]}$= 2.266	$F_{[1,35]}$ .003	$F_{[1,35]}$= .016	$F_{[1,35]}$= .003	$F_{[1,35]}$= .35
	p= .000	p= .19	p= .096	p= .000	p= .000	p= .141	p= .960	p= .69	p= .96	p= .556
	η_{par}^2= .30	η_{par}^2= .05	η_{par}^2= .077	η_{par}^2= .36	η_{par}^2= .48	η_{par}^2= .061	η_{par}^2= .00	η_{par}^2= .01	η_{par}^2= .00	η_{par}^2= .01
Object* Handler	$F_{[1.74,63.9]}$= 3.41	$F_{[1.14,40.15]}$= .63	-	$F_{[2,70]}$= 11.58	$F_{[2,70]}$= 10.36	$F_{[1.189,41.615]}$= 1.19	$F_{[1.505,52.673]}$= .49	$F_{[2,70]}$= 1.87	$F_{[1.53,53.44]}$= .31	$F_{[2,63.01]}$= .014
	p= .046	p= .54		p= .000	p= .000	p= .292	p= .561	p= .10	p= .74	p= .986
	η_{par}^2= .09	η_{par}^2= .02		η_{par}^2= .25	η_{par}^2= .23	η_{par}^2= .033	η_{par}^2= .014	η_{par}^2= .05	η_{par}^2= .01	η_{par}^2= .00

Table 5 (Study 2) Mean percentage± SD of time spent for each behavior across the experimental phases.

Phase	Interaction with Object	Look at Object	Social investigation	Attention to Owner	Attention to Stranger	Interaction with Owner	Interaction with Stranger	Explore room	Orientation to door	Stress
BOW	.60 ±1.89	1.18 ±1.76	-	5.74 ±8.53	5.15 ±6.02	2.44 ±7.04	4.68 ±8.84	36.70 ±25.08	6.31 ±14.32	1.11 ±1.56
FDOW	13.40 ±13.59	14.91 ±18.57	8.81 ±11.08	9.78 ±14.44	1.97 ±3.77	.91 ±1.79	2.26 ±4.26	21.33 ±21.91	3.60 ±8.72	1.61 ±1.99
POW	6.31 ±7.08	6.27 ±8.22	-	5.96 ±5.77	3.82 ±4.81	3.63 ±10.83	3.11 ±7.47	34.13 ±25.09	6.52 ±17.76	1.19 ±1.74
BSTR	2.13 ±6.91	.91 ±1.85	-	7.55 ±10.54	6.43 ±10.86	2.08 ±6.44	6.43 ±17.70	40.55 ±31.47	6.10 ±13.93	1.78 ±2.34
FDSTR	10.04 ±10.87	11.42 ±16.05	4.56 ±6.15	9.60 ±10.57	9.07 ±9.72	1.93 ±4.74	3.86 ±8.36	28.47 ±26.26	2.6 ±7.62	2.06 ±2.20
PSTR	3.42 ±5.57	2.68 ±4.41	-	5.87 ±7.56	7.42 ±13.47	3.58 ±11.53	3.15 ±9.31	34.79 ±29.24	4.93 ±8.87	1.5 ±2.16

BOW: the book is handled by the owner; FDOW: the fake dog is handled by the owner; POW: the puppet is handled by the owner; BSTR: the book is handled by the stranger; FDSTR: the fake dog is handled by the stranger; PSTR: the puppet is handled by the stranger

Table 6 (Study 2) Statistical values of the GLM ANOVA for main and interaction effects.

Effects	Interaction with Object	Look at Object	Social investigation	Attention to Owner	Attention to Stranger	Interaction with Owner	Interaction with Stranger	Explore Room	Orientation to Door	Stress
Object	$F_{[1.45,50.99]}$= 24.59	$F_{[1.17,41.15]}$= 17.39	-	$F_{[1.691,59.172]}$= 2.26	$F_{[2,70]}$= .015	$F_{[1.708,59.763]}$= 2.22	$F_{[1.274,44.588]}$= 1.80	$F_{[2,70]}$= 4.11	$F_{[1.45,50.74]}$= .99	$F_{[2,70]}$= .99
	p= .000	p= .000		p= .121	p= .985	p= .125	p= .186	p= .021	p= .36	p= .374
	η_{par}^2= .41	η_{par}^2= .33		η_{par}^2= .061	η_{par}^2= .00	η_{par}^2= .06	η_{par}^2= .049	η_{par}^2= .105	η_{par}^2= .03	η_{par}^2= .028
Handler	$F_{[1,35]}$= 1.44	$F_{[1,35]}$= 4.43	$F_{[1,35]}$= 4.53	$F_{[1,35]}$= .18	$F_{[1,35]}$= 10.49	$F_{[1,35]}$= .041	$F_{[1,35]}$= .85	$F_{[1,35]}$= 2.01	$F_{[1,35]}$= .87	$F_{[1,35]}$= 3.85
	p= .238	p= .046	p= .04	p= .671	p= .003	p= .840	p= .361	p= .166	p= .358	p= .058
	η_{par}^2= .04	η_{par}^2= .11	η_{par}^2= .115	η_{par}^2= .005	η_{par}^2= .231	η_{par}^2= .001	η_{par}^2= .024	η_{par}^2= .054	η_{par}^2= .02	ηpar2= .099
Object* Handler	$F_{[2,70]}$= 2.76	$F_{[1.25,43.85]}$= .91	-	$F_{[2,70]}$= .42	$F_{[2,70]}$= 3.21	$F_{[1.336,46.743]}$= .26	$F_{[2,70]}$= .44	$F_{[2,70]}$= .69	$F_{[1.53,53.44]}$= .13	$F_{[2,70]}$= .25
	p= .07	p= .409		p= .660	p= .046	p= .682	p= .643	p= .504	p= .87	p= .782
	η_{par}^2= .07	η_{par}^2= .02		η_{par}^2= .012	η_{par}^2= .084	η_{par}^2= .007	η_{par}^2= .013	η_{par}^2= .019	η_{par}^2= .004	η_{par}^2= .007

3.4.1. Object directed behaviors

Social investigation. In both studies, almost all subjects engaged in Social Investigation (ano-genital region and muzzle) of the fake dogs (Study 1, 30 dogs out of 36 distributed as follow: 12 both in FDOW and FDSTR, 11 only in FDOW and 7 only in FDSTR; Study 2, 28 dogs out of 36 distributed as follow: 16 both in FDOW and FDSTR, 8 only in FDOW and 4 only in FDSTR). Overall, the FD was investigated for about 9.5% of time in Study 1 and 13% of time in Study 2. Time spent investigating the fake dog handled by the owner or the stranger was not significantly different in Study 1 (FDOW vs. FDSTR $p = 0.096$), while in Study 2 dogs spent a higher amount of time investigating the fake dog in the FDOW than in the FDSTR phase ($p = 0.04$).

Chew/bite. Aggressive bite was never observed, neither in Study 1 nor in Study 2. Dogs sporadically chewed the fake dog and the puppet. In Study 1, 7 dogs out of 36 (19%)

chewed the furry fake dog, 5 of them did it in the FDOW phase and 2 both in the FDOW and FDSTR phases. Another dog chewed the puppet only in the POW phase. In Study 2, this behavior was exhibited toward the plastic fake dog and the puppet by only 5 dogs out of 36 (14%): 3 dogs chewed the fake dog and 2 chewed the puppet. No statistical analysis was carried out due to negligible frequency of this behavior.

Look at object. In both Study 1 and Study 2 the GLMs revealed a main effect of the object identity: dogs spent significantly more time looking at the fake dog compared to the other objects; the puppet was gazed for a longer time than the book (Study 1: fake dog vs. puppet $p<0.001$, fake dog vs. book $p<0.001$, puppet vs. book $p = 0.002$; Study 2: fake dog vs. puppet $p = 0.006$, fake dog vs. book $p<0.001$, puppet vs. book $p = 0.001$).

Interaction with object. In Study 1 (furry fake dog) a significant interaction was found between object and handler identity: overall, dogs interacted significantly longer with the objects when they were manipulated by the owner compared to the stranger (book $p = 0.04$; fake dog $p = 0.001$; puppet $p = 0.03$). As can be seen in Figure 6, dogs interacted longer with the fake dog and with the puppet than with the book, regardless of the identity of the handler (post-hoc values are reported in figure caption). In Study 2 (plastic fake dog) only the identity of the manipulated object had a significant influence on dogs' behavior: dogs spent significantly more time interacting with the fake dog compared to the puppet (fake dog vs. puppet, $p = 0.001$) and to the book (fake dog vs. book $p<0.001$), and they interacted with the puppet significantly longer than with the book (puppet vs. book $p = 0.002$).

In sum, in both studies the majority of dogs showed social investigation of the fake dogs, but no aggression towards them, and looked at the fake dog significantly longer than the other two objects. In Study 1, dogs interacted with the furry dog and the puppet to a comparable extent, whereas in Study 2 they interacted with the plastic fake dog significantly longer than with the puppet. Only in Study 1 all objects were more attractive when on the owner's lap.

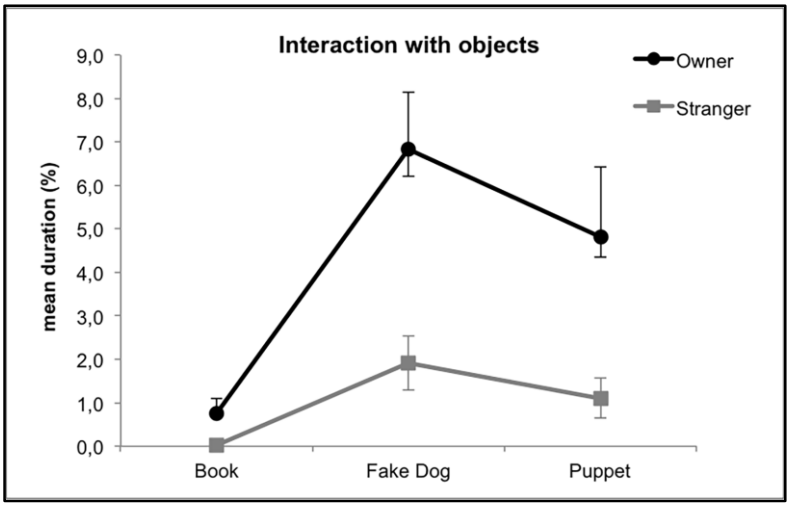

Figure 6 Mean percentage ± SE of time spent by dogs interacting with the object in Study 1. Legend: black line, the owner is manipulating the objects; grey line: the stranger is manipulating the objects. Post-hoc values: Fake dog -Owner vs. Book-Owner, $p<0.001$; Puppet-Owner vs. Book-Owner, $p = 0.035$; Fake dog-Stranger vs. Book-Stranger, $p = 0.014$; Puppet-Stranger vs. Book-Stranger, $p = 0.066$.

3.4.2. Person directed behaviors

Attention to owner. In Study 1, the GLM highlighted a significant interaction Object x Handler (Figure 7): in the book condition dogs paid attention to the owner whether or not the book was in his/her hands, whereas in the fake dog and puppet conditions dogs' attention to the owner was driven by the presence of the object. Furthermore, dogs paid attention to their owner significantly longer when he/she was handling the fake dog compared to the book. In Study 2, even though dogs addressed their attention to the owner mainly in the FDOW and FDSTR phases, the GLM did not highlight any significant effects of object's and handler's identity, nor of the interaction Object x Handler.

Attention to stranger. The GLMs revealed a significant interaction Object x Handler in both studies (Figure 8). In Study 1, both the fake dog and the puppet directed the dogs' attention toward the stranger, and dogs paid attention to the stranger for a significantly higher percentage of time when he/she was handling the furry fake dog compared to the book. No other significant differences emerged. In Study 2, only the fake dog directed the dogs' attention toward the stranger.

Interaction with owner and stranger. The GLM revealed that physical interaction with the owner and the stranger was not differently affected by the objects and handlers' identity.

In sum, in both studies dogs oriented their attention/interaction to the owner and to the stranger manipulating the objects to a similar extent. The fake dogs were the more salient stimuli in eliciting these behaviors.

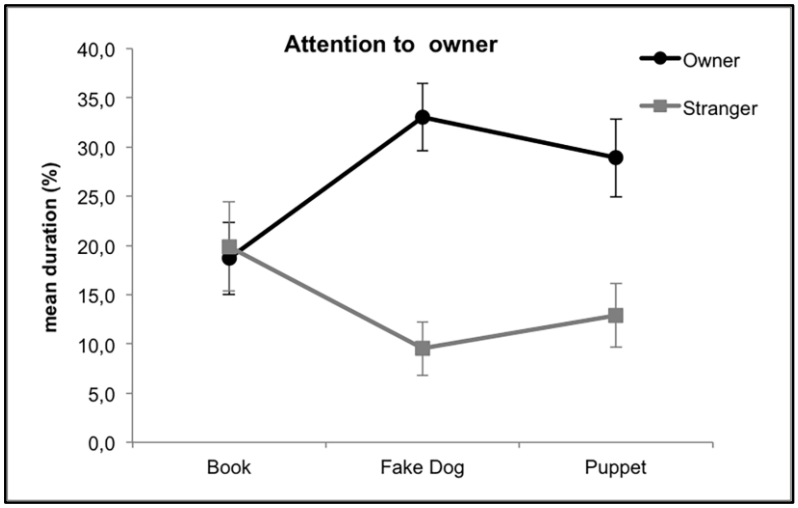

Figure 7 Mean percentage ± SE of time spent by dogs paying attention to the owner in Study 1. Legend: black line, the owner is manipulating the objects; grey line: the stranger is manipulating the objects. Post-hoc values: Fake dog-Owner vs. Fake dog-Stranger, p<0.001; Puppet-Owner vs. Puppet-Stranger, p<0.001; Fake dog-Owner vs. Book-Owner, p = 0.017.

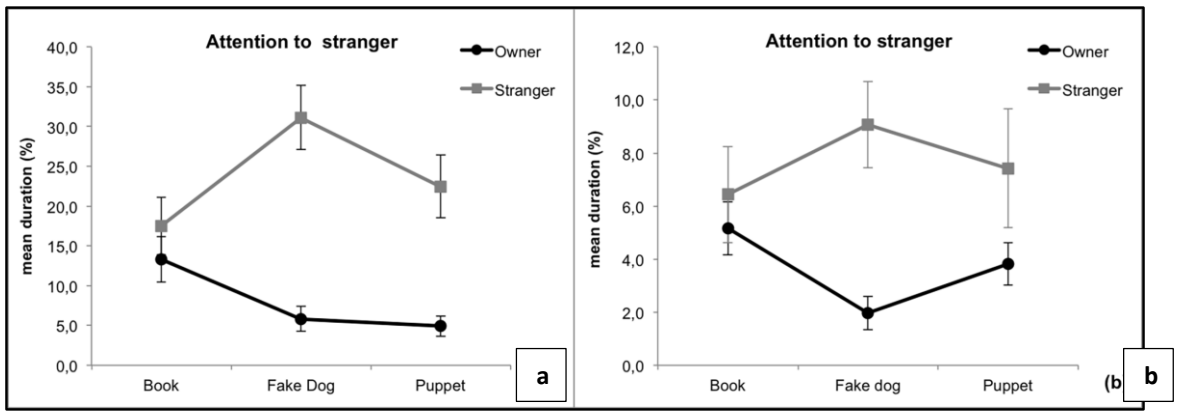

Figure 8 Mean percentage ± SE of time spent by dogs paying attention to the stranger in Study 1(a) and in Study 2(b). Legend: black line, the owner is manipulating the objects; grey line: the stranger is manipulating the objects. Post-hoc values: Fake dog-Stranger vs. Fake dog-Owner, Study 1: p<0.001; Study 2: p<0.001; Puppet-Stranger vs. Puppet-Owner, Study 1: p<0.001; Fake dog-Stranger vs. Book-Stranger, Study 1: p = 0.038.

3.4.3. Vocalizations and stress related behaviors.

Very few dogs tried to attract owner's attention using vocalizations (Study 1: 8 dogs out of 36, 22%; Study 2: 5 dogs out of 36, 14%), doing it uniformly across the testing phases. No statistical analysis was carried out due to negligible frequency of this behavior.

The frequency of stress related behaviors during testing was low and no statistical differences across testing phases emerged.

Therefore, these behaviors did not provide any useful insight to interpret dogs' behavioral reactions in terms of jealousy.

3.4.4. Environment directed behaviors

Explore room and orienting to door. In both studies the GLMs showed a main effect of the object's identity on the dogs' exploratory behavior. Exploration significantly decreased when either the owner or the stranger held the fake dog compared to the other two objects in Study 1, and only compared to the book in Study 2 (Study 1: fake dog vs. book $p = 0.002$, fake dog vs. puppet $p = 0.007$, book vs. puppet $p = 0.47$; Study 2: fake dog vs. book $p = 0.016$; fake dog vs. puppet $p = 0.16$; book vs. puppet, $p = 1$).

As for the time spent being oriented to the door, the GLM did not reveal any difference across the six phases: the dogs spent a similar amount of time oriented to the door whichever objects the owner and the stranger were holding and whoever person was the handler.

3.5. DISCUSSION

The existence of jealousy in dogs, as claimed by Harris and Prouvost [2014], is appealing, but experimental evidence is preliminary. The current study aimed at further understanding whether dogs react with a set of behavioral patterns that could indicate a `primordial' form of jealousy when they lose their owner's attention in favour of a potential rival (a fake dog). For this purpose, we carried out two studies using two types of fake dogs (FD), differing in appearance and texture (Study 1: furry FD; Study 2: plastic FD), a novel object (a puppet) and a book. Moreover, as jealousy should be expressed towards a valuable individual, we controlled for the identity of the handler: thus, the objects were manipulated by the owner and by a stranger who had no social bond with the dog.

Although there were some differences in the behavioral pattern showed by dogs tested in Study 1 and Study 2 (e.g. more attention to people in Study 1 than in Study 2; less interaction with the fake dog in Study 1 than in Study 2; see Tables 3 and 5), results of both studies do not provide convincing proof that the behavioral responses of our dogs were triggered by jealousy, since we did not find clear evidence that the fake dogs were perceived as real social rivals. In addition, dogs did not express, or expressed to a limited extent, many of the behaviors that are considered distinctive features of jealousy (aggression, vocalizations, stress related behaviors, attention/interaction with object and owner). Finally, our dogs did not show, as hypothesized, a differentiated response towards the owner and the stranger.

Our first research question was whether dogs would consider the fake dogs as a real conspecific, as suggested by Harris and Prouvost [2014], on the basis of the number of dogs that in their study exhibited social investigation of the fake dog (86%) and aggressive behavior toward it (25%). Even though in our studies 86% and 78% of dogs exhibited social investigation respectively toward the furry and the plastic fake dog, this investigation was a momentary action and not a careful inspection (Furry FD mean duration: FDSTR: 1.99 s; FDOW: 3.47 s; Plastic FD: mean FDSTR: 2.48 s; mean FDOW: 4.63). Although social investigation of the plastic FD occurred significantly longer when it was on owner's lap than on stranger's lap, in our opinion, this result can hardly be considered a convincing proof that the FDs were effective in deceiving adult and experienced dogs. It is worth considering that the FDs did not smell like a real dog and that during intraspecific interactions between

dogs social investigation allows for individual/sexual recognition through odour cues [Mech, 1970; Fox, 1972]. Olfaction plays such a pivotal role in dogs' social communication that they can discriminate between a familiar and an unfamiliar person using odor cues [Millot et al. 1987, FIliatre et al., 1991] and, remarkably, they show an asymmetric use of nostril when processing odors - emitted by conspecifics/humans - that differ in terms of emotional valence [Siniscalchi et al., 2011, 2016]. Moreover, dogs form cross-modal representations of humans and conspecifics integrating auditory and visual stimuli [Adachi et al., 2007; Taylor et al., 2011]. Likely, a handful of seconds was sufficient for our adult dogs to perceive the FDs as faux and this might account for the complete lack of aggressive behavior. Some of the dogs chewed the FDs, but, differently from what reported by Harris and Prouvost [2014], snapping and biting were never observed. It is worth noting that their fake dog was a toy for human infants that barked/whined and wagged its tail, while our FDs were silent and motionless: thus, the aggressive responses they observed could have been motivated by fear of a novel/odd object or by predatory drive rather than by jealousy [Reisner, 2003]. It is also possible that the dogs tested at their home by Harris and Prouvost [2014] showed aggressive behavior driven by a protective/territorial motivation [Blackshaw, 1991]. In our opinion a neutral testing environment is more suitable to disentangle aggressive behaviors triggered by jealousy from territorial/protective aggression. However, the choice of the testing location is always critical and presents pros and cons that could be interesting topics for further researches.

If it is reasonable to assume that the FDs are not perceived as real dogs, there are no particular reasons to be jealous: thus, which could be the dogs' underlying motivation to show interest towards them? As in Harris and Prouvost's study [2014], our dogs preferentially looked at the furry FD than at the soft puppet, but they did not seem to discriminate between them when interacting (sniffing and touching); this suggests that these objects were both perceived as toys, as they were of similar size and of soft texture, and that the furry FD resembled toys most pet dogs are familiar with. Conversely, in Study 2, the FD and the puppet had a different appearance and a different texture and it is possible that dogs prolonged their interaction with the plastic FD to make sense of it.

We also expected that if dogs were jealous they would have shown signs of distress and protest (vocalizations) when attention and care were directed to the FDs, but not to

the other objects [Harris & Prouvost, 2014; Szabo et al., 2014]. Results show that vocalizations were infrequent and distributed across the test phases without any link to a specific object/person. To a certain extent these results are similar to those of Harris and Prouvost, who found that: 1. vocalization were relatively infrequent; 2. there was no difference across conditions in barking; 3. dogs whined more in the jealousy condition than in the book condition, but not the jack-o-lantern condition [2014]. Overall, it seems to us that dogs did not bark/whine to regain their owner's attention and to re-establish the relationship with him/her, but to express frustration for being ignored and for not obtaining full access to a potentially interesting object. Further confirmation derives from the frequency of stress signals, which was low and uniformly distributed across testing phases, indicating an arousal state due to the testing situation. In sum, these findings suggest that the use of the FD as a potential rival in a jealousy evoking paradigm is critical, as the stimulus is unnatural. In the context of temperament assessment, Barnard and colleagues [2012] questioned the validity of model devices (a fake dog and a child-like doll): they concluded that adult dogs may perceive these models as social stimuli only at distance and for a few seconds at the beginning of the interaction, since the model does not smell, move or interact like a real conspecific or a real child.

In line with Harris and Provoust's results [2014], the book *per se* was largely overlooked, as dogs spent half of the testing time exploring the room when people handled this object. Although to a lesser extent than in the FD conditions, dogs attended to the owner (and the stranger) also in the book condition. This could have at least two different explanations: 1. being sensitive to human inattentiveness [Call et al., 2003]; 2. being uncertain about the situation and looking for human cues [Merola et al., 20012a, 2012b].

Considering that the adaptive function of jealousy is to protect a valuable relationship from an intruder, it should be expected that an unfamiliar person devoting attention and care to a 'conspecific' would not elicit a jealousy response. Thus, to extend Harris and Prouvost's results [2014], we introduced a relevant variation in the experimental paradigm, adopting the procedure devised by Hart and colleagues with human infants [Hart et al., 1998]. A second person, totally unfamiliar to the dogs (but manipulating the same objects) served as control to exclude that dogs' reactions were due to a mere interest towards the more salient/desired object or to the frustration of being deprived of an

interesting toy. Results of both studies showed that dogs' attention (being oriented and gazing) to the owner and the stranger was driven by the presence of the FDs and the puppet in their lap. On the other hand, their attention was not preferentially directed to the attachment figure (the owner), which in the human literature is considered a fundamental requisite to attribute jealousy to an individual. Differently from our results, and in line with an interpretation in terms of jealousy, Hart and colleagues [1998] found that children manifested distress and disapproval of the lack of attention and that these reactions were linked with the identity of the person holding the infant-like doll.

Of course our negative outcome does not necessarily mean that dogs do not possess a rudimentary form of jealousy. Indeed, as highlighted above, we believe that our FDs were inappropriate stimuli to trigger jealousy and rivalry in dogs. It is important to underline that comparing adult dogs and human infants, albeit interesting, requires caution: adult dogs and human infants differ in terms of perceptual abilities, as they rely on different sensory modalities in making sense of the world, in their mobility and possibility to interact with the environment. Physical interaction and contact seeking with the attachment figure are pervasive components of the jealousy response in children [Hart, 2010; Dillon, 2013] and also occur in situation of mild distress such as the Strange Situation Test [Ainsworth et al., 1978]. Nevertheless, these behaviors, which are clearly observable in dogs during the paradigm of separation from the attachment figure [Prato Previde & Valsecchi, 2014], were scarcely expressed in our testing conditions, providing further support that the dogs did not perceive the presence of the faux rival as a threat to the relationship with their owner.

In sum, current data does not exclude that dogs may have a rudimentary form of jealousy, but shows that available evidence is still inconclusive and that different experimental paradigms and additional rigorous research is required. For example, replications using a more naturalistic procedure and a real social interloper (either conspecific or human), rather than a false social stimulus, could be more suitable in ascertaining whether dogs experience and show a rudimentary form of jealousy, as strongly believed and carefully described by dog owners [Morris et al., 2008, 2012]. Our results also suggest that, as for human infants, the investigation of emotions in nonhuman animals is tricky and hampered by limitations, as behavioral expressions may provide ambiguous information about internal emotional states [Hart, 2016; Kujala, 2017].

4. DO DOGS EXHIBIT JEALOUS BEHAVIORS WHEN THEIR OWNER ATTENDS TO THEIR COMPANION DOG?

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4.1. ABSTRACT

Jealousy appears to have clear adaptive functions across species: it emerges when an important social relationship with a valued social partner is threatened by third-party that is perceived as a rival. Dyads of dogs living together and their owners were tested adapting a procedure devised to study jealousy in young human siblings. Owners at first ignored both dogs while reading a magazine (Control episode), and then petted and praised one of the dogs while ignoring the other, and vice versa (Experimental episodes). We found several differences in the dogs' behavior between the Experimental episodes and the Control episode, even though only monitoring (gazing at the owner) was exhibited for a significantly greater amount of time in the Experimental episodes. Remarkable individual behavioral differences emerged, suggesting that the dogs' reactions could be influenced by the relationships that they establish with their owner and the companion dog. Overall, current results do not clearly support our prediction that the ignored dogs would exhibit more behaviors aimed at regaining the owner's attention when their owner directed attention and care to a companion dog, compared to the control situation. The great intra- and inter-dyad behavioral variability and the choice to test cohabiting dogs could have prevented the emergence of a clear jealous reaction. These findings do not exclude that dogs may exhibit a primordial form of jealousy in a realistic situation, but an additional research is needed to fully gauge which situations, if any, could trigger jealousy in dogs and to rule out alternative explanations.

Keywords: Dog; Emotions; Jealousy; Dog–human relationship; Individual differences.

4.2. INTRODUCTION

Despite the increasing interest in understanding emotions in non-human animals, to date, only a limited number of studies have investigated the presence of "secondary emotions" in species other than humans, providing contrasting results [Horowitz, 2009; Custance & Mayer, 2012; Hetch et al., 2012; Steiner & Redish 2014; Harris & Prouvost, 2014; Panskepp & Panskepp, 2013; de Waal & Preston, 2017; Kujala, 2017]. Indeed, the belief that "secondary emotions", such as empathy, guilt, and jealousy, are restricted to relatively mature humans and other non-human primates is still widespread [e.g., Lewis, 2008], since these emotions seem to require some sense of the self and the ability to interpret social situations [Leary, 2003].

However, it is likely that, along with "primary" emotions, at least some "secondary" social emotions have evolved in non-human species to regulate inter-individual social relations [Cubicciotti & Mason, 1978; Panskepp, 2010; Palagi et al., 2015; de Waal & Preston, 2017; Maninger et al., 2017]. A growing body of evidence indicates that many social animals form complex social relationships with their conspecifics, which vary in function, duration, exclusivity, and emotional involvement [Mitani, 2009; Dunbar & Schultz, 2010; Massen et al., 2010]. There is also evidence that animals may have knowledge of their own and others' relationships over time and adapt their behavior accordingly [Schino & Aureli, 2009; Seyfarth & Cheney, 2012]. Social relationships are highly adaptive, as they ensure basic (e.g., food and shelter) and social (e.g., emotional support and stress alleviation) needs and are mediated by emotional states that are both causes and consequences of social interactions [Aureli & Schino, 2004; de Waal, 2008; Seyfarth & Cheney, 2012].

According to the human psychological literature, jealousy is a complex social emotion that involves an array of more basic emotions and arises in a specific social context, namely when one individual believes or perceives that another individual (a rival) is threatening an affectional relationship that is source of material and psychological benefits [Hart, 2010; Pansksepp, 2010; Dillon, 2013].

Jealousy entails primary emotions (e.g., fear, anger, and sadness), which appear to be present in a variety of mammalian species [Plutchik, 2001; Panksepp, 2011], and is expressed through overt behaviors (labeled jealous behaviors) aimed at restoring or

maintaining the relationships being challenged [Harris, 2003; Hart, 2010]. These emotional processes and behavioral displays appear to characterize jealousy in different types of human social bonds, like the one between friends or peers, romantic partners, and between infant and mother [Harris, 2004; DeSteno et al., 2006; Dillon, 2013].

Several studies show that human infants, starting from 6 months of age, become troubled and vocalize when their mother directs her attention and care to an infant-like doll or to a sibling, approach and gaze at her maintaining close proximity, and touch/push the social competitor (doll/sibling); in some cases, their response escalates to aggressive reactions directed either towards the social rival or towards the mother [Teti and Ablard, 1989; Hart et al., 1998, 2004; Miller et al., 2000; Hart and Carrington, 2002; Volling et al., 2010]. These behavioral responses are considered expressions of a primordial form of jealousy, as they combine both attention-seeking and protests reactions aimed at regaining the mother's attention [Mize et al., 2014; Hart, 2016].

Overall, developmental research provides evidence that jealousy is an early arising emotion and supports the emerging view [Harris, 2003; Hobson, 2010] that a primordial form of jealousy could exist without entailing a fully-fledged sense of the self or complex interpretations of social situations and others' intentions [Harris, 2004]. Indeed, cognitively immature infants are sensitive to the loss of maternal attention and react to potential threats to the relationship with their attachment figure before reaching the cognitive and representational complexity that characterizes jealousy in older infants and, later, in adults [Frijda, 1993; Goldie, 2000, p. 45; Hobson, 2012]. Moreover, authors suggest that this emotion could have evolved to protect material and affective resources within the parent–offspring relationship [Hart, 2016], possibly to cope with situations in which the survival/fitness of an individual is threatened by the presence of a rival. The evolutionary/functional view of jealousy in human infants and the possibility that jealousy could exist along with different levels of cognitive complexity has relevant theoretical implications for comparative research. Because social inclusion is essential for the survival of group-living animals, threats to social bonds (e.g., forced separation, being excluded from desired relationships) activate specific emotional responses. Different species show behaviors that allow to reduce the risk of social exclusion and relationship disruption (i.e., post-conflict affiliation, consolation [Aureli et al., 2002; Cools et al., 2008; Fraser et al.,

2008, 2009; Palagi and Cordoni, 2009; Fraser & Bugnyar, 2010]). Many non-human animals face situations that require defending important social resources from potential rivals [Draghi-Lorenz et al., 2001; Harris, 2004; Panskepp, 2010], which could explain the existence of a primordial form of jealousy in some social animals [Forbes, 2010].

Among domestic animals, dogs (*Canis lupus familiaris*) have rather sophisticated socio-cognitive abilities, which, in some cases, parallel those reported for human infants [Prato-Previde et al., 2003; Lakatos et al., 2009; Tomasello & Kaminski, 2009; Marshall et al., 2013], and their emotional life is gradually being uncovered [Kujala, 2017]. They seem to respond to unequal treatments [Range et al., 2009; Horowitz, 2012; Brucks et al., 2016; Essler et al., 2017] and appear to be sensitive to others' distress and social exclusion [Cools et al., 2008; Palagi & Cordoni, 2009; Quervel-Chaumette et al., 2016]. Dogs live in close contact with humans, rely on them for both material and psychological needs [Miklósi et al., 2000; Merola et al., 2012a, 2012b; Gácsi et al., 2013], and form stable relationships and bonds with specific individuals, showing separation distress and behaviors aimed at regaining and maintaining proximity when involuntary separations take place from the attachment figure [for a review: Prato-Previde & Valsecchi, 2014]. In this perspective, dogs are suitable subjects to investigate the existence of jealousy in non-primate species and, thanks to their long-lasting relationship with humans, they provide a unique opportunity to investigate jealousy within interspecific social contexts.

If jealousy has evolved to defend exclusive relationships and important resources that flow through them [Harris, 2004; Panskepp, 2010; Dillon, 2013] and jealous behavior has the function to facilitate the maintenance of an important social relationship, its expression in dogs would be adaptive in the human/familiar "niche" to protect the relationshipwith their human companions. Indeed, pet-owners claim that their dogs show jealousy when they affectionately interact with another dog or another person [Morris et al., 2008, 2012; Martens et al., 2016]. The presence of a primordial form of jealousy in dogs was recently examined using a procedure in which either the owner alone [Harris & Prouvost, 2014] or the owner and an unfamiliar person [Prato-Previde & Nicotra et al., 2018] affectionately interacted with a stuffed dog or other objects, while ignoring the experimental dog. These studies provided contrasting results on whether dogs considered a faux dog as a potential rival and their behavior could be explained in terms of jealousy. In

particular, Harris and Prouvost [2014] reported that dogs exhibited a pattern of behavior that could appear indicative of jealousy (e.g., aggressive behavior and pushing/touching the object/owner) when their owner manipulated the stuffed dog, but not the other objects (i.e., a jack-o-lantern and a book). Conversely, Prato-Previde et al. [2018] found no clear evidence that dogs considered the faux dog as real social rival and reported no differentiated response in dogs when the owner (i.e., their attachment figure) and an unfamiliar person manipulated the faux dog compared to other objects (i.e., a puppet and a book). However, both Harris and Prouvost [2014] and Prato-Previde et al. [2018] agreed that a more realistic situation involving a real interloper would have been more appropriate to investigate the existence of a primordial form of jealousy in dogs.

This topic is gaining attention among researchers, since, in only a few months, three studies were carried out simultaneously [Abdai et al., 2018; Prato-Previde et al., 2018; present study]. Abdai and colleagues [2018] tested the hypothesis that jealous behavior can be evoked in dogs, using real dogs as social test partners and objects as non-social test partners. Their dogs showed more jealous behavior, i.e., owner-oriented behavior and attempts to interrupt the interaction, in the social (a real dog) compared to the non-social (inanimate objects) situations, and thus, they concluded that "jealous" behavior emerges in dogs and it is functionally similar to that observed in children in similar situations. Although these results are interesting in essence, they are not so different from our previous outcome in which dogs ignored the non-social stimulus (i.e., the book; [Prato-Previde et al., 2018]. As we argued in the discussion of our data, the use of a real dog, instead of a fake one, elicited more intense jealous behaviors [Abdai et al., 2018].

In the meanwhile, based on our previous findings [Prato- Previde et al., 2018], we chose to investigate whether, in a triadic social context (two companion dogs with their owner), dogs would show jealous behavior when ignored in favor of the companion dog. The testing procedure was adapted from studies conducted on young human siblings to investigate jealousy towards their parent [Miller et al., 2000; Volling et al., 2002]. Likewise, our procedure involved two dogs with the same owner; owners at first ignored both dogs while reading a magazine (control episodes), and then petted and praised one of the dogs while ignoring the other, and vice versa (experimental episodes).

We predicted that if the ignored dogs perceived the other dog as a threat to the relationship with their owner, they would engage in behaviors aimed at regaining the owners' attention, such as gazing, vocalizing, and touching/pushing the owner and/or the other dog. As these behaviors may be considered an expression of a primordial form of jealousy [Hart et al., 2004; Morris et al., 2008; Harris & Prouvost, 2014; Abdai et al., 2018; Prato-Previde et al., 2018], we expected that they would not occur, or occur to a lesser extent when the dogs were simultaneously ignored by the owner.

4.3. METHODS

4.3.1. Subjects

The experiment was conducted on 25 dyads of dogs living in the same household with their owner. In 4 dyads, the owner was not able to pet one or both dogs, failing to respect the testing procedure: these dyads were excluded from the analyses, and thus, the final sample included 21 dyads of dogs that accepted to be petted (24 females and 18 males; age range in years = 2–14; age range in months = 24–168; mean age = 72.55 months; SD = 36.22 months; characteristics of dogs are reported in Table 7). Owners were volunteers recruited by personal contact, word of mouth and advertisements distributed within the Università degli Studi di Milano. The criteria for including dogs in the study were: being at least 2 years old, cohabiting with the companion dog and the owner for at least 1 year, being healthy and not aggressive.

Dogs had been living with the owner on average for 5 years (59.76 months; SD = 31.16 months) and with the cohabitant dog for an average of 3.8 years (46.19 months; SD = 25.29 months). One dyad was made of brother and sister, one dyad of mother and son, and one dyad of half-brothers; dogs in the remaining dyads were not blood related.

Table 7 Breed, age, and sex information about subjects and dyads' composition.

Dyad dog 1				Dyad dog 2			
Sex	**Age (months)**	**FCI breeds' nomenclature**	**Time living with owner (months)**	**Sex**	**Age (months)**	**FCI breeds' nomenclature**	**Time living with owner (months)**
F	58	Mixbreed	56	F	96	Deutscher boxer	90
M	60	Mixbreed	59	M	36	Border collie	34
F	27	Mixbreed	19	F	24	Mixbreed	21
M	36	Mixbreed	31	F	54	Mixbreed	29
F	84	Mixbreed	36	F	96	Segugio italiano a pelo raso	72
F	24	Zwergschnauzer	24	F	84	Bouledogue français	84
F	38	Chihuahueño	35	M	54	Chihuahueño	51
M	65	Piccolo levriero italiano	63	F	55	Piccolo levriero italiano	53
F	84	American cocker spaniel	48	M	144	Cane corso italiano	60
F	24	Weimaraner	23	M	36	Weimaraner	15
F	110	Pug	108	F	138	Mixbreed	132
M	60	Mixbreed	60	M	60	Mixbreed	51
M	96	Border collie	94	F	66	Mixbreed	43
F	168	Mixbreed	30	F	48	Mixbreed	48
F	63	Collie rough	60	F	30	Collie rough	28
M	96	Fox terrier (smooth)	93	M	96	Fox terrier (smooth)	93
F	33	Australian sheperd	30	M	144	Mixbreed	132
M	84	Beagle	61	M	108	Beagle	73
F	109	Labrador retriever	21	F	24	Labrador retriever	21
M	96	English cocker spaniel	96	M	72	Mixbreed	72
M	90	Labrador retriever	90	F	90	Labrador retriever	90

4.3.2. Setting and procedure

Testing took place in a room (4.5 × 3.5 m) at the "Canis sapiens Lab" of the Università degli Studi di Milano. The room was equipped with one chair for the owner, a small plastic table located next to the chair where a magazine was placed, a water bowl, a computer positioned on a small table, and an HD video camera placed on a wall in a corner of the room to record the test.

Upon arrival, owners signed a consent form and filled up a questionnaire with information about the dogs (e.g., age, breed, training experience, lifestyle, and period of

cohabitation). The owner and the two dogs then entered the testing room and, while the experimenter explained the test procedure to the owner, the dogs were free to explore the room for approximately 10 min. Owners were thoroughly illustrated how to behave and were guided throughout the procedure by a PowerPoint presentation that provided timing and written instructions. After the experimenter left the room, the test started according to the following sequence:

1. Initial episode (1 min): both dogs were ignored and the owner walked around the room paying attention to the posters on the walls;
2. Control episode 1 (1 min, C1): as instructed, the owner sat on the chair reading a magazine, not looking at the dogs nor interacting with them, regardless of their behavior;
3. Experimental episode 1 (1 min, E1): the owner, remaining seated, called one of the two dogs and started to pet and praise him/her, while ignoring the other dog (Ignored Dog 1, hereinafter indicated as ID1). The owner was instructed not to play nor embrace the dog, but could recall the dog if he/she would walk away;
4. Interval episode (1 min): the owner walked away from the chair, called both dogs and greeted them, and then walked around the room ignoring the dogs. This interval was aimed at avoiding, or at least reducing, any potential carryover effects from the Experimental episode;
5. Control episode 2 (1 min, C2): the owner sat on the chair reading the magazine and ignoring both dogs, as in C1;
6. Experimental episode 2 (1 min, E2): the owner acted as in E1, but switched his/her attention to the other dog, while ignoring the dog that received positive attention in the previous Experimental episode (Ignored Dog 2, hereinafter indicated as ID2).

4.3.3. Data collection and analysis

All tests were video recorded and analyzed using Solomon Coder beta ® 15.01.13 (ELTE TTK, Hungary). Dogs' behaviors were coded during the C1, C2, E1, and E2 episodes, recording their duration and/or occurrences according to the ethogram reported in Table

8. The ethogram was compiled after a first video analysis and was partially based on studies on jealousy in human infants [Hart et al., 2004; Mize et al., 2014] and dogs [Harris & Prouvost, 2014; Prato-Previde et al., 2018]. The behavioral analysis was carried out on both dogs in the C1 and C2 episodes, and only on the ignored dog in the E1 and E2 episodes. In the statistical analysis E1 and E2 were considered as a unique episode, and the order of being ignored was used as factor (ID1 and ID2).

Table 8 Behavioral categories recorded during the control episodes (C1 and C2) and the experimental episodes (E1 and E2).

Category	Definition
Dog–dog interplay[a]	Any interaction involving both dogs and being reciprocated such as playing, sniffing, chasing, and physical contact
Interaction with owner[a]	Walking, standing, or sitting between the owner and the other dog, nudging the owner with paw or muzzle, pushing, biting, and jumping on the owner, or sniffing/licking him/her
Interaction with dog[a]	Nudging the other dog with paw or muzzle, pushing, biting and jumping on the other dog or sniffing, licking him/her
Monitor the owner[a]	Gazing at the owner while being close or from a distance
Proximity to owner[a]	Remaining close to the owner without gazing at him/her
Other[a]	Any behavior not included in the ethogram (e.g. exploring, walking around, drinking, looking at the door)
Stress signals[b]	Stress related behaviors, such as paw raising, nose-lip licking, shaking, yawning and scratching
Vocal behavior[b]	All types of vocalizations such as barking, growling and whining
Interaction disrupted[bc]	The interaction between the owner and the other dog was disrupted by the ID

[a]Behaviors recorded as durations; [b]Behaviors recorded as frequencies; [c]Behavior recorded only in experimental episodes.

The duration of the test episodes slightly varied in length due to the owners' differences in readiness to follow the instructions; therefore, durations and frequencies of all behaviors were transformed in percentages of the total time and of total occurrences, respectively, and used as dependent variables in the statistical analysis.

Inter-observer agreement was assessed by means of independent parallel coding of a random sample of 21 dogs out of 42 (50% of the total number of dogs). Agreement was

assessed by Spearman correlation and was significant for all behaviors, with ρs ranging from 0.65 to 0.967 and p ranging from 0.02 to 0.0001.

Models residuals did not meet the required assumption of normality and homoscedasticity: thus, we chose to run Wilcox's robust statistical analysis, based on trimmed means [Mair et al., 2018]. Robust between-groups ANCOVAs were carried out on all behaviors expressed in the Control and Experimental episodes to assess the effect of dog's sex and length of cohabitation of the dogs with their owner (months, used as covariate). Since no significant differences in behavior were found between C1 and C2, the data collected in these episodes were averaged into a single control episode (C) for the following analyses. Robust repeated-measures ANOVAs with order (ID1 and ID2) as between-groups effect and episodes (C and E) as within-subjects effect were carried out.

A K-mean cluster analysis was carried out on the E episode to group our dogs according to their most characterizing behaviors. Robust repeated-measures ANOVAs were carried out to evaluate any difference in the expression of those behaviors emerging from the cluster analysis.

All analyses were performed in R 3.2.5 [R Core Team, 2016], using the WRS package functions [Mair et al., 2018] t2way for two-way ANOVAs, ancova for ANCOVAs, bwtrim for two-way mixed repeated-measures ANOVAs, t1way for one-way ANOVAs, rmanova and rmmcp for repeated-measures ANOVAs and pairwise post hoc test, respectively. The effect size was estimated using the robust coefficient (analog to the ξ2 explicative measure) proposed by Rand, Wilcox, and Tian (2011), based on 20% trimmed mean and Winsorized variance; authors suggest that ESs = 0.15–0.35 and 0.50 should be judged as small, medium, and large effects, respectively.

4.4. RESULTS

Dogs reacted to the experimental situation with a high behavioral variability: while almost all subjects showed proximity to the owner and monitor (proximity: 83 and 88% of dogs in the C and E episodes, respectively; monitor: 100% of dogs in both the C and E episodes), interaction with the owner was exhibited by 67 and 64% of the dogs in the E and the C episodes, respectively. A more limited number of dogs (26% in the E episode; 28% in the C episode) interacted with the companion dog either in a gentle manner (sniffing, licking, nudging with paw or muzzle, and gently biting the other dog) or in a rougher way (i.e., pushing, biting, and jumping on the other dog).

Although dogs showed stress-related behaviors in both the E and the C episodes (59 and 57% of dogs, respectively), the frequency of these behaviors was very low (mean E = 1.78 event/min; mean C = 1.63 event/min). Similarly, vocalizations were limited, with only 11 dogs out of 42 (26%) engaging in vocal behavior during the E episode and 9 out of 42 (21%) in the C episode (mean E = 5.28 event/min; mean C = 3.0 event/min). Interplay between dogs, involving both dogs and being reciprocated (i.e., playing, sniffing, chasing, and physical contact) was rare, with only 4 dyads showing it in the E episode and 4 dyads in the C episode.

In the E episode, only 9 out of 42 dogs (21.42%, 5 large size dogs, 3 medium size dogs, and 1 small size dog) caused the interruption of the affectionate interaction between the owner and the companion dog.

The statistical analysis showed that there was no significant effect ($p > 0.05$) of dogs' sex and length of cohabitation of the dogs with the owner for any of the behaviors considered (Robust ANCOVA, trimmed means = 0.2).

As shown in Figure 9 there were some differences in the expressions of the behaviors between the Control episode (C) and the Experimental episode (E): in particular, dogs remained in proximity of the owner and engaged in dog–dog interplay longer in the C episode than in the E episodes, whereas they spent more time in owner and dog interaction and in monitor in the E episodes than in the C episode. Robust-mixed repeated-measures ANOVAs revealed that the order of being ignored did not affect any behavior. Despite the differences emerged in the expression of proximity, monitor, owner, and dog interaction,

a significant principal effect of Episode emerged only for the behavior Monitor [F(1;39) = 23.0787, p = 0.0003; Fig. 1].

To have an insight on individual behavioral patterns emerging during the Experimental episode, all behavioral variables were scaled and put into a K-mean cluster analysis. The plot of the within cluster sum-of-square suggested that the optimal solution, harmonizing simplicity and sensibility, could be a three clusters partitioning, labeled on the basis of the prevailing behavior as follows: Cluster 1—monitor behavior, Cluster 2—proximity, and Cluster 3—interaction with owner (Figure 10). As shown in Figure 11, the occurrence of stress-related signals is similar in the three Clusters; however, differently from Clusters 2 and 3, vocalization and interruption of the interaction between the owner and the petted dog are absent in Cluster 1 (Figure 11). Fourteen dogs (33.33%) fitted into Cluster 1 (Monitor behavior), 18 (48.86%) into Cluster 2 (Proximity), and 10 (23.81%) into Cluster 3 (Interaction with owner). In 8 dyads out of 21 (38,10%), both dogs fitted in the same Cluster (2 dyads included dogs of Cluster 1, 4 dyads included dogs of Cluster 2, and 2 dyads included dogs of Cluster 3), while, in the remaining dyads, all the other possible combinations were found (Table 9).

Robust repeated-measures ANOVAs were carried out on the behaviors identified by the cluster analysis and revealed significant differences in the expression of Proximity, Monitor, and Interaction with owner, for both dogs of dyads [ID1: Ft(1.85,22.23) = 5.33, p = 0.014, ES = 0.16; ID2: Ft(1.62,19.44) = 11.93, p < 0.001, ES = 0.16].

Robust pairwise post hoc comparisons, following Holm's approach to alpha correction, showed, for ID1, a significant difference between Monitor and Interaction with owner, and for ID2 significant differences between Monitor versus Proximity and between Monitor versus Interaction with owner (Table 10).

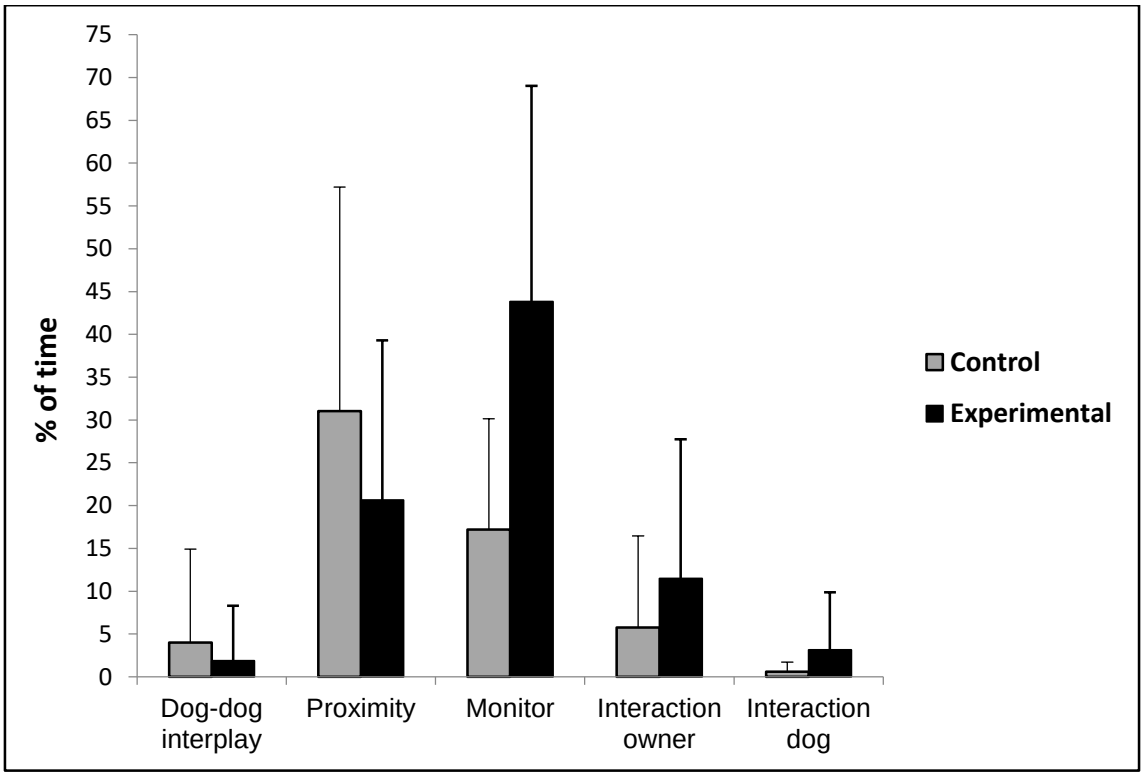

Figure 9 **Mean percentage of time (+ SD) spent by dogs in different behaviors in the Control (C) and Experimental (E) episodes.**

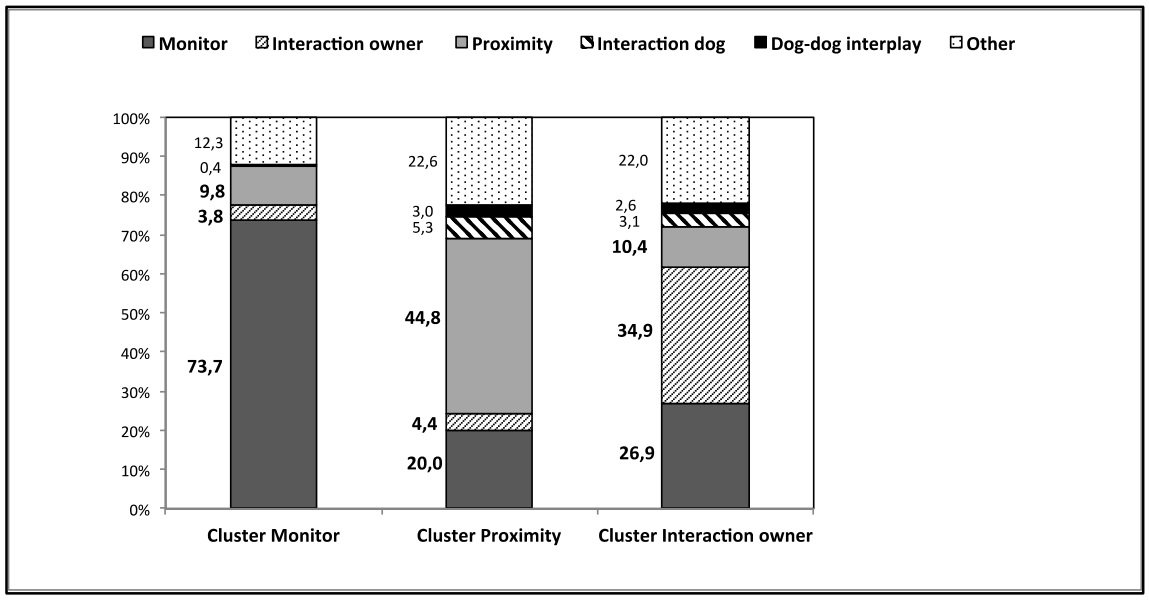

Figure 10 **Behavioral categories measured as duration (% of time) included in Cluster 1 (monitor), Cluster 2 (proximity), and Cluster 3 (interaction with owner).**

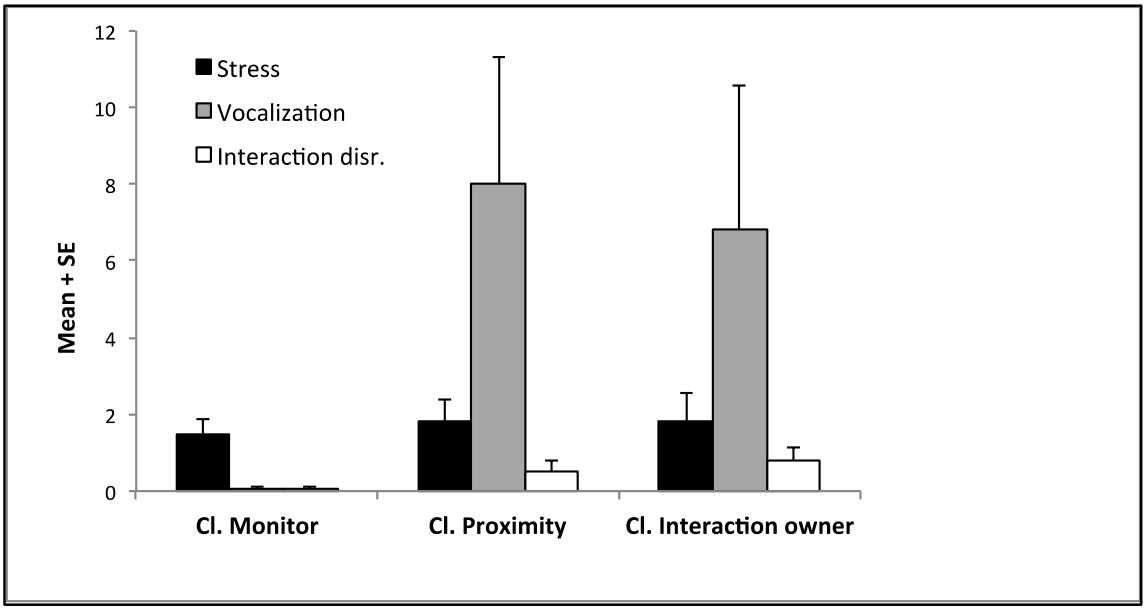

Figure 11 Mean frequency (+ SE) of stress-related behaviors, vocalizations, and interaction disruption included in Cluster 1 (monitor), Cluster 2 (proximity), and Cluster 3 (interaction with owner).

Table 9 Distribution of dogs' dyad fitting in each of the nine possible combinations of clusters expressed as frequency (%).

	ID2's cluster		
ID1's cluster	Monitor (Cl. 1)	Proximity (Cl. 2)	Interaction with owner (Cl. 3)
Monitor (Cl. 1)	2 (9.52)	4 (19.04)	1 (4.76)
Proximity (Cl. 2)	3 (14.28)	4 (19.04)	1 (4.76)
Interaction with owner (Cl. 3)	2 (9.52)	2 (9.52)	2 (9.52)

Table 10 Statistical values of pairwise post hoc t tests.

		Δ	95% CI	*p* value	critical *p*	*H*0
ID1						
Monitor vs						
	Proximity	17.48	− 10.83 to 45.81	0.112	0.025	Accepted
	Interaction with owner	26.13	0.14 to 52.39	0.015	0.017	Rejected
Proximity vs	Interaction with owner	12.29	− 8.31 to 32.90	0.123	0.05	Accepted
ID2						
Monitor vs						
	Proximity	25.71	1.88 to 54.29	0.024	0.025	Rejected
	Interaction with owner	34.78	14.69 to 54.87	< 0.001	0.017	Rejected
Proximity vs	Interaction with owner	7.08	− 5.42 to 19.57	0.141	0.05	Accepted

4.5 DISCUSSION

Although the belief that dogs are capable of jealousy is well rooted among people and dog owners [Morris et al., 2008, 2012; Martens et al., 2016], experimental evidence is limited and provides contrasting results [Harris & Prouvost, 2014; Abdai et al., 2018; Prato-Previde et al., 2018].

This study aimed at further investigating whether dogs would exhibit jealous behaviors [Hart, 2010, 2015; Abdai et al., 2018] in a realistic situation involving a real dog as an interloper. Adapting a procedure devised to assess jealousy towards the mother/father in human infants [Miller et al., 2000; Volling et al., 2002], we assessed the behavioral patterns exhibited by the dogs when they were ignored, while their owners displayed affection to their companion dog. We compared the behaviors of dogs in the experimental situation with their behavior in a control situation in which they were simultaneously ignored by the owner. We expected that if, in the Experimental situation, the dogs perceived their companion dog as a potential rival, they would show patterns of behavior that should not occur, or occur to a lesser extent, when they were simultaneously ignored by the owner.

We found a number of differences in the behavioral patterns exhibited by the dogs: in the Experimental episodes, the dogs showed less proximity to the owner, more monitoring and more interaction with the owner and the other dog, compared to the Control episode; however, these differences did not reach statistical significance, except for monitor behavior and this could be due to the great intraand inter-dyad variability. Only a minority of dogs attracted their owners' attention by barking and/or whining and this occurred mainly in the E episode, suggesting that vocalizing could be part of an individual attention getting strategy (see below). Frequency of stress-related signals was very low and expressed to a comparable extent across the episodes, providing evidence that dogs did not perceive the testing situation as very stressful.

Even though the behaviors exhibited by the dogs in our Experimental episodes are similar to those observed in human infants when their parent interacts with a sibling [Volling et al., 2002, 2014] and in dogs when disregarded by the owner [Harris & Prouvost, 2014; Abdai et al., 2018; Prato-Previde et al., 2018], overall, our results do not clearly support the conclusion that dogs exhibited a primordial form of jealousy. Indeed,

differently from what predicted, the behaviors shown by the dogs in the E episodes were exhibited to a certain extent also in the C episode when the owner simultaneously ignored both dogs while reading a magazine.

Human research suggests that during jealousy-evoking situations' infants express various behaviors, including approaching the caregiver, attention-provoking actions, visual attention/gazing at the caregiver, interposing themselves between the caregiver and the rival [Miller et al., 2000; Harmon-Jones et al., 2009; Dillon, 2013]. In the Experimental episodes, our dogs significantly increased the time spent monitoring the owner, a behavior considered to be an indicator of a primordial form of jealousy also in dogs [interest/attention in Harris and Provoust, 2014; oriented/looking in Abdai et al., 2018]. Although monitoring per se does not provide sufficient evidence that dogs were expressing a primordial form of jealousy, it does indicate sustained social attention, which is considered a component of a jealousy reaction in humans. A more parsimonious explanation could be that dogs' attention and gazing were facilitated by the actions initiated by the owner. Mehrkam et al. [2014] reported an increase in intraspecific affiliative and play behavior in wolf and wolf-dog crosses hosted in a sanctuary when in the presence of a caretaker interacting with them. However, in our opinion, social facilitation is not sufficient to explain why our dogs significantly increased monitoring rather than joining the ongoing interaction between the owner and the companion dog.

Across the entire experiment, it emerged that behaviors such as monitoring and maintaining proximity prevailed over interactive behaviors. It should be underlined that our sample of dogs included well-rooted dyads, composed by adult dogs living together with the owner for at least 1 year. It can be supposed that our dogs were used to attend and monitor the interaction between their owner and their companion dogs, "waiting for their turn". It is also worth noting that, while some subjects actively interacted during the Experimental episodes, they preferentially acted upon their owner than on the companion dog, possibly because the owner is the attachment figure and represents their major source of material and psychological benefits. While there is clear evidence that family dogs form an infant-like attachment with their owner, it is unclear whether the relationship with an adult conspecific conforms to an attachment bond [Mariti et al., 2014; Prato Previde and Valsecchi, 2014]. Furthermore, cohabiting dogs, to maintain the existing equilibrium, have

probably established social dynamics mainly based on prosociality rather than conflicts [Cools et al., 2008; Dale et al., 2016] and this could explain why we found almost no evidence of aggressive behavior. The best strategy to regain their owner's attention and care would be to act on the owner rather than on the other dog pushing him/her away. It is possible that our choice to engage familiar dogs living together, to avoid potential aggressive reactions between unfamiliar subjects, was too restrictive: the high level of familiarity between dogs might have been a bias greater than expected. Interestingly Abdai et al. [2018] found no differences in the behavior of the ignored dog when the owner interacted with either a familiar or an unfamiliar conspecific: this outcome cannot be considered conclusive, since their study lacks of a control situation, included in our study, in which both dogs were simultaneously ignored by the owner to evaluate the effect that the mere loss of owner's attention could have on dogs' behavior.

An interesting result of the current study is the emergence of striking individual differences in the Experimental episodes: a number of dogs reacted more passively monitoring the third-party interaction without vocalizing to attract their owners' attention; the other two groups of dogs showed a more active pattern of responses vocalizing: interrupting the petting of the companion dog and staying in close proximity or acting on the owner. These findings are in agreement with the previous evidence reporting individual differences in dogs' reactions towards a fake dog [Harris and Prouvost, 2014; Prato-Previde et al., 2018], and more generally with the literature showing that non-human animals, including dogs, adopt different behavioral strategies to deal with unpleasant and stressful environmental and social situations [Koolhaas et al., 1999; Korte et al., 2005; Horváth et al., 2007; Passalacqua et al., 2013]. There are evidences that also children and toddlers adopt different strategies to face jealousy-evoking situations, i.e., high levels of monitoring, disruptive behaviors, or solitary play [Volling et al., 2002, 2014]. It has been suggested that behavioral profiles could reflect the type of attachment that the child has with his/her parent: insecurely attached infants, compared to securely attached ones, protest more when their mother interacts with a sibling [Teti & Ablard, 1989], while remain in proximity and physical contact with the mother more when she gives attention to an infant-like doll [Hart & Behrens, 2013]; securely attached children, on the other hand, show less negative and disrupting behaviors when their parents interact with the sibling [Volling et al., 2002].

Given that some studies suggest the presence of different attachment styles in dogs when tested in the Strange Situation [Tòpal et al., 1998; Taggart, 2010; Schöberl et al., 2016], it is possible that the differences in dogs' behaviors emerged in this study were influenced by the type of attachment the dogs which establish with their owner (e.g., secure vs. insecure).

Behavioral differences in our Experimental situation were also detectable within dog dyads: only within 8 dyads both individuals had similar reactions, whereas, within the majority of dyads, dogs showed diverse patterns of responses. The quality of the relationship between the two dogs and the way which they interact in their normal environment (e.g. dominance/affiliation relationship and resources management) could play a role in the expression of these individual differences (e.g., being more disruptive vs. more attentive). This is supported by the fact that most owners (90%), at the end of the test, declared that their dogs behaved as they expected on the basis of what usually happens at home under similar circumstances.

Overall, the current results do not provide a clear support to our prediction that dogs would show more behaviors aimed at regaining their owner's attention when ignored by the owner in favor of the companion dog (a situation that could trigger jealousy) compared to a control situation (i.e., being simultaneously ignored by the owner). It cannot be excluded that the great behavioral variability both intra- and inter-dyads, together with the choice to test cohabiting dogs, may have prevented the emergence of a more clear jealous reactions in our sample of dogs. An alternative explanation could be that dogs were just searching for interaction and owner's attention without experiencing a primordial form of jealousy. Undoubtedly, in the light of all the available data, more research is needed to deepen this topic and to fully gauge which situations, if any, could trigger jealousy in dogs. One possibility could be to use an unfamiliar or a less familiar dog (known but not cohabiting) as interloper-receiving attentions from the owner: this could possibly trigger a stronger reaction than the one emerged in the present study. Another approach could be to compare the reactions of dogs to an unfamiliar person petting the companion dog in presence/ absence of the owner: since the function of jealousy appears to protect a valuable relationship from an intruder, it would be expected that an unfamiliar person petting the companion dog would not elicit, or elicit to a lesser extent, a jealous response. However, a procedure involving an unfamiliar interloper or a stranger requires particular

caution, since aggression between unfamiliar dogs is more likely to occur than between familiar dogs, and not all adult dogs appreciate being petted by unfamiliar people.

In sum, the current findings do not exclude that dogs may have a primordial form of jealousy, being aware that assuming its existence does not imply making inferences on the subjective experience of the individual. Furthermore, our results underline the general difficulty of unravelling emotions in non-human animals and of devising procedures that are suitable to investigate them.

4.5.1 Compliance with ethical standards

Conflict of interest. The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Ethical statement. All procedures were performed in full accordance with Italian legal regulations (National Directive n. 26/14—Directive 2010/63/UE) and the guidelines for the treatments of animals in behavioral research and teaching of the Association for the Study of Animal Behavior (ASAB). A written consent to video-record and use data in an anonymous form was obtained by the owners prior to testing.

5. WHAT DOES DRIVE DOGS' GAZE WHEN ATTENDING A SOCIAL INTERACTION? AN EYE-TRACKER STUDY

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5.1. ABSTRACT

Experiments devised to assess the existence of jealousy in dog entail observations of dogs' behavior when it is attending its owner affectively interacting with a potential rival, but information collected have limits, it is not possible to identify the target of their interest.

The final step of this project was to evaluate what drives dogs' interest during a social interaction. A sample of dogs was tested using the eye tracker method, they were exposed to 8 videos showing different situations (petting/veterinary check) and subjects (owner/stranger; real/fake dog), in order to find what is more attractive for dogs, during a social interaction, between the person who is interacting with the potential rival, the rival itself or the kind of interaction.

Duration of fixations was analysed: no difference in time spent gazing the owner or the unfamiliar person when appeared as first person on the screen emerged, and dogs gazed for a significant higher amount of time the areas of interaction and the paws/wheels, regardless of the type of the ongoing interaction, the kind of dog present and the identity of the person involved.

5.2. INTRODUCTION

The eye-tracking is an advanced non-invasive methodology, which allows to collect information from gaze fixations and eye-movements. The earliest eye-trackers were built in late 1800s and in the last 20 years this tool had spread enormously and researchers adopted it in numerous fields. Usability analysts, sports scientists, cognitive psychologists, reading researchers, psycholinguists, neurophysiologists, electrical engineers, and others use this methodology for different reasons [Holmqvist et al., 2011]. In neuroscience, this methodology is useful to study perception, cognition, and preferences in humans, non-human primates and non-primate animals.

Recently, the usefulness of eye-tracking had been found also in research on dog cognition, allowing to find that dogs, without any task-specific pre-training, have a preference towards images showing dogs' faces compared to human faces, toys, and alphabetic characters, likely because of a natural tendency in giving attention to conspecifics [Somppi et al., 2012].

However, dogs are attentive also to human cues, in a study conducted to assess dogs' social communicative skills with humans, it emerged that dog's gaze following was more accurate when the person on the video got the attention of the experimental dog through direct gaze and addressing, before turning the head, indicating the target. This work demonstrated that the eye-tracker could be adopted to study, not only preferences in dogs and their attentive states, but also their social skills [Téglàs et al., 2012].

Because of both phylogenetic and ontogenetic features [Miklósi et al., 2003; Gácsi et al., 2005; Nitzschner et al., 2012], dogs learned to read human behavior (reviewed in [Virányi et al., 2008; Udell & Wynne, 2011]), understanding human gestures and ostensive signals, like eye contact, name calling and intonations [Kirchhofer, 2012 ; Topál et al., 2014] and being sensitive to the human face [Gácsi et al., 2004]. An fMRI study in awake dogs also found that a region of dogs' temporal cortex shows activation when dogs are exposed both to conspecifics' and human faces, compared to other stimuli [Dilks et al., 2015].

The head and the face in particular are the main source of information for individuals in different species [Leopold & Rhodes, 2010], indeed both humans and chimpanzees, when exposed to an image of an animal figure show a preference for the

region of the face compared to other bodily parts [Kano & Tomonaga, 2009], but dogs are also able to gather information from human faces, both in terms of direct communication and emotional states, indeed an eye-tracking study found that dogs' gaze is driven more on the face region of the eyes, compared to others [Somppi et al., 2013].

In support of the theory that dogs are sensitive to human emotions, dogs exposed to human facial expressions resulted capable of discrimination between different emotions [Huber et al., 2013; Müller et al., 2015] and showed a human-like left gaze bias, which did not emerge with other primates' or conspecifics' faces and which was dependent by the amount of exposure to humans [Guo et al., 2009; Barber et al., 2016]. This bias was elicited by neutral or negative expressions, but not by positive expressions [Racca et al., 2012], suggesting that probably the left bias was due to the different roles of the two brain hemispheres in processing emotions [Ehrlichman, 1987; Alves et al., 2008], a lateralization already found in other species (humans [Bourne, 2008; Watling et al., 2012], apes [Parr & Hopkins, 2000], monkeys [Kalin et al., 1998], sheep [Kendrick, 2006], dolphins [Thieltges et al., 2011], dogs [Quaranta et al., 2007; Siniscalchi et al., 2008, 2010; Racca et al., 2012]; [Adolphs et al., 2001; Salva et al., 2012]).

The attention towards humans shown by dogs is due to both a long evolutionary history and the daily cohabitation between a pet dog and its owner, so it is likely that every human gesture is under dogs' attentive control, but it is hard to get every aspect through the mere observation of dog's behavior. Previous studies of this research project, conducted to assess the existence in dogs of jealous behaviors, entailed observing dogs' reactions when attending a potential rival and the owner positive interacting. Unfortunately, observational studies although fundamental, proved to be not enough to address the topic, it is always hard to give the driving cause to behaviors like "interfering the interaction", "monitoring the interaction" or "seeking for proximity". According to the definition of jealousy, the focus should be always the owner, but, without a technological support, it is not possible to face the issue.

In this perspective, the eye-tracking methodology could be useful. The last step of this project was to assess, through the analysis of the gaze, which is more attracting for a dog, when exposed to a video in which there is a person interacting with another dog. Since owners represent the most important humans in dogs' lives, they should be more attentive

when exposed to videos showing the owner, compared to an unfamiliar person, interacting with another dog, also because in previous studies it was found a preference in dogs for familiar images, compared to novel stimuli [Somppi et al., 2012].

Moreover, since dogs are able to gather human and conspecifics' cues [Virányi et al., 2008; Topàl et al., 2009; Téglàs et al., 2012], different kinds of interaction should trigger attentive states in measured rates. Pet dogs, accustomed to attend human interactions with the environment, should discriminate between a neutral interaction and a positive interaction, therefore when exposed to a video in which there is the owner engaged in a neutral interaction, experimental dogs should be less attentive, compared to a positive interaction, also they should notice the absence of emotional contagion of the dog shown in the video, because of the immobility of its tail.

Finally, another level of control was included: dogs were exposed both to videos in which the interaction involved an unfamiliar adult dog and to videos in which the target of the interaction was a plush dog. From previous studies it seems that dogs can discriminate between images of real conspecific and objects, therefore they should discriminate between the real and the fake dog [Somppi et al., 2012], and since pet dogs living with humans are accustomed to attend them manipulating various kinds of object, the interaction towards a plush dog should not trigger an attentive state.

5.3. METHODS

5.3.1. Subjects

The sample consisted of twenty-five healthy privately owned pet dogs (see Table 11) that had previously participated in other eye tracking studies (Barber et al., 2016) and were habituated to the methodological routines (approval no. 02/03/97/2013, approved 24.04.2013). They were of various breeds and their owners were recruited from a dataset already existing at the Clever Dog Lab (Messerli Research Institute, University of Veterinary Medicine, Vienna). Owners were volunteers and also gave written consent to participate in the study.

Table 11 General information about subjects.

Name	Sex	Age	Breed	Castration
Aeden	M	9	Border Collie	Yes
Akin	M	8	Rhodesian Ridgeback	Yes
Akina	F	9	Akita Inu	Yes
Amy	F	7	Border Collie	No
Apryl	F	8	Border Collie	Yes
Arielle	F	2	Border Collie	No
Cameron	M	5	Border Collie	No
Carlisle	M	6	Border Collie	No
Chasie	F	8	Border Collie	Yes
Emily	F	9	Border Collie	Yes
Gatsby	5	M	Border Collie	No
Hagrid	7	M	Drahthaar-Mix	Yes
Kayleigh	6	F	Border Collie	No
Keksi	5	F	Mix Breed	Yes
Lara	F	5	Border Collie	Yes
Linus	M	3	Australian Shepherd	No
Maeva	F	6	Border Collie	No
Mulan	F	7	Labrador-Drahthaar-Mix	Yes
Müsli	M	4	Border Collie	Yes
Roxie	F	9	Jack Russel-Mix	Yes
Schoko	F	7	Magyar Vizsla	Yes
Tika	F	10	Husky-Mix	Yes
Tini	F	6	Deutscher Boxer	No
Ziva	F	6	Border Collie	Yes
Zuri	F	8	Rhodesian Ridgeback	Yes

5.3.2. Stimuli

The stimulus set consisted of eight videos, lasting about 15 sec, showing eight different situations. The videos were recorded in a standardized setup at the Clever Dog Lab (Messerli Research Institute, University of Veterinary Medicine, Vienna). The camera was fixed on a tripod, positioned at two meters from the actors and one meter from the floor, to get a view of the scene realistic for the dog.

Actors were in front of a white wall with a close door on each side (see Figures 12 a & b). The actors in the video were a person and a dog: the person could be the owner of the experimental dog or a female person unfamiliar to it; the dog could be an adult well-trained Border Collie mix unfamiliar to the experimental dog or a plush dog of the same size of the real dog and position on a wheeled cart.

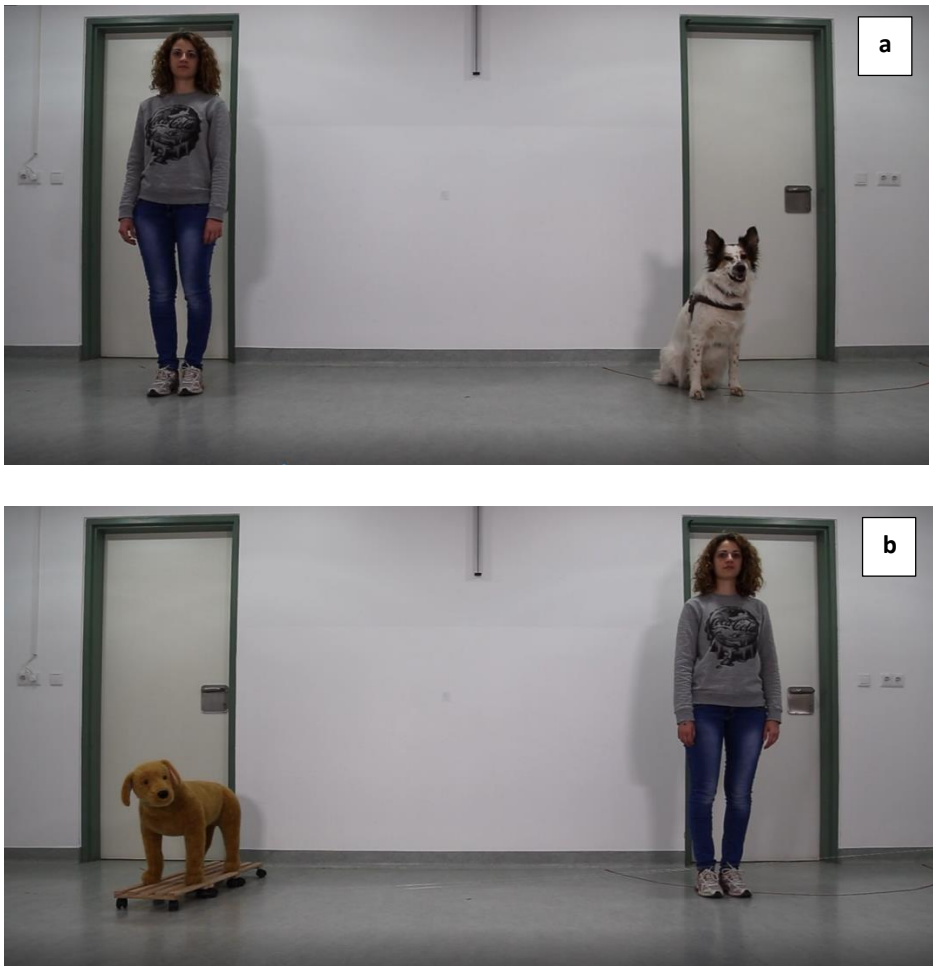

Figure 12 Examples of actors' positioning on the screen during the Presentation phase: a: stranger on the left and real dog on the right; b: plush dog on the left and stranger on the right.

Each video consisted of two phases: **Presentation** and **Interaction**. During **Presentation** a person was standing in front of one of the doors and the dog was positioned in front of the other one, both looking at the camera; this phase lasted for 5 secs. After that both actors moved towards each other (the plush dog was moved by means of a fishing line attached to the wheeled cart from an experimenter invisible in the video), and upon arrival in the middle of the scene the person kneeled down and started the interaction with the dog for 5 s without covering it (**Interaction** phase).

Two kinds of interaction were shown, **petting** and **veterinary check**: petting consisted of strokes and cuddles on dogs' head and shoulders; veterinary check consisted of eye, ear and teeth inspections.

To control for any possible side bias, the position of actors (humans and dogs) in the scenes were randomized.

The eight videos showed the following combinations of actors and interactions:

1. Owner & Real Dog – Petting:
2. Stranger & Real Dog – Petting
3. Owner & Fake Dog – Petting
4. Stranger & Fake Dog – Petting
5. Owner & Real Dog – Veterinary Check
6. Stranger & Real Dog – Veterinary Check
7. Owner & Fake Dog – Veterinary Check
8. Stranger & Fake Dog – Veterinary Check

Each experimental dog was exposed to all the eight videos in a randomized order. Note that videos 2, 4, 6 and 8 were the same for all dogs, showing the same female researcher.

5.3.3. Experimental setup [modified after Barber et al., 2016]

All experiments were conducted at the Clever Dog Lab (CDL), of the University of Veterinary Medicine in Vienna. The experimental room was divided by a wall with two

doors, into two compartments; a small one (149 x 356 cm) housing the computer system operating the eye tracker and a larger one (588 x 356 cm) with a partially-covered modular framework including the chin rest device, a monitor (27”) and the eye tracker. This framework allowed to reduce dogs got distracted during the tests. The stimuli were back-projected onto the monitor.

To record monocular data from the subjects it was used the eye tracking system Eyelink 1000 (SR Research, Ontario, Canada). There was a customized chin-rest device for head stabilization. A pillow with a v-shaped depression was mounted on a frame to allow vertical adjustment of the chin rest to the height of the individual dog. The frame consists of aluminium profiles (MayTec Aluminium Systemtechnik GmbH, Germany) that allowed the easily adjustable but stable fixation of additional equipment (e.g. additional lights). The chin rest was positioned at a distance of 50 cm from the monitor, while the eye-tracking camera with the infrared illuminator was mounted on an extension of the chinrest frame (see Figures 13 and 14). This apparatus is aligned horizontally with the chin rest. Light conditions in the room will be kept constantly at 75 lux using LED-light bulbs (9,5W, 2700k, Philips GmbH Market DACH, Germany).

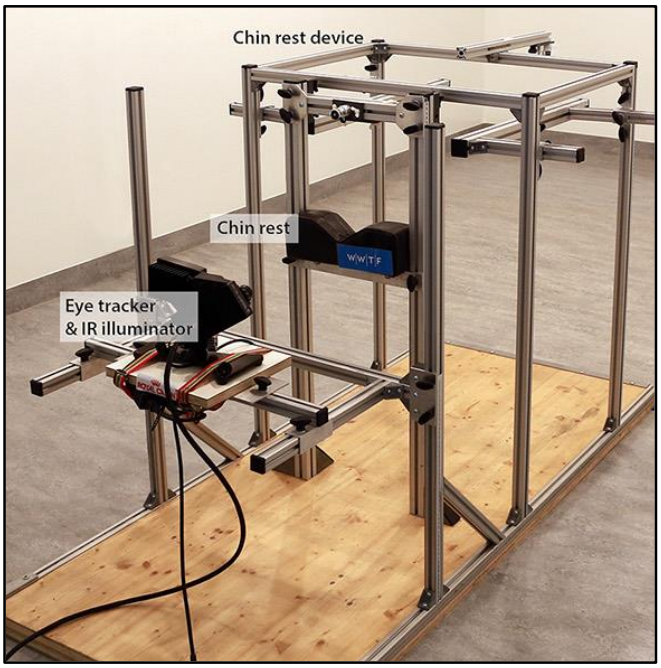

Figure 13 Experimental set up: front view of the chin rest device including the eye-tracking camera with IR illuminator, from Barber et al., 2016.

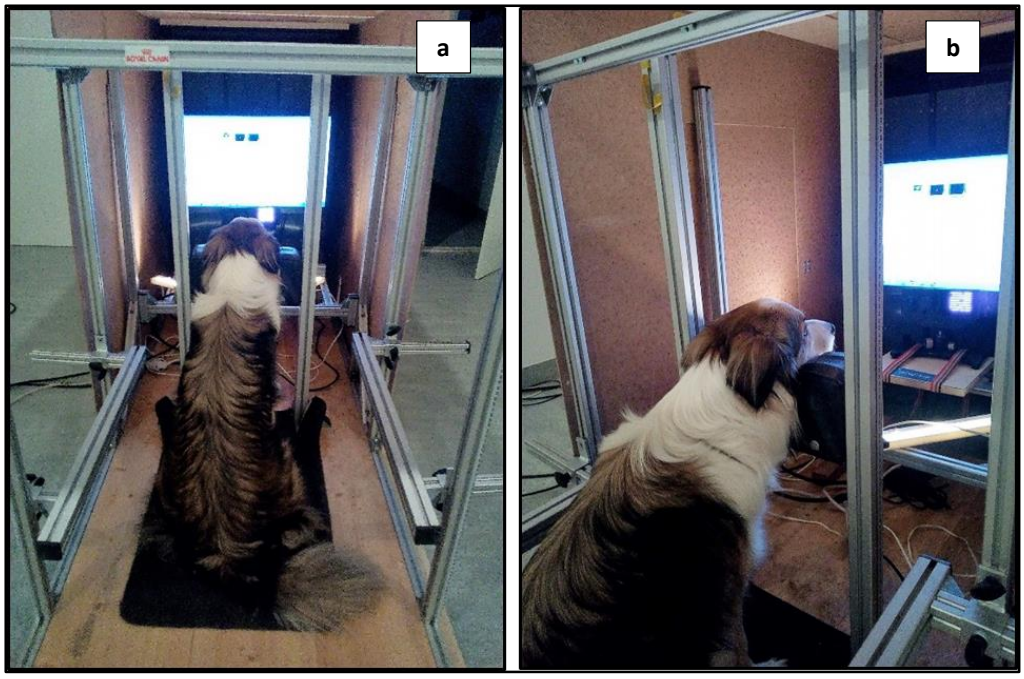

Figure 14 Posterior (a) and lateral (b) view of the chin rest device.

5.3.4. Testing

Each dog was exposed to the eight videos in two different days (test sessions) with an interval of about 10 days. Each test session consisted of two trials: each trial included 2 videos arranged in a sequence of about 32 secs, with an attention trigger (a black frame showing an orange cone in the middle, 1 sec) preceding each video.

At the beginning of a test session, the dog was allowed to explore the room with the eye-tracker apparatus for approximately 5 min. The dogs were previously trained to lay their head on the chin-rest and gaze at the monitor. Before each session a standardized three-point-calibration procedure was run. Thereby three small dots were presented one after the other on the screen (size of the dot: 50 mm, coordinates (x,y): (512,65), (962,702), (61,702) while the dog had its head on the chin rest. When the dog focused on the dot for at least a second, the point was accepted on the operating computer. Calibration did not last longer than 2 minutes [Barber et al., 2016].

During the whole procedure the owners were allowed to sit blindfolded in the rear part of the room.

Following successful calibration, the dog was presented with the stimuli as follows:

a) The first trial was presented on the screen (about 32 seconds).

b) Break (60 seconds), the dog was left free to move out of the device and walk around in the room, releasing tension.

c) The second trial was presented on the screen (about 32 seconds).

d) Rewards.

In total, the whole procedure did not last longer than 20 minutes.

During the whole procedure dogs were never restrained or forced to perform the task. They were free to look at the video that is presented to them and also free to leave the eye-tracking frame.

5.3.5. Analysis

Dogs were included into the analysis only if calibration resulted correct. In addition, since Dataviewer started the registration of the test immediately before the beginning of the trial, in 9 cases a bug in the software used for playing videos emerged, causing a reduction in the duration of the video shown, while in 8 cases Dataviewer did not register properly the test, making data from that video useless.

Therefore, 5 videos lasted less than 5000 ms in the Presentation phase, and 4 in the Interaction phase, while for 4 subjects it was not possible to analyse entirely the stimulus set.

Each video was divided into eight dynamic areas of interest (AoI) during the phase of Presentation (1-8 AoI; Table 12, Figures 15, 16, 17, 18) and into nine dynamic areas of interest during the phase of Interaction (9-17 AoI; Table 12, Figures 15, 16, 17, 18).

Table 12 Dynamic Areas of Interest for each video.

Presentation	1	owner/stranger
	2	real/fake dog
	3-4-5-6-7-8	other
Interaction	9	petting/vetcheck
	10	back's dog
	11	paws/wheels
	12	owner/stranger's legs
	13-14-15-16-17	other

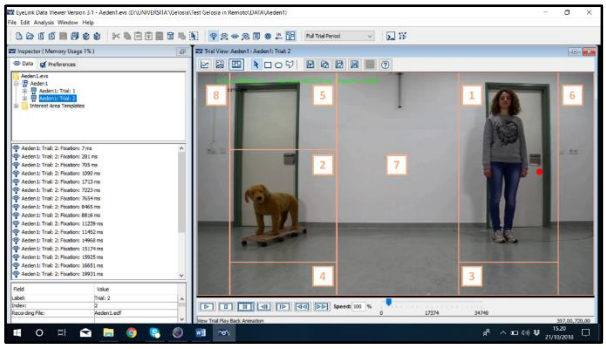

Figure 15 Dynamic Areas of Interest in Presentation phase (left: plush dog, right: stranger).

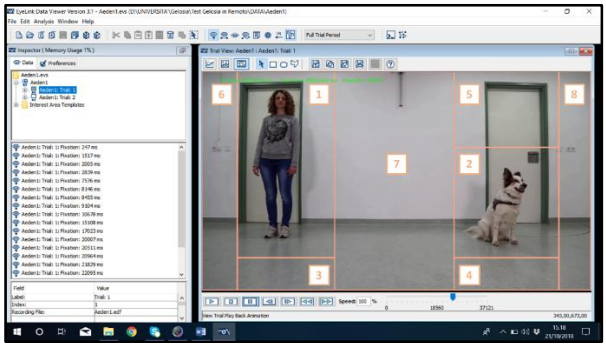

Figure 16 Dynamic Areas of Interest in Presentation phase (left: stranger, right: real dog).

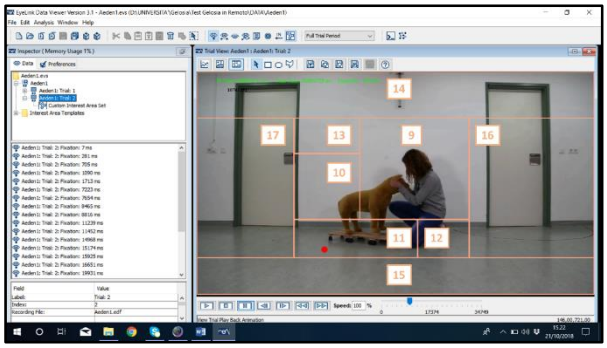

Figure 17 Dynamic Areas of Interest in Interaction phase (positive interaction; left: plush dog, right: stranger).

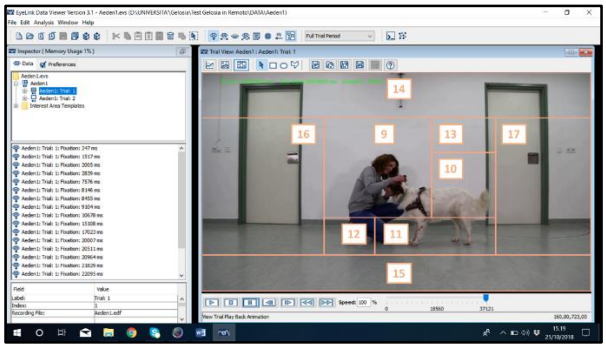

Figure 18 Dynamic Areas of Interest in Interaction phase (neutral interaction; left: stranger, right: real dog).

All the areas of interest (AoI) were rectangular, their positioning and size were established considering height and width of all the actors involved (i.e. people, real dog and dog-like toy).

Raw eye movement data was analysed using Data Viewer 2.1.1 (SR Research, Ontario, Canada). The EyeLink tracker´s on-line parser identified eye movement events. As there is to date no validated literature on the definition of eye movement events in dogs, we were working with raw data without any thresholds for fixation duration [Barber et al., 2016]. From the raw data we extracted fixation durations, number of fixations and latencies to the first fixation (fixation start).

Data from Areas of Interest number 4-5-6-7-8 were added up together, in order to create a unique macro-area “other_P” for the Presentation phase, and from Areas of Interest number 13-14-15-16-17, in order to create a unique macro-area “other_I” for the Interaction phase.

Since Areas of Interest’s surfaces were different, total duration of all fixations fitting in each AoI was divided by the surface of the respective Area.

Since data distribution did not fulfil criteria for parametric analysis, nonparametric statistics was adopted, using the package R WRS2 (Wilcox Robust Statistic 2). It allows to ignore extreme values among the distribution and to analyse interactions between all variables existing.

5.4. RESULTS

Presentation phase. In figure 19 the time spent gazing the owner and the stranger when they appeared as first person on the scene was compared to the time spent gazing the owner and the stranger when they appeared as second person on the scene (whichever type of dog was present).

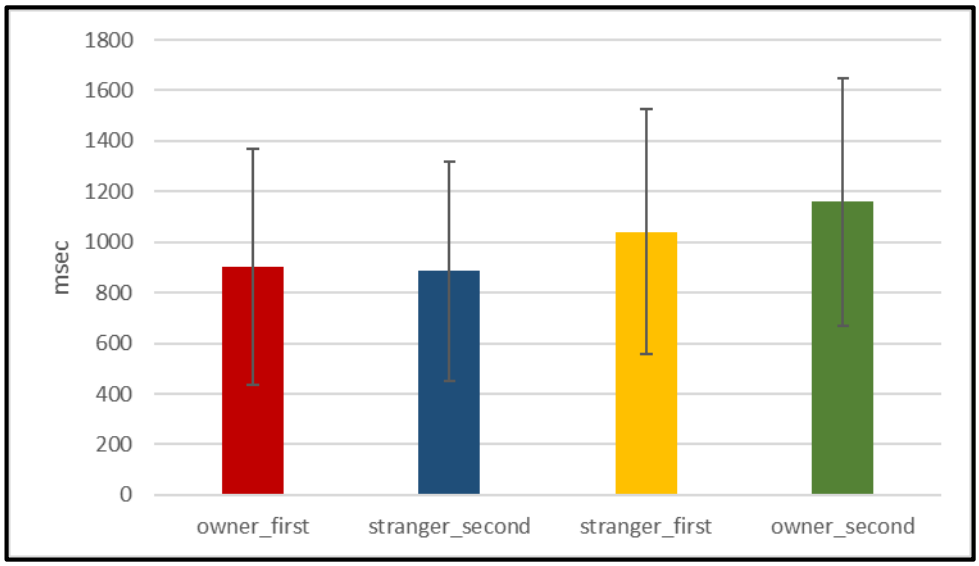

Figure 19 Mean time +SE spent gazing the owner and the stranger when they appeared as first person on the scene (owner_first, stranger_first) and the owner and the stranger when they appeared as second person on the scene (owner_second, stranger_ second). Owner_first's and stranger_second's columns report data from the same individuals, and the same is for stranger_first's and owner_second's columns.

Although the averages of durations resulted extremely similar (owner_first: 902,75 msec (SE=467,05) Vs stranger_second: 885,83 msec (SE=433,45) – stranger_ first: 1040,77 msec (SE=484,47) Vs owner_second: 1160,23 msec (SE=489,76)), data were analysed with nonparametric statistic.

A Wilcoxon test was carried out to evaluate the mean time spent by dogs in gazing the humans, when the owner was shown for first and then the stranger, and vice versa when the stranger was shown for first and then the owner. No statistical difference was found in both conditions (owner_first Vs stranger_second, p=.859; stranger_first Vs owner_second, p=.477). The mean time spent by dogs in gazing the first person shown on videos was analysed with a Mann-Whitney test. No statistical difference was found (owner_first Vs stranger_first, p=.681).

Interaction phase. Robust Two-Way Mixed ANOVA Using Trimmed Means (.2) and Winsorised variance (.1) were carried out using R (3.3 version), to analyse the duration of all fixations to asses if there were any significant effect of the person involved (owner Vs stranger), the type of dog (real Vs plush), the kind of interaction (petting Vs veterinary check), and the area of interest (9-10-11-12 and other_I) and/or any significant interaction effect between these variables. The effect of area resulted significant (see Figures 20a, 20b, 20c, 20d and Table 13)

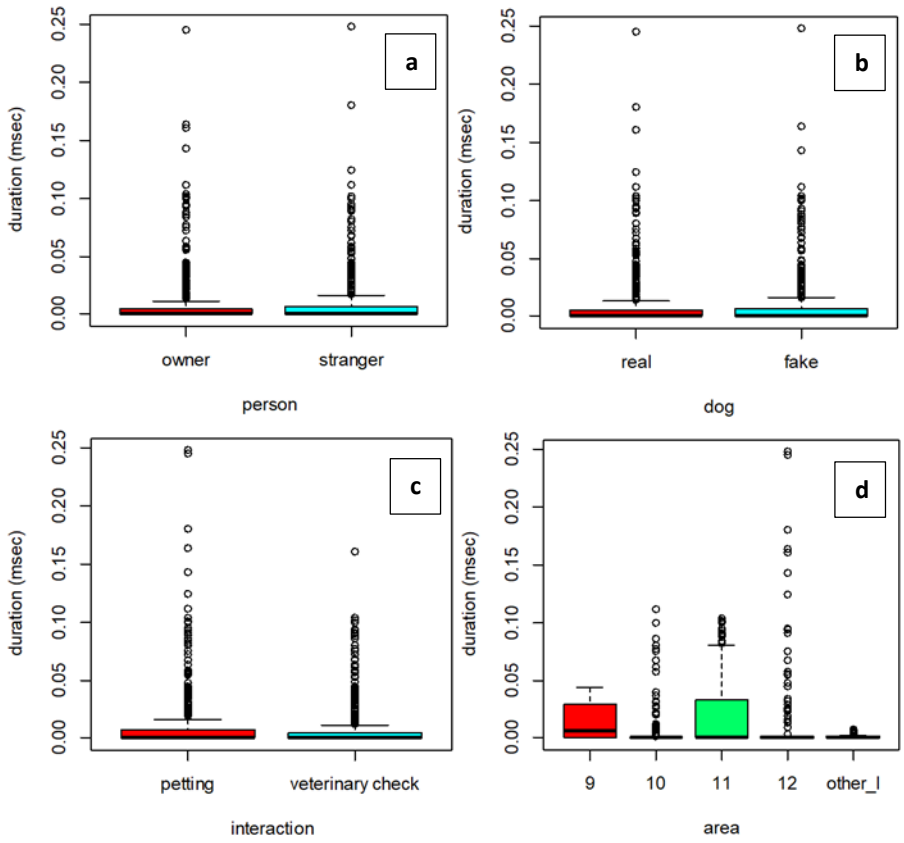

Figure 20 Mean duration (msec) of all fixations. a: person effect; b: dog effect; c: interaction effect; d: area effect.

Table 13 Statistical values of effects interaction, dog, person and area on the duration of all fixations.

	value	*df1*	*df2*	*p.value*
Dog	0.0001	1	248.8865	0.9907
Interaction	0.6493	1	236.8792	0.4212
Dog*Interaction	2.2686	1	248.8865	0.1333
Area	9.7563	4	110.4933	**0.0000**
Dog	0.0023	1	103.8144	0.9615
Area*Dog	0.2484	4	110.4933	0.9101
Area	8.6840	4	125.5934	**0.0000**
Interaction	0.3297	1	117.9430	0.5669
Area*Interaction	0.2222	4	123.2828	0.9256
Dog	0.0509	1	260.5008	0.8216
Person	0.5450	1	259.1847	0.4610
Dog*Person	0.0593	1	259.1847	0.8077
Person	0.1139	1	236.2185	0.7360
Interaction	0.7256	1	223.5359	0.3952
Person*Interaction	1.5564	1	236.2185	0.2134
Area	9.8774	4	110.4933	**0.0000**
Person	0.7865	1	96.0930	0.3774
Area*Person	0.2825	4	110.4933	0.8887

Robust pairwise comparisons (Wilcoxon test), with Bonferroni correction, were carried out. It resulted that duration of fixations fitting in the Area of the interaction (AoI 9) was significantly higher compared to all the other Areas except for the Area of paws/wheels (AoI 11). Duration of fixations fitting in the Area of paws/wheels (AoI 11) was significantly higher compared to all the others, except for in the Area of the interaction (AoI 9).

Table 14 **Post-hoc values on the effect of Area on duration of all fixations.**

AoI	9 (interaction)	10 (back)	11 (paws/wheels)	12 (person's legs)
10	4.8e-05	-		
11	1	0.00048	-	
12	0.00092	1	0.00228	-
other_I	1.3e-14	1	2.6e-09	1

Table 15 **Mean duration (+ SD) of all fixations falling in each AoI.**

	AoI				
	9 (interaction)	**10 (back)**	**11 (paws/wheels)**	**12 (person's legs)**	**other_I**
Mean	0.014	0.008	0.019	0.012	0.001
Standard deviation	0.016	0.021	0.031	0.038	0.002

5.5. DISCUSSION

The eye-tracker method collects data of gaze fixations and eye-movements [Holmqvist et al., 2011], and for what concerns studies in dogs' cognition, it represents a great source of information. Data from eye-tracker methodology are extremely precise and can be useful not only in discrimination/preference experiments but also in studies on dogs' social skills towards humans.

In previous studies on jealous reactions, the main difficulty was to understand which was the real target of behaviors like "monitoring", "seeking for proximity" or "interfering with the interaction", the person or the third party. Observations are not enough to address the topic. In this perspective the eye-tracker method could represent the solution, indeed the goal of this experiment was to analyse dogs' gaze when attending a social interaction, in order to assess which is the most triggering feature.

Twenty-five experimental dogs, already accustomed to the methodological routine of eye-tracker studies were exposed to a stimulus set made of eight videos showing a person interacting with a dog. The person could be the owner or an unfamiliar person, the dog could be real or a plush dog on a cart and the interaction could be positive (petting) or neutral (veterinary check). Since owners are their attachment figure, dogs should be more attentive when exposed to a video showing the owner interacting with another dog, compared to an unfamiliar person [Prato-Previde & Valsecchi, 2014], but, being accustomed to humans' lives, when exposed to a neutral interaction, they should discriminate it from a positive one, also because of the immobility of the tail of the dog shown in the video, and therefore be less attentive compared to a positive interaction: their interest should be measured. The plush dog should represent another level of control: since dogs seem able to discriminate between real conspecifics and objects [Somppi et al., 2012] their interest should not be triggered attending an interaction involving a fake dog.

Findings showed that dogs gazed at the same extent the owner and an unfamiliar person, both during the Presentation phase (whichever was the person shown before and whichever was the kind of dog present) and during the Interaction phase (whichever was the kind of dog present and whichever was the ongoing type of interaction). Although these results did not support the hypothesis of a preferential gaze for the owner, there could be

two explanations: first, it is likely that the Presentation phase lasted too little time (five seconds), not enough to discriminate the stranger, on the other hand even if five seconds were enough, discriminating between the two humans not necessarily would have cause a reduced interest towards the unfamiliar person, since, from Racca and colleagues it emerged that dogs gazed longer novel human faces, compared to familiar ones [2010], and in a food choice task dogs were misled at the same extent by their owners and by an unfamiliar person, showing a natural tendency in rely humans, even though their signals are contradictory and regardless of their familiarity [Marshall-Pescini et al., 2011].

In this experimental paradigm, there were two kinds of dogs shown during the video, a real unfamiliar dog and a plush dog on a cart. The purpose of including the plush dog was to assess if dogs were able to discriminate between a natural biomechanical movement from an artificial one. It is worth remembering that, after the Presentation Phase, the two actors moved towards each other right before starting the Interaction phase. It resulted impossible to analyse the short part of the video when the person and the dog moved toward each other, so data were collected only from Presentation and Interaction phases. However, it emerged that dogs gazed to the two types of dogs at the same extent, and the AoI of Paws/Wheels was gazed at very high rate, significantly more compared to all the others, except for the Area of the Interaction. Probably, the approach droves dogs' interest on the dog shown, also when it was a merely plush one, since the movement it was performing resulted more curious than expected. It made impossible to understand if experimental dogs really discriminate the two dogs on the scene. An option for future research is to analyse if experimental dogs really discriminate a plush dog from a real dog without presenting a moving fake dog. However, it should be highlighted that the usefulness of stuffed dogs in studies on dog's cognition is still under debate. In many experiments it emerged that experimental dogs are not deceived by the presence of a fake dog, since it does not smell or move as a real conspecific [Barnard at al., 2012; Prato-Previde & Nicotra et al., 2018].

Another interesting finding was the complete absence of discrimination between the positive and the neutral interactions. Owners and the unfamiliar person were asked to act in a standardized way, in order to guarantee that petting and veterinary check could be quite distinctive. It is likely that in a very brief time (Interaction phase: five seconds) dogs

could not discriminate between the positive and the neutral interactions, since both entailed touching the head of the dog on the scene. An option for providing more clear results is to show a situation, in which the person interacts with a dog and a control situation in which he/she is alone and acts at the same way but without an object receiving attention.

The eye-tracker is potentially one of the most powerful tools to obtain information on attentional focus, but it carries out many methodological difficulties when it is used in experiments with dogs. First, eye-tracking studies entail for dogs a long lasting period of training, to get familiar with the methodological routine and the experimental setting, not only dogs need to be trained to remain motionless on the chin-rest device, but also they must enter in a partially-covered modular framework, which could get them uncomfortable. For just one day of testing, each dog needs months to be ready. This implicates that different tests are often carried out with the same dogs, risking the insurgency of a bias on subjects. Moreover, studies conducted on dogs should be always extremely brief, in order to avoid getting the dog bored or stressed by the experiment, otherwise data collection could not be reliable, but, the eye-tracking method entails a calibration phase, which lasts a lot, sometimes more than the test itself. Therefore, an eye-tracking session must be very brief, so pictures or videos are presented for few seconds and data collection results superficial. If testing lasts so briefly, it gets hard that differences in the perception of the stimuli emerge and it is challenging to affirm that resulting data are giving information of dogs' "interest". In addition, the analysis of all data collected during this experiment was time consuming, since drawing the dynamic Areas of Interest required months of attempts to opt for a specific surface area, which could fit for all videos in the stimulus set.

6. GENERAL CONCLUSION

The focus of this project was the existence of the emotion of jealousy in non-primate animals, an issue still debated in literature. About secondary emotions a feud exists between researchers who strongly affirm that because of their complexity they could be experienced only by primates [Premack, 1988; Tangney & Fischer, 1995; Hart & Karmel, 1996; Povinelli, 1996; Lewis, 2002] and other researchers who emphasize the importance of some of the secondary emotions for survival and reproductive success also in other species, pride/arrogance and envy/jealousy are considered social emotions, fundamental for the regulation of social dynamics [Buck, 1999; Morris et al., 2008]. Thanks to comparative studies, it was also found that beyond primates, other mammals present the cortical structures necessary to experience complex emotions [Panksepp, 1998, 2010a, 2010b, 2011].

From studies in humans, jealousy had been found also in children younger than two-years, before the development of self-recognition and self-consciousness, which is considered one of the cornerstones for the emerging of self-conscious emotions. Researchers affirm that reactions observed in infants, when exposed to a situation in which the parent ignores them in favour of a rival, are a primordial form of jealousy, essential to regain parents' attention and care [Panksepp, 2010b; Dillon, 2013].

Among mammals, pet dogs represent the most suitable subjects to investigate the existence of the emotion of jealousy in non-primate animals, their evolutionary history is unique and by now pet dogs share homes, habits and lives with humans up to be completely dependent by owners for all their needs, both physiological and psychological.

To deepen the topic, this PhD project entailed four phases. At the very beginning a survey was spread online to collect opinions from Italian dog-owners about the existence of jealousy in their pet dogs, as already done by Morris and colleagues [2008]. A general agreement was registered about the issue, owners reported that the most triggering jealousy-eliciting situation was to ignore their pet dog in favour of another dog, and behavioral reactions were finalized at regaining the owner's interest and interfering with the ongoing interaction. Starting from this report, the experimental part of this projects was devised.

The first experiment entailed to readapt a paradigm already used in children and in dogs [Hart et al., 1998; Hart & Carrington, 2002, 2004; Hart & Behrens, 2013; Mize et al., 2014; Harris & Prouvost, 2014]. Dogs were exposed to a situation in which their owner and an unfamiliar person ignored them in favour of three different objects: a book, a novel object and a fake dog.

For the second part of the experimental phase, a more naturalistic approach was pursued. Readapting a paradigm used in human siblings, dogs' dyads were exposed to a situation in which their owner initially ignored both of them simultaneously and then ignored one dog in favour of the companion and vice versa.

The last experiment of this PhD project was devised to face the principal problems emerging from paradigms used to study jealousy. When dogs attend a social interaction it is hard to define which is the real target of behaviors like "monitoring" or "trying to disrupt the interaction", for this reason dogs were exposed to an eye-tracking test: they watched a stimulus set of eight videos showing all the combinations between two kinds of interaction (positive and neutral), two types of dog (real/plush) and two humans (owner/unfamiliar person).

Results from the first experiment do not support the hypothesis that dogs experience jealousy when ignored by owners in favour of a faux rival. Behaviors did not differ when the person manipulating the fake dog was the owner compared to the stranger. Since the definition of jealousy specifies that this emotion is triggered when the individual perceives a threat to a valuable relationship, seeing the unfamiliar person positively interacting with the fake dog should not trigger a jealous reaction. Since owners are their attachment figures, dogs should gaze longer to the owner, compared to a novel person, when they appear as the first person on a scene, but this was not supported by eye-tracking results: dogs gazed to the same extent at both humans. Altogether, results do not support the hypothesis of a higher interest towards the owner, however, it is likely that dogs gazed similarly at both humans because of an intrinsic interest shown by dogs for novel images emerged in previous eye-tracker studies [Racca et al., 2010].

Although in the first experiment the fake dogs were gazed at and experimental dogs interacted with them at high levels, there were no evidence that fake dogs were perceived

as real rivals, indeed no aggressive behaviors, stress or protest were observed. Using a plush/plastic dog has been the main problem emerging from this experiment. The use of stuffed dogs in studies on dog's cognition is still debated, some researchers criticize this methodology because of the importance of the olfactory system in dogs' sensory world. When an experimental dog is exposed to a stuffed dog which does not smell like a real dog, it is a short-term trick, after few seconds the experimental dog becomes aware that it is an inanimate object. However, from the eye-tracking study a high level of attention was registered in the Area of Paws/Wheels, regardless of the type of dog involved. In this study, experimental dogs could not investigate (i.e. smell) the plush dog, nevertheless it is hard to say if they perceived the plush dog as real or not. Testing experimental dogs with a plush dog on a cart with wheels probably caused an increased interest because of the wired movement they attended, it is not possible to say what it would have happened with a motionless plush dog. However, beyond the difficulties, using stuffed dogs in studies on dog's emotions is necessary, mainly for three reasons. First, it is not possible to rely only on owners' reports, although these offer insightful suggestions, they should be considered only a starting point to devise experiments. Owners, whether possessing notions of ethology or not, are influenced in their opinions by the existing relationship with their dogs, so they cannot be considered trustworthy. Then, for an ethical issue, using a real unfamiliar dog in experiments on dog's emotions, including jealousy, would be unfair, the risk of injuries in case of bad reactions would be high, with consequently high levels of stress for both dogs. Also, after each test, the "rival" dog would acquire experience and it would cause a behavioral change in the following test, failing the concept of standardized conditions [Prato-Previde & Nicotra et al., 2018]. Lastly, the second experiment of this project highlighted that using a familiar dog in studies on dog's jealousy, although useful, produces results biased by a high individual variability, influenced by existing hierarchies between dogs, and by the style of attachment existing between the owner and the two dogs [Prato-Previde et al., 2018]. For all these reasons, stuffed dogs are necessary, but researchers should discuss possible results bearing in mind the limits of this methodology.

In the eye-tracking experiment, dogs showed a preference for the dynamic Areas of Interest of Interaction regardless of the identity of the human, the type of dog involved and the kind of the ongoing interaction. Apparently dogs did not discriminate the two kinds of

interaction, likely because both entailed touching the dog's head, also the Area of Interest of Back was mostly ignored, so dogs did not pay attention to the emotional contagion of the dog involved. It should be highlighted that even if a preference towards the owner positively interacting with the real dog had emerged, actually it would not have meant that dogs were disliking the scene.

The first two experiments share an interpretative obstacle. Collecting dogs' behavioral reactions when exposed to situations in which their caregiver is ignoring them in favour of a rival, faux or real, does not give information about dogs' subjective experience. Behaviors observed could also be expressed in the sphere of protection of a resource, not strictly emotional. Animals strongly defend those resources which are fundamental for their survival, but it does not entail an emotional motivation or complex cognitive skills. Cannibalism between siblings in birds of prey is a normal strategy to compete for maternal resources, but there is not an emotional reason behind [Mock et al., 1990]. Also in dogs there is the risk of an overestimation of observations. Cook and colleagues [2018] found a higher activation of the region of the amygdala in dogs exposed to their owner feeding a fake dog, compared to a situation in which the owner put the food in a bucket. Authors ascribed this activation to a jealous reaction, because amygdala is involved in aggression in humans, but it is questionable how a strictly feeding situation could evoke the complex emotional reaction of jealousy. Moreover, experimental dogs again were exposed to a fake dog and there is no evidence that could support the hypothesis that it was perceived as real [Abdai & Miklosi, 2018; Bräuer & Amici, 2018; Prato-Previde & Valsecchi, 2018; Serpell, 2018; Zentall, 2018].

Findings from this project are not definitive, there is no evidence whether dogs experience or not a primordial form of jealousy, therefore further research is needed. Although the above discussed limits, this topic deserves further deepening.

REFERENCES

- Abdai J, Baño Terencio C, Pérez Fraga P, Miklósi A (2018) Investigating jealous behaviour in dogs. Scientific Reports 8: 8911
- Abdai J, Miklósi A (2018) Displaying jealous behavior versus experiencing jealousy. Animal Sentience 22(21)
- Adachi I, Kuwahata H, Fujita K (2007) Dogs recall their owner's face upon hearing the owner's voice. Animal Cognition 10(1): 17-21
- Adolphs R, Jansari A, Tranel D (2001) Hemispheric perception of emotional valence from facial expressions. Neuropsychology 15: 516–524
- Ainsworth MDS (1989) Attachment beyond infancy. American Psychologist 44: 709-716
- Ainsworth MDS, Blehar MC, Waters E, Wall S (1978) Patterns of Attachment: a Psychological Study of the Strange Situation. Hillsdale, NJ: Erlbaum
- Albuquerque N, Guo K, Wilkinson A, Savalli C, Otta E, Millas D (2016) Dogs recognize dog and human emotions. Biology Letters 12: 20150883
- Alves NT, Fukusima SS, Aznar-casanova JA, Paulo UDS, Preto R (2008) Models of brain asymmetry in emotional processing. Psychology & Neuroscience 1: 63–66
- Aureli F, Schino G (2004) The role of emotions in social relationships. In: Thierry B, Sinsh W, Kaumanns W (eds) Macaque Societies: a Model for the Study of Social Organizations. Cambridge University Press, London, 38–55
- Aureli F, Cords M, van Schaik CP (2002) Conflict resolution following aggression in gregarious animals: a predictive framework. Animal Behaviour 64(3):325–343
- Bard, P. (1928) A diencephalic mechanism for the expression of rage with special reference to the sympathetic nervous system. American Journal of Physiology. 84: 490–516
- Barnard S, Siracusa C, Reisner I, Valsecchi P, Serpell J (2012) Validity of model devices used to assess canine temperament in behavioral tests. Applied Animal Behaviour Science 38: 79-87
- Barber ALA, Randi D, Müller CA, Huber L (2016) The Processing of Human Emotional Faces by Pet and Lab Dogs: Evidence for Lateralization and Experience Effects. PLoS ONE 11(4): e0152393

- Blackshaw JK (1991) An overview of types of aggressive behaviour in dogs and methods of treatment. Applied Animal Behaviour Science 30: 351-361
- Bonanni R, Cafazzo S (2014) The social organization of a population of free-ranging dogs in a suburban area of Rome: a reassessment of the effects of domestication on dogs' behaviour. In: Kaminski J, Marshall-Pescini S, editors. The Social Dog. Behavior and Cognition. Academic Press, Boston 65-104
- Bourne V (2008) Chimeric faces, visual field bias, and reaction time bias: have we been missing a trick? Laterality 13(1): 92–103
- Bowlby J (1958) The nature of the child's tie to his mother. International Journal of Psycho-Analysis 39: 350-373
- Bräuer J, Amici F (2018) Fake or not: Two prerequisites for jealousy. Animal Sentience 22(18)
- Brucks D, Essler JL, Marshall-Pescini S, Range F (2016) Inequity aversion negatively affects tolerance and contact-seeking behaviours towards partner and experimenter. PLoS ONE 11(4): e0153799
- Buck R (1999) The biological affects: a typology. Psychological Review 106(2): 301-336
- Burnham D, Kitamura C, Wollmer-Conna U (2002) What's new, pussicat? On talking to babies and animals. Science 296(5572): 1435.
- Buss DM (2014) Comment: Evolutionary Criteria for Considering an Emotion "Basic": Jealousy as an Illustration. Emotion Review 6(4): 1–3.
- Call J, Bräuer J, Kaminski J, Tomasello M (2003) Domestic dogs (*Canis familiaris*) are sensitive to the attentional state of humans. Journal of Comparative Psychology 117(3): 257-63
- Cannon WB, Lewis JT, Britton SW (1927) The dispensability of the sympathetic division of the autonomic system. The Boston medical and surgical journal 197(13): 514-515
- Centers for Disease Control and Prevention (CDC). (2000). Family planning methods and practice: Africa (2nd ed.). Atlanta, GA: United States Department of Health and Human Services.

- Chijiiwa H, Kuroshima H, Hori Y, Anderson JR, Fujita K (2015) Dogs avoid people who behave negatively to their owner: third-party affective evaluation. Animal Behaviour 106: 123-127
- Cook P, Prichard A, Spivak M, Berns GS (2018) Jealousy in dogs? Evidence from brain imaging. Animal Sentience 22(1)
- Cools AKA, Van Hout AJM, Nelissen MHJ (2008) Canine reconciliation and third-party-initiated postconflict affiliation: do peacemaking social mechanisms in dogs rival those of higher primates? Ethology 114(1): 53–63
- Cubicciotti DD, Mason WA (1978) Comparative studies of social behavior in *Callicebus* and *Saimiri*: heterosexual jealousy behavior. Behavioral Ecology and Sociobiology 3(3):311–322
- Custance D, Mayer J (2012) Empathetic-like responding by domestic dogs (*Canis familiaris*) to distress in humans: an exploratory study. Animal Cognition 15(5):851–859
- Dale R, Quervel-Chaumette M, Huber L, Range F, Marshall-Pescini S (2016) Task differences and prosociality; investigating pet dogs' prosocial preferences in a token choice paradigm. PLoS ONE 11(12): e0167750
- Darwin C. (1998) The Expressions of the emotions in man and animals (3rd ed.). London, England: John Murray (Original work published in 1872)
- de Waal FBM (2008) Putting the altruism back into altruism: the evolution of empathy. Annual Review of Psychology 59: 279–300
- de Waal FBM (2011) What is an animal emotion? Annals of the New York Academy of Sciences 1224: 191-206
- de Waal FBM, Preston SD (2017) Mammalian empathy: behavioural manifestations and neural basis. Nature Reviews. Neuroscience 18(8): 498–509
- DeSteno D, Valdesolo P, Bartlett MY (2006) Jealousy and the threatened self: getting to the heart of the green-eyed monster. Journal of Personality and Social Psychology 91(4): 626–641
- Dilks DD, Cook P, Weiller SK, Berns HP, Spivak M, Berns GS (2015) Awake fMRI reveals a specialized region in dog temporal cortex for face processing. PeerJ. 3: e1115

- Dillon L (2013) Functional aspects of jealousy across the lifespan. Human Ethological Bulletin 28(2): 13–26
- Draghi-Lorenz R, Reddy V, Costall A (2001) Rethinking the development of “nonbasic” emotions: a critical review of existing theories. Developmental Review 21(3): 263–304
- Dunbar RIM, Schultz S (2010) Bondedness and sociality. Behaviour 147(7):775–803
- Ehrlichman H (1987) Hemispheric Asymmetry and Positive-Negative Affect. Duality and Unity of the Brain Unified Functioning and Specialisation of the Hemispheres. Springer US 194–206
- Ekman P (1992) An argument for Basic Emotions. Cognition and Emotion 6(3/4): 169-200
- Ekman, P. (1994) All emotions are basic. In P. Ekman & R. J. Davidson (Eds.), The Nature of Emotion: Fundamental Questions, 15–19. New York, NY: Oxford University Press
- Ekman P & Friesen W (1978) Facial Action Coding System. Palo Alto, CA: Consulting Psychologists Press
- Ekman P & Friesen W (1971) Constants across cultures in the face and emotion. Journal of Personality and Social Psychology, 17(2): 124-129
- Ekman, P. & Friesen, W. V. (1969). The Repertoire of Nonverbal Behavior: Categories, Origins, Usage, and Coding. Semiotica, 1(1): 49-98
- Essler JL, Marshall-Pescini S, Range F (2017) domestication does not explain the presence of inequity aversion in dogs. Current Biology 27(12): 1861–1865
- Filiatre JC, Millot JL, Eckerlin A (1991) Behavioural variability of olfactory exploration of the pet dog in relation to human adults. Applied Animal Behaviour Science 30(3-4): 341-350
- Forbes S (2010) Sibling rivalry among the birds and the bees. In: Hart SL, Legerstee M (eds) Handbook of Jealousy: Theory, Research, and Multidisciplinary Approaches. Wiley, Malden 121–143
- Fox M. (1972) Behavior of Wolves, Dogs, and Related Canids. Malabar, FL: Krieger Publishing Co.

- Fraser ON, Bugnyar T (2010) Do ravens show consolation? Responses to distressed others. PLoS ONE 5(5): e10605
- Fraser ON, Stahl D, Aureli F (2008) Stress reduction through consolation in chimpanzees. Proceedings of the National Academy Sciences of the USA 105(25):8557–8562
- Fraser ON, Koski SE, Wittig RM, Aureli F (2009) Why are bystanders friendly to recipients of aggression? Communicative Integrative Biology 2(3): 285-291
- Frijda NH (1993) The place of appraisal in emotion. Cognition and Emotion 7(3-4):357–387
- Gácsi M, Gyori B, Miklósi Á, Virányi Z, Kubinyi E, Topál J, et al. (2005) Species-specific differences and similarities in the behavior of hand-raised dog and wolf pups in social situations with humans. Developmental Psychobiology 47(2): 111–122
- Gácsi M, Maros K, Sernkvist S, Farago T, Miklósi Á (2013) Human analogue safe haven effect of the owner: behavioural and heart rate response to stressful social stimuli in dogs. PLoS ONE 8(3): e58475
- Gácsi M, Miklósi A, Varga O, Topál J, Csányi V (2004) Are readers of our face readers of our minds? Dogs (*Canis familiaris*) show situation-dependent recognition of human's attention. Animal Cognition 7(3): 144-153
- Goldie P (2000) The Emotions: a Philosophical Exploration. Clarendon Press, Oxford
- Guo K, Meints K, Hall C, Hall S, Mills DS (2009) Left gaze bias in humans, rhesus monkeys and domestic dogs. Animal Cognition 12(3): 409–418
- Hare B, Tomasello M (2005) Human-like social skills in dogs? Trends in Cognitive Science 9(9): 439-444
- Harlow HF, Zimmermann RR (1959) Affectional responses in the infant monkey. Science 130: 421-432
- Harmon-Jones E, Peterson CK, Harris CR (2009) Jealousy: novel methods and neural correlates. Emotion 9(1): 113–117
- Harris CR (2003) A review of sex differences in sexual jealousy, including self report data, psychophysiological responses, interpersonal violence, and morbid jealousy. Personality and Social Psychology Review 7: 102–128
- Harris CR (2004) Evolution of jealousy. American Scientist 92: 62-71

- Harris CR, Prouvost C (2014) Jealousy in dogs. PloS ONE 9(7): e94597
- Hart SL (2010) The ontogenesis of jealousy in the first year of life: A theory of jealousy as a biologically-based dimension of temperament. In: Hart SL, Legerstee M (eds) Handbook of Jealousy: Theory, Research, and Multidisciplinary Approaches. Wiley-Blackwell, Malden 57–82
- Hart SL (2015) Jealousy in Infants. Laboratory Research on Differential Treatment. Springer, New York
- Hart SL (2016) Jealousy protest: ontogeny in accord with the 9-month period of human gestation. Evolutionary Psychology 1-9
- Hart SL (2016) Proximal foundations of jealousy: expectations of exclusivity in the infant's first year of life. Emotion Review 8(4): 358–366
- Hart SL, Behrens KY (2013) Affective and behavioral features of jealousy protest: association with child temperament, maternal interaction style, and attachment. Infancy 18(3): 369–399
- Hart SL, Carrington H (2002) Jealousy in 6 month-old infants. Infancy 3: 395–402
- Hart SL, Field T, del Valle C, Letourneau M (1998) Infants protest their mother's attending to an infant-size doll. Social Development 7: 54–61
- Hart SL, Carrington HA, Tronick EZ, Carroll SR (2004) When infants lose exclusive maternal attention: is it jealousy? Infancy 6: 57–78
- Hart D, Karmel MP (1996) Self-awareness and self-knowledge in humans, apes, and monkeys. In A. E. Russon, K. A. Bard, & S. T. Parker (Eds.), Reaching into Thought: The Minds of the Great Apes. Cambridge, UK: Cambridge University Press 325-347
- Hecht J, Miklósi A, Gácsi M (2012) Behavioral assessment and owner perceptions of behaviors associated with guilt in dogs. Applied Animal Behaviour Science 139: 134–142
- Hirsh-Pasek K, Treiman R (1982) Doggerel: motherese in a new context. Journal of Child Language 9(1): 229-237
- Hobson RP (2010) Is jealousy a complex emotion? In: Hart SL, Legerstee M (eds) Handbook of Jealousy: Theory, Research, and Multidisciplinary Approaches. Wiley-Blackwell, Malden 293–311
- Hobson RP (2012) Emotion as personal relatedness. Emotion Review 4(2): 169–175

- Holmqvist K, Nyström M, Andersson R, Dewhurst R, Jarodzka H, Weijer van de J. (2011) Eye Tracking: A Comprehensive Guide to Methods and Measures. OUP Oxford.
- Horowitz A (2009) Disambiguating the guilty look: salient prompts to a familiar dog behaviour. Behavioural Processes 81(3): 447–452
- Horowitz A (2012) Fair is fine, but more is better: limits to inequity aversion in the domestic dog. Social Justice Research 25(2): 195–212
- Horváth Z, Igyártó BZ, Magyar A, Miklósi A (2007) Three different coping styles in police dogs exposed to a short-term challenge. Hormones and Behaviour 52(2): 621–630
- Huber L, Racca A, Scaf B, Virányi Z, Range F (2013) Discrimination of familiar human faces in dogs (Canis familiaris) Learning and Motivation 44(4): 258–269
- Izard C. & Dougherty L. (1982) Two complementary systems of measuring facial expressions in infants and children. In Izard C. (Ed.) Measuring Emotions in Infants and Children New York: Cambridge University Press 97-126
- Izard CE (1992). Basic emotions, relations among emotions, and emotion-cognition relations. Psychological Review 99(3): 561-565
- James, W. (1884). What is an emotion? Mind 9(34): 188-205
- Joseph Ledoux (1998). The Emotional Brain (The Mysterious Underpinnings of Emotional Life). Simon & Schuster, Touchstone.
- Kalin NH, Larson C, Shelton SE, Davidson RJ (1998) Asymmetric frontal brain activity, cortisol, and behaviour associated with fearful temperament in rhesus monkeys. Behavioral Neuroscience 112(2): 286–292
- Kano F, Tomonaga M (2009) How chimpanzees look at pictures: a comparative eye-tracking study. Proceedings of the Royal Society B 276(1664): 1949–1955
- Kendrick KM (2006) Brain asymmetries for face recognition and emotion control in sheep. Cortex 42: 96–98
- Kirchhofer KC, Zimmermann F, Kaminski J, Tomasello M (2012) Dogs (*Canis familiaris*), but not chimpanzees (*Pan troglodytes*), understand imperative pointing. PLoS ONE 7: e30913

- Koolhaas JM, Korte SM, De Boer SF, Van Der Vegt BJ, Van Reenen CG, Hopstre H, De Jong IC, Ruis MAW, Blokhuis HJ (1999) Coping styles in animals: current status in behavior and stressphysiology. Neuroscience and Biobehavioral Reviews 23(7): 925–935
- Korte SM, Koolhaas JM, Wingfield JC, McEwen BS (2005) The Darwinian concept of stress: benefits of allostasis and costs of allostatic load and the tradeoffs in health and disease. Neuroscience and Biobehavioral Reviews 29(1): 3–38
- Kujala MV (2017) Canine emotions as seen through human social cognition. Animal Sentience .013
- Lakatos G, Soproni K, Dóka A, Miklósi Á (2009) A comparative approach to dogs' (*Canis familiaris*) and human infants' comprehension of various forms of pointing gestures. Animal Cognition 12: 621–631
- Lange CG, James W (1922) The Emotions. Baltimore, Williams & Wilkins Company (Original work published 1885)
- Leary MR (2003) The self and emotion: the role of self-reflection in the generation and regulation of affective experience. In: Davidson RJ, Scherer KR, Goldsmith HH (eds) Handbook of Affective Sciences. Oxford University Press, New York 773–786
- Leopold DA, Rhodes G (2010) A comparative view of face perception. Journal of Comparative Psychology 124(3): 233–251
- Lewis, M. (1992) Shame: The Exposed Self. New York: Free Press
- Lewis M (2002) Early emotional development. In A. Slater & M. Lewis (Eds.), Introduction to Infant Development. Oxford, UK: Oxford University Press 192-209
- Lewis M (2008) The emergence of human emotions. In: Lewis M, Haviland-Jones JM, Barrett LF (eds) Handbook of Emotions, 3rd edn. Guilford Press, New York 265–280
- Lorenz KZ (1952) King's Solomon Ring. Crowell, New York.
- MacLean PD (1952) Some psychiatric implications of physiological studies on frontotemporal portion of limbic system (visceral brain). Electroencephalography and Clinical Neurophysiology 4(4): 407–418.
- Mair P, Schoenbrodt F, Wilcox R (2018) WRS2: Wilcox robust estimation and testing

- Maninger N, Mendoza SP, Williams DR, Mason WA, Cherry SR, Rowland DJ, Shaefer T, Bales K (2017) Imaging, behavior and endocrine analysis of “Jealousy” in a monogamous primate. Frontiers in Ecology and Evolution 5:119
- Mariti C, Carlone B, Ricci E, Sighieri C, Gazzano A (2014) Intraspecific attachment in adult domestic dogs (*Canis familiaris*): Preliminary results. Applied Animal Behaviour Science 152: 64–72
- Marshall-Pescini S, Ceretta M, Prato-Previde E. (2014) Do domestic dogs understand human actions as goaldirected? PLoS ONE 9(9): e106530
- Marshall-Pescini S, Colombo E, Passalacqua C, Merola I, Prato-Previde E (2013) Gaze alternation in dogs and toddlers in an unsolvable task: evidence of an audience effect. Animal Cognition 16(6): 933–943
- Marshall Pescini S, Kaminski J (2014) The social dog: history and evolution. In: Kaminski J, Marshall-Pescini S (eds) The Social Dog. Behavior and Cognition. Academic Press, Boston 3-33
- Marshall-Pescini S, Passalacqua C, Ferrario A, Valsecchi P, Prato Previde E (2011) Social eavesdropping in the domestic dog. Animal Behaviour 81(11): 1177-1183
- Marshall-Pescini S, Prato Previde E, Valsecchi P (2011) Are dogs (*Canis familiaris*) misled more by their owners than by strangers in a food choice task? Animal Cognition 14(1):137-42
- Martens P, Enders-Slegers MJ, Walker JK (2016) The emotional lives of companion animals: attachment and subjective claims by owners of cats and dogs. Anthrozoös 29(1): 73–88
- Massar K, Buunk A, Dechesne M (2009) Jealousy in the blink of an eye: Jealous reactions following subliminal exposure to rival characteristics. European Journal of Social Psychology 39(5):768-79
- Massen JJM, Sterck EHM, de Vos H (2010) Close social associations in animals and humans: functions and mechanisms of friendship. Behaviour 147(11): 1379–1412
- Mech LD. (1970) The Wolf: The Ecology and Behavior of an Endangered Species. 1st ed. New York, NY: Natural History Press

- Mehrkam LR, Verdi NT, Wynne CDL (2014) Human interaction as environmental enrichment for pair-housed wolves and wolf–dog crosses. Journal of Applied Animal Welfare Science 17(1): 43–58
- Merola I, Prato-Previde E, Lazzaroni M, Marshall-Pescini S (2013) Dogs' comprehension of referential emotional expressions: familiar people and familiar emotions are easier. Animal Cognition 17(2): 373-385
- Merola I, Prato-Previde E, Marshall-Pescini S (2012a) Dogs' social referencing towards owners and strangers. PloS ONE 7: e47653
- Merola I, Prato-Previde E, Marshall-Pescini S (2012b) Social referencing in dog-owner dyads? Animal Cognition 15(2):175–185
- Lewis M, Haviland-Jones JM, Feldman Barrett L (2008). Handbook of Emotions.(3rd ed) Guilford Press
- Miklosi A (2007) Dog Behavior, Evolution and Cognition. Oxford University press, Oxford.
- Miklósi Á, Kubinyi E, Topál J, Gácsi M, Virányi Z, Csányi V (2003) A simple reason for a big difference: Wolves do not look back at humans, but dogs do. Current Biology 13(9): 763–766
- Miklósi Á, Polgárdi R, Topál J, Csányi V (2000) Intentional behaviour in dog–human communication: an experimental analysis of "showing" behaviour in the dog. Animal Cognition 3(3):159–166
- Miller AL, Volling BL, McElwain NL (2000) Sibling jealousy in a triadic context with mothers and fathers. Social Development 9(4): 433–457
- Millot JL, Filiatre JC, Eckerlin A, Gagnon AC, Montagner H (1987) Olfactory and visual cues in the interaction systems between dogs and children. Applied Animal Behaviour Science 19: 189-195.
- Mitani JC (2009) Male chimpanzees form enduring and equitable social bonds. Animal Behaviour 77(3): 633–640
- Mitchell RW (2001) Americans' talk to dogs: similarities and differences with talk to infants. Research on Language and Social Interaction 34(2): 183-210
- Mize KD, Pineda M, Blau AK, Marsh K, Jones NA (2014) Infant physiological and behavioral responses to a jealousy provoking condition. Infancy 19(3): 338–348

- Mock DW, Drummond H and Stinson CH (1990) Avian Siblicide American Scientist 78(5): 438-449
- Mongillo P, Bono G, Regolin L, Marinelli L (2010) Selective attention to humans in companion dogs, *Canis familiaris*. Animal Behaviour 80: 1057- 1063
- Morris PH, Doe C, Godsell E (2008) Secondary emotions in non-primate species? Behavioural reports and subjective claims by animal owners. Cognition and Emotion 22(1): 3-20
- Morris PH, Knight S, Lesley S (2012) Belief in animal mind: Does familiarity with animals influence beliefs about animal emotions? Society and Animals 2(30):211–224
- Müller CC, Schmitt K, Barber ALA, Huber L (2015) Dogs can discriminate emotional expressions of human faces. Current Biology 25(5): 601-605
- Nesse RM (1990) Evolutionary explanations of emotions. Human Nature, 1: 261–289
- Nitzschner M, Melis AP, Kaminski J, Tomasello M (2012) Dogs (*Canis familiaris*) evaluate humans on the basis of direct experiences only. PLoS ONE 7: e46880
- Palagi E, Cordoni G (2009) Postconflict third-party affiliation in *Canis lupus*: do wolves share similarities with the great apes? Animal Behaviour 78:979–986
- Palagi E, Nicotra V, Cordoni G (2015) Rapid mimicry and emotional contagion in domestic dogs. Royal Society Open Science 2:150505
- Panksepp J (1998) Affective Neuroscience: The Foundations of Human and Animal Emotions. New York: Oxford University Press
- Panksepp, J (2005) Affective consciousness: Core emotional feelings in animals and humans. Consciousness and Cognition 14(1): 30–80
- Panksepp J (2010) Affective consciousness in animals: perspectives on dimensional and primary process emotion approaches. Proceedings of the Royal Society 277(1696): 2905-2907
- Pansksepp J (2010) The evolutionary sources of jealousy: cross-species approaches to fundamental issues. In: Hart SL, Legerstee M (eds) Handbook of Jealousy: Theory, Research, and Multidisciplinary Approaches. Wiley-Blackwell, Malden 101–120

- Panksepp J (2011) The basic emotional circuits of mammalian brains: do animals have affective lives? Neuroscience and Biobehavioral Reviews 35(9): 1791–1804
- Panskepp J, Panskepp JB (2013) Toward a cross-species understanding of empathy. Trends in Neurosciences 36(8): 489-496
- Panksepp J, Watt D. (2011) What is basic about basic emotions? Lasting lessons from affective neuroscience. Emotion Review 3(4): 387-396
- Papez JW (1937) A proposed mechanism of emotion. Archives of Neurology and Psychiatry 38(4): 725–743
- Parr LA, Hopkins WD (2000) Brain temperature asymmetries and emotional perception in chimpanzees, *Pan troglodytes*. Physiology and Behaviour 71(3-4): 363–371
- Passalacqua C, Marshall-Pescini S, Merola I, Palestrini C, Prato Previde E (2013) Different problem-solving strategies in dogs diagnosed with anxiety-related disorders and control dogs in an unsolvable task paradigm. Applied Animal Behaviour Science 147(1-2): 139–148
- Pinker S, Bloom P (1990) Natural language and natural selection. Behavioral and Brain Sciences 13(4): 707–784
- Plutchik R (1980) Emotion: a Psychoevolutionary Synthesis. Harper & Row, New York
- Plutchik R (2001) The nature of emotions: Human emotions have deep evolutionary roots, a fact that may explain their complexity and provide tools for clinical practice. American Scientist 89(4): 344–350
- Povinelli DJ (1996) Chimpanzee theory of mind? The long road to strong inference. In P. Carruthers & P. Smith (Eds.) Theories of Theories of Mind Cambridge, UK: Cambridge University Press 159-189
- Prato-Previde E, Custance DM, Spiezio C, Sabatini F (2003) Is the dog–human relationship an attachment bond? An observational study using Ainsworths' strange situation. Behaviour 140(2): 225–254
- Prato-Previde E, Ghirardelli G, Marshall-Pescini S, Valsecchi P (2006) Gender differences in owners interacting with pet dogs: an observational study. Ethology 112(1): 64-73

- Prato-Previde E, Nicotra V, Fusar Poli S, Pelosi A, Valsecchi P (2018) Do dogs exhibit jealous behaviors when their owner attends to their companion dog? Animal Cognition 21(5): 703–713
- Prato-Previde E, Nicotra V, Pelosi A, Valsecchi P (2018) Pet dogs' behavior when the owner and an unfamiliar person attend to a faux rival. PLoS ONE 13: e0194577
- Prato-Previde E, Valsecchi P (2014) The immaterial cord: the dog-human attachment bond. In: Kaminski J, Marshall-Pescini S (eds) The Social dog. Behavior and Cognition. Academic Press, Boston 165–189
- Prato Previde E, Valsecchi P (2018) What is it like to be a jealous dog? Animal Sentience 22(16)
- Premack D (1988) Does the chimpanzee have a theory of mind?'' revisited. In R. Byrne & A. Whiten (Eds.) Machiavellian intelligence. Oxford, UK: Oxford UniversityPress 159-189.
- Quaranta A, Siniscalchi M, Vallortigara G (2007) Asymmetric tail-wagging responses by dogs to different emotive stimuli. Current Biology 17(6): 199–201
- Quervel-Chaumette M, Faerber V, Faragó T, Marshall-Pescini S, Range F (2016) Investigating empathy-like responding to conspecifics' distress in pet dogs. PLoS ONE 11(4): e0152920
- R Core Team (2016) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria
- Racca A, Amadei E, Ligout S, Kun Guo, Meints K, Mills D (2010) Discrimination of human and dog faces and inversion responses in domestic dogs (*Canis familiaris*) Animal Cognition 13(3): 525–533
- Racca A, Guo K, Meints K, Mills DS (2012) Reading faces: Differential lateral gaze bias in processing canine and human facial expressions in dogs and 4-year-old children. PLoS ONE 7(4): e36076
- Rand R, Wilcox R, Tian S (2011) Measuring effect size: a robust heteroscedastic approach for two or more groups. Journal of Applied Statistics 38(7): 1359–1368
- Range F, Horn L, Virányi Z, Huber L (2009) The absence of reward induces inequity aversion in dogs. Proceedings of the National Academy Sciences of the USA 106(1): 340–345

- Reisner I (2003) Differential diagnosis and management of human directed aggression in dogs. The Veterinary Clinics of North America. Small Animal Practice 33(2): 303-320
- Salva OR, Regolin L, Mascalzoni E, Vallortigara G (2012) Cerebral and Behavioural Asymmetries in Animal Social Recognition. Comparative Cognition and Behavior Reviews 7: 110–138.
- Serpell JA (2018) Jealousy? or just hostility toward other dogs? The risks of jumping to conclusions. Animal Sentience 22(13)
- Schino G, Aureli F (2009) Reciprocal altruism in primates: partner choice, cognition, and emotions. Advances in the Study of Behavior 39: 45–69
- Schöberl I, Beetz A, Solomon J, Wedl M, Gee N, Kotrschal K (2016) Social factors influencing cortisol modulation in dogs during a strange situation procedure. Journal of Veterinary Behavior 11: 77–85
- Schwab C, Huber L (2006) Obey or not obey? Dogs (*Canis familiaris*) behave differently in response to attentional states of their owners. Journal of Comparative Psychology 120(3): 169-75
- Seyfarth RM, Cheney DL (2012) The evolutionary origins of friendship. The Annual Review of Psychology 63: 153–177
- Sherrington CS (1900) Experiments on the value of vascular and visceral factors for the genesis of emotion Proceedings of the Royal Society 66: 390-403
- Siniscalchi M, d'Ingeo S., Quaranta A (2016) The dog nose 'KNOWS' fear: Asymmetric nostril use during sniffing at canine and human emotional stimuli. Behavioural Brain Research 304: 34-41
- Siniscalchi M, Quaranta A, Rogers LJ (2008) Hemispheric specialization in dogs for processing different acoustic stimuli. PLoS ONE 3(10): e3349
- Siniscalchi M, Sasso R, Pepe AM, Dimatteo S, Vallortigara G, Quaranta A (2011) Sniffing with the right nostril: lateralization of response to odour stimuli by dogs. Animal Behaviour 8(2): 399-404
- Siniscalchi M, Sasso R, Pepe AM, Vallortigara G, Quaranta A (2010) Dogs turn left to emotional stimuli. Behavioural Brain Research 208(2): 516–521

- Somppi S, Tönqvist H, Hänninen L, Krause C, Vainio O (2012) Dogs do look at images: eye tracking in canine cognition research. Animal Cognition 15(2): 163–174
- Somppi S, Tönqvist H, Hänninen L, Krause C, Vainio O (2014) How dogs scan familiar and inverted faces: an eye movement study Animal Cognition 17(3): 793–803
- Szabo N, Dubas JS, van Aken MAG (2014) Jealousy in firstborn toddlers within the context of the primary family triad. Social Development 23(2): 325-39
- Steiner AP, Redish AD (2014) Behavioral and neurophysiological correlates of regret in rat decision-making on a neuroeconomic task. Nature Neuroscience 17(7): 995–1002
- Taggart JM (2010) Dog owner interaction style: the transmission of working models in human/nonhuman caregiving relationships. University of South Hampton, School of Psychology, Ph.D. Thesis
- Tangney JP, Fischer KW (1995) Self-Conscious Emotions: The Psychology of Shame, Guilt, Embarrassment, and Pride. New York: Guilford Press
- Taylor AM, Reby D, McComb K (2011) Cross modal perception of body size in domestic dogs (*Canis familiaris*). PLoS ONE 6(2): e17069
- Téglàs E, Gergely A, Kupàn K Miklòsi A, Topàl J (2012) Dogs' Gaze Following Is Tuned to Human Communicative Signals Current Biology 22(3): 209–212
- Teti DM, Ablard KE (1989) Security of attachment and infant–sibling relationships: a laboratory study. Child Development 60(6): 1519–1528
- Thieltges H, Lemasson A, Kuczaj S, Böye M, Blois-Heulin C (2011) Visual laterality in dolphins when looking at (un)familiar humans. Animal Cognition 14(2): 303–308
- Tomasello M, Kaminski J (2009) Like infant. Like Dog. Science 325(5945): 1213–1214
- Tooby J, Cosmides L (2008). The evolutionary psychology of the emotions and their relationship to internal regulatory variables. In M Lewis, JM Haviland-Jones & LF Barrett (Eds.) Handbook of Emotions (3rd ed). New York, NY: Guilford 114–137
- Topàl J, Gergely G, Erdohegyi A, Csibra G, Miklòsi A (2009) Differential sensitivity to human communication in dogs, wolves, and human infants. Science.; 325(5945): 1269-1272

- Topàl J, Kis A, Oláh K (2014) Dogs' Sensitivity to Human Ostensive Cues: A Unique Adaptation? In: Kaminski J, Marshall-Pescini S (eds) The Social Dog: Behavior and Cognition. Academic Press, Boston 319-346
- Topàl J, Miklósi A, Csanyi V, Doka A (1998) Attachment behavior in dogs (*Canis familiaris*): a new application of Ainsworth's (1969) strange situation test. Journal of Comparative Psychology 112(3): 219–229
- Topàl J, Miklòsi A, Gàcsi M, Dòka A, Pongràcz P, Kubinyi E, Virànyi Z, Csànyi V (2009) The dog as a model for understanding human social behavior. Advances in the Study of Animal Behavior 39: 71–116
- Tracy J (2014) An evolutionary approach to understanding distinct emotions. Emotion Review 6(4): 308-312
- Trisko RK, Sandel AA, Smuts B (2016) Affiliation, dominance and friendship among companion dogs. Behaviour 153: 693-725
- Udell MAR, Wynne CDL (2011) Reevaluating canine perspective-taking behavior. Learning and Behavior 39(4): 318–323
- Virányi Z, Gácsi M, Kubinyi E, Topál J, Belényi B, Ujfalussy D, et al. (2008) Comprehension of human pointing gestures in young human-reared wolves (*Canis lupus*) and dogs (*Canis familiaris*). Animal Cognition 11(3): 373–87
- Volling BL, McElwain NL, Miller AL (2002) Emotion regulation in context: the jealousy complex between young siblings and its relations with child and family characteristics. Child Development 73(2): 581–600
- Volling BL, Kennedy DE, Jackey LMH (2010) The development of sibling jealousy. In: Hart SL, Legerstee M (eds) Handbook of Jealousy: Theory, Research, and Multidisciplinary Approaches. Wiley-Blackwell, Malden 387–417
- Volling BL, Yu T, Gonzales R, Kennedy DE, Rosemberg L, Oh W (2014) Children's responses to mother-infant and father-infant interaction with a baby sibling: jealousy or joy? Journal of Family Psychology 28(5): 634–644
- Walter B. Cannon (1927) The James-Lange Theory of Emotions: A Critical Examination and an Alternative Theory Source. The American Journal of Psychology, 39(1/4): 106-124

- Watling D, Workman L, Bourne VJ (2012) Emotion lateralisation: Developments throughout the lifespan. Laterality: Asymmetries of Body, Brain and Cognition 17(4): 389–411
- Zentall TR (2018) Jealousy, competition, or a contextual cue for reward? Animal Sentience 22(4)

SUPPLEMENTARY MATERIALS

QUESTIONARIO SULLE EMOZIONI DEL CANE	**QUESTIONNAIRE ON DOG'S EMOTIONS**
Buongiorno. Questo questionario è stato creato da alcuni ricercatori afferenti all'Università degli Studi di Milano e all'Università degli Studi di Parma e fa parte di uno studio in corso sul comportamento del cane. ***Le piacerebbe partecipare e raccontarci qualcosa a proposito di Lei e del Suo cane?*** ***I dati raccolti sono e resteranno anonimi e verranno usati esclusivamente dai ricercatori per lo studio in corso.*** ***Il questionario richiede circa 5 minuti, se possiede più cani Le sarà richiesto di compilare una parte del questionario per ognuno di essi e in tal caso sarà necessario qualche momento in più.*** ***L'intero procedimento sarà guidato ed estremamente intuitivo.*** ***La ringraziamo per la Sua collaborazione, buon lavoro.***	Good morning. This questionnaire has been created by some researchers of the University of Milan and of the University of Parma and is part of an ongoing study on dog's behavior. Would you like to participate and tell us something about you and your dog? The collected data are and will remain anonymous and will be used exclusively by researchers for the current study. The questionnaire takes about 5 minutes, if you have more dogs, you will be asked to fill out a part of the questionnaire for each of them and in that case you will need few more time. The whole procedure will be guided and extremely intuitive. We thank you for your cooperation, good job.
Parte 1: Alcune informazioni iniziali.	**Part 1: Some initial information**
In questa sezione introduttiva Le verranno chieste alcune informazioni riguardanti Lei e il Suo nucleo familiare. ***Si tratta di poche domande generali e del tutto anonime!***	In this introductive section You will be asked to answer to some information regarding You and Your family unit. They are few general and totally anonymous questions!
Il Suo genere: ○ ***Uomo*** ○ ***Donna***	**Your gender:** ○ Man ○ Woman
La Sua età: **_____**	**Your Age:** **_____**
Quante persone fanno parte del Suo nucleo familiare? **_____**	**How many people belong to Your familiar unit?** **_____**

Ci sono bambini nel Suo nucleo familiare? Se sì ne indichi l'età. ***Nel caso di bambini di età diverse può segnare più di una risposta.*** ○ ***No*** ○ ***Sì (0-3 anni)*** ○ ***Sì (3-6 anni)*** ○ ***Sì (6-12 anni)*** ○ ***Sì (sopra i 12 anni)***	Are there children in your Familiar unit? If yes, please indicate the related age. If there are children of different age you can indicate more than an answer. ○ **No** ○ **Yes (0-3 years)** ○ **Yes (3-6 years)** ○ **Yes (6-12 years)** ○ **Yes (more than 12 years)**
Ha avuto cani in passato? ○ ***Sì*** ○ ***No***	**Have you owned other dogs in the past?** ○ Yes ○ No
Ha specifiche conoscenze sull'etologia del cane? ○ ***Sì*** ○ ***No***	**Do you have any specific knowledge on dog's ethology?** ○ Yes ○ No
Frequenta o ha frequentato corsi di educazione/addestramento con il/i suo/suoi cane/cani? ○ ***Sì*** ○ ***No***	**Are you attending or did you attend a training course with your dog/dogs?** ○ Yes ○ No
Se sì, quale tipologia? ***Se lo ritiene necessario, può segnare più di una risposta.*** ○ ***Educazione di base*** ○ ***Agility*** ○ ***Ricerca*** ○ ***Riporto*** ○ ***Altro:*** **_____** **_____**	**If yes, which kind?** **If necessary, please indicate more than an answer.** ○ Basic ○ Agility ○ Hunting ○ Retriever ○ Other: **_____** **_____**
Quanti cani possiede attualmente? ○ ***1*** ○ ***2*** ○ ***3***	**How many dogs do You own at the moment?** ○ 1 ○ 2 ○ 3

***Parte 2A:* Ci parli del Suo cane.**	Part 2A: Let's talk about Your dog.
***In questa sezione Le faremo alcune domande esclusivamente a proposito del Suo cane e delle sue abitudini giornaliere*.**	In this section we will ask You some questions regarding only Your dog and its daily habits.
Sesso del cane: o ***Maschio*** o ***Femmina***	**Dog's sex:** o Male o Female
Età del cane: **_____**	**Dog's age:** **_____**
Età del cane al momento dell'adozione: **_____**	**Dog's age at the time of adoption:** **_____**
Provenienza del cane: o ***Negozio*** o ***Allevamento*** o ***Cucciolata in casa*** o ***Canile*** o ***Strada*** o ***Altro:*** **_____** **_____**	**Dog's origin:** o Shop o Breeding o Domestic litter o Kennel o Street o Other: **_____** **_____**
Dove vive abitualmente il Suo cane? ***Se lo ritiene necessario, può dare più di una risposta.*** o ***In casa*** o ***In giardino*** o ***In recinto*** o ***Altro:*** **_____** **_____**	**Where does Your dog usually live?** **If necessary, please indicate more than an answer.** o At home o In the garden o In an enclosure o Other: **_____** **_____**
Dove dorme abitualmente il Suo cane? ***Se lo ritiene necessario, può dare più di una risposta.*** o ***Fuori casa*** o ***Cuccia in casa*** o ***Divano*** o ***Letto*** o ***Altro:*** **_____** **_____**	**Where does Your dog usually sleep?** **If necessary, please indicate more than an answer.** o Outside home o Kennel at home o Couch o Bed o Other: **_____** **_____**

Durante il giorno, quante ore trascorre in media con il Suo cane? ***Faccia una media approssimativa, senza considerare le ore notturne.*** **_____**	**During the day, how many hours do You spend with Your dog?** **Please, give an approximated average, not considering the night.** **_____**
Date le vostre rispettive abitudini, direbbe di essere la principale figura di riferimento del Suo cane? ○ ***1 [Non credo di esserlo]*** ○ ***2*** ○ ***3*** ○ ***4*** ○ ***5 [Sono assolutamente sicuro/a di esserlo]***	**Considering Your respective habits, do You think to be Your dog's main point of reference?** ○ 1 [I do not think so] ○ 2 ○ 3 ○ 4 ○ 5 [I am absolutely sure]
Parte 2B: Opinioni ed Esperienze	**Part 2B: Opinions and Experiences**
Le prossime domande riguarderanno le Sue esperienze con il cane e le Sue opinioni al riguardo. ***Le ricordiamo che il questionario è del tutto anonimo e che non esistono risposte giuste o sbagliate.***	Next questions will concern Your experiences with Your dog and Your opinions about them. Remind, the questionnaire is totally anonymous and there are not right or wrong answers.
Quanto spesso il Suo cane le fa richieste di attenzione? ○ ***1 [Mai]*** ○ ***2*** ○ ***3*** ○ ***4*** ○ ***5 [In continuazione]***	**How often does Your dog try to get Your attention?** ○ 1 [Never] ○ 2 ○ 3 ○ 4 ○ 5 [Continuously]
In quali contesti è più probabile che il Suo cane ricerchi la Sua attenzione? **_____** **_____**	**In which context is more likely that Your dog tries to get Your attention?** **_____** **_____**
In che modo il Suo cane ricerca la sua attenzione? **_____** **_____**	**How does Your dog try to get Your attention?** **_____** **_____**

Se tocca/prende la ciotola del Suo cane durante il pasto, il cane come reagisce? ***Se lo ritiene necessario, può dare più di una risposta.*** ○ ***Indifferente, non reagisce in alcun modo*** ○ ***Annusa la mia mano*** ○ ***Mi guarda*** ○ ***Allontana la mia mano dalla ciotola*** ○ ***Si allontana dalla ciotola*** ○ ***Ringhia*** ○ ***Minaccia di mordere*** ○ ***Altro:*** ***_____***	If You touch/pick up Your dog's bowl, how does it react? If necessary, please indicate more than an answer. ○ **Indifferent, it does not react in any way** ○ **It sniffs my hand** ○ **It looks at me** ○ **It removes my hand from the bowl** ○ **It moves away from the bowl** ○ **It growls** ○ **It threatens to bite** ○ **Other:** **_____**
Se tocca/prende il giocattolo preferito del Suo cane mentre ci gioca, il cane come reagisce? ***Se lo ritiene necessario, può dare più di una risposta.*** ○ ***Indifferente, non reagisce in alcun modo*** ○ ***Annusa la mia mano*** ○ ***Mi guarda*** ○ ***Allontana la mia mano dal giocattolo*** ○ ***Si allontana dal giocattolo*** ○ ***Ringhia*** ○ ***Minaccia di mordere*** ○ ***Altro:*** ***_____***	**If You touch/pick up Your dog's favourite toy, while it is playing, how does it react?** **If necessary, please indicate more than an answer.** ○ Indifferent, it does not react in any way ○ It sniffs my hand ○ It looks at me ○ It removes my hand from the toy ○ It moves away from the toy ○ It growls ○ It threatens to bite ○ Other: **_____**

Se una persona vi interrompe mentre state giocando, il cane come reagisce? ***Se lo ritiene necessario, può dare più di una risposta.*** ○ ***Indifferente, non reagisce in alcun modo*** ○ ***Mi guarda/Mi tocca per stimolarmi a riprendere*** ○ ***Annusa la persona che ci ha interrotto*** ○ ***Guarda la persona che ci ha interrotto*** ○ ***Si allontana*** ○ ***Ringhia alla persona che ci ha interrotto*** ○ ***Minaccia di mordere la persona che ci ha interrotto*** ○ ***Altro:*** **_____** **_____**	If a person interrupts You and Your dogs, while You are playing, how does Your dog react? If necessary, please indicate more than an answer. ○ **Indifferent, it does not react in any way** ○ **It looks at/touches me, to stimulate me to resume** ○ **It smells the person who interrupted us** ○ **It looks at the person who interrupted us** ○ **It moves away** ○ **It growls to the person who interrupted us** ○ **It threatens to bite the person who interrupted us** ○ **Other:** _____ _____
Se una persona La interrompe mentre sta coccolando il cane, il cane come reagisce? ***Se lo ritiene necessario, può dare più di una risposta.*** ○ ***Indifferente, non reagisce in alcun modo*** ○ ***Mi guarda/Mi tocca per stimolarmi a riprendere*** ○ ***Annusa la persona che ci ha interrotto*** ○ ***Guarda la persona che ci ha interrotto*** ○ ***Si allontana*** ○ ***Ringhia alla persona che ci ha interrotto*** ○ ***Minaccia di mordere la persona che ci ha interrotto*** ○ ***Altro:*** **_____** **_____**	**If a person interrupts You, while You are petting Your dog, how does Your dog react?** **If necessary, please indicate more than an answer.** ○ Indifferent, it does not react in any way ○ It looks at/touches me, to stimulate me to resume ○ It smells the person who interrupted us ○ It looks at the person who interrupted us ○ It moves away ○ It growls to the person who interrupted us ○ It threatens to bite the person who interrupted us ○ Other: **_____** **_____**

Ritiene che il Suo cane sia in grado di provare rabbia? ○ ***1 [Assolutamente no]*** ○ ***2*** ○ ***3*** ○ ***4*** ○ ***5 [Assolutamente sì]***	Do You think Your dog is able to experience anger? ○ **1 [Absolutely no]** ○ **2** ○ **3** ○ **4** ○ **5 [Absolutely yes]**
Ritiene che il Suo cane sia in grado di provare paura? ○ ***1 [Assolutamente no]*** ○ ***2*** ○ ***3*** ○ ***4*** ○ ***5 [Assolutamente sì]***	**Do You think Your dog is able to experience fear?** ○ 1 [Absolutely no] ○ 2 ○ 3 ○ 4 ○ 5 [Absolutely yes]
Ritiene che il Suo cane sia in grado di provare sorpresa? ○ ***1 [Assolutamente no]*** ○ ***2*** ○ ***3*** ○ ***4*** ○ ***5 [Assolutamente sì]***	**Do You think Your dog is able to experience surprise?** ○ 1 [Absolutely no] ○ 2 ○ 3 ○ 4 ○ 5 [Absolutely yes]
Ritiene che il Suo cane sia in grado di provare gioia/felicità? ○ ***1 [Assolutamente no]*** ○ ***2*** ○ ***3*** ○ ***4*** ○ ***5 [Assolutamente sì]***	**Do You think Your dog is able to experience joy/happiness?** ○ 1 [Absolutely no] ○ 2 ○ 3 ○ 4 ○ 5 [Absolutely yes]
Ritiene che il Suo cane sia in grado di provare tristezza? ○ ***1 [Assolutamente no]*** ○ ***2*** ○ ***3*** ○ ***4*** ○ ***5 [Assolutamente sì]***	**Do You think Your dog is able to experience sadness?** ○ 1 [Absolutely no] ○ 2 ○ 3 ○ 4 ○ 5 [Absolutely yes]

In quali contesti ritiene che il Suo cane manifesti empatia? ***Se lo ritiene necessario, può dare più di una risposta.*** ○ ***Quando io sono triste*** ○ ***Quando io sono felice*** ○ ***Quando io sono sofferente*** ○ ***Quando un membro della famiglia è triste*** ○ ***Quando un membro della famiglia è felice*** ○ ***Quando un membro della famiglia è sofferente*** ○ ***Quando un altro cane sembra triste*** ○ ***Quando un altro cane sembra felice*** ○ ***Quando un altro cane sembra sofferente*** ○ ***Mai*** ○ ***Altro:*** ***_____***	In which contexts do You think Your dog shows empathy? If necessary, please indicate more than an answer. ○ **When I am sad** ○ **When I am happy** ○ **When I am suffering** ○ **When a family member is sad** ○ **When a family member is happy** ○ **When a family member is suffering** ○ **When another dog seems sad** ○ **When another dog seems happy** ○ **When another dog seems suffering** ○ **Never** ○ **Other:** **_____**
Il Suo cane in che modo manifesta empatia? ***Dia una breve descrizione delle situazioni in cui il Suo cane ha manifestato empatia e delle modalità in cui si è verificato.*** **_____**	***How does Your dog show empathy?*** ***Please, give a brief description of the situations in which Your dog showed empathy and how it occurred.*** **_____**
Ritiene che il Suo cane sia in grado di provare gelosia? ○ ***1 [Assolutamente no]*** ○ ***2*** ○ ***3*** ○ ***4*** ○ ***5 [Assolutamente sì]***	**Do You think Your dog is able to experience jealousy?** ○ 1 [Absolutely no] ○ 2 ○ 3 ○ 4 ○ 5 [Absolutely yes]

In quali contesti ritiene che il Suo cane manifesti gelosia? ***Se lo ritiene necessario, può dare più di una risposta.*** ○ ***Quando gioco con un altro cane*** ○ ***Quando coccolo un altro cane*** ○ ***Quando gioco con un bambino*** ○ ***Quando coccolo un bambino*** ○ ***Quando gioco con una persona adulta*** ○ ***Quando coccolo una persona adulta*** ○ ***Mai*** ○ ***Altro:*** _____	In which contexts do You think Your dog shows jealousy? If necessary, please indicate more than an answer. ○ **When I am playing with another dog** ○ **When I am petting another dog** ○ **When I am playing with a child** ○ **When I am cuddling a child** ○ **When I am playing with an adult person** ○ **When I am cuddling an adult person** ○ **Never** ○ **Other:** _____
Il Suo cane in che modo manifesta gelosia? ***Se lo ritiene necessario, può dare più di una risposta.*** ○ ***Interrompe fisicamente l'interazione*** ○ ***Richiama l'attenzione su di sè abbaiando/uggiolando*** ○ ***Mi tocca con il muso o con la zampa*** ○ ***Ringhia verso la persona o il cane con cui sto interagendo*** ○ ***Minaccia di mordere la persona o il cane con cui sto interagendo*** ○ ***Nessuno dei precedenti*** ○ ***Altro:*** _____	**How does Your dog show jealousy?** **If necessary, please indicate more than an answer.** ○ It physically interrupts the interaction ○ It tries to get the attention by barking/whining ○ It touches me with the muzzle or the paw ○ It growls to the person or the dog I'm interacting with ○ It threatens to bite the person or dog I'm interacting with ○ None of the previous ones ○ Other: _____
Ritiene che il Suo cane sia in grado di provare senso di colpa? ○ ***1 [Assolutamente no]*** ○ ***2*** ○ ***3*** ○ ***4*** ○ ***5 [Assolutamente sì]***	**Do You think Your dog is able to experience guilty?** ○ 1 [Absolutely no] ○ 2 ○ 3 ○ 4 ○ 5 [Absolutely yes]

In quali contesti il Suo cane manifesta il senso di colpa? ***Dia una breve descrizione delle situazioni in cui è capitato che il suo cane abbia manifestato senso di colpa.*** **_____**	**In which contexts does Your dog show guilty?** **Please, give a brief description of the situations in which Your dog showed guilty.** **_____**

PLOS ONE

RESEARCH ARTICLE

Pet dogs' behavior when the owner and an unfamiliar person attend to a faux rival

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Abstract

While dog owners ascribe different emotions to their pets, including jealousy, research on secondary emotions in nonhuman animals is very limited and, so far, only one study has investigated jealousy in dogs (*Canis familiaris*). This work explores jealousy in dogs one step further. We conducted two studies adapting a procedure devised to assess jealousy in human infants. In each study 36 adult dogs were exposed to a situation in which their owner and a stranger ignored them while directing positive attention towards three different objects: a book, a puppet and a fake dog (Study 1: furry; Study 2: plastic). Overall, the results of both studies do not provide evidence that the behavioral responses of our dogs were triggered by jealousy: we did not find a clear indication that the fake dogs were perceived as real social rivals, neither the furry nor the plastic one. Indeed, dogs exhibited a higher interest (i.e. look at, interact with) towards the fake dogs, but differences in the behavior towards the fake dog and the puppet only emerged in Study 2. In addition, many of the behaviors (protest, stress, attention seeking, aggression) that are considered distinctive features of jealousy were not expressed or were expressed to a limited extent, revealing that dogs did not actively try to regain their owner's attention or interfere with the interaction between the owner and the faux rival. Finally, a differentiated response towards the attachment figure (the owner) and the unfamiliar person (the stranger) did not emerge. Differently from what reported in human infants, dogs' behavior towards the attachment figure and the stranger interacting with the potential competitor (in this case, the fake dog) did not significantly differ: in both studies dogs paid attention to the owner and the stranger manipulating the fake dog to the same extent. In conclusion, we do not exclude that dogs could possess a rudimentary form of jealousy, but we suggest that research on this topic should require the use of a real social interloper (conspecific or human) and more naturalistic procedures.

Introduction

Scientists generally agree that some emotions ("primary" or "basic") have a long evolutionary history and can be found across a wide range of vertebrate species, due to their fundamental

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ORIGINAL PAPER

Do dogs exhibit jealous behaviors when their owner attends to their companion dog?

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Abstract
Jealousy appears to have clear adaptive functions across species: it emerges when an important social relationship with a valued social partner is threatened by third-party that is perceived as a rival. Dyads of dogs living together and their owners were tested adapting a procedure devised to study jealousy in young human siblings. Owners at first ignored both dogs while reading a magazine (Control episode), and then petted and praised one of the dogs while ignoring the other, and vice versa (Experimental episodes). We found several differences in the dogs' behavior between the Experimental episodes and the Control episode, even though only monitoring (gazing at the owner) was exhibited for a significantly greater amount of time in the Experimental episodes. Remarkable individual behavioral differences emerged, suggesting that the dogs' reactions could be influenced by the relationships that they establish with their owner and the companion dog. Overall, current results do not clearly support our prediction that the ignored dogs would exhibit more behaviors aimed at regaining the owner's attention when their owner directed attention and care to a companion dog, compared to the control situation. The great intra- and inter-dyad behavioral variability and the choice to test cohabiting dogs could have prevented the emergence of a clear jealous reaction. These findings do not exclude that dogs may exhibit a primordial form of jealousy in a realistic situation, but an additional research is needed to fully gauge which situations, if any, could trigger jealousy in dogs and to rule out alternative explanations.

Keywords Dog · Emotions · Jealousy · Dog–human relationship · Individual differences

Introduction

Despite the increasing interest in understanding emotions in non-human animals, to date, only a limited number of studies have investigated the presence of "secondary emotions" in species other than humans, providing contrasting results (Horowitz 2009; Custance and Mayer 2012; Hetch et al. 2012; Steiner and Redish 2014; Harris and Prouvost 2014; Panskepp and Panskepp 2013; de Waal and Preston 2017; Kujala 2017). Indeed, the belief that "secondary emotions", such as empathy, guilt, and jealousy, are restricted to relatively mature humans and other non-human primates is still widespread (e.g., Lewis 2008), since these emotions seem to require some sense of the self and the ability to interpret social situations (Leary 2003).

However, it is likely that, along with "primary" emotions, at least some "secondary" social emotions have evolved in non-human species to regulate inter-individual social relations (Cubicciotti and Mason 1978; Panskepp 2010; Palagi et al. 2015; de Waal and Preston 2017; Maninger et al. 2017). A growing body of evidence indicates that many social animals form complex social relationships with their conspecifics, which vary in function, duration, exclusivity, and emotional involvement (Mitani 2009; Dunbar and Schultz 2010; Massen et al. 2010). There is also evidence that animals may have knowledge of their own and others' relationships over time and adapt their behavior accordingly (Schino and Aureli 2009; Seyfarth and Cheney 2012). Social relationships are highly adaptive, as they ensure basic (e.g., food and shelter) and social (e.g., emotional support

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"*L'universo ha senso solo quando abbiamo qualcuno con cui condividere le nostre emozioni*." (Paulo Coelho)

…per questa ragione la mia tesi è dedicata a te.