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Dyadic relationships and operational performance of male and female owners and their male dogs

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ABSTRACT

In the paper we investigate how owner personality, attitude and gender influence dog behavior, dyadic practical functionality and the level of dog salivary cortisol. In three meetings, 12 female and 10 male owners of male dogs answered questionnaires including the Neo-FFI human personality inventory. Their dyadic behavior was video-taped in a number of test situations, and saliva samples were collected. Owners who scored highly in neuroticism (Neo-FFI dimension one) viewed their dogs as social supporters and spent much time with them. Their dogs had low baseline cortisol levels, but such dyads were less successful in the operational task. Owners who scored highly in extroversion (Neo-FFI dimension two) appreciated shared activities with their dogs which had relatively high baseline cortisol values. Dogs that had female owners were less sociable–active (dog personality axis 1) than dogs that had male owners. Therefore, it appears that owner gender and personality influences dyadic interaction style, dog behavior and dyadic practical functionality.

1. Introduction

Across history and cultures, humans engage in social relationships with other animals (Podberscek et al., 2000; Robinson, 1995; Serpell, 1986; Turner and Bateson, 2005; Wilson, 1984). Dogs are certainly the oldest and the most widespread animal companions (Serpell, 1995; Vilà et al., 1997). However, the relationships that exist between owners and their dogs, and the function of such relationships, may vary widely between dyads (Hart, 1995). Some owners regard their dogs as a close friend, whereas others considered their dogs as buddies in joint activities and for still others, dogs are merely backyard animals (Topàl et al., 1997). Some owner–dog teams perform in a highly coordinated way in complex tasks, whereas in others the dog will not even reliably return when called (Serpell, 1996, 1995). O'Farrell (1995) found a correlation between owner personality and attitudes and dog behavior problems. In the present paper, we elaborate on this idea and propose that particularly owner personality, attitude towards the dog and owner and dog sex will affect interaction styles and hence, the practical performance of a human–dog dyad (Hennessy et al., 1998; Prato-Previde et al., 2006).

Notwithstanding the recent co-evolution debate (e.g. Schleidt and Shalter, 2003), owning a dog may significantly affect human lifestyles; vice versa, dog development, behavior and performance will be shaped by the human partner(s) (Hart, 1995; Kotrschal et al., 2004), who will generally provide the socioeconomic and cultural frame for the companionship (Scott and Fuller, 1965). In a way, human–animal relationships may be more basic than human–human dyads, because they mainly operate on the emotional level, with only little contributions by those cognitive and societal components that add much complexity to the relationships between humans.

Humans and animals may engage in truly social relationships, in the sense that these do not just somehow mimic social relationships between humans, but are based on common (convergent or even homologous) biological and psychological substrates (DeVries et al., 2003; Goodson, 2005; Panksepp, 1998; Podberscek and Gosling, 2000). These include the major bonding mechanisms (Curley and Keverne, 2005) and striking parallels even in the ontogeny and expression of personality traits (Groothuis and Carere, 2005; Koolhaas et al., 1999; Sih et al., 2004; Wilson et al., 1994). The social nature of the human–animal bond is evident in the development of mutual attachment (Voith, 1985) and other features, such as the temporal patterning of human–dog dyadic interactions (Kerepesi et al., 2005) and synchronized dyadic stress hormone modulation (Jones and Josephs, 2006). Furthermore, dogs are known to stimulate social interactions between humans and to benefit the social development of children (e.g. Kotrschal and Ortbauer, 2003).

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For all these reasons, it seems appropriate to study between-species dyadic relationships and human–animal companionship using a general evolutionary theory framework developed for within-species dyadic relationships. The central tenet of such a framework is that long-term dyadic relationships are maintained because both partners benefit (Kummer, 1978). Furthermore, because the interests of partners will not always be symmetrical or stable over time, dyadic partners need to dynamically negotiate their individual interests through cycles of conflict and reconciliation (Aureli and de Waal, 2000). Both partners have their specific physical and social needs, such as the animal companion's requirement to be cared for and adequately provisioned by its human partner. In return, owners expect appropriate behavior/conduct/service from the animal (whatever the owner's perspective on this may be; Hart, 1995; Serpell, 1996). Clearly, not only material factors are important in such dyadic negotiations, but above all, partners have social needs, for example, to receive social support from their companion (Friedmann et al., 2000; Scheiber et al., 2005).

The development of complex, mutually compatible, or even rewarding human–animal relationships will depend, at least in part, on the mode and intensity of attachment (Bowlby, 1999). For example, individuals with an insecure bonding style (human or dog) may seek more intense interactions than those capable of secure bonding. Such factors may also determine whether the dyadic partners will be a source of social support (accompanied by a positive modulation of cardiovascular and other stress parameters) and consequently, a source of general well-being and good health (Friedmann et al., 2000; Robinson, 1995; Wilson and Turner, 1998). Although these are proximate mechanisms in the sense of Tinbergen (1963), they may have ultimate consequences. Via a straight link to metabolism and energy efficiency, modulation of individual stress coping by a social partner will affect individual energy balance (McEwen and Wingfield, 2003) and therefore, may have consequences for evolutionary fitness. While it would be far-fetched to imply a direct evolutionary fitness relevance for human–animal companionship (i.e. more successful reproduction when with a companion animal), it is reasonable to assume that the evolutionary bio-psychological dispositions for long-term bonding with same-species individuals also provide the base for human–animal bonding and companionship.

With this evolutionary, socio-psychological framework in mind we propose that, in general, the needs of the owner will determine the style of companionship with a particular animal (McCune et al., 1995; Serpell, 1996, 1995). For example, the ability of human partners to form attachments, their personalities, and not least, owner sex (Prato-Previde et al., 2006), will affect interaction style with the animal and determine the animal's behavior within the dyad, but also within its wider social surrounding. It is well established that the social context modulates steroid hormones (DeVries et al., 2003; Mehta et al., 2008), and we expect that interaction style will affect dog cortisol levels. We therefore predict that owners scoring high on the neuroticism dimension (NEO-FFI-axis 1; McCrae and Costa, 2003) may be in particular need of social support and hence, will tend to regard their animal as being a close social partner. Such owners may asymmetrically seek contact, giving the dog an edge in the continuous dyadic negotiation, which is driven by the owners' demand for social attention. In such socially close dyads stress loads and hence, cortisol levels of dogs may be low, but performance in practical tasks may be sub-optimal (Topàl et al., 1997; Vas et al., 2005). In contrast, we predict that owners scoring high on the NEO-FFI dimensions extraversion and conscientiousness may regard their animals as partners for activities rather than as the focus of love. These owners may have attentive animals and engage in a practically functional dyadic relationship. Finally, we expect some differences in the relationship female and male owners have with their male dogs, for example because women tend to be more emphatic and socially interested than men (reviewed in Hart, 1995; Prato-Previde et al., 2006) and because dogs may be sensitive to owner sex. In essence, this is what we found.

2. Materials and methods

2.1. Subjects and recruitment

Between January and May 2007, 22 human–dog dyads consisting of intact male dogs and their 12 female and 10 male owners were recruited via ads in local newspapers and via personal contact with owners in dog training centers. Via telephone we checked that the following criteria were met: only one intact male dog in the household, adopted as a pup, body weight at least 10 kg, age 18 months to 6 years, living in the Vienna area. All breeds including mongrels were accepted.

2.2. Data collection

Human–dog dyads were observed in standard situations with full information and consent of the owners. Three meetings with each of these dyads were scheduled, a few days apart, the first one at the owner's home, the second and third in a test room at the University of Vienna. Meetings were supervised and data were collected by two investigators (MW and IS). During the first meeting, the focus was on the behavior of the dog and owner in their familiar home, and on recording the dog's response to the visiting strangers. This initial observation period was followed by an outdoor walk during which dog and owner were video-taped. During this first visit, the owner was asked to complete most of the questionnaires including questions regarding the bond. Owner–dog relationship, owner attitudes towards the dog and a NEO-FFI personality test.

The aim of the second and third meetings was measurement of both, owner and dog behavior and their interactions in a series of test situations. Saliva samples for cortisol analysis were taken from the owner and from the dog before, during and after all meetings, in 20 min intervals. In addition, owners sampled their own and their dog's saliva in the mornings and afternoons of non-test control days. Here, only relevant information on dog cortisol is given. Eight test situations were devised to investigate the operational relationship between the dog and its owner: (1) researchers visiting the dyad at home to observe communication between the owner, the dog and strangers during the first visit; (2) saliva sampling: dog and owner behavior during saliva sampling by the owner or by one of the experimenters; (3) dog training: teaching two simple tricks to the dog chosen by the owner out of a list of 12; (4) picture viewing: the dogs' response to its distracted owner who was asked to associate freely in writing to images on the walls of the experimental room, while the dog was unrestrained; (5) bridge: as a practical task, the owner was asked to lead the dog over a wire mesh bridge (4 m long, 1 m wide, 1 m high); (6) Vet-check: a physical examination of the dog by the experimenter similar to a basic examination by a veterinarian. (7) Threatening the dog: confrontation of the dog with a mildly threatening stranger (IS entering the room disguised in a black gown and staring at the dog) at the presence, and in a second run, in the absence of the owner. (8) A retention test of the two novel commands that have been trained previously at the second meeting.

All three meetings were video-taped. All observable behaviors of dog and owner and their interactions (187 behavior items, including dog personality; Table 1) were later coded from these tapes by MW and IS by aid of the Observer Video Pro 5.0 software. Mean (±S.D.) inter-observer agreement on all items was .87 ± .03.

Table 1
The 187 variables coded/rated by the observers (mainly BB and IS). 1–161: behavioral frequencies (F) or frequencies and durations (F, D) coded via the Observer software (Noldus) in the different test situations (Material and Methods). 162–170: Variables rated by the observers over the test situations on a 5-point Likert scale. 171–187: Dog personality items rated by the observers along a continuous scale.

No.	Behavioral variables coded
1	Dog approaches the owner F
2	Dog approaches the observer F
3	Dog leaves the owner F
4	Dog leaves the observer F
5	Dog leans or rubs towards the owner F, D
6	Dog leans or rubs towards the observer F, D
7	Dog nudges the owner F
8	Dog nudges the observer F
9	Dog pawing the owner F
10	Dog pawing observer F
11	Dog resists holding by owner F, D
12	Dog resists holding by observer F, D
13	Dog avoids being held by the owner F
14	Dog avoids being held by the observer F
15	Dog tilts head towards observer F
16	Dog sniffs the owner F, D
17	Dog sniffs the observer F, D
18	Dog jumps at the owner F
19	Dog jumps at the observer F
20	Dog licks the owner F, D
21	Dog licks the observer F, D
22	Dog orientates towards the owner F, D
23	Dog orientates towards the observer F, D
24	Dog averts head towards the owner F
25	Dog averts head towards the observer F
26	Dog eats treat F
27	Dog avoids being touched/stroked by owner F
28	Dog climbs owner F
29	Dog avoids being touched/stroked by observer F
30	Dog climbs observer F
31	Dog does not interact (stopcodon) F, D
32	Dog interaction unspecified, not visible F, D
33	Dog sitting F, D
34	Dog lies head up F, D
35	Dog lies head down F, D
36	Dog lies on its side F, D
37	Dog lies on its back F, D
38	Dog rolls F
39	Dog stands F, D
40	Dog walks F, D
41	Dog trots F, D
42	Dog runs F, D
43	Dog leaps F
44	Dog standing on ist back legs F, D
45	Dog stretching F
46	Dog shakes body F
47	Dog creeps F, D
48	Dog steps on bridge F, D
49	Dog stands on bridge F, D
50	Dog walks over bridge F, D
51	Dog trot-runs over bridge F, D
52	Dog jumps onto bridge F, D
53	Dog jumps off bridge F, D
54	Dog locomotion unspecified/unclear F, D
55	Dog locomotion unspecified/not visible F, D
56	Dog tail up, wagging F, D
57	Dog tail up, not wagging F, D
58	Dog tail horizontal, wagging F, D
59	Dog tail horizontal, not wagging F, D
60	Dog tail low, wagging F, D
61	Dog tail low, not wagging F, D
62	Dog tail flat, wagging F, D
63	Dog tail flat, not wagging F, D
64	Dog tail between legs, not wagging F, D
65	Dog tail unspecified/unclear F, D
66	Dog tail unspecified/not visible F, D
67	Dog sniffs object F, D
68	Dog licks lips F
69	Dog yawns F
70	Dog pants F, D
71	Dog no sniff/pant (stopcodon) F, D
72	Dog head unspecified/not visible F, D
73	Dog barks F, D
74	Dog whimpers F, D
75	Dog growls F, D
76	Dog howls F, D
77	Dog no vocal behavior F, D
78	Dog vocal behavior unspecified/unclear F, D
79	Dog vocal behavior unspecified/not visible F, D
80	Dog feeding unspecified/excluded F, D
81	Dog groom-lick-nibble F, D
82	Dog scratches F, D
83	Dog drinks water F, D
84	Dog no groom (stopcodon) F, D
85	Dog grooming unspecified/not visible F, D
86	Dog object plays alone F, D
87	Dog play with mouth F, D
88	Dog solicits person to play F, D
89	Dog play runs F, D
90	Dog object plays with owner F, D
91	Dog no play (stopcodon) F, D
92	Owner approaches the dog F
93	Owner leaves the dog F
94	Owner sits on furniture F, D
95	Owner sit on floor F, D
96	Owner stands F, D
97	Owner walks F, D
98	Owner trots F, D
99	Owner crouches F, D
100	Owner creeps F, D
101	Owner stoops F, D
102	Owner displacement behavior F
103	Owner locomotion unspecified/excluded F, D
104	Owner strokes dog F, D
105	Owner touches dog F, D
106	Owner hugs dog F, D
107	Owner nuzzle-kisses dog F
108	Owner commands dog with hand sign F
109	Owner gesturing F, D
110	Owner orientates towards dog F, D
111	Owner muzzle-holds dog F, D
112	Owner treats dog F
113	Owner averts head F
114	Owner brings dog in position F
115	Owner no interactive behavior (stopcodon) F, D
116	Owner interactive behavior unspecified/not visible F, D
117	Owner interactive behavior unspecified/excluded F, D
118	Owner holds dog at collar F, D
119	Owner holds dog at leash F, D
120	Owner holds dog's body F, D
121	Owner picks dog up F, D
122	Owner no holding behavior (stopcodon) F, D
123	Owner holding behavior unspecified/not visible F, D
124	Owner holding behavior unspecified/excluded F, D
125	Owner calls dog F
126	Owner praises dog F
127	Owner talks to dog F, D
128	Owner issues verbal command F
129	Owner no talk (stopcodon) F, D
130	Owner vocal behavior unspecified/unclear F, D
131	Owner vocal behavior unspecified/excluded F, D
132	Owner feeding behavior unspecified/excluded F, D
133	Owner engaged in bodily play F, D
134	Owner engaged in object play F, D
135	Owner solicits dog to play F, D
136	Owner no play behavior (stopcodon) F, D
137	Owner play behavior unspecified/excluded F, D
138	Observer approaches dog F
139	Observer leaves dog F
140	Observer measuring dog body F, D
141	Observer opening dog mouth F, D
142	Observer looks dog into eyes F, D
143	Observer looks dog into ears F, D
144	Observer touched dog F, D
145	Observer strokes dog F
146	Observer walk and threatens dog F, D
147	Observer stand and threatens dog F, D
148	Observer reconciles with dog F, D
149	Observer guide no interaction (stopcodon) F, D
150	Observer guide interaction unspecified/not visible F, D
151	Observer guide interaction unspecified/excluded F, D

Table 1 (*Continued*)

No.	Behavioral variables coded
152	Observer begin test F
153	Observer ends test/owner stops test F
154	End test by time out F
155	Dog next to owner F, D
156	Dog close do owner F, D
157	Dog intermediate distance to owner F, D
158	Dog distant to owner F, D
159	Closeness to owner unspecified/not visible F, D
160	Closeness to owner unspecified/excluded F, D
161	Cut scene F
Observer-rated variables (5-point scale)	
Test situations	
162	Approach owner (1: never. 5: always)
163	Interaction style qualitative (1: harsh. 5: soft)
164	Interaction style quantitative (1: hardly. 5: intensely)
165	Reaction of dog to threat (1: ignoring. 5: intense)
166	Involvement of owner (1: not. 5: fully attentive to dog)
167	Effort of owner for bridge
168	Achievement for bridge (1: not mastered. 5: perfect)
169	Handling/approach observer (1: avoiding. 5: trusting)
170	Duration (e.g. bridge task) in s (measured)
Dog personality (continuous scale)	
171	Sociable–distant
172	Active–inactive
173	Cheerful–not cheerful
174	Interested–uninterested
175	Playful–not playful
176	Calm–hectic
177	Wild–gentle
178	Self-confident–uncertain
179	Anxious–non-anxious
180	Nervous–non-nervous
181	Dependable–unreliable
182	Calm–vocal
183	Aggressive–non-aggressive
184	Friendly–unfriendly, not relating to people
185	Balanced–unbalanced
186	Clever–stupid-stubborn
187	Attentive–inattentive

To characterize the quality of attachment and of the dyadic relationship, a questionnaire with 34 items (modified, after Topàl et al., 1997; Johannson, 1999) was answered by the owners. It consisted of six groups of questions: owner data, owner lifestyle, relationship owner–dog, dog character/temperament, upbringing, training of the dog, and dog-related attitudes of the owner. This questionnaire was answered by the 22 owners participating in full in our study and by 18 additional owners of intact male dogs, who also took personality tests but were not tested as a dyad, resulting in a total of 40 respondents. A PCA ($n = 40$, KMO = 77) performed with the 15 attachment items revealed four axes: (1) social support, (2) bond strength, (3) bond quality, and (4) cognitive component (Table 2). A PCA ($n = 40$, KMO = .72) performed with the 14 owner–dog relationship items also revealed four axes: (1) time spent together, (2) responsibility, (3) pay attention, and (4) shared activities (Table 3).

2.3. Owner personality

We used the NEO-Five Factor Inventory (Costa and McCrae, 1992; McCrae and Costa, 2003) for exploring owner personality dimensions, because this is a well established and evaluated empirical approach, revealing major and relevant human personality dimensions. This 60-item instrument measures normal adult personality in five dimensions, in the following ranked according to decreasing proportions of inter-individual variability explained: neuroticism, extroversion, openness, agreeableness, and conscientiousness (Table 4). The following descriptions follow Borkenau and Ostendorf (2008).

The neuroticism scale depicts individual differences in emotional lability/stability among healthy human subjects. Individuals high on this scale frequently experience negative emotions, are often overwhelmed by them and tend to have unrealistic ideas. In contrast, emotionally stable persons are calm and balanced even in stressful situations.

Persons high in extraversion like to be in company of others, they are self-secure, active, verbally expressive, energetic, cheerful and optimistic. Introverts (i.e. those low on the extraversion scale) are controlled, rather than unfriendly, tend to be independent and are balanced rather than phlegmatic. They enjoy being on their own.

The openness scale measures how interested individuals are in novel experiences, how intensely they seek and deal with novelty. Open persons are interested in a wide range of personal and public matters, are intellectual and creative, are interested in the arts, are ready to discuss existing norms and ethical, political or moral values and tend to think and act unconventionally. Persons with a low score in openness tend to be conventional and conservative.

Agreeableness, similar to extraversion primarily describes intrapersonal behavior. Individuals scoring high in agreeableness are altruistic, warm, understanding and emphatic and are convinced that others will respond the same way. They tend to be trustful, cooperative and forgiving and appreciate harmony in their relationships. Persons low on this dimension describe themselves as antagonistic, egocentric and distrustful towards others. They are competitive rather than cooperative.

Conscientious persons control their impulses, wishes and needs. Whereas individuals low in neuroticism are in control of their emo-

Table 2
Factor loadings of the four axes resulting from a PCA with the 15 items in the owner questionnaire relating to owner–dog attachment ($n = 40$, KMO = .77, Bartlett-Test: $chi^2 = 400.67$, d.f. = 105, $p < .01$; Varimax-rotation. Kaiser-normalization; 75.3% of the variability in the data set explained by the four axes). All loadings >.5 shown in bold.

Degree of owner agreement–disagreement to the following questions	F1: Social support	F2: Bond strength	F3: Bond quality	F4: Cognitive component
Only through being together with my dog I feel good	**.87**	.32	.13	0.02
My dogs helps me to keep in balance	**.81**	.27	.18	−.13
I improve by talking to my dog when I am sad. Angry or in discomfort	**.76**	.05	.02	.39
I like to care for my dog-the daily routines do not bother me	**.69**	.09	.28	.49
It feels good to talk to my dog	**.66**	.12	.41	.49
Would be very sad if I would loose my dog or if the dog would be injured or sick	.16	**.88**	.05	.27
I feel responsible for my dog and I like that	.24	**.85**	.13	.18
My dog means a lot to me	.17	**.73**	.52	.13
My dog is a good pal or friend	.28	**.59**	**.56**	.18
Do you consider your dog just an animal—full social partner/family animals	.22	.20	**.80**	−.19
How frequently do you talk to your dog?	.39	−.03	**.70**	.32
My dog loves me unconditionally	−.07	.25	**.69**	.38
My dog knows how I feel	−.01	.34	−.07	**.74**
I belief my dog understands me	.16	.08	.09	**.71**
I am missing my dog when we cannot be together	.19	.18	.25	**.61**

Table 3
Factor loadings of the axes resulting from a PCA with the 14 items of the owner questionnaire relating to owner–dog operational relationship ($n = 40$, KMO = .723, Bartlett-Test: $chi^2 = 307.37$, d.f. = 91, $p < .001$; Varimax-rotation. Kaiser-normalization; 70.3% of the variability in the data set explained by the four axes). All loadings >.5 shown in bold.

Degree of owner agreement–disagreement to the following questions	F1: Time together	F2: Responsibility	F3: Pay attention	F4: Shared activity
I appreciate spending much time with my dog	**.93**	.10	.16	.06
In fact I spend much time with my dog	**.83**	.27	.18	.15
I love to cuddle with my dog	**.82**	.01	.09	−.18
I walk/train my dog for extended periods of time several times per week	**.71**	.23	.01	.18
Sometimes my dog makes me laugh	**.64**	.47	.18	−.01
I make sure that my dog always has access to fresh water	**.51**	**.50**	.23	−.41
Every day it is my exclusive responsibility to feed my dog	.13	**.90**	.18	−.16
Even at the presence of other family members my dog turns to me when wanting out	.16	**.79**	−.23	.05
Of all family members. It is usually me who walks the dog	.25	**.74**	.23	.21
My dog often demands my attention	.14	.22	**.77**	−.10
Sometimes I spend time with the dog even if I should be busy with other things	.17	−.19	**.70**	.02
How often per day you play with your dog (never–very often)	.01	.11	**.53**	.13
How often do you take your dogs to work, excursions, holidays, shopping, etc.	.47	.21	.12	**.76**
I like to simply hang around with my dog and relax	.57	.24	−.10	**−.61**

tions, conscientiousness rather describes the ability of planning, organizing and performing in tasks. Persons high on the conscientiousness scale describe themselves as goal-orientated, ambitious, diligent, strong-willed, systematic, enduring, tidy and precise, but may also be compulsive.

Here we simply assume that much of the intrapersonal aspects of the five personality dimension are also relevant in the interactions of humans with their companion animals. However, it remains to be investigated whether persons approach their companion animals in a similar way as they would approach other persons.

The NEO-FFI is highly practicable and fairly compatible with biological personality theory (Koolhaas et al., 1999; Sih et al., 2004). It is known that the NEO-FFI personality dimensions are neither fully independent of each other, nor of gender (Borkenau and Ostendorf, 2008). For example, in our data set, neuroticism was negatively correlated with extroversion (Pearsons, $r = -0.57$, $n = 40$, $p < .01$), openness ($r = -.39$, $n = 40$, $p = .01$), agreeableness ($r = -.31$, $n = 40$, $p = .05$) and conscientiousness ($r = -.49$, $n = 40$, $p < .01$).

2.4. Dog personality

Dogs are known to develop consistent personality profiles (Svartberg et al., 2005) and rating of animal personalities by human observers has been shown to reveal reliable and consistent results (Gosling and John, 1999; Gosling, 2001). Therefore, dog personality was scored after completion of video analysis by the two observers (BB and IS) on a scale featuring 17 items (Table 1, items 171–187) (modified after Feaver et al., 1986) by ticking off along a line between opposing attributes. The two observers (BB and IS) rated all dogs independently from each other after observing the dog's behavior during selected situations from the video tapes (at the owner's home: experimenters entering, owner feeding the dog, owner playing with the dog; experimental room: all test situations described above, owner training the dog two new commands and presenting them to the experimenter). The position of each rating on a left-to-right scale was measured and transcribed for further analysis. The mean value from scorings of the two observers was used. A PCA was performed on these 17 items (Table 5). This resulted in four axes: (1) sociable–active; (2) anxious–nervous; (3) vocal–aggressive; and (4) clever–attentive.

2.5. Salivary hormones

Throughout all three meetings saliva samples of the dog were taken every 20 min for measuring cortisol and androgens. In addition, saliva samples were collected during 2 days between the first and the third meeting to reveal baseline hormone levels. In dogs, these hormones hardly show episodic peaks over the day (Koyama et al., 2003). Saliva samples were taken from the dog by the owner by putting a cotton pad on a stick into the dog's cheek pouch for 30 s. Samples were stored frozen at −80 °C until analysis. Enzyme immunoassays (EIA) were used to analyze the cortisol levels from the saliva samples (Palme and Möstl, 1997). This non-invasive analysis of steroids is a long-standing routine procedure in our lab applied in much of recent research on social complexity (summarized by Hirschenhauser et al., 2005).

Data were analyzed with SPSS, employing principal component analysis (PCA) for reduction of dimensions, as appropriate. Because data were not normally distributed in most of the parameters considered, we resorted to the non-parametric Spearmans rank correlation and to the non-parametric Mann–Whitney *U*-test for comparing female owners with male owners, or for comparing owners high or low on a particular personality dimension (we split the range of NEO-FFI personality scores at its median). For dependent comparisons the Wilcoxon test was employed. We did not consider alpha correction for multiple comparisons, because this generally increases the risk of type-II error at a comparatively low potential of decreasing type-I error (Nakagawa, 2004). All significances are given two-tailed.

Table 4
Means ± standard deviations and ranges of Neo-FFI personality scores of a norm population from Austria, Germany and Switzerland (Borkenau and Ostendorf, 2008) and of the dog owners included in this study.

Populations	Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness
Population norm ($n = 11724$), range	21.95 ± 8.36, 0–48	28.38 ± 6.7, 0–48	32.10 ± 6.48, 0–48	30.23 ± 5.69, 0–48	30.87 ± 7.13, 0–48
Dog owners ($n = 22$); mean ± standard deviation, range	15.73 ± 9.21, 1–36	31.09 ± 6.98, 16–41	33.47 ± 4.85, 26–44	31.32 ± 6.95, 17–43	34.15 ± 6.33, 26–44
Female norm ($n = 7505$); mean ± standard deviation, range	23.25 ± 8.34, 0–48	28.76 ± 6.63, 0–48	32.43 ± 6.29, 0–48	30.97 ± 5.48, 0–48	31.10 ± 7.01, 0–48
Female dog owners ($n = 12$); mean ± standard deviation, range	16.92 ± 7.76, 1–31	28.92 ± 4.06, 22–35	32.95 ± 4.61, 38–42	31.34 ± 7.69, 17–43	34.65 ± 5.66, 27–44
Male norm; mean ± standard deviation, range	19.64 ± 7.86, 0–48	27.71 ± 6.77, 0–48	31.50 ± 6.75, 0–48	28.93 ± 5.81, 0–48	30.47 ± 7.30, 0–48
Male dog owners ($n = 10$); mean ± standard deviation, range	14.30 ± 10.97, 1–36	33.70 ± 8.92, 16–41	34.10 ± 5.30, 26–44	31.30 ± 6.36, 24–41	33.56 ± 7.31, 26–42

Table 5
Factor loadings of a PCA based on the 17 dog personality items obtained by observer scoring by BB and IS (Table 1; $n = 22$, KMO = .67, Bartlett-Test: $chi^2 = 374.16$, d.f. = 136, $p < .01$; Varimax-rotation. Kaiser-normalization; 85.5% of the variability in the data set explained by the four axes). All loadings >.5 shown in bold.

Dog personality items	F1: Sociable–active	F2: Anxious–nervous	F3: Vocal–aggressive	F4: Clever–attentive
Sociable	**.88**	.09	−.30	−.05
Active	**.88**	.37	.03	.07
Cheerful	**.86**	.27	.37	.10
Interested	**.85**	.19	.24	−.01
Playful	**.85**	.14	−.26	.02
Calm	**−.77**	−.49	−.14	−.02
Wild–gentle	**.60**	.40	.41	−.14
Self-confident	−.25	**−.92**	−.01	−.04
Anxious	.09	**.91**	.15	.14
Nervous	.38	**.79**	.23	−.32
Dependable	−.49	**−.73**	−.02	.31
Calm–vocal	.06	.04	**.86**	−.29
Aggressive	−.13	.23	**.81**	.14
Friendly	.55	.01	**−.76**	−.05
Balanced	.48	.53	**.53**	−.23
Clever	−.04	−.18	−.13	**.92**
Attentive	.46	.49	.09	**.61**

3. Results

3.1. Owner personalities

Those 22 owners participating in our tests with their dogs scored lower in neuroticism, but higher in extraversion and conscientiousness than the means of NEO-FFI scores of a norm population from Austria, Germany and Switzerland (Table 4). Except for the highest scores, respondents covered much of the neuroticism scale, but only occupied the upper two third of the ranges of the other four personality dimensions (Table 4). Whereas female owners showed a somewhat higher mean in neuroticism score than male owners (n.s.), the latter had higher mean score in extraversion ($t = -2.08$, $p = 0.04$) and conscientiousness (n.s.).

The higher the owners scored in neuroticism (Neo-FFI dimension one), the greater their attachment to the dog, i.e., the more they considered their dog a social supporter (attachment PCA-axis one, Table 2; Spearman rank correlation: $r_s = .37$, $n = 39$, $p = .02$). This was reflected by both dog and owner behavior, because the more owners considered their dogs as social supporters, the less time the dog spent far distant from the owner in the Picture viewing test ($r_s = -.46$, $n = 22$, $p = .03$), the less displacement behavior (scratching, yawning; Table 1, item 102) indicative of stress owners showed in this test situation ($r_s = -.54$, $n = 22$, $p = .01$) and the less aggressive ($r_s = -.43$, $n = 39$, $p = .05$) and the more friendly ($r_s = .49$, $n = 39$, $p = .02$) they rated their dogs.

However, close social relationships of owners with their dogs were linked with a low dyadic functionality: the more owners considered their dog as a social supporter, the less they engaged in shared activities with the dog (relationship PCA-axis four, Table 3; $r_s = -.33$, $n = 39$, $p = .04$), the lower their dyadic achievement was rated in the bridge task ($r_s = -.52$, $n = 22$, $p = .01$) and the longer it took the dyad to master this task ($r_s = -.57$, $n = 22$, $p = .01$). This relates to a rather tactile-friendly interaction style, because the more owners regarded their dogs as social supporters, the more often ($r_s = -.54$, $n = 22$, $p = .01$) and the longer ($r_s = -.48$, $n = 22$, $p = .03$) the owner touched and held the dog in the bridge situation and the more friendly the owner was rated by the observers in interaction with the dog in the threat situation ($r_s = .47$, $n = 19$, $p = .05$). The dogs in such socially close dyads behaved confidently and calmly. For example, the more owners considered their dog as a social supporters, the more often these dogs approached the examining observer in the Vet-check situation ($r_s = .44$, $n = 22$, $p = .04$) and the longer they lied head down in this situation ($r_s = .46$, $n = 22$, $p = .03$). This was supported by the fact that the dogs salivary cortisol in control situations was negatively correlated ($r_s = -.44$, $n = 22$, $p = .04$), the dogs salivary testosterone was positively correlated ($r_s = .65$, $n = 22$, $p = .01$) with the degree owners considered them as social supporters.

Cortisol modulation in the dog was generally related to owner gender and to a gender–personality interaction. For example, the more female owners paid attention to their dogs (questionnaire-based PCA-axis three for human–dog relationship) and the higher female owners were in neuroticism, the lower their dogs' morning cortisol values on control days (attention: Spearmans: $r_s = -.82$, $n = 12$, $p < .01$; neuroticism: $r_s = -.76$, $n = 12$, $p < .01$) and the less their dogs' cortisol increase after the threat situation (attention: $r_s = -.66$, $n = 11$, $p = .03$; neuroticism: $r_s = -.68$, $n = 19$, $p < .01$).

Male dogs behaved differently towards their social surrounding depending on whether they were with female or male owners: dogs of male owners were more sociable–active (towards other humans; dog personality axis one, Table 3) than those of female owners (Mann–Whitney $U = 27$, $Z = -2.18$, $p = .03$; Fig. 1). Also, following the Threat challenge, the dogs of male owners were higher in salivary cortisol than the dogs of female owners (Mann–Whitney

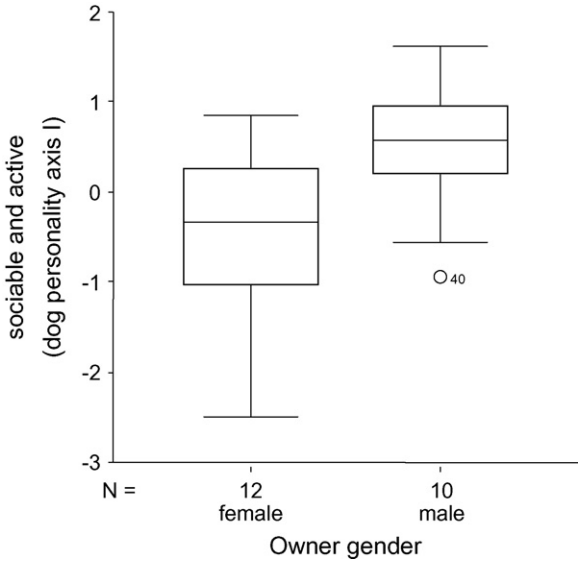

Fig. 1. Difference between factor scores of dog personality axis 1 (Table 3) between the male dogs of female and male owners (Mann–Whitney $U = 27$, $Z = -2.176$, $p = 0.03$).

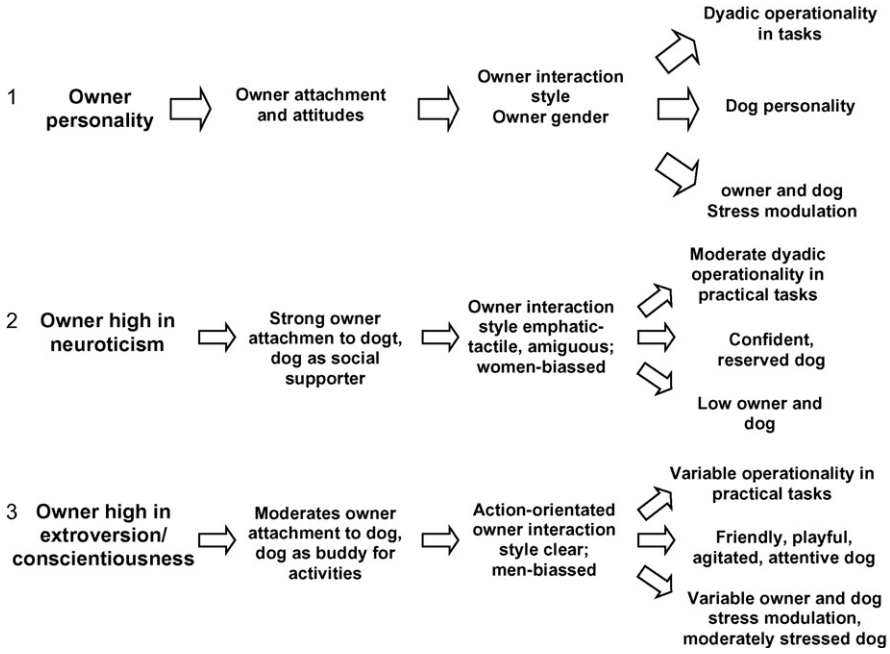

Fig. 2. Proposed contingency chain from owner personality to dyadic operationality, dog personality and owner–dog stress modulation. (1) Generalized working model of the owner–dog dyadic bio-psychological collusion. (2) Model for owners high in neuroticism as based on our present data. (3) Model for extravert/agreeable/conscientious owners as based on our present data.

$U = 17$, $Z = -2.47$, $p = .01$) Only the dogs of male owners showed a significant cortisol increase in response to the threat challenge (Mann–Whitney $U = 18$, $Z = -1.99$, $p = .05$).

3.2. Owner extroversion, agreeableness and conscientiousness

The higher owners were in extroversion, the less they tended to consider their dogs as social supporters (attachment scale, PCA-axis one; Spearmans: $r_s = -.27$, $n = 39$, $p = .09$) and the more these owners appreciated shared activities with their dogs (relationship scale, PCA-axis four; $r_s = .35$, $n = 39$, $p = .03$). Still, owner extroversion did not scale with achievement in the bridge task ($r_s = .34$, $n = 22$, n.s.), but agreeableness and conscientiousness at least produced such tendencies (FFI-axes four and five; for both dimensions: $r_s = .38$, $n = 22$, $p = .08$). The more conscientious the owner, the shorter the dog barked and growled during the mild threat situation with the owner present (Spearmans: barking: $r_s = -.47$, $n = 22$, $p = .03$; growling: $r_s = -.47$, $p = .03$). In general, the dogs growled for longer periods of time with owner present in the threat situation than with owner absent (Wilcoxons: $n = 22$, $Z = -2.5$, $p = .01$).

An analysis of dyadic behavior in the bridge test showed that the dogs of owners high in extroversion also differed from those low in that dimension by panting and trotting more (Mann–Whitney U: panting: $Z = -2.19$, $n = 22$, $p = .03$; trotting: $Z = -2.32$, $n = 22$, $p = .02$) which may be regarded as behavioral indication of stress in the dog. However, this was not confirmed by the salivary cortisol related to this task. Interestingly, the more a male owner shared activities with his dog (questionnaire-based PCA-axis four for human–dog relationship), the greater the owner's cortisol increase after the Threat challenge (Spearmans: $r_s = .92$, $n = 10$, $p < .01$). No significant differences were found between female and male owners with respect to dyadic achievement in the bridge task, although women tended to consider their dogs more as social supporters (attachment PCA-axis one, Table 2; Mann–Whitney U: $Z = -1.94$, $p = .05$) and meaningful companions (attachment PCA-axis two; Mann–Whitney U: $Z = -1.86$, $p = .06$) than men. Male owners, in contrast, like their dogs more than women for the activities they share with their dogs (relationship PCA-axis four, Table 3; Mann–Whitney U: $Z = -2.74$, $p = .01$).

4. Discussion

We found the predicted relationships between owner personality, dyadic relationship and functionality (Fig. 2), although our sample size necessitates cautious interpretation. Neuroticism and extroversion (NEO-FFI dimensions one and two) were particularly important. Owners higher in neuroticism were more closely attached and paid more attention to their dogs, which in turn, were confident-friendly, but somewhat distant to other humans when in company of a female owner. These dogs also showed low basal cortisol and hardly increased their stress hormones in response to mild challenges. Seemingly, owners scoring high in neuroticism not only considered their dogs as social supporters, but in turn, themselves seemed to be effective social supporters of their own dogs (defined as the stress-dampening effect of a social ally; Scheiber et al., 2005; DeVries et al., 2003). However, such dyads were neither greatly engaged in shared activities nor were they high achievers in a practical task. This was apparently mediated by owner interaction style.

In contrast, owners scoring high in extroversion, considered their dog mainly as a companion for shared activities, but there was no clear relationship with dyadic achievements or stress levels on in the dog. On average, women score higher in neuroticism in norm populations, whereas men are higher in extraversion (Borkenau and Ostendorf, 2008). In our limited sample, men were indeed, significantly higher in extraversion, but there was no significant difference between genders in neuroticism. We expect that with a larger sample one would indeed, find a female bias with respect to neuroticism-related attachment and a male bias towards extraverts who mainly appreciate their dogs as a partner in shared activities. Because much of the neuroticism scale is covered by our respondents (Table 4), our results with respect to this dimension may be more representative than results regarding the other four personality dimensions, where our respondents only covered parts of the ranges.

Particularly striking was our result that the male dogs of women owners were less sociable–active (dog personality axis 1; Fig. 1) than the male dogs in the company of men. Cautiously interpreted, this may mean that a more relaxed interaction style of women with their male dogs combined with the evolutionary disposition of dogs to be sex-sensitive in their social interactions with human companions (Prato-Previde et al., 2006; Zimen, 1978) prompts these dogs to assume a different social role when associated with a woman than with a man. In the wolf ancestors of dogs, positions in the hierarchy are mainly contested within the sexes and alphas tend to be socially distant and tense (Creel, 2005). There may still be social dispositions of this kind in dogs (Zimen, 1972), which they extend to their human companions. In interaction with a self-confident male owner, a male dog will assume the beta-position, but it may adopt the social alpha role in at least some contexts when with a female owner. Because of the separate female and male dominance ranks in packs, this will hardly produce a dominance conflict in women–male dog dyads, but may well be a source of friction in men–male dog dyads. With a few exceptions (Prato-Previde et al., 2006, present data), such gender aspects of human–animal companionship have not been investigated.

The interpretation of the present dog cortisol results with respect to animal welfare remains unclear. Long-term dyadic relationships undergo regular cycles of conflict and reconciliation (Aureli and de Waal, 2000); in addition, social interactions are always among the most potent stressors (McEwen and Wingfield, 2003; Von Holst, 1988). Hence, low glucocorticoid levels in the dog may also indicate a low modulation of emotionality by an over-protective owner. The interpretation of cortisol results always needs the behavioral background. In the present sample the impression was that persons needy of social support provided a particularly interactive social environment for their dogs. These partnerships may indeed be considered social symbioses, mutually satisfying the social needs of partners. In our sample, the basic dog cortisol levels and their modulation in the experimental situations seemed to be moderate, although we lack information on potential maxima (and minima), which could have been obtained by severe behavioral stress or by ACTH injection. For ethical reasons, such experiments have not been considered.

Our findings may also have practical implications. In contemporary dog training, the emphasis tends to be on methodology (i.e. how to handle and train the dog, for example, positive reinforcement, clicker training, etc.) but little on owner personality and the dyadic functionality which is a consequence thereof. Our pilot data indicate that owners higher in neuroticism may need a different approach and advice in training their dogs than owners higher in extroversion; furthermore, owner gender should be a matter of consideration in dyadic training. Hence, a purely method-centered approach in dog/team training does not do justice to the complex social nature of human–dog companionship, the more so as dogs also may share complex psychological traits with their owners, including inequity avoidance (Range et al., 2009).

Our results are preliminary and should rather be regarded as working hypotheses, not the least because of a relatively low sample size. Still, the proposed contingencies of dog behavior and dyadic performance with owner psychology and attitudes were supported. We found that owner psychology affects dog behavioral expression, dyadic functioning and the stress loads of the animal companion via interaction style. This suggests that human–animal dyads may show structural elements characteristic for higher vertebrate dyads in general. Hence, human–animal dyads, in addition to being interesting in their own right, may have a considerable potential as research models towards the basics of human dyadic relationships.

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References

Aureli, F., de Waal, F.B.N., 2000. Natural Conflict Resolution. University of California Press, Berkley, 409 pp.
Borkenau, P., Ostendorf, F., 2008. NEO-FFI. NEO-Fünf-Faktoren-Inventar nach Costa und McCrae. 2. neu normierte und vollständig überarbeitete Auflage. Manual. Hogrefe, Göttingen, 112 pp.
Bowlby, J., 1999. Attachment and Loss. Basic Books, New York, 428 pp. (reprint from 1974).
Costa, P.T., McCrae, R.R., 1992. Revised NEO Personality Inventory (NEO PI-R) and NEO Five-Factor Inventory (NEO-FFI): Professional Manual: Psychological Assessment Resources, Odessa, Florida.
Creel, S., 2005. Dominance, aggression and glucocorticoid levels in social carnivores. J. Mammal. 86, 255–264.
Curley, J.P., Keverne, E.B., 2005. Genes, brains and mammalian social bonds. TREE 20, 561–567.
DeVries, C.A., 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.
Friedmann, E., Thomas, S.A., Eddy, T.J., 2000. Companion animals and human health: physical and cardiovascular influences. In: Podberscek, A.L., Paul, E., Serpell, J.A. (Eds.), Companion Animals and Us: Exploring the Relationships Between People and Pets. Cambridge University Press, Cambridge, UK, pp. 125–142.
Goodson, J.L., 2005. The vertebrate social behaviour network: evolutionary themes and variations. Horm. Behav. 48, 11–22.
Gosling, S.D., 2001. From mice to men: what can we learn about personality from animal research? Psychol. Bull. 127, 45–86.
Gosling, S.D., John, O.P., 1999. Personality dimensions in nonhuman animals: a cross-species review. Curr. Dir. Psychol. Sci. 8, 75.
Groothuis, T.G.G., Carere, C., 2005. Avian personalities: characterization and epigenesis. Neurosci. Biobehav. Rev. 29, 137–150.
Hart, L., 1995. Dogs as human companions: a review of the relationship. In: Serpell, J. (Ed.), The Domesticated Dog: Its Evolution, Behaviour and Interaction with People. Cambridge University Press, Cambridge, UK, pp. 161–178.
Hennessy, M.B., Williams, M.T., Miller, D.D., Douglas, C.W., Voith, V.L., 1998. Influence of male and female patters on plasma cortisol and behaviour: can human interaction reduce the stress of dogs in a public animal shelter? Appl. Anim. Behav. Sci. 61, 63–77.
Hirschenhauser, K., Kotrschal, K., Möstl, E., 2005. A synthesis of measuring steroid metabolites in goose feces. Ann. NY Acad. Sci. 1046, 138–153.
Johannson, E.E., 1999. Human–animal bonding: an investigation of attributes. PhD Thesis. University of Alberta.
Jones, A.C., Josephs, R.A., 2006. Interspecies hormonal interactions between man and the domestic dog (*Canis familiaris*). Horm. Behav. 50, 393–400.
Kerepesi, A., Jonsson, G.K., Miklòsi, À., Topàl, J., Csànyi, V., Magnusson, M.S., 2005. Detection of temporal patterns in dog–human interaction. Behav. Proc. 70, 69–79.
Koolhaas, J.M., Korte, S.M., Boer, S.F., Van Der Vegt, B.J., Van 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., Bromundt, V., Föger, B., 2004. Faktor Hund. Eine sozio-ökonomische Bestandsaufnahme der Hundehaltung in Österreich. Czernin-Verlag, Wien, 96 pp.
Kotrschal, K., Ortbauer, B., 2003. Behavioural effects of the presence of a dog in the classroom. Anthrozoös 16, 147–159.
Koyama, T., Omata, Y., Saito, A., 2003. Changes in salivary cortisol concentrations during a 24-hour period in dogs. Horm. Metabol. Res. 35, 355–357.
Kummer, H., 1978. On the value of social relationships to nonhuman primates: a heuristic scheme. Soc. Sci. Inform. 17, 687–705.
McCrae, R.R., Costa, P.T., 2003. Personality in Adulthood, second edition. Guilford Press, NY, 268 pp.
McCune, S., McPherson, J.A., Bradshaw, J.W.S., 1995. Avoiding problems. In: Robinson, I. (Ed.), The Waltham Book of Human–Animal Interactions. Pergamon Press, Kidlington, pp. 71–86.
McEwen, B.S., Wingfield, J.C., 2003. The concept of allostasis in biology and biomedicine. Horm. Behav. 43, 2–15.
Mehta, P.H., Jones, A.C., Josephs, R.A., 2008. The social endocrinology of dominance: basal testosterone predicts cortisol changes and behaviour following victory and defeat. J. Person. Soc. Psychol. 94, 1078–1093.

Nakagawa, S., 2004. A farewell to Bonferroni: the problems of low statistical power and publication bias. Behav. Ecol. 15, 1044–1045.
O'Farrell, V., 1995. Effects of owner personality and attitudes on dog behaviour. In: Serpell, J. (Ed.), The Domesticated Dog its Evolution Behaviour and Interaction with People. Cambridge University Press, Cambridge, UK, pp. 151–158.
Palme, R., Möstl, E., 1997. Measurement of cortisol metabolites in faeces of sheep as a parameter of cortisol concentration in blood. Z. Säugetierkunde – Mamm. Biol. 62 (Suppl. II), 192–197.
Panksepp, J., 1998. Affective Neuroscience. The Foundations of Human and Animal Emotion. Oxford University Press, NY, 466 pp.
Podberscek, A.L., Gosling, S.D., 2000. Personality research on pets and their owners: conceptual issues and review. In: Podberscek, A.L., Paul, E., Serpell, J.A. (Eds.), Companion Animals and Us: Exploring the Relationships Between People and Pets. Cambridge University Press, Cambridge, UK, pp. 143–167.
Podberscek, A.L., Paul, E., Serpell, J.A. (Eds.), 2000. Companion Animals and Us: Exploring the Relationships Between People and Pets. Cambridge University Press, Cambridge, UK, 335 pp.
Prato-Previde, E., Fallani, G., Valsecchi, P., 2006. Gender differences in owners interacting with pet dogs: an observational study. Ethology 112, 63–73.
Range, F., Horn, L., Viranyi, Z., Huber, L., 2009. The absence of reward induces inequity aversion in dogs. Proc. Natl. Acad. Sci. USA 106, 340–345.
Robinson, I., 1995. The Waltham Book of Human–Animal Interaction: Benefits and Responsibilities of Pet Ownership. Pergamon Press, Kidlington, 148 pp.
Scheiber, I.B.R., Weiss, B.M., Frigerio, D., Kotrschal, K., 2005. Active and passive social support in families of Greylag geese (*Anser anser*). Behaviour 142, 1535–1557.
Schleidt, W.M., Shalter, M.D., 2003. Co-evolution of humans and canids. Evol. Cogn. 9, 57–71.
Scott, J.P., Fuller, J.L., 1965. Genetics and the Social Behavior of the Dog. Univ. Chicago Press, Chicago, 468 pp.
Serpell, J.A., 1986. In the Company of Animals. Basil Blackwell, Oxford, 283 pp.
Serpell, J.A. (Ed.), 1995. The Domestic Dog. Cambridge University Press, Cambridge, 268 pp.
Serpell, J.A., 1996. Evidence for association between pet behavior and owner attachment levels. Appl. Anim. Behav. Sci. 47, 49–60.
Sih, A., Bell, A.M., Johnson, J.C., Ziemba, R.E., 2004. Behavioral syndromes: an integrative overview. Quart. Rev. Biol. 79, 241–277.
Svartberg, K., Tapper, I., Temrin, H., Radesäter, T., Thorman, S., 2005. Consistency of personality traits in dogs. Anim. Behav. 69, 283–291.
Tinbergen, N., 1963. On aims and methods of ethology. Zeitschrift für Tierpsychologie 20, 410–433.
Topàl, J., Miklòsi, À., Csànyi, V., 1997. Dog–human relationship affects problem solving behavior in the dog. Anthrozoös 10, 214–223.
Turner, D.C., Bateson, P. (Eds.), 2005. The Domestic Cat, 2nd ed. Cambridge Univ. Press, Cambridge, 244 pp.
Vas, J., Topál, J., Gácsi, M., Miklósi, Á., Csányi, V., 2005. A friend or an enemy? Dogs' reaction to an unfamiliar person showing behavioural cues of threat and friendliness at different times. Appl. Anim. Behav. Sci. 94, 99–115.
Vilà, C., Savolainen, P., Maldonado, J.E., Amorim, I.R., Rice, J.E., Honeycutt, R.L., Crandall, K.A., Lundeberg, J., Wayne, R.K., 1997. Multiple and ancient origins of the domestic dog. Science 276, 1687–1689.
Voith, V.L., 1985. Attachment of people to companion animals. Vet. Clin. N. Am.: Small Anim. Pract. 15, 289–296.
Von Holst, D., 1988. The concept of stress and its relevance for animal behavior. Adv. Behav. 27, 1–131.
Wilson, E.O., 1984. Biophilia. Harvard University Press, Harvard, 157 pp.
Wilson, D.S., Clark, A.B., Coleman, K., Dearstyne, T., 1994. Shyness and boldness in humans and other animals. TREE 9, 442–446.
Wilson, C.C., Turner, D.C. (Eds.), 1998. Companion Animals in Human Health. Sage, London, 310 pp.
Zimen, E., 1972. Wölfe und Königspudel - vergleichende Verhaltensbeobachtungen. R. Piper Verlag, München, 232 pp.
Zimen, E., 1978. Der Wolf. Meyster Verlag, Wien, München, 448 pp.