Animal Cognition
https://doi.org/10.1007/s10071-022-01674-w

ORIGINAL PAPER

Discrimination of cat-directed speech from human-directed speech in a population of indoor companion cats (*Felis catus*)

Charlotte de Mouzon[1,2] · **Marine Gonthier**[2] · **Gérard Leboucher**[1]

Received: 8 March 2022 / Revised: 29 July 2022 / Accepted: 1 August 2022

Abstract

In contemporary western cultures, most humans talk to their pet companions. Speech register addressed to companion animals shares common features with speech addressed to young children, which are distinct from the typical adult-directed speech (ADS). The way dogs respond to dog-directed speech (DDS) has raised scientists' interest. In contrast, much less is known about how cats perceive and respond to cat-directed speech (CDS). The primary aim of this study was to evaluate whether cats are more responsive to CDS than ADS. Secondarily, we seek to examine if the cats' responses to human vocal stimuli would differ when it was elicited by their owner or by a stranger. We performed playback experiments and tested a cohort of 16 companion cats in a habituation–dishabituation paradigm, which allows for the measurement of subjects' reactions without extensive training. Here, we report new findings that cats can discriminate speech specifically addressed to them from speech addressed to adult humans, when sentences are uttered by their owners. When hearing sentences uttered by strangers, cats did not appear to discriminate between ADS and CDS. These findings bring a new dimension to the consideration of human–cat relationship, as they imply the development of a particular communication into human–cat dyads, that relies upon experience. We discuss these new findings in the light of recent literature investigating cats' sociocognitive abilities and human–cat attachment. Our results highlight the importance of one-to-one relationships for cats, reinforcing recent literature regarding the ability for cats and humans to form strong bonds.

Keywords Companion cats · Human–animal interaction · Vocal communication · Interspecific communication · Interspecific social cognition · Human–cat relationship

Introduction

Who has not, once in their lives, seen someone having a conversation with a non-human animal? It is no longer a standing secret that, in contemporary western cultures, most humans talk to their pet companions (Burnham et al. 1998, 2002; Lesch et al. 2019; Mitchell 2001, 2004; Xu et al. 2013). It has been reported that humans use a particular kind of speech register when addressing dogs (Ben-Aderet et al. 2017; Benjamin and Slocombe 2018; Gergely et al. 2017; Hirsh-Pasek and Treiman 1982; Jeannin et al. 2017a, b; Ringrose 2015), horses (Lansade et al. 2021) and cats (Schötz 2019, de Mouzon et al. submitted). The speech register addressed to companion animals shares common features with speech addressed to young children, or Infant-directed speech (IDS), (Kaplan et al. 1995), including: hyperarticulation, shorter utterances, more repetitions, elevated pitch and increased pitch variation. These features are distinct from the typical adult-directed speech or ADS (Burnham et al. 1998; Gergely et al. 2021; Hirsh-Pasek and Treiman 1982; Jeannin et al. 2017b; Mitchell 2001; Mitchell and Edmonson 1999; Ringrose 2015; Xu et al. 2013). One might be tempted to merge IDS, PDS (Pet-directed speech), DDS (Dog-directed Speech) and CDS (Cat-directed Speech) into one category, sometimes referred to as "caregiver speech" (Rowland et al. 2003). However, it is likely that caregiver speech may subtly vary according to the receiver. For example, Ben-Aderet and co-workers (2017) found that, even though human adults produced DDS to dogs of all ages, pitch was higher when addressing to puppies compared to adult dogs. This subtle variation is most probably extra specific as well, as humans

✉ Charlotte de Mouzon
cdemouzon@parisnanterre.fr

1 Laboratoire Ethologie Cognition Développement (LECD), Université Paris Nanterre, 92000 Nanterre, France

2 EthoCat-Cat Behaviour Research and Consulting, 33000 Bordeaux, France

Published online: 25 October 2022

increase the modulation of their pitch when talking to dogs (Jeannin et al. 2017b) but not to cats (de Mouzon et al. submitted). Based on these observations, we chose to refer to speech addressed to cats as cat-directed speech (CDS) in the present study.

The way dogs respond to dog-directed speech has long drawn the attention of the research community. Mitchell (2001) noted that "baby talk" to dogs was used for attention-getting and enabled the expression of friendliness and affection. Using playback experiments, Jeannin et al. (2017a) found that DDS draws dogs' attention more efficiently than ADS. Additionally, Ben-Aderet et al. (2017) reported that puppies showed a higher behavioural response to DDS than to ADS, even though in their study cohort dog's response seemed to decrease with age. Benjamin and Slocombe (2018) investigated the possible function of DDS with adult dogs in a more ecological setting, where attention and affiliation towards the individuals who produced DDS was directly measured. Their results suggest that naturalistic DDS, comprising of both dog-directed prosody and dog-relevant content words, improves dogs' attention. In contrast, much less is known about how cats perceive and respond to CDS. For instance, Sims and Chin (2002) observed that the percentage of time that the cat spent next to humans was positively correlated with women's ratings of how much they liked cats and negatively correlated with the percentage of imperatives used by men. However, cats' responsiveness to CDS compared to ADS has not yet been investigated.

The primary aim of this study was to evaluate whether cats are more responsive to CDS than ADS, which would imply that they can evaluate when humans specifically address them. Secondarily, we seek to examine if the cats' responses to human vocal stimuli would differ when it is elicited by their owner or by a stranger. In playback experiments performed with dogs, subjects' responses to DDS was evaluated using strangers' voices only. Based on previous findings in dogs (Jeannin et al. 2017b), we hypothesised that, similar to dogs, cats would display a stronger behavioural response to CDS compared to ADS, either uttered by their owner or by a stranger.

Methods

Subjects and environmental conditions

Nineteen cats were recruited to participate to this study. Out of them, 16 cats (9 males and 7 females) completed the whole study. All cats were indoor cats: 12 were single cats living with a female owner, 4 were kept in pairs and were living with heterosexual couples. All cats were adult with a mean age of 1.5 ± 0.1 years (8 months to 2 years). Cats were neutered, except for one male. To exclude a behaviour-changing effect of an unknown environment (Pongrácz and Onofer 2020) and cats being more likely to express stress-induced behaviours when taken out of their usual environment (Nibblett et al. 2015), the experiment was conducted in their homes. All cats were living in small studio apartments, their owners being veterinary students at the "Ecole national vétérinaire d'Alfort" (EnvA). Studying human–cat dyads at the EnvA was advantageous for two reasons: first, we recorded human voices through direct human–cat interactions, in the same room used by Jeannin and colleagues (2017a, b) in their experiments investigating Dog-directed speech. This enabled us to perform experiments in a similar context, except that the 24 m^2 room was adapted to become "cat-friendly" to best fit cats' behavioural needs (Ellis 2009). We provided our cat participants with numerous hiding spots, height-access, a large litter box, various scratchers and games. As they were living within a few minutes' walk from the cat-friendly room, the stress induced by transport was reduced. Second, when performing the playback experiments in the cats' homes, we were able to measure cats' responses to the stimuli in very similar environments, i.e., small studio apartments.

Apparatus and stimuli

The following protocol was adapted from the study of Saito and Shinozuka (2013) investigating cats' response to their owner's voice compared to a stranger's voice. In line with this study, we used the habituation–dishabituation paradigm, which allows experimenters to measure subjects' reactions during a one-time visit; therefore, no extensive training was required (Saito and Shinozuka 2013). Three identical vocal stimuli were presented serially, followed by a fourth distinct vocal stimulus and then a fifth one, that was the same as the first three ones. If the subjects habituated to the three first stimuli and dishabituated to the fourth, a decrease, followed by a rebound of response to the presentation of the fourth stimulus should be observed. The number of stimuli (five stimuli) and duration of the Inter-Stimulus Interval (ISI, 30 s) were determined following Saito and Shinozuka's protocol.

All vocal stimuli used in the present study were human utterances recorded in a previous study investigating acoustic characteristics of speech register addressed to cats (de Mouzon et al. submitted). Voices of human participants had been recorded with a lapel microphone (Rode SmartLav+®) connected to a digital recorder (MARANTZ PMD620®), under two separate conditions: through direct human–cat interactions (condition 1) and by human participants addressing cats presented through video recordings (condition 2). The first recording condition (1) took place at EnvA, in the cat-friendly room. Direct interactions between owners and their cats allowed us to record human utterances addressed to cats in four types of interactions: play, treat, separation and reunion conditions. In the play and treat condition, humans were asked to play with their cats and to give them a treat in a counterbalanced order, while pronouncing the words: “tu veux jouer ?” [ty vø ʒwe] (French for “do you want to play?”) or “tu veux manger ?” [ty vø mɑ̃.ʒe] (do you want a treat?). In the separation condition, owners left the room and were asked to say “à tout à l’heure” [a tu.t‿a l‿œʁ] (see you later) to their cat, in the way they usually do when they leave home. In the reunion condition, owners returned to the room and were asked to say “comment ça va ?” [kɔ.mɑ̃ sa va] (how are you?), in the way they usually greet their cat. These four sentences addressed to cats constitute the CDS stimuli of the present study. The same four sentences were recorded in ADS condition, by the experimenter asking the owner to pronounce these sentences to her, in the way she would address a friend or family member. Through these direct human–cat interactions, we also recorded cat owners calling their cat’s name. The second recording condition (2) was carried out in the LECD research Lab, at Paris Nanterre University. We recorded 16 different women calling the 16 different cats’ names, addressing cats presented through video recordings. These latter recordings constitute the *stranger* stimuli presented in Series-1.

From the above-described audio recordings, three series of five-sound stimuli were prepared for each cat. Series-1 aimed at examining the response of cats to their owner’s voice compared to that of a stranger. Stimuli 1, 2, 3 and 5 were identical—i.e., the voice of a female stranger calling out the cat’s name and stimulus 4 was the voice of the female owner calling her cat’s name. As all stimuli consisted of the cat’s own name presented to each cat, phonological elements were identical between the owners’ and strangers’ calls. The purpose of this first experiment was to validate our methodological approach by comparing our results to those of Saito and Shinozuka’s (2013) study, obtained in a habituation–dishabituation setting. Series-2 aimed at examining cats’ responses to their owner uttering a sentence in CDS compared to their owner uttering a sentence in ADS. Thus, stimulus 4 contained the voice of the owner uttering a sentence in CDS, stimuli 1, 2, 3 and 5 contained the voice of the owner uttering the same sentence in ADS. Cats were randomly presented one of the four sentences described in the former paragraph, in ADS (stimuli 1, 2, 3 and 5) and CDS (stimulus 4). For each cat, the same sentence was used throughout Series-2. Series-3 aimed at comparing cats’ responses to ADS and CDS utterances pronounced by a stranger. Thus, stimulus 4 contained the voice of a female stranger (owner of another cat from the same study) uttering a sentence in CDS, and stimuli 1, 2, 3 and 5 contained the voice of the same stranger uttering the same sentence in ADS. To avoid inter-series habituation, the sentence used in series-3 was different from the sentence used in series-2. For example, if the cat heard “do you want to play” in series-2, they could hear “do you want a treat”, “how are you” or “see you later” in series-3. Series 1 to 3 were presented in a randomised order.

The sound stimuli were prepared and adjusted to the same volume level using Audacity® recording and editing software 2.2.0. During the experiment, stimuli were presented through a speaker (Yamaha MS101 III) and a video camera (GoPro Hero CHDHB-501-RW) recorded cats’ reactions during the playback of the stimuli.

Procedure

Experiments were conducted in the subject’s homes. The experimenter was positioned next to the speaker. As this research was part of a broader project investigating human–cat vocal communication, cats knew the experimenter from previous visits. In order for the cats to feel as comfortable as possible, the owner was also present in the room and was sitting on a couch, approximately 2 to 3 m away from the speaker. During stimulus presentations, the owner sat silently and was instructed not to interact with her cat. We used the habituation–dishabituation procedure for the presentation of the three above-described series. There was a 30 s ISI between stimuli, each series thus lasted around 2 min. The experimenter waited until the subjects were calm before beginning the experiment, i.e., they were not moving around the room and their body language was not representative of apparent stress (e.g., head scan, escape attempt, hiding, distress vocalisation; Nibblett et al. 2015). The five stimuli of the first series were then played. The experimenter waited at least five minutes between the series, and–if relevant–waited until the subjects were calm again to start a new series. Between the series, owners, cats and the experimenter stayed in the room and could interact freely. Among each series, subjects’ responses to the presentation of stimuli 1 through 3 were expected to decrease because of habituation. According to Saito and Shinozuka (2013)’s protocol, cats whose response did not decrease from stimulus 1 to 3 were rated as “non-habituated cats”, and their data were not used for the corresponding analysis. For series 1 and 2, 10 out of the 16 cats successfully habituated. For series-3, 11 cats successfully habituated.

Behavioural analysis

For each stimulus presentation, recorded videos of subjects’ responses were clipped with VideoPad Video Editor 7.21, from 10 s before stimulus onset to 10 s after stimulus offset. Human voices in the clips were masked with a 300 Hz pure tone to allow blind evaluation. In total, 350 video clips of about 20 s each were created. Clips were anonymised and observed in a randomised order by a blinded rater. Although the protocol used in the present study resembled experiments described by Saito and colleagues (2013; 2019) in several ways, one main difference relied upon the way we generated behavioural data. In their experiments, Saito and co-workers compared cats' behaviours before and after the presentation of each stimulus, by subjectively rating the magnitude of the cat's responses to the stimuli from 0 (no response) to 3 (marked response). In our experiments, videos of trials were observed and coded using the Behavioral Observation Research Interactive Software (BORIS-Friard and Gamba 2016), which enabled us to measure the duration of behavioural responses before and after stimulation. The ethogram was designed according to previous research (Saito and Shinozuka 2013; Stanton et al. 2015) and a total of 14 behaviours were considered (see Table 1). All events in the ethogram were coded as "state events", allowing us to export the total duration for each behaviour expressed by cats (a) 10 s before and (b) ten seconds after the playback of each sound. To permit a thorough exploration of these data, all behaviours were analysed separately in the first instance: cats' responses were very different from one stimulus to another. For example, one cat could be performing an action—such as grooming—and the sound might have interrupted the action, whereas another cat might be resting quietly before the sound diffusion and start moving towards the experimenter or the owner afterwards (see supplemental Figs. 1, 2 for illustrations of behavioural changes). Of course, in some cases, cats' behaviours remained unchanged. Consequently, determining a behavioural score was the most accurate measure of cats' magnitude of response to each stimulus presentation. For this purpose, the difference of behaviour duration before and after the playback of each sound was calculated for each behaviour (DiffBD = b–a). The absolute values of all DiffBDs were then summed to obtain a time difference used as a behavioural score, representative of each cat's intensity of response to each sound: the higher the time difference, the stronger the cat's response. Thus, if behaviours expressed 10 s before the playback continued for 10 s after the stimulus presentation, the behavioural score was null. However, if behaviours that were absent before the stimulus appeared afterwards or if behaviours that were present before the stimulus disappeared afterwards, the behavioural score would be higher.

Statistical analysis

Statistical analysis was performed using jamovi® 2.2 Computer Software (The jamovi project 2021). A Friedman two-way analysis of variance by ranks, a non-parametric repeated measures ANOVA, was used to compare cats' responses to the five sound stimuli presented in each series. For post hoc analysis, responses were compared pairwise and p-values were calculated using Conover's test (post hoc Friedman Conover test, Pereira et al. 2015). p-values were adjusted using the Bonferroni method. For each ANOVA, it was necessary to perform ten pairwise tests to compare the different conditions, so the p-values were multiplied by ten. Thus, p-values of 0.0029 and 0.069 before adjustment became 0.029 and 0.69 after adjustment and so on. Post-hoc comparisons were performed using the *R* package pmcmr under jamovi Rj Editor (R Core Team 2021).

Table 1 Ethogram of considered behaviours for quantification with BORIS software

Behaviour	Description
Resting	Cat is resting
Grooming	Cat cleans itself by licking, scratching, biting or chewing the fur on its body
Scratching	Cat is scratching itself
Rolling	While lying on the ground, cat rotates body from one side to another
Freezing	Cat interrupts movement or activity and suddenly becomes immobile
Locomotion	Cat is moving around the room (more than one step displacements)
Ear moving	Ear(s) movement in any direction
Head moving	Head movement in any direction other than the owner or the experimenter
Experimenter	Cat is looking towards the experimenter/speaker
Owner	Cat is looking towards the owner
Blinking	Cat is blinking (eyes narrowing)
Pupil dilation	The width of the cat's pupils is distinctly increasing
Tail moving	Any movement of tail
Vocalising	Any vocalisation

Results

Owner's voice discrimination, series-1

Measures of discrimination between owner and stranger voices were assessed using behavioural scores, representing cats' intensity of response to each presented stimulus (Fig. 1). Pairwise comparisons indicate that habituated cats significantly decreased response intensity from stimulus 1 (mean behavioural score = 14.08 ± 2.5) to stimulus 3 (9.44 ± 1.69; $p = 0.0002$), which was expected, as habituated cats were selected on this basis. These cats also increased their response from stimulus 3 to stimulus 4 (11.41 ± 1.64; $p = 0.012$). These data indicate that cats that were habituated to the voice of a stranger dishabituated when they heard their owner's voice calling their name. This response rebound suggests that cats could discriminate their owner's voice from that of a stranger.

Speech register discrimination to the owner's voice, series-2

The behavioural scores of the cats' responses to their owner uttering a sentence in ADS vs CDS are presented in Fig. 2. Pairwise comparisons indicate that subjects significantly decreased response intensity from stimulus 1 (mean behavioural score = 10.15 ± 1.77) to stimulus 3 (3.92 ± 1.2; $p = 0.006$). These habituated cats also increased their response from stimulus 3 to stimulus 4 (12.82 ± 2.14; $p = 0.0001$). These data indicate that cats that were habituated to their owner's voice uttering ADS dishabituated when they heard their owners' voice using CDS, suggesting that they could discriminate CDS from ADS, when uttered by their owner.

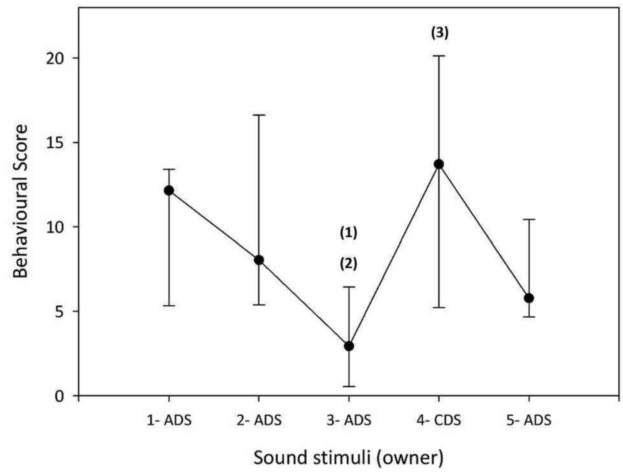

Fig. 2 Behavioural scores of habituated cats. Behavioural scores are represented by the time gap between expressed behaviours before and after sound stimuli. The numbers in brackets indicate significant differences: stimulus 3 differs from stimuli 1 and 2, stimulus 4 differs from stimulus 3. $n = 10$. Median, lower and upper quartile of the data are given, error bars indicate the 25th and 75th percentiles

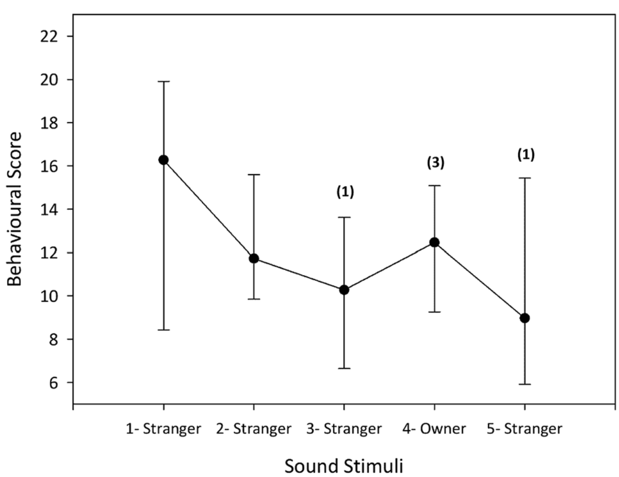

Fig. 1 Behavioural scores of habituated cats**.** Behavioural scores are represented by the time gap between expressed behaviours before and after sound stimuli, indicating cats' responses to each sound stimulus. The numbers in brackets indicate significant differences: stimuli 3 and 5 differ from stimulus 1, stimulus 4 differs from stimulus 3. $n = 10$. Median, lower and upper quartile of the data are given, error bars indicate the 25 and 75th percentiles

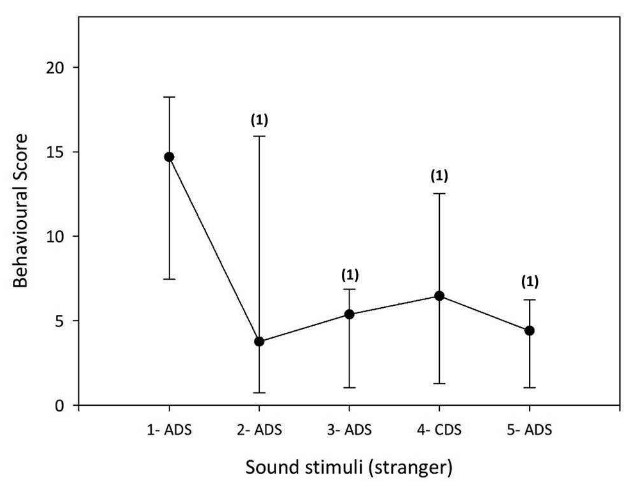

Fig. 3 Behavioural scores of habituated cats. Behavioural scores are represented by the time gap between expressed behaviours before and after sound stimuli presentation, indicating cats' responses to each sound stimulus. The numbers in brackets indicate significant differences: stimuli 2, 3, 4 and 5 all differ from stimulus 1. $n = 11$. Median, lower and upper quartile of the data are given, error bars indicate the 25th and 75th percentiles

Speech register discrimination to a stranger's voice, series-3

Behavioural scores in response to a stranger uttering a sentence in ADS vs CDS are presented in Fig. 3. Pairwise comparisons indicate that cats significantly decreased response intensity from stimulus 1 (mean behavioural score = 13.43 ± 1.86) to stimulus 3 (4.48 ± 0.87; $p = 0.0003$), as expected. However, these habituated cats did not increase their response from stimulus 3 to stimulus 4 (7.64 ± 2.32). Actually, they showed a general habituation through series-3, as responses to stimuli 4 and 5 also significantly decreased compared to response to stimulus 1 ($p = 0.001$ and $p < 0.0001$, respectively). These data indicate that cats that were habituated to a stranger's voice uttering a sentence in ADS did not dishabituate when they heard the same stranger's voice uttering this sentence in CDS. This general habituation suggests that cats did not discriminate CDS from ADS when uttered by a stranger.

Discussion

Our results suggest that cats can discriminate speech specifically addressed to them (CDS) from speech addressed to adult humans (ADS). Interestingly, this pattern of discrimination was found only when sentences were uttered by the cats' owners. Unlike our second prediction, when hearing sentences uttered by strangers, cats in our study cohort did not discriminate between ADS and CDS. As Jeannin et al. (2017a, b) found that DDS drew adult dogs' attention more efficiently than ADS, by using sentences uttered by strangers only, we expected that cats would discriminate CDS form ADS under the same conditions (i.e., when hearing sentences uttered by strangers). A lack of familiarisation to strangers, associated with less exposure to CDS from unfamiliar people, could be a contributing factor explaining the differences between dogs and cats. It can be hypothesised that cats having opportunities to interact with people outside of their home may be able to discriminate CDS from ADS, when uttered by strangers as well. In a recent review investigating sociality in free-ranging cats, Vitale (2022) pointed out that cats' social behaviour towards humans was very complex and flexible. In this context, our results highlight the importance of one-to-one relationships for indoor companion cats, who do not seem to generalise the communication developed with one human to all human interlocutors. These findings bring a new light to the study of human–cat relationship, as they suggest the development of a particular communication into human–cat dyads, that relies upon experience of the other protagonist's way of communicating. Our results also highlight the importance of familiarity in cats' discrimination of different vocal stimuli, as we cannot exclude that cats could have been using familiarity to guide discrimination. This more parsimonious explanation implies that cats could detect a vocal difference between the stranger and the owner stimulus, without necessarily being able to "tag" the emitter as stranger or owner. Of note, the primary aim of the present study was to investigate cats' responses to CDS. The fact that our results regarding owner vs stranger discrimination (series-1) were concordant with Saito and Shinozuka's (2013), even though we used slightly different methods of behavioural analysis, strengthens the relevance of the newly reported findings in the present study.

Our findings bring a new dimension to the understanding of cats' sociocognitive abilities. Having shared our ecosystem for over 10,000 years (Hu et al. 2014), cats have developed sociocognitive abilities toward humans, which enabled them to successfully adapt to the anthropogenic niche. These skills are also very dependant of life experiences, especially during early development. Positive interactions with humans are important for favouring cats' understanding of human cues. Consequently, cats' sociocognitive skills depend on both ontogenetic and evolutionary mechanisms. As pointed out by Jardat and Lansade (2022), these skills include: recognition of individual human features relying upon vocal cues (Saito and Shinozuka 2013), cross-modal and multimodal mental representations of owner (Takagi et al. 2019, 2021), perception of human emotions (Galvan and Vonk 2016; Quaranta et al. 2020), interpretation of humans' attentional state (Vitale and Udell 2019), interspecific communication (Miklósi et al. 2005; Miklósi and Soproni 2006; Humphrey et al. 2020), social referencing (Merola et al. 2015), and sensitivity to ostensive cues (Pongrácz et al. 2019; Pongrácz and Onofer 2020). Ostensive cues are signals given specifically to attract an auditor's attention and initiate an interaction (Jardat and Lansade 2022). Therefore, responsiveness to ostensive cues can be used to determine whether non-human animals perceive that we are speaking to them and seeking interaction with them. In recent studies, cats followed an experimenter's gaze sooner and were more influenced by the experimenter producing ostensive cues—such as making calling noises and calling their name—than by the experimenter making other noises or reading a poem (Pongrácz et al. 2019; Pongrácz and Onofer 2020). In the present study, CDS may be considered as an ostensive cue, compared to ADS, that cat owners can use when seeking interaction with their cat. The understanding of cats' sociocognitive abilities is crucial for improving the quality of human–cat relationships, as well as cat welfare in the domestic environment (Quaranta et al. 2020). The knowledge that cats display the ability to understand a particular way of communicating from their owner, brings further evidence to encourage humans to consider cats as sensitive and communicative individuals.

Although our findings bring a new contribution to the animal cognition literature, limitations of the study should be mentioned, especially relating to our small sample size. Out of the 19 initial participants, only 16 cats completed the study, which is slightly fewer than the 20 cats of Saito and Shinozuka's study. Also, for the sake of standardisation, all cats that participated to this study were living with veterinary students. We are aware that this narrow demographic sample might impact the generalisation of our results.

The present study reinforces recent literature regarding the human-cat relationship. Indeed, cats—who were not so long ago considered as independent and ungrateful creatures—are in fact very well capable of creating and fostering attachment bonds with humans, as uncovered by recent research. For example, Eriksson et al. (2017) reported that cats spent more time with their owners after a longer period of separation. Vitale Shreve et al. (2017) pointed out that when given the choice, most cats would favour human social interaction over food, toys, and scents. Additionally, it was found that some human personality traits could impact the behaviour and affect the wellbeing of cats (Finka et al. 2019). This situation being commonly observed in parent–child relationships, the authors concluded that the relationship between a caregiver personality and the care received by a dependent, may extend beyond the human family, to human-cat relationships. Furthermore, Vitale and colleagues (2019) showed that cats can display secure attachment toward their owners, as previously observed in dogs (Topál et al. 1998). This was true for kittens, but also for adult cats, which indicates a stability overtime of attachment mechanisms between cats and humans. Most recently, Bouma et al. (2022) reported that more than half of their human participants considered their cat as a "family member", more than a quarter as "a child", while only 14% considered them as just "a pet animal". Overall, increasing evidence brings us to consider the human–cat relationship as a close and valuable one. Communication being a major component in this interspecific relationship, our data underline the specificity of the relationship between cats and their owners. As it was previously reported, cats have developed specific types of vocalisations addressed to humans (Bradshaw and Cameron-Beaumont 2000; Tavernier et al. 2020). For example, Yeon and colleagues (2011) found that companion cats' vocalisations were different from feral cats' vocalisations, fundamental frequency of house cats being of significantly higher frequency than those of feral cats. In a pilot study, Schötz (2019) also reported a higher mean fundamental frequency in interspecific than intraspecific utterances for both humans and cats. Additionally, McComb et al. (2009) reported that cats purred differently when soliciting food from humans, as they found a high frequency voiced component within the purr, that they qualified as being a reminiscence of a cry. Indeed, when they were played purrs of cats actively seeking food, humans judged the 'solicitation' purrs to be more urgent than the non-solicitation purrs played at equal amplitude. The fact that, in return, cats show a greater reaction when their humans specifically address them, brings a new dimension to previous considerations of this reciprocal relationship.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10071-022-01674-w.

Acknowledgements We would like to thank MARTIN SELLIER® for their financial support. Thanks to Caroline Gilbert for allowing this study to take place at EnvA and to Laëtitia Matray for helping in the recruitment of cat owners. Thanks to Chloé Tavernier and Alexandre Clasen for their participation in these experiments. Many thanks to owners and to their cats, who accepted to take part in this study.

Funding This research was supported by French ministry of higher education and research (Ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation) and MARTIN SELLIER® company, through the CIFRE program.

Data availability Data are available from the corresponding author on request.

Code availability Not applicable.

Declarations

Conflicts of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in the present study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. All applicable international, national and/or institutional guidelines for the care and use of animals were followed and all procedures performed in experiments involving animals were in accordance with the ethical standards of the institution at which the study was conducted. The study received the approval of the ethical committee of EnvA (COMERC), Saisine n 2018-10-24.

Consent to participate Written informed consent was obtained from all animal owners.

Consent for publication Written consent was obtained from all animal owners to include the image of their cat in the article.

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