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The socio-cognitive relationship between cats and humans – Companion cats (*Felis catus*) as their owners see them

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ABSTRACT

Although domestic cats are among the most common companion animals, we still know very little about the details of the cat-human relationship. With a questionnaire, we asked 157 Hungarian cat owners about their pet's behavior, cognitive abilities and social interactions. We analyzed the responses with PCA resulting in 11 traits. The effect of cats' and owners' demographic variables on the main components was further analyzed with GLM. The results showed strong similarity to the surveys performed with companion dogs, but we also found features that were mainly cat-specific. We found that women considered their cats to be more communicative and empathetic, than men did ($p = 0.000$). The higher education owners also considered their cat as being more communicative and empathetic ($p = 0.000$). We also found that owners use pointing signals more often if the cat is their only pet ($p = 0.000$), and otherwise they do not give verbal commands often to the cat ($P = 0.001$). Young owners imitated cat vocalization more often ($p = 0.006$); while emotional matching of the cat was more commonly reported by elderly owners ($p = 0.001$). The more an owner initiated playing with his/her cat, the imitation of cat vocalizations was also more common in his/her case ($p = 0.001$). Owners think that their cat shows stronger emotional matching if otherwise they experience human-like communicative capacity from the cat ($p = 0.000$). Owners use more pointing signals in the case of those cats that show attention-eliciting signals in more than one modality ($p = 0.000$). Owners who react to the meows of unfamiliar cats, initiated interactions more often with their own cats ($p = 0.000$). Owners also think that cats vocalize in every possible context, and this result was not affected significantly by any of the independent factors. Our results show that owners considered their cat as a family member, and they attributed well developed socio-cognitive skills to them. Because cats have an important role as a companion animal, it would be worthy to study cat behavior with similar thoroughness as with dogs. Our questionnaire may provide a good starting point for the empirical research of cat-human communication. The deeper understanding of cats' socio-cognitive abilities may also help to improve cat welfare.

1. Introduction

The last two decades of ethological research established the scientifically supported notion that dogs (Canis familiaris) can be regarded as the archetype of a 'companion animal'. We have ample empirical evidence behind the theory that the natural environment for dogs is the human social group (Topál et al., 2009) and the main forces of selection during its domestication created/enhanced those socio-cognitive attributes of the dog that in turn made this species the most successful in co-existing with humans (Miklósi and Topál, 2013). While not arguing against this theory, we must wonder whether dogs are truly unique in their niche of being the 'perfect companion', and if so, why there is no other species that could reach the level of mutual understanding (Kaminski and Nitzschner, 2013; Pongrácz et al., 2010), cooperation (Hare and Tomasello, 2005; Range and Virányi, 2015) and attachment (Topál et al., 1998, 2005) with humans that dogs have?

Domestic cats (Felis catus) are definitely in the position of challenging the primacy of dogs as being the favorite companion in developed countries, at least in numbers (Downes et al., 2013; Rodan, 2010). However, although there is a surprising amount of scientific evidence that cats do possess high level socio-cognitive capacities (see for a review Shreve and Udell, 2015) the possible role of cats as non-human companions still remains rather under-investigated (but see Enders-Slegers, 2000; Planchon et al., 2002; Zasloff, 1996). Among many reasons why the cat-human relationship is less studied than dog-human interactions, we could mention the effect of popular beliefs

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about cats being 'selfish', 'unfaithful', 'not-human centric' (Shreve and Udell, 2015), making cats an unlikely subject for anthrozoological investigations. Cat-human interactions were also described as resembling to cat-cat (intraspecific) contacts (Bradshaw, 1992) - this is probably a discouraging feature for those who look for the behavioral correlates of domestication. There is also an undeniable difficulty when it comes to testing companion cats - unlike dogs, cats are very difficult, if not impossible to test in any location other than the home of the owner (Rodan, 2010).

Using the already discovered peculiarities of the dog-human relationship as a template, researchers recently focused on different aspects of the human-directed interactions and cognitive capacities of cats. For example there is compelling evidence that cats may show attachment-equivalent ties with their owner (Edwards et al., 2007): cats follow visual cues given by humans (pointing with arm: Miklósi et al., 2005; cueing with gazing: Pongrácz et al., 2018), and they can also recognize auditory stimuli of their owner (Saito and Shinozuka, 2013). What is probably even more important, from the aspect of a safe and satisfying co-existence with cats kept as pets, are the elements of socialization with humans that were also studied (Karsh and Turner, 1988; Reisner et al., 1994), providing knowledge about both the role of genetic (i.e. paternal effect and breed, Turner et al., 1986; Turner, 2000); and environmental factors (i.e. exposure to preferably many humans in the early sensitive period (Collard, 1967)). While it is widely acknowledged that particular behavioral features (like friendliness, playfulness) are important for the successful companion cat-human relationship (i.e. Turner, 2000), the aspect of how cat owners appraise the behavior, personality and cat-human interactions of their pet are still largely unknown.

Questionnaire-based personality and behavioral assessments are rather common in the case of companion (e.g. King et al., 2009; Turcsán et al., 2012), shelter (e.g. Segurson et al., 2005) and working dogs (e.g. Rooney and Bradshaw, 2004; Wilsson and Sinn, 2012). While the results always remain somewhat prone to the assessor's subjectivity, large scale and correctly validated questionnaires provide unique access to such aspects of the subject population that would be hard (or even impossible) to test empirically. In the case of family-owned pets, questionnaires usually target such specific aspects of dog-human interactions that would be difficult to elicit in staged experiments. At the same time, as these questionnaires are usually completed by the dogs' owners (e.g. Arhant et al., 2010), they utilize the accumulated experience of those individuals who have the best access to the details of the subject's behavior. Meanwhile recent efforts to assess dog personality and dog-owner relationships has resulted in a complex system of information (e.g. Hsu and Serpell, 2003), the same is not true for the cat. From the past we know several attempts to categorize consistent individual differences in cat's behavior to personality traits/personalities (for a review, see Gartner and Weiss, 2013; Mendl and Harcourt, 2000), that described well distinguishable (although rather simple) categories between the subjects. However, some of these studies involved cats living in groups rather than family pets (Feaver et al., 1986), while others concentrated on specific behaviors belonging to a single scenario (such as feeding, Bradshaw and Cook, 1996); or to such, seemingly odd features (at least from the aspect of behavior/personality, as coat color (Delgado et al., 2012). In general, in the case of companion cats, there is a lack of larger scale assessments (but see Adamelli et al., 2005) that would include several aspects of the cat-owner interaction and the assessment of the cat's socio-cognitive capacities by the owner (unlike in dogs, where such questionnaires have been evaluated and published in the past (Hsu and Serpell, 2003; Turcsán et al., 2011).

In this paper we show the results of a study in which owners of companion cats were asked to complete a questionnaire, including such items as (1) the owner's attitude towards his/her cat; (2) the cat's socio-cognitive and behavioral features; and (3) more general questions about the cat-human interactions regarding the particular owner's situation. Our goal was to find those cases where both the owner and the cat had similar features of dog-human relationships, or cases which were rather exclusive to cat-human interactions. Based on the owners' assessment, we wanted to know which factors (originating from either the cat or the human) would affect the behavior of the companion cats, as well as the opinion of the owners about their feline companions.

2. Methods and materials

2.1. Subjects

Our goal was to involve the possible widest selection of Hungarian cat owners in the study. To achieve a balanced sample, we used the responses from young and elderly owners, as well as those living either in urban or rural locations and those with different education levels. Participation in the survey was voluntary.

Owners were allowed to complete the questionnaire regardless of the age, sex, breed and keeping conditions of their cats. We collected completed questionnaires for 157 cats.

2.2. The questionnaire

Printed copies of the questionnaire were handed out personally to the participants or were sent to them via e-mail. The questionnaire can be divided into four main sections (see https://goo.gl/forms/0xPtaNQ8HBw1MgOx1). The first section consists of questions regarding the basic demographic data of the cat and its owner. The second section contains general questions about the cat-owner relationship. In the third section we placed those questions that targeted directly the owner's cat-directed behaviors, while the fourth section was comprised of those questions that characterized the cat's behavior.

2.2.1. Statistical analyses

2.2.1.1. Principal component analysis. All statistical analyses were performed in SPSS 22. Since we initially had a large set of items, we first performed principal component analysis (PCA) based on correlations between variables with varimax rotation to assess whether there were significant associations among the questions. Three separate PCAs were run on the Likert-scale type items, one for the second (general cat-owner relationship), third (cat-directed behavior of the owner) and fourth (cat behavior) sections of the questionnaire. The number of PCA components was chosen using the break point of the scree plot (see Cattell, 1966). To further simplify the components, we applied a backward elimination approach, excluding step-by-step, those parameters that had low loading (< 0.5) or contributed to more than one component with similar absolute loading (this approach is commonly used in PCA analysis). Cronbach's alpha was calculated to assess the internal consistency of the final extracted factors and for testing the repeatability of the measurement (DeVellis, 1991). The extracted components were further analyzed with GLM procedure.

2.2.1.2. General linear models. Factor scores of the extracted components were analyzed with separate GLMs. The normality of the residual distributions were analyzed with Kolmogorov-Smirnov test and with visual examination of the Q-Q plots during normality test.

In the GLM analysis factor, scores were the dependent variables, while the demographic questions, plus some of the other items that were not included to the PCA, acted as independent variables. In some cases where an independent variable provided groups with very different Ns, we had to merge some of these. The exact steps of how the independent variables were derived from the questionnaire are shown in the Appendix.

During the GLM we performed a step-by-step model selection in which we excluded all the non-significant interactions. On the final models, Tukey post hoc tests were performed, and as a correction for multiple comparisons, only $P \leq 0.01$ differences were considered as

Table 1
Traits extracted with PCA from the 'general cat-owner relationship' section of the questionnaire. Traits were named arbitrarily after extraction, based on the items that belonged to them.

Trait	Items	Loading	Variance explained	Cronbach' Alpha
Friendly with strangers	Cat is afraid of strangers	−0.829	25.07	0.743
	Cat allorubbs to strangers	0.889		
Allorubbing and easygoing	Owner cannot control Cat	−0.598	23.78	0.553
	Cat allorubs to Owner	0.855		
	Cat allorubs to family member	0.704		
Communication and empathy	Cat calls Owner's attention	0.844	19.39	0.501
	Cat responds to Owner's emotions	0.776		

Table 2
Traits extracted with PCA from the 'cat-directed behavior of the owner' section of the questionnaire. Traits were named arbitrarily after extraction, based on the items that belonged to them.

Trait	Items	Loading	Variance explained	Cronbach's Alpha
Owner uses pointing for communicating with Cat	hand signals	0.727	17.0	0.826
	head turns	0.681		
	Pointing with arm/finger	0.760		
	'Pointing' with gazing	0.650		
	Directing with arm/finger	0.784		
	Directing with gazing	0.653		
Owner initiates interaction with Cat	Owner greets other cats	0.574	15.5	0.772
	Owner talks to Cat	0.563		
	Owner explains tasks to Cat	0.751		
	Owner explains forbidden/disliked things to Cat	0.789		
	Owner smiles when sees other cats	0.652		
	Owner smiles when sees Cat	0.620		
Owner imitates Cat vocalizations	Cat-sound during play	0.785	11.0	0.713
	Cat-sound to forbid something	0.702		
	Cat-sound miscellaneous	0.797		
Assessment of Cat emotions	Owner assesses Cat's mood	0.603	10.26	0.632
	Owner recognizes what the Cat wants	0.756		
	Owner knows why Cat does not obey	0.617		
	Owner recognizes Cat vocalizations	0.697		

significant. Results where $P \leq 0.02$, were considered as non-significant trend.

3. Results and discussion

3.1. Principal component analysis

Tables 1–3 show the extracted traits given names by the separate PCAs run on three subdivisions of the questionnaire. Within the items of 'general cat-owner relationship' we found three traits where the internal consistency was acceptable (Table 1). These traits explained 68.24% of the total variance. Allorubbing emerged as an important behavior in two of the three traits, determining cats' relationship with either the strangers and the owner/family members. The third trait, 'Communication and empathy' is comprised of two items, referring cats as both signalers and receivers during cat-human interactions.

Within the items of 'cat-directed behavior of the owner' we found four traits with good internal consistency (Table 2). These traits explained 53.76% of the total variance. One trait contains items of various forms of human visual cueing, indicating that owners use not only hand signals but also cues given with head turns and gazing. The second trait involves the items of initiating interaction with the cat, these are mainly verbal, however smiling was also included as contact initiation. The third trait was a specific aspect of cat-human interactions, consisting of various occasions when the owner imitated cat vocalizations. The fourth trait contained such items that may help the owner with assessing the cats' inner state – these cues could be derived either from vocal or other behaviors, or in general from the 'mood' of the cat.

Table 3
Traits extracted with PCA from the 'cat behavior' section of the questionnaire. Traits were named arbitrarily after extraction, based on the items that belonged to them.

Trait	Items	Loading	Variance explained	Cronbach's Alpha
Emotional matching	Cat overtakes Owner's emotion	0.748	20.70	0.730
	Cat tries to cheer up Owner	0.740		
	Cat recognizes if Owner is truly angry	0.590		
	Cat reacts to Owner's smile	0.747		
	Cat starts to play when Owner laughs	0.585		
Gaze following	Cat gazes where Owner points with arm	0.843	19.08	0.821
	Cat gazes where Owner looks at	0.850		
	Cat follows Owner's gazing to distance	0.854		
Predatory behavior	Cat brings home dead prey	0.874	13.74	0.741
	Cat brings home alive prey	0.882		
Cat vocalizes	Cat vocalizes when wants to go out	0.865	12.79	0.678
	Cat vocalizes when hungry	0.856		

Table 4
Results of the GLMs performed on the traits derived from the' general cat-owner relationship' subsection of the questionnaire. Main effects and significant interactions from the final model (following backward model selection) are shown. Significant effects are marked with bold, non-significant trends are marked with italic.

Friendliness with strangers			
	F	df, error: 142	p
Cat's sex	0.251	3	0.861
Owner's gender	1.049	1	0.308
Education	2.803	2	0.064
Purpose	3.344	1	0.070
Owner's gender*purpose	**10.077**	**1**	**0.002**
Cat's sex*education	**3.898**	**6**	**0.001**
Allorubbing and easygoing			
	F	df, error: 152	p
Purpose	**9.634**	**1**	**0.002**
Clever	**6.054**	**2**	**0.003**
Behavioral problem	**8.504**	**1**	**0.004**
Communication and empathy			
	F	df, error: 150	p
Owner's gender	**13.985**	**1**	**0.000**
Education	**15.406**	**2**	**0.000**
Intelligence	**6.310**	**3**	**0.000**

Within the items of 'cat behavior' we found four traits with good internal consistency (Table 3). These traits explained 66.31% of the total variance. Two traits from the four were specifically related to the predatory or vocal behavior of cats, respectively. The most numerous items belonged to a trait that described how cats may apparently 'empathize' with the owner. Finally, the fourth trait is comprised of items that are related to the cats' gaze following behavior.

3.2. General linear models

Because of the complexity of the results (separate GLMs on 11 behavioral traits), we combined the actual results with those sections of discussion that directly belong to particular models. We believe that this structure, with an additional 'General Discussion', serves clarity the best.

Table 4 shows the results of the GLMs run on the traits that were extracted from the 'general cat-owner relationship' section of the questionnaire.

The 'Friendliness with strangers' trait shows how cats react to unknown people. Besides our results, cats' friendliness also emerged as a trait in the paper of Wedl et al (Wedl et al., 2011). Cats' age and sex did not have a significant main effect on the friendliness trait. This result is in line with the findings of Lee et al. (2007), who also found that the cat's sex did not have significant effect to the friendliness. In case of dogs, when an unknown experimenter approached the subjects either in a mildly threatening, or friendly manner, the sex of the dog did not influence the friendliness, however, the breed proved to be a more influential factor (Vas et al., 2005). So far the only study we know about, is one where the effect of cats' sex on social interactions was conducted on indoor-kept, neutered/spayed cats (Barry and Crowell-Davis, 1999). They found no effect of that cat's sex on the affiliative and aggressive behavior of the subjects.

According to the post hoc comparisons the friendliest were those cats that were kept by female owners as a mouser, and also the ones that were kept by male owners exclusively as pets. Male owners' mouser cats were the least friendly (Fig. 1). It was found recently that women prefer multifunctionality, that is, they like if something can fulfill more than one purpose (Villamor et al., 2014). We can assume that female cat owners also appreciate when the cat has other purposes in addition to being a loveable companion, e.g. fulfilling the role of a pest controller. Therefore women may favor cats which show the preferred behavior, not only as an effective mouser, but also behave amicably with people. In companion dogs, it has been shown that dogs are more afraid of threatening men than women (Bálint et al., 2016). We can hypothesize that this would also be the case with cats, resulting in a generally more tolerant ('friendly') behavior in cats that are owned by women.

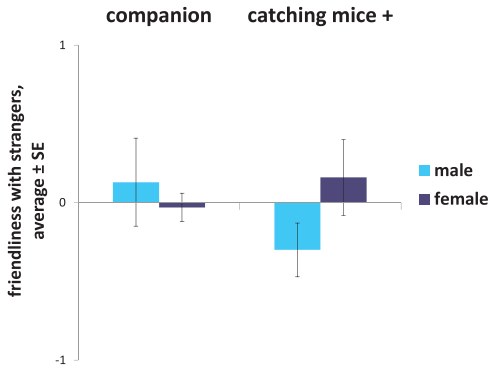

Fig. 1. The interaction between owners' sex and the reason for keeping the cat on the scores of 'Friendliness with strangers' trait. Mouser cats with female owners scored the highest, meanwhile similar cats with male owners scored the lowest.

Male cat owners expressed very different opinions about their cats' friendliness with strangers, depending on the purpose of having the cat. Meanwhile mouser cats of male owners were considered the least friendly, companion cats of men were thought to be the friendliest. There is a possibility that owners of companion cats have more opportunity to observe the behavior of their pet cat. It seems also that in our sample, male cat owners live mostly in the countryside (14 of the 28 male owners live in smaller villages). The cats of these owners were typical 'rural mousers' without being regarded as classical pets. In the case of these cats, there is a chance that the owner does not observe the animal closely enough to notice its friendliness with other people. Alternatively, rural cats may truly avoid strangers.

Female cats were generally the least friendly, except in the case of

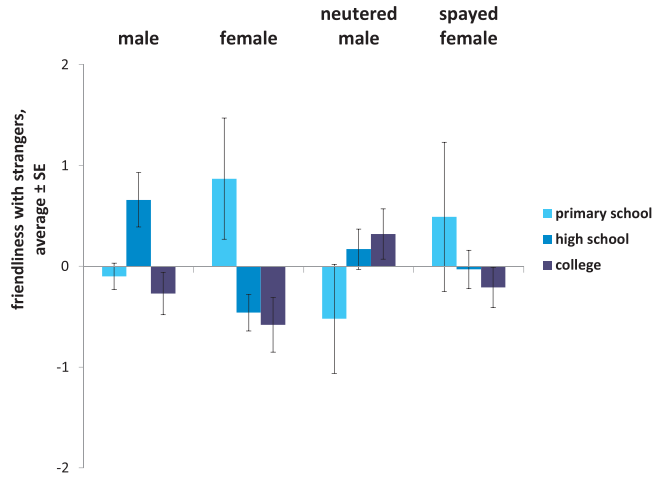

Fig. 2. The interaction between cats' sex and owners' education level in the case of the 'Friendliness with strangers' trait. In the case of owners with only primary school education, female and spayed female cats scored high on the trait, meanwhile male and neutered male cats from the same education group scored low.

owners with only elementary school education – as female cats with these owners had the highest score of friendliness (Fig. 2). Although neutering/spaying did not have a significant effect on the friendliness of cats with strangers, this interaction with the owners' education level showed that in male cats neutering apparently resulted in higher friendliness scores. Other studies also showed that the behavior of male cats can change after neutering, meanwhile the behavior of females did not change significantly after spaying – with the exception of the estrus related behaviors (Adamelli et al., 2005). We can hypothesize that because the neutered male cats roam less (Adamelli et al., 2005; Hart and Barrett, 1973), their increased presence at home can make a friendlier impression. Additionally, people who regard the scent marking behavior in male cats as a nuisance, and opt for neutering the cat, may consider the changes in their cat's behavior as a positive consequence of the intervention. Most owners think that neutering/spaying is a useful and required intervention in the case of cats (McKay et al., 2009). A comparative study between dogs/cats kept by owners or living in shelters, showed that the relinquished animals were more likely to be intact (New et al., 2000). There are similar indications in our results compared to investigations done on the behavioral changes in dogs after castration – it was also found that the behavior of male dogs changed to a larger extent – for example they become more friendly with people (Heidenberger and Unshelm, 1990).

For the trait 'Allorubbing and easygoing', mouser cats scored higher than cats with the single role of companion. Cats also scored high on this scale if they were considered to be problem-free and cleverer than average (Table 4). Controllability seemingly played an important role in the case of the trait 'allorubbing and easygoing'. Mouser cats are usually kept outdoors and their owners may not need to control their behavior as is often the case for indoor cats. Similarly, outdoor (mouser) cats spend less time in the presence of their owner, therefore he/she might notice less frequently incontrollable behaviors from these cats. The similar effect of being problem-free and very clever on controllability is understandable if we consider that many owners may consider the cat as 'clever' and free of 'problems' if the animal is easily controllable. More importantly, it was found earlier that behavioral controllability played a significant role in determining how responsibly owners behaved with their cats (Gunaseelan et al., 2013). In general, 'allorubbing and easygoing' can be considered as a positive trait, which shows strong association with such features as apparent controllability and 'cleverness' of the animal. However, we should treat these results with caution as cat owners may overrate their cats' controllability, driven by a desire to comply with public expectations.

In the case of the trait 'Communication and empathy' women gave higher scores to their cats than men did. Owners with a higher level of education, considered their cats more communicative and empathic than owners with lower levels of education. Cats that were considered as more 'intelligent' also received higher scores of communication and empathy (Table 4). The association between cats' apparent intelligence and the trait 'communication and empathy' can be the consequence of a theoretical scenario where the owner considers a cat more intelligent when the animal seems more empathetic and communicative. As an alternative hypothesis, we can assume that if an owner considers his/her cat as intelligent, consequently this cat will be attributed with higher levels of qualities such as being empathetic and communicative.

Women were found in general to have more intense connections with their pets (Adamelli et al., 2005), their interactions involve more repeating, complex behavioral patterns (Wedl et al., 2011), and women are also more empathic with their pets (Angantyr et al., 2011). There are indications that being more empathetic and communicative has a closer evolutionary association with females (Tanner and Zihlman, 2014; Vitulli, 2006). Brain areas that are connected to communication and empathy were also found to be more developed in women, from both the anatomical and functional aspects (Schulte-Rüther et al., 2008), and the importance of these attributes in females was also confirmed by a number of psychological tests (e.g. Austin et al., 2005; Hoffman, 1977). The fact that women consider their cat more empathic than men do, can be the result of the higher level of empathy in female participants, as it was confirmed by a recent questionnaire survey, where it was found that more empathic owners also considered their dogs as being more empathic (Szánthó et al., 2017).

Table 5 shows the results of the GLMs run on the traits that were extracted from the 'cat-directed behavior of the owner' section of the questionnaire.

In the case of the 'Pointing' trait, the lowest scores were given to cats that initiate playful interactions with the owner themselves. Owners use pointing more frequently with cats that communicate in all three modalities (visual, vocal, tactile) than with cats that communicate in only one single modality. Owners who command their cats mostly verbally, use pointing signals less frequently than the owners who prefer the gestural signals towards their cat. Owners point for their cats most frequently if the cat is their sole pet in the household (Table 5).

Table 5
Results of the GLMs performed on the traits derived from the 'Cat-directed behavior of the owner' subsection of the questionnaire. Main effects and significant interactions from the final model (following backward model selection) are shown. Significant effects are marked with bold, non-significant trends are marked with italic. Where = place where the cat is kept.

Principal components derived from questions related to owners' behavior.			
Pointing			
	F	df, error: 147	p
Owner controls	**5.408**	**3**	**0.001**
Play initiation	**6.654**	**2**	**0.002**
Cat attention getting	**5.481**	**2**	**0.005**
Other animal	**9.127**	**2**	**0.000**
Owner initiates interaction			
	F	df, error: 154	p
Owner's sex	**12.270**	**1**	**0.001**
Owner reacts unknown Cat	**13.424**	**1**	**0.000**
Imitation of cat vocalizations			
	F	df, error: 148	p
Owner's age	**7.802**	**1**	**0.006**
Education	1.234	2	0.294
Play initiation	**7.335**	**2**	**0.001**
Way of talking	0.063	1	0.803
Education*way of talking	**5.669**	**2**	**0.004**
Assessment of cat emotion			
	F	df, error: 155	p
Where	6.555	1	0.011

Similarly to companion dogs, cats were also found to be highly effective in following the visual signals of humans (points with arm: Miklósi et al., 2005; directional gazing: Pongrácz et al., 2018). This capacity may partly originate from the intraspecific visual communication of cats (Cafazzo and Natoli, 2009). We found that the way playful interactions were initiated in the case of the cat-owner dyads, had an effect on the frequency of human-given pointing signals. The effect showed an asymmetry – if cats were the initiators of play, the owner reported less frequent pointing cueing. Such an asymmetry in cat-human interactions was also suggested by others before (Wedl et al., 2011). In our case, the asymmetry can be the result of the different levels of attention particular owners assign to their cats. Those who are less attentive to the signals of the cat, may use more directional signals, meanwhile owners who are more reactive to the cats' communication, could refrain from directing the animal with gestures. Alternatively, an owner who prefers to be the initiator of play may use pointing as part of a game with the cat.

We found that owners use more pointing when they think that their cat communicates with them in multiple modalities. This effect can have several explanations. Cats that experience a rich gestural communication from their owner may themselves react with more various repertoire of communicative signals. Alternatively, a highly interactive cat may trigger more frequent pointing cueing from the owner.

We found that those owners who mostly command their cats with pointing gestures, in general also use pointing frequently. Owners, who command the cat mostly verbally, used pointing with the lowest frequency. This result shows that the preference for gestural signals may be a trade-off for verbal communication with companion animals.

We found that owners use pointing to the cat more frequently if they keep no other pet at home. This result is somewhat surprising because one could expect that cats that are kept together with dogs in the same household will receive the most pointing signals, as there are lots of indications about the willingness of dogs to follow pointing signals (e.g. Hegedüs et al., 2013; Pongrácz et al., 2013a, b). In our case it can be that cats in the single pet status receive the most devoted care from their owners, including a rich repertoire of gestural signals. The presence of other animals (mostly livestock in the case of our sample) may affect how the owners treat their cats as well. In the case of dogs, it was found earlier in a questionnaire study, that those owners who thought that their dog had the weakest cognitive performance considered the dog as one of the livestock species (versus 'friend' or 'family member') (Pongrácz et al., 2012).

In the case of the 'Owner initiates interaction' trait, female owners scored higher than male owners. Owners who often initiate interaction with their cats react more actively to unknown cats' vocalizations. According to our hypothesis, just as women are more empathetic with others than men are, this may also be the reason why they are more likely to initiate interaction with their cat. Interestingly, the frequency of interacting with someone's own cat showed strong association with the responsiveness to unknown cats' vocalizations as well. This may be the result of some owners' general sensitivity to the presence of nearby cats.

Regarding the 'Imitation of cat vocalizations' trait, cat owners below 30 years of age received higher scores than older cat owners. Owners who do not play with their cats seldom imitate cat vocalizations. Owners are more likely to imitate cat vocalizations when the cat initiates the play sessions, than where the owner initiates play (Table 5). Among children and during infant-mother interactions, the imitation of animal's vocalizations (onomatopoeia) is a commonly observed phenomenon (Dofs, 2008; Hashimoto et al., 2006), however in adults the frequency of onomatopoeia may decrease (Aliyeh and Zeinolabedin, 2014). Our results can also be explained by the higher activity levels of the younger owners, which may result in more frequent and variable interactions with their cats. The imitation of cat vocalizations occurs mostly during play sessions with the cat. It was found earlier that cats often use vocalizations during cat-human interactions, and additionally

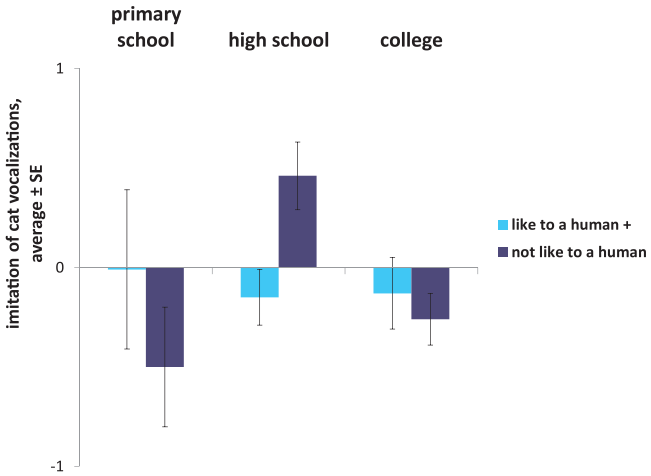

Fig. 3. The interaction between owners' education level and their talking style with the cat indicating the frequency of imitating cat vocalizations. In the case of owners whose highest education level was high school, these owners imitate cat vocalizations mostly when they otherwise do not talk to their cats as they would with a human.

they can also recognize their owners' voice from sound recordings (Saito and Shinozuka, 2013). Compared to dog-human interactions, it is a rather specific habit of cat owners that they imitate the vocalizations of their pets – by our best knowledge no similar indications were reported in the case of dog owners. It would require further experimentation to discover whether human-emitted cat vocalizations enhance the success of human-cat communication, or do they elicit some kind of specific reaction from the cats.

According to the significant interaction, owners who have a secondary school degree, do not talk to their cats as they would with humans, they more often imitate cat vocalizations than those owners who have either a basic or high level education (Fig. 3). These results may indicate that when the owner considers his/her cat more human-like (i.e. when he/she talks to the cat as they would to a human), he/she will not frequently use cat vocalizations during the interactions; contrary to the owners who consider their cats less human-like, and opt more often to imitate cat-sounds. We found this result only in the case of owners with secondary-level education (who were the most numerous subset of the sample). A theoretical explanation for this could be that owners with primary education may not consider the cat as a pet, so they may not aspire to communicate with it in any way. In the case of the owners with the highest education level, the situation may be the opposite. Dotson and Hyatt (2008) found that in the case of dog owners, the higher the education level the owner had, he/she reported a closer relationship with their dog (Dotson and Hyatt, 2008). We can assume that from a high level of education, owners may show stronger anthropomorphic attitude to their pets, resulting in less frequent imitation of vocalizations.

In the case of the 'Assessment of cat emotions' trait, high scores were more typical in the case of those cats that were allowed in the house, than in the case of outdoor-kept cats (Table 5). The majority of cat owners responding to our questionnaire agreed that it is not easy to assess a cat's inner state. It was found earlier that cat owners had difficulties in guessing the contextual information of cat meows, apart from a general judgement that the cat 'wants something' (Nicastro and Owren, 2003). The same authors reported that cat owners who had extended experience and a more intense attraction to their pets were more successful in assessing cat vocalizations. Contrary to the results with cat meows, human listeners are considerably better in assessing the emotional and contextual content of dog barks (Pongrácz et al., 2005, 2006), and this skill seems to be independent of the level of experience with dogs (Molnár et al., 2010; Pongrácz et al., 2011). This

Table 6
Results of the GLMs performed on the traits derived from the 'Cat behavior' subsection of the questionnaire. Main effects and significant interactions from the final model (following backward model selection) are shown. Significant effects are marked with bold, non-significant trends are marked with italic. In the case of 'Gaze following' and 'Cat vocalizes' there were no significant effects in the models.

Principal components derived from questions related to cats' behavior.			
Emotional matching			
	F	df, error: 146	p
Cat's age	**4.773**	**2**	**0.010**
Owner's age	**12.210**	**1**	**0.001**
Owner's sex	**7.161**	**1**	**0.008**
Topic of talk	**8.859**	**2**	**0.000**
Cat-communication's resemblance to speech	**20.496**	**2**	**0.000**
Cat's age*Owner's sex	**5.518**	**2**	**0.005**
Predatory behavior			
	F	df, error: 154	p
Cat's age	**5.111**	**2**	**0.007**
Gaze following			
	F	df, error: 153	p
–	–	–	–
Cat vocalizes			
	F	df, error: 154	p
–	–	–	–

difference might have an evolutionary explanation either due to the longer dog-human coexistence with dogs (Pongrácz, 2017); or because cats are less social than dogs are, they may therefore lack such expressive signals of finer internal states which dogs are more capable of (Galvan and Vonk, 2016).

In our study owners reported a better understanding of their cats' emotions that are kept at least partly indoors – probably because they spend more time in each other's vicinity, which in turn may provide greater opportunity for the owner to observe and learn more about cat behavior. In the case of assessment of cat emotions, the non-significant results are also worthy to mention, because these show that this trait does not change neither with experience (i.e. with the number of previously kept cats), nor with the owner's age.

Table 6 shows the results of the GLMs run on the traits that were extracted from the 'cat behavior' section of the questionnaire.

In case of the trait' Emotional matching', cats of elderly owners received the highest scores. If the owner thought his/her cat did not communicate as humans do, those cats received low scores of emotional matching. Finally, emotional matching by the cat was scored high where the owners admitted they even shared their thoughts with their cat, meanwhile scores of emotional matching were the lowest in the case of those owners who do not talk to their cats at all. Regarding the effect of owners' age on the perceived emotional matching in their cats, we hypothesize that this could be caused by the difference in how younger and older people detected this behavior in the cat. Elderly people may be more patient when observing their cats, thus they can notice finer details of their apparent inner state, contrary to the younger owners who are interested in more active interactions with the cat. This result shows an interesting contrast with human literature, where older people were self-reportedly less empathetic with others (Schieman and Van Gundi, 2000). One hypothesis explaining our results is that older people may have collected more cat-related experience than younger people, and additionally, older owners may have more time to observe their pets as well. It was also found that people who had fewer emotional bonds, showed stronger attachment to their cats (Adamelli et al., 2005).

Owners with a more anthropomorphic attitude towards their cats rated the emotional matching of their pet higher. Dog owners also considered their dogs more empathic if they thought that dogs think like children (Szánthó et al., 2017). According to an alternative hypothesis, if the cat shows high skills of emotional matching, in turn this can convince an owner that the cat communicates as humans do.

The emotional closeness between an owner and his/her cat may affect the level of emotional matching the cat apparently shows. The opposite can also be true: if the owner notices high levels of emotional matching from the cat, the owner may share more of his/her thoughts and feelings with the animal. It was shown earlier that people who need extra social support will express stronger attachment and emotional bonds towards their cats (Stammbach and Turner, 1999; Zasloff and Kidd, 1994). From this aspect, companion animals may provide exactly what their owner needs, because it may be relatively easy to interpret the cat's behavior as being emotionally matching to the owner's feelings. Meanwhile many of the cat owners in our study believed that their cats have empathetic abilities, so far this has not been proven empirically by others – for example Galvan and Vonk found that cats fail in a discrimination task between human emotional expressions (Galvan and Vonk, 2016) – although this may be the consequence of participants which only pretended to show emotional expressions. In another study it was shown that cats more readily interact with their owners if the owners were extroverted and agitated, than was the case with less emotional owners (Turner and Rieger, 2001).

According to a significant interaction, older cats with female owners show the highest scores of emotional matching, while young cats with men show the lowest (Fig. 4). Similarly to the 'communication and empathy' trait, we found that (older) cats of female owners received higher scores of emotional matching than the cats of male owners. Contrary to cats, it was found that older companion dogs tended to be less reactive towards their owner's emotions (Szánthó et al., 2017). It has also been found that women have stronger understanding and empathetic capacity towards the feelings and emotions of others (Schieman and Van Gundi, 2000; Tanner and Zihlman, 2014). Additionally, in the case of older cats, there could be more opportunity for learning the subtle signs of emotional matching to each other, and it is also possible that female owners feel stronger emotional bonds with their cat. Another hypothesis could be that younger cats are in general more active, therefore they spend less time observing their owners' behavior. In the case of dogs, excessive activity levels in young animals represents a common problem according to shelter records (Pierantoni et al., 2011). Compared to the principal component 'assessment of cat emotion' we found strong differences. This is important, because one could assume that identifying a cat's emotional matching depends on a capability for recognizing the cat's inner state. The difference can be caused by the fact that the 'emotional matching' trait involves mostly emotion-related items, while the 'assessment of cat emotion' trait is comprised of items which are only partly about the inner states of the

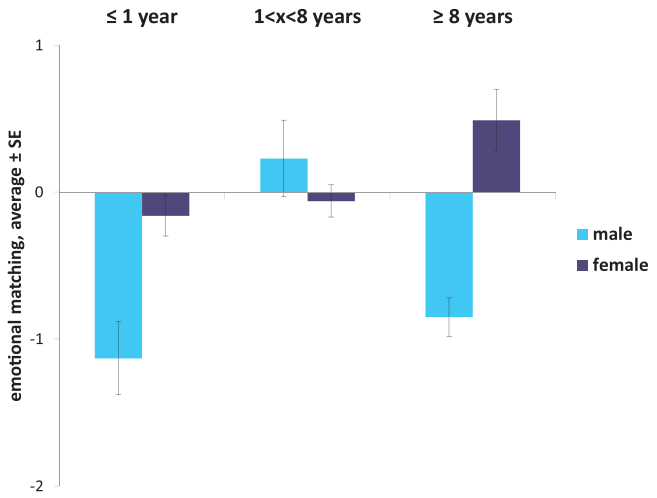

Fig. 4. The interaction between the cats' age and owners' sex in the case of the trait 'Emotional matching'. Highest scores were reported by female owners with older cats.

cat, the other items are related to the recognition of the cat's communicative signals and intentions.

In the case of the 'Predatory behavior' trait, we found only one significant association, the age of the cats. Cats younger than one year had the lowest scores, adult cats less than eight years old received the highest scores, and old cats had intermediate scores. These results indicate that predatory behavior may become more effective in cats as they age, with very old cats becoming less successful/motivated to hunt. The predatory behavior of domestic cats raises widespread concerns as it can have a deleterious effect on local wildlife, especially on the suburban songbird and reptile populations (e.g. Woods et al., 2003). The empirical assessment of the severity and prey-composition of cats' hunting activity includes reports by the cat owners about the prey items brought home (Woods et al., 2003); and also ingeniuous methods of equipping the cats with small cameras that record their predatory attempts (Loyd et al., 2013). Results of the latter study showed that cats usually eat their prey on site, therefore owner reports of presented prey items can seriously under estimate the predatory success of cats. As in our study the owner-reported prey presentation in cats showed an association with cats' age, there is also a possibility that this behavior could be age-dependent in cats.

In the case of two further traits ('Gaze following' and 'Cat vocalizes') we did not find any significant main effects or interactions of the independent factors. In a recent two-way object choice study (Pongrácz et al., 2018) we found that companion cats follow both momentary and dynamic gazing cues of the experimenter above chance level. However, in the case of the present questionnaire study, the gaze following behavior of cats could be such a subtle and sporadic phenomenon which mostly eluded owners' attention, therefore their answers may lack any recognizable pattern. Regarding the 'Cat vocalizes' trait, according to the owners, cats always vocalized if they wanted something (e.g. when the cat is hungry or wants to go out). These results are in line with earlier results, where human listeners found cats' meowing without context or inner-state specificity (Nicastro and Owren, 2003). At the same time cats' meowing shows acoustic resemblance to a baby's cry, consequently it is very hard to ignore (Brewster et al., 1998; Hechler et al., 2015; Lawrence, 2003).

4. General discussion

Our results show that some features of the cat-human relationship, from the viewpoint of cat owners, resemble dog-owner relationship features. Demographic factors (cats' and owners' sex and age, owners' education level) had a strong influence on several traits derived from our questionnaire study. These results show strong similarity to earlier questionnaire studies about the social and socio-cognitive features of the dog-human relationship (e.g. Kubinyi et al., 2009; Pongrácz et al., 2012). In cat-related questionnaires, some authors found that demographic characteristics of the owner (e.g. sex) had a stronger effect than the features of the cat (Adamelli et al., 2005; Wedl et al., 2011). In a recent study by Arahori et al. (2017), it was found that cat owners who considered their cats as family members, rated their pets as more capable of feeling emotions, than owners who considered their cats as non-family members. However, in another questionnaire study, Duffy et al. (2017) showed that particular demographic features of the cat (e.g. age, being the only pet in the household) can have a significant effect on the owners' opinion of their cat. Our results showed that playful interactions may enhance the relationship between owner and cat, similarly to dogs where Svartberg (2005) found that playful dogs were more trainable and they showed more interest in their owners.

Other aspects of our results show divergence from the features of dog-human interactions. While dog vocalizations are highly informative for humans (e.g. Molnár et al., 2010; Pongrácz et al., 2011, 2017), cat vocalizations were considered by the owners as mere expressions of the cats' intention to 'get something' – a result that is similar to the earlier playback study done by Nicastro and Owren (2003). Although there are indications of the personality differences between cat and dog owners (Gosling et al., 2010), our and others findings regarding the lack of complex meaning of cat vocalizations for humans, might be one of the reasons why cats are considered as being capable of expressing less emotions than dogs (Arahori et al., 2017).

Our questionnaire study is among the first endeavors that investigated extensively cat owners' opinions about the extent of the complex socio-cognitive capacity of companion cats and their everyday interactions with humans. Besides discovering such peculiarities of cat ownership as the imitation of cat vocalizations during interaction with these animals, our results shed light on the role cats play as companions in the average cat owners' lives. Although there are obvious differences among the opinions of the surveyed population, our main conclusion is that owners usually consider their cats as family members with a high capacity for emotional and empathetic understanding towards human emotions and communicative signals and considerable levels of mental capacity. Obviously, the main limitation of our study comes from the anthropomorphic approach of the participating owners, however, it provides several testable hypotheses for future empirical research.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.applanim.2018.07.004.

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