Social referencing and cat-human communication

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Abstract

Cats' (*Felis catus*) communicative behaviour toward humans was explored using a social referencing paradigm in the presence of a potentially frightening object. One group of cats observed their owner delivering a positive emotional message, whereas another group received a negative emotional message. The aim was to evaluate whether cats use the emotional information provided by their owners about a novel/unfamiliar object to guide their own behaviour towards it. We assessed the presence of social referencing, in terms of referential looking towards the owner (defined as looking to the owner immediately before or after looking at the object), the behavioural regulation based on the owner's emotional (positive vs. negative) message (vocal and facial), and the observational conditioning following the owner's actions towards the object. Most cats (79%) exhibited referential looking between the owner and the object, and also to some extent changed their behaviour in line with the emotional message given by the owner. Results are discussed in relation to social referencing in other species (dogs in particular) and cats' social organization and domestication history.

Keywords: Social-referencing, Cats, Gaze alternation, Social learning, Human–cat communication

Introduction

Cats (*Felis catus)* are one of the most widespread and beloved companion animals: they are ubiquitous, share their life with people and are perceived as social partners by their owner (Karsh and Turner 1988). Recent findings suggest that their association with humans can be traced back to approximately 8,000 –10,000 years ago (Clutton-Brock 1979; Davis 1987; Vigne et al. 2004) and not just to 4,000 years ago, as previously thought (Serpell 2000). In fact, recent genetic and archaeological evidence indicates that the cat was actually domesticated in the Near East (Driscoll et al. 2007) about 10,000 years ago (Vigne et al 2004). Thus, like dogs (*Canis familiaris*), cats began to live in association with humans in ancient times, though dogs' history of domestication is thought to be substantially longer (Savolainen et al. 2002; von Holdt et al. 2010; Hu et al. 2014). One hypothesis relating to cat domestication is that the driving force behind this process was a mutualistic relationship established between people and cats, with wild cats learning to exploit the human environment, feeding on rodents attracted by humans' stocks of grains and cereals (Clutton-Brock 1988) and on food scraps found in human settlements. These factors coupled with humans' tolerant attitude towards them, potentially due to the recognition of their utility in keeping rodents at bay, would have contributed to the rapid domestication process of this species (Todd 1978; Driscoll et al. 2009, Hu et al. 2014). Thus, it has been suggested that the domestic cat represents a product of self domestication and natural selection and that compared to dogs or other domestic species, it has been exposed to a less strict and conscious process of artificial selection (Clutton-Brock 1988; Driscoll et al. 2009).

Despite a shorter history of domestication and a less intense artificial selection process than dogs, the living environment of cats and humans has overlapped considerably (Bradshaw et al. 1999), with cats establishing enduring relationships with humans, which often start at early stages of their development and last all their lives.

In recent years an increasing number of studies have investigated social cognitive skills in domestic species such as dogs (see Bensky et al. 2013; Kaminski and Nitzschner 2013; Prato Previde and Marshall-Pescini, 2014 for recent reviews), horses (McKinley and Sambrook 2000; Maros et al. 2008; Proops and McComb 2010; Kruger et al 2011; Proops et al. 2013), pigs (e.g. Albiach-Serrano et al. 2012) and goats (e.g. Kaminski et al. 2005), testing the hypothesis that domestication has favoured, at least in some species, the emergence of a number of behavioural changes and cognitive skills evolved to better exploit the human world and effectively communicate with humans (Kaminski et al. 2005; Miklósi and Soproni 2006; Hare et al. 2010; Udell et al. 2010).

Cats and dogs are the most common nonhuman animals interacting with us daily: they have fully adapted to the human social environment and are capable of establishing long-term social relationships with humans (Miklósi et al. 2005). However, whereas the communicative abilities and the ability to discriminate human emotional expressions of domestic dogs have received growing attention (Nagasawa et al. 2011, Merola et al. 2013b), there are only a few studies that have investigated cat cognitive abilities (e.g Pisa and Agrillo 2009; Whitt et al. 2009, Pan 2013), and even fewer looking at cat social cognition and cat-human communication and expression (e.g. Miklósi et al. 2005; Saito and Shinozuka 2013).

Unlike their wild ancestors (*Felis silvestris*), domestic cats are social animals (Crowell-Davis et al. 1997; Macdonald et al. 2000). They show intraspecific communication not present in other solitary felids (Bradshaw and

Cameron-Beaumont 2000), and entertain strict and complex relationships with their owners, adapting flexibly to them (Mertens 1991; Turner 1991; Leyhausen 1988; Rieger and Turner 1999). There is evidence that cats react to unfamiliar and familiar humans differently (Collard 1967; Casey and Bradshaw 2008) and recognize their owners' voices, distinguishing them from other human voices (Saito and Shinozuka 2013). Furthermore, it has been shown that they become bonded to their owners and that the cat-owner relationship appears to fulfil the behavioural criteria for an attachment bond (Edwards et al. 2007).

However, to our knowledge, only one study has investigated cat-human communication by comparing the ability of both cats and dogs to communicate with humans by either responding to a person's gestural signals (i.e. pointing) or by using attention-getting signals (i.e. gaze and gaze alternation) to communicate in a feeding context (Miklósi et al. 2005). This study showed that cats, like dogs, were successful in using four different types of human pointing cues (differing in visibility and duration of the given cue and in the distance between the end of the fingertip and signalled object) to locate hidden food in an object-choice task. However, when facing a problem situation in which the food was hidden in an inaccessible place and human intervention was needed, cats lacked certain components of the attention-getting behaviour shown by dogs. Indeed, dogs showed higher levels of gazing behaviour, looked earlier and for longer at their owners, and showed more gaze alternation between the hidden food and the human compared to cats. Thus, these results suggest the presence of similar abilities in "reading" human signals (i.e. pointing) in cats and dogs, but differences in their tendency to communicate with humans in a problem situation (i.e. the impossibility of reaching food).

It has recently been shown that dogs engage in human-directed communication (looking behaviour and gaze alternation) not only to request human intervention when unable to obtain a desired goal, but, also in a context of *uncertainty*, possibly as a way to monitor their human partner's behaviour and synchronize their own response to an unfamiliar environment with him/her (see Prato Previde and Marshall-Pescini 2014 for a review). In particular, Merola and colleagues (2012a; 2012b; 2013a) found that, like human infants (Mumme et al. 1966; Vaish and Striano 2004; de Rosnay et al. 2006) and human-raised chimpanzees (Russell et al. 1997), dogs look at humans when facing unfamiliar situations that are difficult to interpret, and act in accordance with the informer's positive or negative emotional reactions, a process known as 'social referencing'. In these studies, when confronted with a new and potentially frightening object (a fan with ribbons attached to it) in the presence of their owner providing either a positive or a negative emotional message towards it, dogs engaged in visual communication with him/her (referential looking) and also changed their behaviour towards the object in line with the emotional message received (i.e. behavioural regulation).

The aim of the current study was to investigate cat-human communication in a social referencing context.

Using a procedure similar to that previously used by Merola et al. (2012a) with dogs, we (1) tested whether cats would show referential looking (defined as looking to the owner immediately before or after looking at the object), when presented with a potentially frightening stimulus; (2) assessed the effect on cats' behaviour of the emotional (facial and vocal) message (positive vs. negative) expressed by the owner towards the ambiguous object, and (3) evaluated whether cats would be influenced by their owner's overt approach versus avoidance behaviour towards the object (observational conditioning).

To assess the potential presence of referential looking, cats were initially confronted with an ambiguous stimulus in the presence of their silent and neutral owner. Then, to evaluate the behavioural regulation aspect of social referencing, cats' behaviour was recorded when the owner delivered either a positive (happy) or a negative (fearful) message about the ambiguous stimulus using only their voice and facial expression. Finally, in the last stage of the experiment, we evaluated whether cats would, through a process of observational conditioning (Whiten et al. 2004; Zentall 2006), be influenced by their owner's approach vs. avoidance behaviour towards the stimulus.

We predicted that if cats used human-directed gazing behaviour to obtain information about the new ambiguous stimulus they would look at it and rapidly look at the owner (referential looking). Furthermore, if cats used humans' vocal and facial emotional expressions to guide their behaviour, we would expect cats in the negative group to show more interaction with the owner, gaze alternating more often between the fan and the exit screen, and showing more stress signals, whereas cats in the positive group would vocalize, alternate gaze between the fan and the owner more, and be more likely to enter the fan zone.

Method

Participants

36 cat-owner dyads participated in the study. Owners were all female except one. Cats (20 neutered males, 13 neutered females, and 3 tom cats), 8 of pure-breed[1] and 28 of mixed-breed, ranged in age from 2 to 13 years (mean=5.9 years; *SD*=3). All cats were pets living at home with their owners. As an inclusion criteria we required cats to be friendly towards strangers, not escaping or showing aggressive behaviours towards them, but rather seeking contact with them. Furthermore, they had to be used to changes in their living environment (e.g. going on holiday with their owners) and accustomed to travelling in a carrier at least twice a month. To assess the above criteria we asked owners on the phone prior to inviting them to the lab. No tests were carried out during the pre-selection of the subjects. Following this initial selection, cat-owner dyads were then randomly assigned to the positive and negative message group.

[1] 1 Norwegian forest, 1 Siamese, 1 Bengal, 3 Devon Rex, 2 Maine Coon

Unfamiliar Stimulus

The experimental stimulus was the same for all cats in both conditions (positive and negative): a 50 cm tall and 34 cm wide electric fan, with plastic green ribbons attached to it. This stimulus was the same as used in previous studies on social referencing in dogs (Merola et al. 2012a; 2012b) and was aimed at eliciting a mild fear reaction, i.e. neither very positive (approaching directly and touching), nor very negative (running in the opposite direction or strong stress such as trembling, or hiding). It did not elicit predatory behaviour.

Procedure

The cats were individually tested in an unfamiliar (3.5 x 4.5 m) room at the laboratory *Canis Sapiens* of the University of Milan. The testing room was an empty space with a black screen (*h* 1m, *w* 30 cm) at one end: the screen hid a video camera and prevented the cats from going out of sight (see Figure 1). It had previously been used by testing dogs, but was thoroughly cleaned before starting experiments with cats. This screen was built in a way that cats could hardly jump over it, but they could see the space behind it. On arrival the owner and the experimenter entered the testing room and for 5 minutes the experimenter explained the procedure to the owner, who was then asked to repeat and also perform the entire procedure as if the cat was being tested. During this time the cat remained in another room in its open carrying basket, free to stay inside it or to move around. Then the owner and experimenter left the testing room and the owner re-entered holding the cat in his/her arms.

As soon as the door was closed the owner reached Location 1 holding the cat in his/her arms and then put the cat on the floor. Prior to starting the test the cat was allowed to move around and explore the room for 1 minute in the presence of the silent and relaxed owner standing in Location 1. After this exploration time the test started. The test lasted 125 seconds and was divided into four phases. During the first three phases the fan, placed at the far end of the room (see Figure 1), was in motion; during Phase 4 it was switched off. Each test phase was characterized by the owner behaving in a different way. Since in Phase 3 and 4 owners were required to move to specific locations in the room, coloured sticky tape was placed in the appropriate spots (Figure 1). Each cat was allocated to one group only and thus exposed either to the positive or negative message.

- FIGURE 1-

Test phases were as follows:

Phase 1: this phase was the same for both the positive and negative groups. The owner, while standing at Location 1, called the cat by name: as soon as the cat approached he/she crouched over it with his/her body and turned so as to have their backs to the door whilst petting the cat. This position and action prevented the cat from seeing the experimenter opening the door and positioning the fan in front of it. The fan was then activated via remote control. Immediately after the experimenter left the room, the owner released the cat and stood at Location 1 facing the fan, while the cat was free to move around the room. At this moment we activated a stopwatch. The owner remained silent looking at the fan with a neutral facial expression for 25 seconds.

Phase 2: in this phase, regardless of the cat's behaviour, the owner stood in Location 1 and talked throughout the whole phase, using either a happy (positive group) or fearful (negative group) voice and facial expression and gaze alternating between the cat and the fan continuously for 25 seconds.

Phase 3: in the positive group the owner approached the fan reaching Location 2, crouched down facing the fan and started to touch it, whilst still talking in a happy voice and expressing a positive emotion and gaze alternating between the cat and the fan continuously; in the negative group the owner moved away from the fan reaching Location 3, crouching down whilst talking with a fearful voice, expressing a negative emotion and gaze alternating between the cat and the fan. In both groups the phase lasted 25 seconds.

Phase 4: This phase lasted 50 seconds and started when the experimenter turned the fan off from an adjacent room using a remote control. In the positive group, whilst still crouching in Location 2, talking in a positive manner and gaze alternating between the cat and the fan continuously, the owner touched the fan and the ribbons for the entire phase. In the negative group, the owner stayed crouched down in Location 3 whilst continuing to talk with a negative tone of voice for the entire phase and gaze alternating between the cat and the fan continuously.

In both groups, in Phases 2, 3 and 4 the owners were instructed to continue talking throughout the entire phase and to communicate with their cats as they would normally, using typical phrases such as "that's nice" or "that's scary", accompanied by either a smiling happy face or a scared worried expression. They were also explicitly told not to use the cat's name and potential directions (look, come, touch, etc.). Finally, they were instructed to show, through facial and vocal expressions, the feeling either that the cat could safely and happily approach the object, or that the object was to be avoided. After the test ended, the researcher entered the room with a handful of treats and asked to the owner to sit next to the fan, giving the cat treats when it came into proximity of the fan. If the cat was not eating the treat, the owner and the experimenter sat next to the fan until the cat started to explore the room in a relaxed manner. All cats, regardless of condition, received this treatment so that they would not become sensitive to fans.

Data collection and analysis

The test was recorded by two video cameras (Panasonic NVGS330) and analysed using Solomon Coder (beta 081122, Copyright 2006-2008 by Andràs Péter).

Five non-mutually exclusive categories of behaviour were recorded: Gaze, Action, Body posture, Stress signals (following van de Bos 1998) and Vocalization. In addition, the location of the cats when in closer proximity to the fan (i.e. within 50 cm), during each phase of the test was recorded (Fan Zone) (see Table 1).

- TABLE 1-

As in previous studies on dogs (Merola et al. 2012a; 2012b; 2013a), in line with Russell et al. (1997) referential looking was defined as a gaze towards the owner that was preceded by a look to the fan, and gaze alternation as a consecutive sequence of three looking behaviours (fan-owner-fan or owner-fan-owner). The percentage of cats carrying out these behaviours is recorded for Phase 1 for comparison with other species. A Generalized Linear model analysis (binomial distribution) was carried out to assess whether the likelihood of alternating the gaze between owner and fan and fan and screen (hence two-way alternations) would vary according to group.

The screen was a barrier placed at the far end of the room behind the initial location of cat and owner and farthest away from the fan. As mentioned above this barrier hid the video camera placed on a tripod but was not tall enough to reach the ceiling, hence cats could see that there was space behind it. The fact that the screen was the furthest location from the fan and that cats seemed aware of there being space behind it, led us to analyse both gazing and interaction behaviours directed at the screen as possible indication that cats were looking for a way out of the room (keeping in mind that the door from which they had entered was located directly behind the fan during testing).

A series of Generalized Linear Models (Poisson distribution) were used to evaluate the potential group differences on the frequencies of behaviours. Given their relatively low frequencies, the three behaviours towards the owner were considered as a sum (Interact owner, Rubbing against the owner and Tail up whilst interacting with the owner). A Generalized Linear Model (binomial distribution) was also used to assess whether the likelihood of entering the fan zone was affected by group and phase. Finally we analysed the potential group differences in the latency and the duration of being static and moving around the room (locomotion), using a Mann-Whitney test, since despite transformation the residuals were not normally distributed.

The cats' behaviour was coded by M.L., and a second independent coder (E.P.) analysed 25% of the data. The interobserver reliability on the duration of the major behavioural categories analysed was calculated using Cronbach's alpha (Gaze Fan: α=0.97; Gaze Owner: α=0.79; Gaze screen: α=0.89; Static: α=0.98; Interact owner: α=0.94; Tail up interact owner: α=0.85; Vocalization: α=0.98). GLM analyses were conducted using the lme4 package in R (www.r-project.org). All other analyses were conducted in SPSS v.19. All tests were two-tailed and the alpha level was set at 0.05.

Results

Of the 36 cats tested, nine (6 males and 3 females) were excluded from the analyses: one subject (male) because of procedural errors committed by the owner during testing, and eight (5 males and 3 females) because they succeeded in jumping or hiding behind the screen during the test.

Of the remaining 27 subjects, 3 (all males) approached and touched the fan during Phase 1 exhibiting a confident and positive attitude towards the stimulus. These cats were excluded both in the analysis of referential looking/gaze alternation behaviour (Phase 1), and of behavioural regulation, since a pre-condition for the test was that cats had an ambiguous (or mildly fearful) behaviour towards the stimulus object (Feinman 1982; Gunnar and Stone 1984; Rosen et al. 1992).

Referential Looking and Gaze alternation

To assess whether cats carried out referential looking when confronted with the ambiguous stimulus, we analysed cats' referential looking and gaze alternation behaviour in Phase 1 (regardless of group since this phase was the same for all cats). Of the 24 cats considered (9 F and 15 M), 19 (79%) showed referential looking towards the owner at least once (and a maximum of 8 times). As regards gaze alternation, 13 out of 24 cats (54%) showed at least one and a maximum of 3 gaze alternation sequences (i.e. fan-owner-fan or owner-fan-owner).

Behavioural regulation

Given that cats showed referential looking towards the owner in Phase 1, when confronted with an ambiguous stimulus, we then evaluated whether they would be differently affected by the owners' positive vs. negative emotional expressions. Of the 24 cats that showed an ambiguous approach towards the fan in Phase 1, 12 (6 FN and 6 MN) were in the positive message group and 12 (3 FN, 8 MN and 1 MUn) in the negative message group (in this group there was the only male owner).

There was no interaction (glm: z=0.75, P=0.46) and no main effect for neither phase (glm: z=0.35, P=0.73) nor group (glm: z=1.76, P=0.08) on the likelihood of cats gaze alternating between the fan and the owner. There was no effect of phase (glm: z=1.7, P=0.09) and no interaction (glm: z=0.46, P=0.64) between phase and group on the likelihood of cats showing gaze alternation between the screen and the fan. However overall, cats in the negative group were significantly more likely to gaze alternate between the screen and the fan than cats in the positive group (glm: z=3.9, P <0.001).

Results showed no interaction between group and phase (glm: Phase 2 z=1.69, P=0.09, Phase 3 z=1.22, P=0.22 Phase 4 z=0.42, P=0.67), but a main effect of both group (glm: z= 4.43, P <0.001) and phase with cats alternating their gaze significantly less between the screen and the fan in Phase four than Phase one (glm: Phase four z=5.7 P<0.001, Phase two: z=1.7 P=0.08; Phase three z=0.02, P=0.9), and cats in the positive group alternating their gaze between the screen and the fan significantly less than cats in the negative group.

An interaction emerged between phase and group in gaze alternation between fan and owner, in that the pattern of results was significantly different for groups in Phase 4 than in Phase 1 (glm: group*Phase 4 z=0.36, P<0.001; group*Phase 3, z=0.02, P=0.98; group*Phase 2 z=1.73, P=0.08). Since we were mainly interested in group differences in each phase of the test, we ran separate models comparing the behaviour of cats in the two groups in each phase. No significant difference emerged in Phase 1 and Phase 2 (glm: Phase 1: z=0.7 P=0.5; Phase 2 z=0.4, P=0.7), however cats in the positive group alternated their gaze between fan and owner significantly more than cats in the negative group both in Phase 3 (glm: z=54.8, P<0.001) and Phase 4 (glm: z=3.05, P<0.001).

No interaction emerged between group and phase in the frequency of interacting with the owner (glm: Phase 2 z=0.08, P=0.93: Phase 3 z=0/9, P=0.37 Phase 4 z=0.35, P=0.72). However, overall cats in the negative group interacted with their owner more frequently than cats in the positive group (glm: z=3.2 P<0.001), and cats interacted more in Phase 3 and Phase 4 compared to Phase 1, but no differences emerged between Phase 1 and Phase 2 (glm: Phase 2 z=0.53, P=0.14; Phase 3 z=4.36, P<0.001; Phase 4 z=3.53 P<0.001).

An interaction between group and phase emerged on the frequency of meowing (glm: Phase 2 z=1.7, P=0.09; Phase 3 z=2.55, P=0.01; Phase 4 z=2.44, P=0,014). Because we were predominantly interested in the potential differences between groups, we ran subsequent models comparing cats in the positive vs. negative group in each phase. Cats in the positive group meowed more frequently than cats in the negative group but only in Phase 4 (glm: Phase 1 z=0.74 P=0.46: Phase 2 z=0.94, P=0.34: Phase 3 z=1.64, P=0.11:Phase 4 z=1.97, P=0.048)

Stress signals were infrequent, with only 8 cats showing between 1 and 2 stress signals during the whole test. Hence we ran a generalized linear model (with binomial distribution) including Phases 2 to 4 as a whole and analysing whether the likelihood of a cat expressing a stress signal was affected by which group they were in. No such effect was found (glm: z=0.86, P=0.4). Furthermore, the likelihood that cats would enter the 'fan zone' was not affected by the group they belonged to in none of the test phases (glm: Phase 2: z=0 P=1; Phase 3: z=0.12 P=0.9; Phase 4: z=0.82 P=0.4).

Interaction with the fan, which occurred only in Phase 4, was shown by only 2 cats in the positive group and 1 in the negative group.

Duration and Latency (Static and Locomotion)

In Phase 2 (when the owner was in location 1 expressing either a positive or negative emotional message) there was a tendency between groups in the latency to show Locomotion (z=1.91, df=23, P=0.055), with cats in the negative group showing this behaviour earlier than cats in the positive group. No difference emerged in the duration of neither static nor locomotion (static z=0.96, df=23, P=0.33, locomotion z=1.5, df=23, P=0.13). However, in Phase 3 (when the owner either approached or moved away from the fan) cats in the two groups differed in the amount of time spent in

Static behaviour (z=2.36, df=23, P=0.017), with cats in the positive group being more static than those in the negative one. No difference emerged in the latency to perform these behaviours in this phase (static z=0.37, df=23, P=0.7, locomotion z=1.43, df=23, P=0.14). Finally in Phase 4 no differences emerged in duration (static z=0.37, df=23, P=0.7, locomotion z=0.34, df=23, P=0.72) and latency (static z=0.76, df=23, P=0.44, locomotion z=0.82, df=23, P=0.41) of neither static nor locomotion.

Discussion

The aim of this study was to investigate cat-human communication by evaluating the presence of a social referencing process in cat-human dyads. As no other studies have been carried out in cats on this topic before, we aimed at assessing the presence of referential looking and behavioural regulation, based on the owners' emotional expression (vocal and facial). Furthermore, we evaluated the occurrence of observational conditioning.

Results showed that 79% of cats looked referentially towards their owner and the fan and 54% showed gaze alternation (3 consecutive looking behaviours) when the owner was still and silent in the room. This percentage was similar to the one found in previous studies on dogs, where 76% showed referential looking and 62% showed gaze alternation (Merola et al. 2012a; 2012b): this suggests that cats, like dogs, will look to their owner when faced with an ambiguous object. Our results contrast with those found in a previous study on gazing behaviour in cats (Miklósi et al. 2005), in which cats, when facing a situation in which food was in an inaccessible place, showed lower rates of gazing behaviour, looking later and for shorter periods of time as well as showing less gaze alternation between the human and food compared with dogs. One possible explanation for the difference between these two studies could be the different motivation behind the two experimental situations: in our study cats were placed in a situation of uncertainty where they could choose to use their owner as a guide to action. In this situation, their initial response, at least appears to be similar to dogs, in that both look at the owner. It is not however clear what motivates this looking behaviour, and one possibility is that cats sought comfort from their owner. This interpretation, however, is not supported by the cats' behaviour: in fact just 2 cats of the 19 looking referentially, sought contact with the owner after having looked at him/her. Another possible explanation is the different environments in which the tests were carried out: our study took place in a laboratory room, whilst Miklósi et al. (2005), tested cats in a room of the owner's flat. Finally, as put forward to explain dogs' referential looking in social referencing paradigms (Merola et al. 2012a; 2012b), cats may have looked to the owner to coordinate/synchronize their actions with theirs.

To best understand the potential significance of looking behaviour in the second part of the study we assessed whether cats would take into account their owners' reaction to the fan and modulate their own actions accordingly. Although there is some evidence that cats react differently to unfamiliar vs. familiar humans (Collard 1967; Casey and

Bradshaw 2008) and that they recognize their owners' voices (Saito and Shinozuka 2013), no study has evaluated cat's behavioural reaction to human emotions so far. Results provide some indication that cats could discriminate between their owner's different reactions. In fact, both the likelihood and frequency of gaze alternating between the screen and the fan were higher in the cats exposed to the owner showing a negative reaction to the object. As described above, the screen was the only possible way out, and thus looking at the screen and then at the fan potentially suggests the cats' were worried about the fan and wanted to get away from it. A further indication comes from the fact that cats in the negative group showed a tendency to start moving earlier than cats in the positive group in Phase 2, potentially showing that they started looking for an escape route sooner than cats in the group where the owner was expressing a positive emotion.

These results show an influence of the owner's emotional expression on the cat's behaviour, but they differ from results of previous studies with dogs and infants (Merola et al. 2012a; 2012b; Hornik et al. 1987). In fact, both infants and dogs when seeing their caregiver/owner expressing a negative emotion spent more time being static, whereas cats showed the opposite type of reaction i.e. a tendency to move earlier than cats whose owner had expressed a positive emotion. This opposite reaction could be explained by the different species-typical behaviour where cats, being both a predator (Bradshaw 1992), like dogs, but also a prey species, may be more inclined to use a flight response when in a fearful situation.

Overall cats in the negative group also showed a higher frequency in their interaction with the owner than cats in the positive group, potentially suggesting they were looking for security from their owner. However, results as regards the gaze alternation between screen and fan, and the higher frequency of interacting with the owner shown by cats in negative group, appeared across all phases, hence including Phase 1, in which no emotional cues was delivered as the owner had to remain silent with a neutral expression. This was unexpected since we assigned the cats randomly to the two groups. One possibility is that owners in the negative group inadvertently carried out 'negative' behaviours already in Phase 1, and cats 'picked up' on these subtle cues. Hence in future studies it may be important to give instructions to owners only once the initial 'baseline' phase is over or, as was carried out in a previous study (Merola et al. 2012b), ask owners to immediately deliver their emotional message, which in dogs enhanced their response to the owner's emotional reactions.

Finally, we wanted to assess if cats would synchronize their behaviour towards the object with that of their owners. Results showed that when the owner started to act towards the fan (and when they continued to do so but the fan was turned off in Phase 4), cats in the positive group were static for longer and alternated their gaze from the fan to the owner more often than cats in the negative group; they also tended to vocalize more often when the fan was turned off. However, only 3 cats in these phases approached the fan, two being in the positive and one in the negative group.

Hence, taken together results suggest that cats discriminated between the owner's reactions to the fan, but they did not adjust their distance from the fan in accordance with their owner's emotional expression or behaviour.

The lack of synchrony between the cats' behaviour and that of their owners contrasts with results found with dogs and could depend both on the procedural differences between studies and the evolutionary history of the two species. The fact that the owner did not start expressing the assigned emotional expression from the start may have negatively affected the likelihood of cats being influenced by their owner's behaviour, as we observed in dogs (Merola et al. 2012a; 2012b).

A second potential reason is that the level of fear induced by the unfamiliar stimulus may have been significantly different in the two species. Indeed in the current study only 3 subjects (11%) touched the fan in the first phase, whereas in the dog studies (Merola et al. 2012a; 2012b; 2013a) 30% of dogs touched it in this phase. Hence, the level of fear may have inhibited the cat's tendency to mirror the owner's reaction to the fan. Consistent with this the positive group had a tendency to exhibit more meowing than cats in the negative group in the fourth phase (i.e. when the fan was switched off) and showed more static behaviour and gaze alternation between the fan and the owner, as if waiting to choose how to act and potentially communicating with the owner to obtain more information. The 'meow' seems to be specifically associated with vocal communication directed at people (Nicastro 2004); it is among the most common cat-to-human vocalizations (Bradshaw and Cameron-Beaumont, 2000) and its increase in intensity and frequency is usually related with a growing level of tension in the subject (McCune 1994).

There may be also reasons for the lack of synchrony with owners in cats compared with dogs, based on the evolutionary history of the two species, which may affect the likelihood of displaying social referencing. Whereas cats' ancestors were solitary, and today this species is dubbed 'optionally social' (i.e. likely to choose whether to establish strong relationships or simply tolerate social situations, Bradshaw 2013), dogs' ancestor were pack-living animals and dogs today have been shown to organize in multi-male, multi-female packs when food is prevalent (Cafazzo et al. 2010). It would hence seem that for individuals of social species, being able to take into account a conspecific's reaction to external objects and mirror their behaviour may be more relevant than for individuals of a more solitary one. Furthermore, during the course of domestication, dogs have been selected for work with humans, which potentially enhanced the likelihood of their being willing to coordinating actions with people (Soproni et al. 2001; Hare et al. 2002; Miklósi et al. 2003), whereas cats have not undergone this selection and their utility for humans has mostly been linked with independent hunting of small rodents (Clutton-Brock 1988). Hence, although more studies are needed to assess cat's social referencing tendency, the dog-cat species differences observed may be related to the social structure and domestication history which characterize them.

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Figure and Table description

Table 1

Ethogram of the behaviours analysed during the four phases of the study.

Figure 1

Experimental room (3.4 m x 3.9 m) with owner's location during the different phases of the test (Location 1 (L1), Location 2 (L2), Location 3 (L3). The black thicker line is representing the Screen, while the two thin lines show the Owner and Fan Zone. The distance between L1 and L2 was 1.6 m, while the distance between L1 and L3 was 1.3 m.

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