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Factors influencing the temporal patterns of dyadic behaviours and interactions between domestic cats and their owners

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ABSTRACT

Human–cat dyads may be similar in interaction structure to human dyads because many humans regard their cats as being social companions. Consequently, we predict that dyadic structure will be contingent on owner and cat personalities, sex, and age as well as duration of cohabitation of the partners. Forty owner–cat dyads were visited in their homes, on four occasions, during which their behaviours and interactions were video-taped. Behaviour was coded from tape and was analysed for temporal (t)-patterns using Theme® (Noldus; Magnusson, 1996). Owner personality was assessed using the NEO-FFI. Five cat personality axes were identified by Principal Component Analysis (PCA) based on observer-rated items and on coded behaviours. We found that the higher the owner in neuroticism, the fewer t-patterns occurred per minute. The higher the owner in extraversion, the higher was the number of non-overlapping patterns per minute. The more "active" the cat, the fewer non-overlapping patterns occurred per minute, but the higher was the event type complexity. The older the cat, the lower was dyadic event type complexity. We suggest that basic temporal structures similar to those of human–cat dyads may also be found in other long-term and complex dyadic relationships, including those between humans.

1. Introduction

Most household cats are regarded as being social partners by their owners (Karsh and Turner, 1988; own unpublished data). This is probably not merely a matter of anthropomorphic projection, but rather considers that vertebrates in general, and mammals in particular, share a number of "social tools" (Kotrschal, 2007). These include common brain substrates of emotions (Panksepp, 1998, 2005), instinctive socio-sexual behaviour (Goodson, 2005) and social bonding (Curley and Keverne, 2005), as well as common mechanisms for coping with stress across vertebrate species (McEwan and Wingfield, 2003; DeVries et al., 2003). Hence, socialization between humans and their companion animals appears possible on the basis of common biological grounds. In addition, domesticated animals have been selected for tameness, making them generally more attentive and cooperative towards human partners than their wild ancestors (Hare and Tomasello, 2005; Miklosi et al., 2004). In fact, companion animals, such as dogs or cats may provide social support for their owners (Podberscek et al., 1995). Contact with cats, for example, may reduce stress (Allen, 2003) and may positively affect health (Allen et al., 2002). Furthermore, human–cat dyads may be regarded as long-term valuable relationships (Kummer, 1978), probably characterized by dynamic negotiations of interests between partners. For these reasons, in the present paper, we applied the contemporary framework of evolutionary theory for dyadic social relations (Aureli and De Waal, 2000) to the study of human–cat dyads.

Relationships between cats and owners are considered to be complex, with contributions from both sides (Mertens, 1991; Turner, 1991). Owners often report a perfect fit with their cats (Karsh and Turner, 1988). This may be due mainly to the flexibility and variability of cat social behaviour (Mertens and Turner, 1988), which enables them to adapt to their human companions (Leyhausen, 1988). For instance, cat behaviour and time spent interacting with the owner has been found to be influenced by activity, mood, gender, and age of owner (Mertens, 1991; Rieger and Turner, 1999). Also, in both humans and in non-human animals, personality (an inclusive synonym for "individual behavioural phenotype", also covering "coping style" Koolhaas et al., 1999) is a major determinant of decision making, i.e., of how

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individuals respond to environmental challenges and how they interact socially (Buss, 1999; Gosling and John, 1999; Groothuis and Carere, 2005; Kralj- Fišer et al., 2007; Sih et al., 2004). On these grounds we base our current emphasis on human and cat personality. Expanding on previous observational (e.g., Feaver et al., 1986; Turner, 1991) and questionnaire-based (e.g., Turner and Stammbach-Geering, 1990) studies we conducted a quantitative observational, and partly experimental, study in 40 owner–cat dyads in the Vienna area. Our aim was to explore the human–cat relationship as close to its social core as possible via determining regularities in the behaviours and interactions of cats and humans.

The temporal organization of behaviour is inaccessible to the human eye, necessitating special software to detect "hidden" temporal (t) patterns (Theme®, Noldus bv, The Netherlands; Magnusson, 1996, 2000). Such tools enable the investigation of the structure of behaviour through automatic detection of special relations between the time distributions of behavioural event types. A temporal pattern (t-pattern) is hierarchically and temporally structured. The number of event types (different behaviours) in a pattern is ordered in chronological sequence (for details and formal definitions of t-patterns see the Section 2.4 of this article and Magnusson, 2000).

Theme® has already been successfully applied in a number of areas (Anolli et al., 2005) that include the modulation of human hormone–behaviour (Hirschenhauser et al., 2002), behaviour in hens (Hocking et al., 2007; Merlet et al., 2005), chicks (Martaresche et al., 2000), and mice (Bonasera et al., 2008). In humans, Theme® has been used to analyse interactions and synchronies (Magnusson, 1996) in activities such as sport (Borrie et al., 2001, 2002; Jonsson et al., 2006) and dancing (Grammer et al., 1998), and also in studies of schizophrenia and mania (Lyon and Kemp, 2004). For example, Borrie et al. (2001) showed that the temporal patterning of behaviour was linked to the performance of a football team. Kerepesi et al. (2005) showed that in human–dog dyads, the behaviours exhibited during cooperative interactions are organized in interactive temporal patterns, and that such patterns have a functional role for the successful completion of the cooperative task. Kerepesi et al. (2006) compared human–dog interactions with human–robot (AIBO) interactions and found that the number of interactive t-patterns did not differ but that the structure of the t-patterns did. Given these results, we expected to find temporal structuring of dyadic interactions in human–cat dyads and that these would, to some extent, depend on the interaction style of the human partner. We proposed that these would shed light on the nature and specificity of these dyadic relationships. Furthermore, we predicted that temporal patterns would vary between dyads depending on some major factors affecting dyadic relationships, such as human and cat personalities, sex and age of partners, and duration of cohabitation. We hypothesized that the t-patterning of dyadic behaviour would vary between male and female owners and between male and female cats. We also hypothesized that the human personality dimension Neuroticism would have an especially strong impact on dyadic t-patterning, assuming that owners scoring high in neuroticism may be in particular need of social support and thus tend to consider their animal companion as a social supporter and may asymmetrically seek contact with their cats. Similar contingencies have been found in previous studies of human–dog relationships (Kotrschal et al., 2009).

2. Methods

2.1. General procedure

Data were collected between February 2005 and March 2006 in the dyads' apartments in urban Vienna. Our subjects were 40 cats (25 males and 15 females; 9–156 months; 38 domestic shorthairs, two longhairs) and 39 owners (10 men and 29 women, 21–78 years old; one woman had two cats in two different apartments). Of our dyads, 19 were same-sex (7 male owner–male cat, 12 female owner–female cat) and 21 were opposite-sex (3 male owner–female cat, 18 female owner–male cat). The cat's primary attachment figure ("owner") participated with her/his cat. All cats except two (one female, 9 months of age; one male, 7 years), were neutered. Twenty cats had limited access to outdoors (small gardens, rooftops); one cat, the single un-neutered male, ranged more widely. All of these cats still spent much of their time inside. At the beginning of our study, owners and cats had lived together from 3 to 154 months (Table 1). Cats were considered friends, members of the family or even "children" (own unpublished questionnaire data) by all participating owners, indicating strong social bonds.

Two observers visited each dyad four times at approximately weekly intervals (range: 4–14 days) at around the cat's feeding time. Visits lasted approximately 45 min; total observation time was thus approximately 120 h. One of the observers interacted with the owner, guided the procedure, conducted interviews and explained the questionnaires; the other used a hand-held digital camcorder to video-tape cat and owner behaviours and interactions. During the first visit, the owner was interviewed to obtain information concerning the dyad's history and the owner's perceptions of the cat and their relationship. This approach and the arrangement of the visit around the feeding event were chosen to provide consistency in context for the dyad's interactions. We regarded the visits, intrusive as they may have been, as experimental challenges and coded appropriate parameters (see below). Before conducting the main study, we had optimised our procedure through a pilot study with seven dyads. These pilot data were not included in the present analysis.

2.2. Personality

During our second visit, owners were asked to complete the German version (Borkenau and Ostendorf, 1993) of the NEO Five Factor Inventory of personality (NEO-FFI; Costa and McCrae, 1989). We opted for this five-factor model of human personality (FFM, "Big Five": neuroticism, extroversion, openness, agreeableness and conscientiousness; Costa and McCrae, 1989, 1992, 1999; McCrae and John, 1992), because of its empirical structure, practicability and compatibility with biological personality theory (Koolhaas et al., 1999). In our studies using this model, we have found factors other than openness not to be independent. Neuroticism correlated negatively with agreeableness, extraversion, and conscientiousness in this cat study and in a similar human–dog study that also included 40 dyads (Kotrschal et al., 2009).

In non-human animals, coping style may be defined as a coherent set of behavioural and physiological individual responses to challenging situations that is relatively constant over time (Benus et al., 1991; Hessing, 1994; Koolhaas et al., 1999; Suomi, 1991). Human observers have repeatedly and successfully used FFM-like lists of traits to assess cat personality (Feaver et al., 1986; Gosling and Bonnenburg, 1998; Gosling and John, 1998, 1999). Feaver et al. (1986) found three personality axes, "alert", "sociable" and "equable with cats". Gosling and John (1998) identified four: emotional reactivity (neuroticism), affection (agreeableness), energy (extraversion) and competence (openness). Bergler (1989) created a convergent cat "psychogram" based on owner interviews.

We evaluated cat personality by integrating observer scoring and tests. The tests included: (1) whether the cat accompanied the owner to the door when the observers arrived, (2) whether and how much the cat hid during the four visits, (3) the cat's responses to a novel object to which it was exposed once, during the third visit (a plush owlet with large glass eyes was placed on the floor so the cat would encounter it by surprise), and (4) the cat's reactions to

Table 1
Means and range of age of owner and age of cat as well as duration of living together, shown for each gender-owner and sex-cat combination and total.

Dyads	Number of dyads	Mean age of owners (years)	Age range of owners (years)	Mean age of cats (months)	Age range of cats (months)	Mean duration of living together (months)	Range of duration of living together (months)
Male owner–male cat	7	38.43	26–48	73.43	10–156	67.71	8–154
Female owner–female cat	12	49.33	25–67	70.50	12–144	45.92	3–138
Male owner–female cat	3	54.67	50–58	47.00	9–102	42.00	9–90
Female owner–male cat	18	46.00	21–78	76.27	9–144	57.44	6–120
Total	40	46.33	21–78	71.85	9–156	54.63	3–154

Table 2
Factor loadings of a Principal Components Analysis (PCA; varimax rotation; Bartlett-test: KMO = 0.625; sphericity: $chi^2 = 532.6$; df = 190; $p < 0.001$) based on observer rating and behavioural coding. Loadings of 0.500 or above are highlighted in bold text.

Original variables	Active	Anxious	Feeding	Sociable	Rough
Curious	**0.853**	−0.332	−0.115	0.147	−0.060
Active	**0.847**	−0.020	0.029	0.141	0.185
Playful	**0.842**	−0.174	0.011	0.149	0.152
Excitable	**0.794**	0.347	0.131	0.114	0.201
Vigilant	**0.725**	0.368	−0.131	0.083	−0.142
Tense	0.003	**0.916**	0.183	−0.167	−0.023
Anxious	0.137	**0.911**	0.002	−0.043	−0.136
Hiding	−0.114	**−0.722**	0.023	−0.438	0.311
Attention to visitor	0.498	**−0.688**	0.046	−0.034	0.004
Gluttonous feeder	0.004	−0.011	**−0.894**	−0.062	−0.113
Examine food	*−0.086*	*0.079*	***0.833***	*0.072*	*0.052*
Eats steadily	*−0.043*	*0.137*	***0.803***	*0.273*	*−0.087*
Playing	−0.456	0.128	**−0.566**	0.367	0.149
Vocal	−0.197	0.110	−0.095	**−0.678**	0.080
Locomotion	*−0.146*	*−0.184*	*−0.290*	***−0.636***	*−0.002*
Ears erect	*−0.154*	***0.515***	*0.352*	***0.579***	*−0.066*
Sociable	0.257	−0.386	−0.269	**0.577**	0.050
Eating hesitantly	*−0.062*	*−0.147*	*−0.023*	*−0.194*	***0.711***
Rough (in play)	*0.445*	*−0.024*	*−0.136*	*−0.043*	***0.670***
Ambivalent (pickup test)	*0.130*	*−0.108*	*0.287*	*0.269*	***0.530***

contact (uninitiated by the cat) with the owner versus an observer (during the final visit, two "pickup tests" were performed, in which the owner and then the observer-guide each picked up and held the cat in the same way, allowing us to compare the cat's responses to being handled by the owner and the visitor). In addition, observers scored 17 items of cat temperament (an appropriate subset of those used by Feaver et al. (1986); all items only applicable to cats in shelters were excluded) by ticking off along a scale between opposing attributes. Inter-observer agreement was generally better than 0.8. Mean scores from the three observers on the different items were used. A Principal Component Analysis performed on selected items coded by the observers and on selected behaviours (Bartlett-test: KMO = 0.625; sphericity: $chi^2 = 532.6$, df = 190, $p < 0.001$) revealed five cat personality axes: (1) "Active", (2) "Anxious", (3) "Feeding", (4) "Sociable" and (5) "Rough" (Table 2).

2.3. Behavioural coding

During each of the four visits, data were collected during a structured period that started 5 min before feeding of the cat and ended 5 min after the cat had finished eating.

The videos that were captured during this time were continuously coded with the aid of the software package THE OBSERVER Video Pro® (version 5.0; Noldus). For a complete list of coded variables see Table 3.

2.4. Theme® analysis

Theme® (Noldus bv, The Netherlands) was used to detect "hidden" temporal patterns of behavioural interactions ("t-patterns"; Anolli et al., 2005; Magnusson, 1996, 2000). Strings of owner and cat behaviours were analysed separately for each of the four visits, resulting in a sample size of $n = 4$ per dyad for all Theme® parameters. The main Theme® algorithm detects sets of events which follow each other non-randomly in the temporal sequence. Essentially, within a given observation period, two actions, a and b (by the individuals or specified interactions between individuals), that occur repeatedly and regularly in alternation, form a basic t-pattern (ab). Hierarchically structured t-patterns emerge via the detection of relationships of these simple, already-detected (primary or first-order) patterns (Fig. 1) through an iterative use of the algorithm scanning the string of behaviours in its temporal order. Clusters

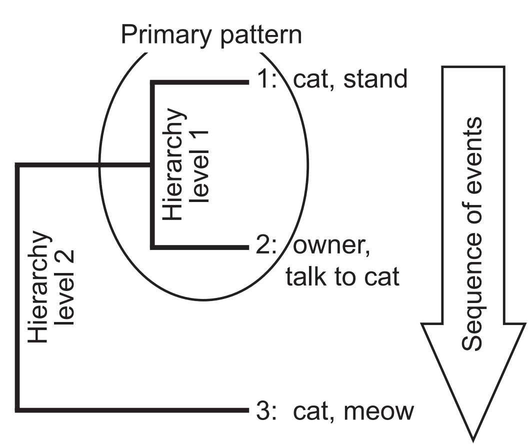

Fig. 1. Example of a hidden temporal pattern (t-pattern) featuring three events and two levels of hierarchy found by Theme®. "Cat stand" and "owner talk to cat" comprise a primary t-pattern, connected at a second hierarchy level with the event "cat meow". The interactive sequence of events from top to bottom in order of occurrence may be interpreted as: first cat stands, then owner talks to cat, followed by cat meowing. This pattern is significant at $p < 0.001$.

Table 3
Behaviour classes and behaviours used in coding via "The Observer".

Subject	Class	Behaviour	Type	Description
Division	Cut	Cut	Event	Cut in video
Division	Phases	Start phase 1	Event	5 min before the beginning of phase 2
		Start phase 2	Event	Cat's first reaction to the prospect of being fed (or, if cat does not react, when first can is opened)
		Start phase 3	Event	When the second can is opened
		Start phase 4	Event	When the owner starts preparing the cat's meal
		Start phase 5	Event	When the cat stops eating and leaves (if the cat returns and resumes eating, phase 4 continues, but ends when the cat leaves for the second time)
		End phase 5	Event	At the end of 5 min after the cat has finished the meal
Cat/owner	Approach	Approach	Event	Cat/owner moves to within-reach distance of other
		Leave	Event	Cat/owner withdraws from within-reach distance of other
Cat	Cat location	Present	State	Cat visible, in or out of room, and within visual or vocal communication range
		Absent	State	Out of room and not visible; no overt communication
		Hide	State	Cat hides inside or outside of room; is partly or fully invisible
		Location unspecified[a]	State	Unclear or undefined location
Cat	Cat tactile interactions	Head rub	Event	Cat rubs face against owner
		Body rub	Event	Cat rubs body against owner
		Tail rub	Event	Cat rubs tail against or curls tail around owner
		Head butt	Event	Cat bumps owner with forehead
		Pawing	Event	Cat reaches out with forepaw and touches owner
		Cat huddle	State	Cat in voluntary close body-contact with owner for 15 s
		Resists hold	Event	Cat struggles while being held
		Knead	State	Cat kneads owner or substrate
		Tactile interacts unspecified[a]	State	Unclear or undefined tactile interactions
		No tactile interactions	State	No cat tactile interaction with owner
Cat	Posture locomotion	Sit	State	Cat sits on a surface
		Crouch	State	Cat lowers body close to surface, legs bent
		Lie	State	Cat reclines on surface, on belly with legs curled under, on side or back, or curled up
		Roll	Event	Cat rolls over while lying
		Stand	State	Cat stands still
		Stretch	Event	Cat stretches body
		Walk	State	Cat walks forward
		Circle	State	Cat walks in tight circles near owner or around owner's legs
		Trot	State	Cat moves in rapid gait between walk and run
		Run	State	Cat moves in swift "gallop"
		Leap	Event	Cat jumps up, down, horizontally
		Reach up	Event	Cat stands on hind legs and reaches up with forelegs
		Shakes body	Event	Cat rapidly shakes body back and forth
		Sneakwalk	Event	Cat moves in rapidly gliding motion with head, body, tail lowered
		Scratch	Event	Cat scratches a surface with claws
		Scrape	Event	Cat scrapes substrate as if to dig or bury something
		Posture/locomotion unspecified[a]	State	Unclear or undefined posture or locomotion
Cat	Cat tail	Tail up	State	Tail is approximately perpendicular to back, straight up
		Tail up/tip curl	State	Tail is approximately straight up with tip curled over
		Tail up/half curve	State	Tail is approximately perpendicular to back with top half curved over
		Tail horizontal	State	Cat's tail is approximately level with back
		Tail low	State	Cat's tail is about 45° below back
		Tail flat	State	Cat's tail is flat on floor (or hanging and still)
		Tail quiver	Event	Cat rapidly quivers vertically held tail
		Tail jerk	Event	Cat abruptly jerks entire tail

Table 3 (*Continued*)

Subject	Class	Behaviour	Type	Description
		Tail tip twitch	State	Cat twitches tail tip (up to top third) once or repeatedly
		Tail flip/flop	Event	Cat flops upper half of tail over once or back and forth a few times (tail is approximately vertical)
		Tail swing	State	Cat undulates entire tail relatively slowly back and forth (tail approximately horizontal)
		Tail lash	State	Cat flails entire tail rapidly back and forth (tail approximately horizontal)
		Tail unspecified[a]	State	Unclear or undefined tail behaviour
Cat	Cat head	Head tilt	Event	Cat tilts head while watching activity or object
		Head shake	Event	Cat rapidly shakes head back and forth
		Bite-shake	Event	Cat takes food or toy in mouth and shakes it (coded by shaking episode, not by how many shakes occur within episode)
		Sniff	Event	Cat sniffs food, object, person
		Lick lips	Event	Cat lick lips/nose (including in feeding context but not while cat is in the act of eating)
Cat	Cat ears	Ears erect	State	Ears are both erect; may swivel in different directions
		Ears down/back	State	Cat's ears are flattened and drawn back
		Ears flat/side	State	Cat's ears are flattened and held sideways
		Ear flick	Event	Cat rapidly flicks one ear
		Ears unspecified[a]	State	Ear behaviour unclear or undefined
Cat	Cat eyes	Eyes open	State	Cat's eyes open
		Eyes half-closed	State	Cat's eyes approximately half-closed
		Eyes closed	State	Cat's eyes are closed
		Look at owner	State	Cat looks toward owner's face
		Slow blink	Event	Cat slowly blinks both eyes in context of making eye contact with owner
		Eyes wide open	State	Cat's eyes stretched open more widely than normal ("bug-eyed")
		Stare	State	Cat looks fixedly at owner or object with eyes fully or wide open
		Observe from distance	State	Cat gazes at owner (owner may be close to or apart from others)
		Eyes unspecified[a]	State	Unclear or undefined eye behaviour
Cat	Cat vocalisation	Meow	Event	Cat meows or mews, mouth open
		Trill/murmur	Event	Cat meows with or without trill, mouth nearly or completely closed
		Squeak	Event	Cat emits brief high-pitched, sometimes harsh sound with mouth open and lips tight
		Wack	Event	Cat emits low-pitched, shortened version of meow, lips slightly tightened
		Purr	State	Cat emits low rhythmic vibrating sound, mouth closed
		Pidgin duet with owner	State	Cat engages in exchange of nonverbal, similar sounds with owner
		Hiss/spit	Event	Cat emits hiss or abrupt spit with mouth open
		Cat vocalisation unspecified[a]	State	Unclear or undefined vocalisation
		No cat vocalisation	State	No cat vocal behaviour
Cat	Cat feeding	Looks at food	State	Cat glances or gazes at food but does not approach it
		Lick food/dish	State	Cat licks food, can, bowl
		Eat hesitantly	State	Cat eats relatively slowly with frequent pauses
		Eat steadily	State	Cat eats relatively rapidly with few pauses
		Look up	Event	Cat pauses and looks up while eating
		Reject food	Event	Cat does not taste food (may or may not sniff it)
		Ignores food	Event	Cat neither approaches, sniffs nor tastes food
		Paw in can	State	Cat probes can of food with paw
		Eats non-test food	State	Cat eats non-test food (own food left in dish or given by owner, or snack)
		Feeding behaviour unspecified[a]	State	Unclear or undefined feeding behaviour
		No feeding	State	No cat feeding behaviour
Cat	Cat grooming	Groom lick nibble	State	Cat licks or nibbles body
		Groom paw rub	State	Cat rubs head with paw
		Groom unspecified[a]	State	Unclear or undefined grooming behaviour
		No groom	State	No cat grooming behaviour
Cat	Cat playing	Play bat	Event	Cat bats or pokes at object or owner with forepaw

Table 3 (*Continued*)

Subject	Class	Behaviour	Type	Description
		Play grab	Event	Cat grasps object or owner with forepaw
		Play grabble	State	Cat wraps forelegs around object or owner's arm or leg; may kick with hind feet
		Play bite	Event	Cat bites while grabbing or grappling
		Play run	State	Cat runs about, tail arched
		Play chase	State	Cat chases or runs from toy or owner
		Stalk	State	Cat creeps up on object or owner
		Pounce	Event	Cat jumps on object or owner after stalking or hiding
		Play fetch	State	Cat fetches or chases and plays with object thrown by owner
		Buckel stance	State	Cat stands piloerected with back and tail arched
		Play unspecified[a]	State	Unclear or undefined play behaviour
		No cat play	State	No play behaviour
Owner	Owner tactile interactions	Stroke cat's head	Event	Owner strokes top of cat's head and/or ears
		Scratch cat's head	Event	Owner scratches cat's head, ears, cheeks, and/or chin
		Stroke cat's body	Event	Owner caresses cat's body
		Stroke cat's tail	Event	Owner closes hand around cat's tail and allows cat to draw tail through or moves hand up tail till tail is released
		"Thump-pet" cat	Event	Owner pets cat vigorously on back or side
		Owner huddle	State	Owner in voluntary close contact with cat for 15 s
		Grasp cat	Event	Owner takes hold of cat
		Pickup cat	Event	Owner grasps cat and lifts him/her up
		Hold cat in arms	State	Owner hold cat in arms
		Mutual nose sniff	Event	Owner and cat reciprocally sniff noses
		Nuzzle/kiss cat	Event	Owner rubs cat with his/her face; may kiss cat
		Put cat down	Event	Owner lowers cat to substrate
		Let cat go	State	Owner releases resisting cat from hold
		Tactile behaviour unspecified[a]	State	Unclear or undefined tactile interactions
Owner	Owner vocalisation	Call cat	Event	Owner calls cat by name or nickname
		Talk to cat	State	Owner speaks to cat in conversational tone
		Whistle to cat	Event	Owner whistles to cat
		Clck/smch/sqk	Event	Owner makes nonverbal clucking, kissing, squeaking sounds to cat
		"Motherese" to cat	State	Owner talks in soft high tones to cat
		Pidgin duet with cat	State	Owner and cat engage in exchange of nonverbal, similar sounds
		Scold cat	Event	Owner rebukes cat, speaking in relatively loud or harsh or abrupt tones
		Vocalisation behaviour unspecified[a]	State	Unclear or undefined owner vocal interactions with cat
		No owner vocalisation	State	No owner vocal interactions with cat
Owner	Owner feeding related	Can-sniff cat	State	Owner holds and offers open can of food to cat
		Sniffs food	Event	Owner sniffs food
		Bowl-feed cat	Event	Owner empties chosen can into cat's bowl and gives to cat
		Encourage cat to eat	State	Owner calls or talks to cat or extends food to cat or brings cat back to food in attempt to get cat to eat
		Finger-feed cat	Event	Owner feeds cat with fingers
		Spoon-feed cat	Event	Owner feeds cat with spoon
		Owner feeding behaviour unspecified[a]	State	Unclear or undefined owner feeding behaviour
		No feeding	State	No owner feeding behaviour
Owner	Owner playing	Play body	State	Owner gestures, grabs, tickles, wrestles with cat in play context
		Play toy	State	Owner induces cat to stalk and capture toy
		Play chase	State	Owner chases or ambushes cat
		Owner play fetch	State	Owner throws object for cat to retrieve
		Owner play unspecified[a]	State	Unclear or undefined owner play behaviour
		No play	State	No owner play with cat
Cat	Cat tests	Start test[b]	Event	Observer places object on floor
		End test[b]	Event	Observer removes object from cat's access
		Ignores object	State	Cat shows no evident reaction
		Looks at object	State	Cat looks at, watches object
		Hesitates at object	Event	Cat pauses at sight of object
		Starts at object	Event	Cat shows startle reaction

Table 3 (*Continued*)

Subject	Class	Behaviour	Type	Description
		Sniffs object	Event	Cat smells novel object
		Scent-marks object	Event	Cat rubs novel object (with cheeks, sometimes also body)
		Plays with object	State	Cat bats, grapples with object
		Retreats from object	Event	Cat moves away from object after sighting or sniffing it
		Threatens object	Event	Cat hisses, piloerects
		Attacks object	Event	Cat grabs and gives object a hard bite
		No test	State	Test not done
		Accepts pickup[b]	State	Cat allows pickup with no overt objection
		Ambivalent[b]	State	Cat allows pickup but appears tense (sniff posture, ears back, staring at holder, etc.)
		Resists pickup[b]	State	Cat actively resists or rejects pickup
		No observer pickup	Event	Observer decides not to pickcat up because of concerns cat may bite or scratch

[a] Modifier class 1: not visible: behaviour cannot be coded because cat is fully or partially invisible; unclear: behaviour element not clearly discernable; unspecified: behaviour not listed in configuration; cat interaction with observer: cat interacts with observer; test: novel object test or pickup test in progress.
[b] Modifier class 2: novel object, pickup owner, pickup observer.

Table 4
Medians, minima and maxima of parameters obtained trough analysis of Theme® patterns (based on one value per dyad; $n = 40$). *Italics*: variables derived from the original Theme® variables.

Theme® – variable	Median	Minimum	Maximum
Number of patterns	65.38	23.50	126.00
Number of patterns per minute	3.14	1.28	6.66
Number of non-overlapping patterns	5.50	3.67	9.25
Percentage of non-overlapping patterns of all patterns	11.04	5.44	21.61
Number of non-overlapping patterns per minute	0.27	0.18	0.48
Number of primary t-patterns	79.63	24.75	175.67
Number of primary t-patterns with cat only	57.13	18.67	168.75
Number of primary t-patterns with owner only	5.25	1.00	37.25
Number of primary t-patterns with cat and owner	10.25	0.75	44.50
Cat-initiated primary t-pattern	6.75	0.50	23.00
Owner-initiated primary t-pattern	4.38	0.00	30.00
Only cat in pattern	41.00	17.00	118.25
Only owner in pattern	2.13	0.75	16.00
Cat and owner in pattern	14.13	1.25	57.50
Cat initiator of pattern	52.75	19.67	121.50
Owner initiator of pattern	7.79	1.25	43.00
Event type complexity	*4.45*	*3.39*	*5.91*
Percentage of cat and owner in primary patterns	*20.31*	*7.40*	*35.70*
Percentage of cat and owner in all patterns	*27.81*	*11.19*	*39.30*

of pattern pairs may thus be identified (see, for example, Kerepesi et al., 2005). Potential combinatorial hypertrophy due to redundant detection of the same patterns is dealt with by an evolution algorithm.

For Theme® analysis, “states” (i.e., behaviours of a certain duration) obtained from behavioural measurements were all converted into “events” (frequencies) after importing the 160 data files (40 dyads times four visits) from The Observer software. Theme® settings were determined empirically through pre-analysis to best suit our questions (i.e., to achieve a useful range of 15–206 patterns per visit). The following Theme® settings were used in all analyses: “minimum occurrence”: 3; “significance level” = 0.001; “maximal search level”: 12; “lumping factor: 0.9; “FARR: 90; no “fast free limit”; “exclude frequent event types”: 2.5; “minimum sample”: 100.

For each dyadic Theme® variable, a mean value was calculated over the four visits. The number of patterns per human–cat dyad varied between 23.5 and 126. Of these, dyads had 24.8–175.7 primary t-patterns (i.e., those consisting of just two behaviours; for further variables, see Table 4). The most complex patterns found showed 9 behaviours at 5 levels of hierarchy. On average, 0.8–44.5 primary t-patterns per dyad were found with both owner and cat represented. As the behaviours in t-patterns are arranged in temporal order, the initiator of an interaction, owner or cat, can be identified (Figs. 1 and 2).

The t-pattern structure as obtained by Theme® may be considered as being both a result in itself, and as a set of new variables representing the structure and complexity of the behaviour string analysed. Hence, apart from qualitative assessment of patterns, one may ask questions such as what percent of behaviours found are organized in patterns, what proportion of time the string in

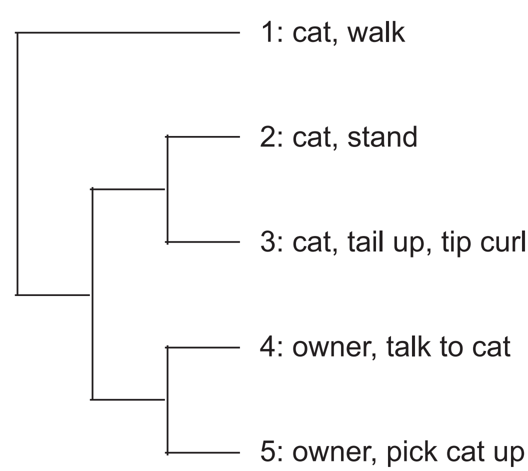

Fig. 2. Example of a t-pattern found by Theme®, featuring five events (two primary t-patterns: events 2, 3 and 4, 5) and three levels of hierarchy. The pattern can be read from top to bottom: cat walks, stands with tail up, tip curl (a sign of friendly contact), then the owner talks to the cat and finally picks the cat up. This pattern is significant at $p < 0.001$.

question is patterned, what the most abundant behaviours are in patterns, or what the proportion of higher order hierarchical patterns is of all patterns found. We used two measures of pattern complexity, "non-overlapping patterns" and "event type complexity". "Non-overlapping patterns" are subsets of patterns whose combined occurrences account for a greater percentage of the entire observation period than any other subset. "Event type complexity" includes the most complex 20% of all patterns. In fact, dyads were differentiated by numbers of t-patterns and by a wide variety of other qualitative and quantitative parameters.

2.5. Statistical analysis

Data were generally analysed via SPSS 15.0 software. To examine whether and how the investigated factors (sex of owner and cat, age of owner, age of cat, owner and cat personality, duration of living together) influenced the "number of patterns", we applied a general linear model (GLM). The dependent variable "number of patterns" was normally distributed when analysed with Kolmogorov–Smirnov test for normality, as were the other investigated dependent variables.

We applied one GLM with "Number of Patterns" as the dependent variable (response variable), sex of owner and sex of cat as factors, and human personality dimensions 1–5 and cat personality axes 1–5 as well as age of owner and age of cat and the duration of living together as covariates. The other four GLMs were applied with "number of patterns per minute", "number of non-overlapping patterns", "number of non-overlapping patterns per minute" and "event type complexity" as response variables. We made pair-wise comparisons with Bonferroni-correction to determine gender differences.

In all five models we selected the explanatory variables as main effects and removed them in the order of decreasing significance if $p > 0.1$. Only terms with $p < 0.1$ remained in the final model. Excluded terms were re-entered one by one into the final model to confirm that they did not explain a significant part of the variation (Poesel et al., 2006).

3. Results

3.1. Owner gender

In dyads with a female owner, the number of patterns per minute tended to be higher than in dyads with a male owner (tendency, GLM 2: df = 1, $F = 3.472$, $p = 0.071$, post-hoc test: $p = 0.071$).

3.2. Owner personality

The higher the owner's score in neuroticism (NEO-FFI-axis 1), the lower was the number of patterns (tendency, GLM 1: df = 1, $F = 4.004$, $p = 0.053$) and the lower the number of patterns per minute (GLM 2: df = 1, $F = 7.244$, $p = 0.011$). The higher the owner in extraversion (NEO-FFI-axis 2), the higher the number of non-overlapping patterns (GLM 3: df = 1, $F = 6.141$, $p = 0.018$), and the higher the number of non-overlapping patterns per minute (GLM 4: df = 1, $F = 5.579$, $p = 0.024$). The more conscientious the owner (NEO-FFI-axis 5), the higher was the dyadic event type complexity (tendency, GLM 5: df = 1, $F = 3.648$, $p = 0.064$).

3.3. Age of the cat

The older the cat, the lower was the dyadic event type complexity (GLM 5: df = 1, $F = 7.499$, $p = 0.010$).

3.4. Cat personality

The more "active" the cat (PCA axis 1), the fewer non-overlapping patterns (GLM 3: df = 1, $F = 4.637$, $p = 0.038$) and non-overlapping patterns per minute occurred (GLM 4: df = 1, $F = 5.953$, $p = 0.020$), but the higher was the event type complexity (GLM 5: df = 1, $F = 6.103$, $p = 0.018$). The more "sociable" the cat (PCA axis 4), the lower was the number of patterns (GLM 1: df = 1, $F = 4.420$, $p = 0.042$) and the number of patterns per minute (GLM 2: df = 1, $F = 4.388$, $p = 0.043$). The more "sociable" the cat (PCA axis 4), the less non-overlapping patterns (GLM 3: df = 1, $F = 11.487$, $p = 0.002$) and the less non-overlapping patterns per minute (GLM 4: df = 1, $F = 12.496$, $p = 0.001$) occurred.

4. Discussion

Our present findings demonstrate, for the first time, that temporal patterning of behaviours and interactions exists in human–cat dyads. Of particular interest was whether and how human and cat personality, sex and age of partners, and duration of cohabitation might influence the number and complexity of these temporal patterns. These potential effects on temporal patterns have not been previously investigated in dyadic relationships. We found that most of these factors were indeed important; notably the effects of owner and cat personality on t-patterning of dyadic behaviour. To our knowledge, we are the first to report such personality-related results in vertebrate dyads, including those of humans.

In particular, the findings of Kerepesi et al. (2005, 2006), in studies on the human–dog relationship, led us to expect that temporal structure would provide some insight into the nature of human–cat interactions. In both studies, these authors also used Theme® pattern detection and analysis software (Magnusson, 1996, 2000).

Previous research has shown that the gender of dyad members affects human–cat relations (Mertens, 1991; Rieger and Turner, 1999; Turner, 1991). Several other studies have shown gender differences in interactions with, and attitudes towards, animals (reviewed by Herzog, 2007; Kotrschal et al., 2009; Prato-Previde et al., 2006; Ray, 1982; Rost and Hartmann, 1994; Wedl and Kotrschal, 2009). We therefore also anticipated effects of cat and/or owner sex on t-patterning of dyadic behaviour. In this study we found a tendency suggesting that, in dyads with a female owner, the number of patterns per minute was higher than in dyads with a male owner. Cat sex did not have any significant or trend effect on the temporal patterning of dyadic behaviour. These results are consistent with results from other studies of the human–cat relationship. For example, Mertens (1991) showed that female owners were more active toward their cats (e.g., spoke more with them) than were male owners, that the cats likewise made more frequent approaches and withdrawals toward female owners, and concluded that female owners have a more intense relationship with their cats than male owners. Mertens and Turner (1988) found that during first encounters between humans and cats, women vocalised more than men, and cats tended to approach women more often than men, but had found no other influence of human or cat gender on other human–cat interactions (e.g., petting or playing) or cat behaviour. Adamelli et al. (2005) found that the level of care given to the cat, cat behaviour, and amount of time the cat spent with the owner were (among other factors) influenced by owner gender. They also found that cat behaviour depended mainly on features of the owner, as gender, but not of the cat.

In our human–animal research, the effect of personality in dyadic relationships is a central focus. We have previously shown that human personality is an important factor influencing interactions and relations between humans and pets (Kotrschal et al., 2009; Wedl and Kotrschal, 2009; Wedl et al., 2010). Earlier, Asendorpf and Wilpers (1998) found that human personality factors predict aspects of human social relationships such as number of peer relationships, conflict with peers, and falling in love. Phillips and Peck (2007) showed that self-assessed keeper but not keeper-assessed tiger personality was strongly connected to behaviour between the two in an interactive zoo exhibit; e.g., they found that keepers scoring higher in neuroticism had fewer interactions with the tigers.

In the present study, we found that owner personality traits affected temporal patterning of human and cat behaviour and its complexity; higher owner scores in "neuroticism" (NEO-FFI-axis 1) correlated with fewer and less frequent patterns. In another study (Kotrschal et al., 2009), we found that owners scoring high in neuroticism viewed their dogs as social supporters and spent much time with them. If this relationship also occurs in human–cat dyads, it would be likely that humans high in neuroticism would seek more contact with their cats, i.e., take the initiative in interacting with their cats. This asymmetric social interest may prompt cats to be less active contact seekers themselves. Turner (1991) investigated the relationships between female cat owners and their cats and found that duration of interaction between woman and cat was determined by which member of the dyad initiated the interaction. The higher the proportion of all successful intents to interact that were due to the cat, the longer was the duration of interactions. Thus, the more successful the human was in initiating interactions, the shorter the total interaction time with the cat. This correlation could also be linked to less frequent temporal patterns in behaviour and interaction in human–cat dyads.

Interestingly, the human personality dimensions "extraversion" (NEO-FFI-axis 2) and "conscientiousness" (NEO-FFI-axis 5) both influenced pattern complexity but not frequency; that is, dyads with "extraverted" and "conscientious" owners had a higher pattern complexity. As "conscientious" people are reliable and control their impulses, wishes and needs, another correlation Turner (1991) found could also have an effect on time patterning: if the owner complies with the cat's wishes to interact, then the cat complies with the owner's wishes at other times; if the owner does not comply, then neither does the cat. Responsive compliance could thus be related to the emergence of high complex temporal patterns in dyads with "conscientious" owners.

Hence, it seems that an important area of negotiation between the owner and cat is mutual attention and friendly tactile interactions. The cat, by its mere presence, may have an edge in this negotiation, at least with contact-seeking owners. The owners' main asset in motivating the cat to be trustful, devoted and open to contact may be in proving to be a trustworthy and dependable social companion (e.g., as may be the case particularly in highly conscientious owners). Negotiations may also include trading food for social attention, as both social behaviour and feeding can be considered central elements in the context of "allostatic load" (roughly equivalent to stress load; McEwan and Wingfield, 2003).

Because human–cat dyads are truly social at least in some of their elements, there will be asymmetry between partners in interactions such as contact seeking and conflict (e.g., over amount of social contact demanded/provided (Aureli and De Waal, 2000). Hence, depending on owner personality and need for contact, cats may have a lever in negotiating social contact with their human partners. Particularly in the case of owners high in "neuroticism", contact with the cat may be regarded an asset in the context of social support (Allen, 2003; Allen et al., 2002). In a previous study, we found that owners high in the neuroticism dimension need their dogs as emotional social supporters and are firmly attached to their dogs as a consequence (Kotrschal et al., 2009). In a test where we diverted owners' attention away from their dogs, we found that social support correlated with the dog's contact and proximity seeking behaviour, e.g., dog approaching owner more often and dog staying longer in proximity to owner in dyads with owners high in neuroticism (NEO-FFI-axis 1) and in which owner considers dog a social supporter (Wedl et al., 2010). Whether these findings may also apply to cats and how they would affect temporal patterning in human–cat dyads would be interesting to address in future studies.

Cat features also affected the temporal patterning of human and cat behaviour and its complexity. Specifically, the older the cat was, the lower the dyadic event type complexity. Furthermore, in dyads with more "active" cats (PCA axis 1), fewer non-overlapping patterns and non-overlapping patterns per minute occurred, but event type complexity was higher. Higher ratings of "sociability" in cats (PCA axis 4), coincided with lower numbers of patterns and number of patterns per minute, and with fewer non-overlapping patterns and non-overlapping patterns per minute.

Such dyadic patterning lends support to the idea that the "valuable relationship hypothesis" (Aureli and De Waal, 2000; Kummer, 1978) also applies to human–cat dyads. This might seem a surprising conclusion, because, in contrast to human–dog relationships, the human–cat companionship is not overtly operational in the sense that the partners go places and do things together. In many modern households, cats that get their food from their owners do not reciprocate by catching mice. But human–cat dyads are surely functional in a social sense. The cats in our dyads were regarded by their owners as valuable social companions and social supporters (Kotrschal et al. unpublished data). The social significance of this companionship is less clear on the cats' side, although well-socialized cats do actively seek human contact (Leyhausen, 1988; Turner, 2000). It is unlikely that cats do this just for the sake of obtaining food. Cats are clearly capable of attaching socially to "their" humans. In general, attachment in higher vertebrates is basically contingent upon, but not caused, by the provision of food (Bowlby, 1972; Curley and Keverne, 2005).

In our study, 20 cats had limited access to outdoors (small gardens, rooftops). Only one cat, the single un-neutered male, ranged more widely. Because these cats still spent much of their time inside, we did not include housing conditions of the cat as an independent variable in the present analysis. However, given that Turner (1991) found that exclusively indoor-living cats were more interactive with their owners than cats with outdoor access, it would be worthwhile to investigate in future studies whether and how cat housing conditions affect temporal patterning of cat–owner behaviours and interactions.

We would expect that in human dyads, quality and quantity of t-patterning depends on the same factors as in human–cat dyads, most notably personality traits in both partners. However, due to the potentially intrusive nature of human ethology research, human dyads could be prohibitively difficult to study. Furthermore, in human dyads, added complexities may obscure the view of such basic patterns as those we have found. Considering these issues and that the temporal patterning we found in human–cat dyads may be a relatively general phenomenon in vertebrate dyads, human–animal dyads hold promise as research models.

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References

Adamelli, S., Marinelli, L., Normando, S., Bono, G., 2005. Owner and cat features influence the quality of life of the cat. Appl. Anim. Behav. Sci. 94, 89–98.

Allen, K., 2003. Are pets a healthy pleasure? The influence of pets on blood pressure. Curr. Dir. Psychol. Sci. 12 (6), 236–239.

Allen, K., Blascovich, J., Mendes, W.B., 2002. Cardiovascular reactivity and the presence of pets, friends, and spouses: the truth about cats and dogs. Psychosom. Med. 64, 727–739.

Anolli, L., Duncan, S., Magnusson, M.S., Riva, G., 2005. The Hidden Structure of Interaction. IOS Press, Amsterdam.

Asendorpf, J.B., Wilpers, S., 1998. Personality effects on social relationships. J. Pers. Soc. Psychol. 74, 1531–1544.

Aureli, F., De Waal, F., 2000. Natural Conflict Resolution. University of California Press, Berkeley.

Benus, R.F., Bohus, B., Koolhaas, J.M., Oortmerssen, G.A., 1991. Heritable variation in aggression as a reflection of individual coping strategies. Experientia 47, 1008–1019.

Bergler, R., 1989. Mensch & Katze. Kultur - Gefühl - Persönlichkeit. Deutscher Instituts Verlag, Köln.

Bonasera, S., Schenk, A., Luxenberg, E., Tecott, L., 2008. A novel method for automatic quantification of psychostimulant-evoked route-tracing stereotypy: application to *Mus musculus*. Psychopharmacology 196, 591–602.

Borkenau, P., Ostendorf, F., 1993. NEO-Fünf-Faktoren Inventar (NEO-FFI) nach Costa und McCrae. Handanweisung. Verlag für Psychologie, Göttingen.

Borrie, A., Jonsson, G.K., Magnusson, M.S., 2001. Application of t-pattern detection and analysis in sports research. Metodol. las Ciencias del Comportamiento 3, 215–226.

Borrie, A., Jonsson, G.K., Magnusson, M.S., 2002. Temporal pattern analysis and its applicability in sport: an explanation and exemplar data. J. Sports Sci. 20, 845–852.

Bowlby, J., 1972. Attachment and loss. Attachment, vol. 1. Basic Books, New York.

Buss, D., 1999. Human nature and individual differences: the evolution of human personality. In: Pervine, L.A., John, O.P. (Eds.), Handbook of Personality: Theory and Research, 2nd ed. Guilford Press, New York, pp. 31–56.

Costa, P.T., McCrae, R.R., 1989. The NEO PI/FFI Manual Supplement. Psychological Assessment Resources. Odessa, Florida.

Costa, P.T., McCrae, R.R., 1992. Trait psychology comes of age. In: Sonderegger, T.B. (Ed.), Nebraska Symposium and Motivation: Psychology and Aging. University Nebraska Press, Lincoln, Lincoln, pp. 169–204.

Costa, P.T., McCrae, R.R., 1999. A five-factor theory of personality. In: Pervine, L.A., John, O.P. (Eds.), Handbook of Personality: Theory and Research, 2nd ed. Guilford Press, New York, pp. 139–153.

Curley, J.P., Keverne, E.B., 2005. Genes, brains and mammalian social bonds. Trend Ecol. Evol. 20, 561–567.

DeVries, A.C., Glasper, E.R., Detillion, C.E., 2003. Social modulation of stress responses. Physiol. Behav. 79, 399–407.

Feaver, J., Mendl, M., Bateson, P., 1986. A method for rating the individual distinctiveness of domestic cats. Anim. Behav. 34, 1016–1025.

Goodson, J.L., 2005. The vertebrate social behaviour network: evolutionary themes and variations. Horm. Behav. 48, 11–22.

Gosling, S.D., Bonnenburg, A.V., 1998. An integrative approach to personality research in anthrozoology: rating of six species of pets and their owners. Anthrozoös 11, 148–156.

Gosling, S.D., John, O.P., 1998. Personality dimensions in dogs, cats and hyenas. In: Annual Meeting of the American Psychological Society, Washington, DC.

Gosling, S.D., John, O.P., 1999. Personality dimensions in nonhuman animals: a cross-species review. Curr. Dir. Psychol. Sci. 8, 69–75.

Grammer, K., Kruck, K.B., Magnusson, M.S., 1998. The courtship dance: patterns of nonverbal synchronisation in opposite-sex encounters. J. Nonverbal Behav. 22, 3–29.

Groothuis, T.G.G., Carere, C., 2005. Avian personalities: characterization and epigenesis. Neurosci. Biobehav. Rev. 29, 137–150.

Hare, M., Tomasello, M., 2005. Human-like social skills in dogs? Trends Cogn. Sci. 9, 440–444.

Herzog, H.A., 2007. Gender differences in human–animal interactions: a review. Anthrozoös 20, 7–21.

Hessing, M., 1994. Individual behavioural characteristics in pigs and their consequences for pig husbandry. PhD thesis, Agricultural University, Wageningen.

Hirschenhauser, K., Frigerio, D., Grammer, K., Magnusson, M.S., 2002. Monthly patterns of testosterone and behaviour in prospective fathers. Horm. Behav. 42, 172–182.

Hocking, P.M., Rutherford, K.M.D., Picard, M., 2007. Comparison of time-based frequencies, fractal analysis and T-patterns for assessing behavioural changes in broiler breeders fed on two diets at two levels of feed restriction: a case study. Appl. Anim. Behav. Sci. 104, 37–48.

Jonsson, G.K., Anguera, M.T., Blanco-Villasenor, A., Losada, J.L., Hernandez-Mendo, A., Arda, T., Camerino, O., Castellano, J., 2006. Hidden patterns of play interaction in soccer using SOF-CODER. Behav. Res. Methods 38, 372–381.

Karsh, E.B., Turner, D.C., 1988. Die Mensch/Katze-Beziehung. In: Turner, D.C., Bateson, P. (Eds.), Die domestizierte Katze. Albert Müller Verlag, Zürich.

Kerepesi, A., Johnsson, G.K., Miklosi, A., Topál, J., Csanyi, V., Magnusson, M.S., 2005. Detection of temporal patterns in dog–human interaction. Behav. Proc. 70, 69–79.

Kerepesi, A., Kubinyi, E., Jonsson, G.K., Magnusson, M.S., Miklósi, Á., 2006. Behavioural comparison of human–animal (dog) and human–robot (AIBO) interactions. Behav. Proc. 73, 92–99.

Koolhaas, J.M., Korte, S.M., De Boer, S.F., Van Der Vegt, B.J., Wan Reenen, C.G., Hopster, H., De Jong, I.C., Ruis, M.A.W., Blokhuis, H.J., 1999. Coping styles in animals: current status in behavior and stress-physiology. Neurosci. Biobehav. Rev. 23, 925–935.

Kotrschal, K., 2007. The evolutionary base of human–animal relations. IAHAIO-Meeting Tokyo, Oct. 2007.

Kotrschal, K., Schöberl, I., Bauer, B., Thibeaut, A.-M., Wedl, M., 2009. Dyadic relationships and operational performance of male and female owners and their male dogs. Behav. Proc. 81, 383–391.

Kralj- Fišer, S., Scheiber, I.B.R., Blejec, A., Moestl, E., Kotrschal, K., 2007. Individualities in a flock of free-roaming greylag geese: behavioral and physiological consistency over time and across situations. Horm. Behav. 51, 239–248.

Kummer, H., 1978. On the value of social relationships to non-human primates. A heuristic scheme. Soc. Sci. Inf. 17, 687–705.

Leyhausen, P., 1988. The tame and the wild – another just-so story? In: Turner, D.C., Bateson, P. (Eds.), The Domestic Cat: The Biology of its Behaviour. Cambridge University Press, Cambridge, pp. 57–66.

Lyon, M., Kemp, A.S., 2004. Increased temporal patterns in choice responding and altered cognitive processes in schizophrenia and mania. Psychopharmacology 172, 211–219.

Magnusson, M., 1996. Hidden real-time patterns in intra- and inter-individual behavior: description and detection. Eur. J. Psychol. Assess. 12, 112–123.

Magnusson, M., 2000. Discovering hidden time patterns in behavior: T-patterns and their detection. Behav. Res. Methods Instrum. Comput. 32, 93–110.

Martaresche, M., Le Fur, C., Magnusson, M.S., Faure, J.M., Picard, M., 2000. Time structure of behaviour patterns related to feed pecking in chicks. Physiol. Behav. 70, 443–451.

McCrae, R.R., John, O.P., 1992. An introduction to the five-factor model and its applications. J. Pers. 60, 175–215.

McEwan, B.S., Wingfield, J.C., 2003. The concept of allostasis in biology and biomedicine. Horm. Behav. 43, 2–15.

Merlet, F., Puterflam, J., Faure, J.M., Hocking, P.M., Magnusson, M.S., Picard, M., 2005. Detection and comparison of time patterns of behaviours of two broiler breeder genotypes fed ad libitum and two levels of feed restriction. Appl. Anim. Behav. Sci. 94, 255–271.

Mertens, C., 1991. Human–cat interactions in the home setting. Anthrozoös 4, 214–231.

Mertens, C., Turner, D.C., 1988. Experimental analysis of human–cat interactions during first encounters. Anthrozoös 2, 83–97.

Miklosi, A., Topal, J., Csányi, V., 2004. Comparative social cognition: what can dogs teach us? Anim. Behav. 67, 995–1004.

Panksepp, J., 1998. Affective Neuroscience. The Foundations of Human and Animal Emotions. Oxford University Press, NY, Oxford.

Panksepp, J., 2005. Affective consciousness: core emotional feelings in animals and humans. Conscious Cogn. 14, 30–80.

Phillips, C., Peck, D., 2007. The effects of personality of keepers and tigers (*Panthera tigris tigris*) on their behaviour in an interactive zoo exhibit. Appl. Anim. Behav. Sci. 106, 244–258.

Podberscek, A.L., Paul, E.S., Serpell, J.A., 1995. Companion Animals and Us. Exploring the Relationships Between People & Pets. Cambridge University Press, Cambridge.

Poesel, A., Kunc, H.P., Foerster, K., Kempenaers, B., 2006. Early birds are sexy: male age, dawn song and extrapair paternity in blue tits, *Cyanistes* (formerly *Parus*) *caeruleus*. Anim. Behav. 72, 531–538.

Prato-Previde, E., Fallani, G., Valsecchi, P., 2006. Gender differences in owners interacting with pet dogs: an observational study. Ethology 112, 63–73.

Ray, J.J., 1982. Love of animals and love of people. J. Pers. Soc. Psychol. 116, 299–300.

Rieger, G., Turner, D.C., 1999. How depressive moods affect the behavior of singly living persons toward their cats. Anthrozoös 12, 224–233.

Rost, D.H., Hartmann, A., 1994. Children and their pets. Anthrozoös 7, 242–254.

Sih, A., Bell, A.M., Johnson, J.C., Ziemba, R.E., 2004. Behavioral syndromes: an integrative overview. Q. Rev. Biol. 79, 241–277.

Suomi, S.J., 1991. Uptight and laid-back monkeys: individual differences in the response to social challenges. In: Brauth, S.E., Hall, W.S., Dooling, R.J. (Eds.), Plasticity of Development. MIT Press, Cambridge, MA, pp. 27–56.

Turner, D.C., 1991. The ethology of the human–cat relationship. Schweiz. Arch. Tierheilk. 133, 63–70.

Turner, D.C., 2000. The human–cat relationship. In: Turner, D.C., Bateson, P. (Eds.), The Domestic Cat: The Biology of its Behaviour, 2nd ed. Cambridge University Press, Cambridge, pp. 194–206.

Turner, D.C., Stammbach-Geering, K., 1990. Owner assessment and the ethology of human–cat relationships. In: Burger, I. (Ed.), Pets, Benefits and Practice. BVA British Veterinary Association Publications, London, pp. 25–30.

Wedl, M., Kotrschal, K., 2009. Social and individual components of animal contact in preschool children. Anthrozoös 22, 383–396.

Wedl, M., Schöberl, I., Bauer, B., Day, J., Möstl, E., Kotrschal, K., 2010. Relational factors affecting dog social attraction to human partners. Interact. Stud. 11 (3), 482–503.