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Title: Teenage dogs? Evidence for adolescent-phase conflict behaviour and an association between attachment to humans and pubertal timing in the domestic dog

Short title: Adolescent behaviour in domestic dogs

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Abstract

The relationship between parent and child changes around adolescence, with children believed to have: i) an earlier puberty if they have less secure attachments to their caregivers; ii) a phase of increased conflict behaviour toward their caregiver and; iii) heightened conflict behaviour when caregiver attachments are less secure. We find support for analogous associations in adolescent dogs based on behaviour and reproductive timing of potential guide dogs. Bitches with behaviour indicative of insecure attachments pre-adolescence became reproductively capable earlier. Providing the first empirical evidence in support of adolescent-phase behaviour in dogs, we found a passing phase of caregiver specific conflict-like behaviour during adolescence (reduced trainability and responsiveness to commands). An effect that was more pronounced in dogs with behaviour indicative of less secure attachments. These results indicate a possibility for cross-species influence on reproductive development and highlight adolescence as a vulnerable time for dog-owner relationships.

Introduction

Parent-child relationships share a surprising number of similarities with owner-dog relationships, including analogous behavioural and hormonal bonding mechanisms [1,2]. Adolescence is a vulnerable time for parent-child relationships, but little is known about owner-dog relations during adolescence. Adolescence is the final developmental stage of reproductive function, in which a juvenile becomes an adult, and incorporates puberty. In mammals, dramatic hormonal changes and reorganization of the brain [3,4] occurs during puberty. When puberty starts so will potentially competing motivations in the domestic dog; to breed with conspecifics and to live in the care of humans. Together this means adolescence could be a vulnerable time for owner-dog relationships.

During puberty in humans, and alongside changes to hormones [5] and brain reorganisation [6], there are transitory changes in risk taking, mood, irritability and conflict with parents (collectively known as 'adolescent-phase behaviour'). Increased adolescent conflict behaviour between child and parent (generally mundane disagreements) is believed to be related to a need for individuation or autonomy [7-8]. Children with insecure attachments towards their caregivers are observed to have greater conflict and risk taking [9-10]. The timing of puberty is also associated with the quality of early relationships: children have an earlier onset of puberty if they have less attached, more insecure, relationships with caregivers [9,11-14].

Due to behavioural and physiological similarities between parent-child and owner-dog relationships, the aim of this study was to examine the extent to which adolescence in dogs' shares characteristics of adolescence in humans. Specifically, we investigated owner-dog parallels of three proposed characteristics of human parent-adolescent relations: i) an earlier puberty for female dogs with less secure attachments to their caregiver; ii) adolescent-phase

63 conflict behaviour exhibited toward their caregiver and; iii) greater conflict behaviour in dogs
64 with less secure attachments to their caregiver.
65
66 # Results
67 **Influence of attachment on puberty**
68 To investigate an association between attachment and puberty, we collected prospective data
69 on attachment behaviour and monitored puberty (indicated by the first proestrus) in a cohort
70 of 70 potential guide dog bitches born in 2012 (German Shepherd Dogs, Golden & Labradors
71 Retrievers, and crosses of these). Attachment can be characterised by proximity seeking and
72 distress upon separation [15] and relevant questions are found in two scales of the validated
73 and widely used C-BARQ questionnaire [16] which we scored on a visual analogue scale.
74 The first, Attachment and Attention Seeking was a scored as a mean of six questions related
75 to proximity seeking (e.g. “Tends to sit close to or in contact with you…”, “Displays a strong
76 attachment for one… member of the household”) and the second Separation-related
77 behaviour was a mean of nine questions (e.g. “Shakes shivers of trembles when left, or about
78 to be left”, “Appears agitated …when separated from you..”). We were able to confirm that
79 these two scales were measuring insecure attachments, as higher scores in both scales were
80 found in dogs categorised as insecurely attached based upon direct behaviour observations
81 and using methods based on [17] (See Methods Details ESM). Since insecure attachments
82 and pubertal timing could both be related to general fearfulness we also considered
83 associations between puberty timing and a scale of general anxiety designed for this
84 population [18]. Questions for these scales were completed by the dog’s main caregiver, a
85 Guide Dogs UK puppy walker who the dog lives with from ~2-3 until 12-14 months of age.
86

Attachment and attention seeking was positively correlated with the age at which bitches had their first proestrus compared to their breed mean (calculated from population-level Guide Dog records of all dogs born 2012-2014). Bitches that displayed more Attachment and attention seeking behaviour at 5 months of age entered puberty earlier (Fig. 1A, R=-0.423, n = 64, p = 0.0004, based on partial correlation, controlling for diet and shared parentage confounds and Fig. 1B, with no control for confounds R=-0.315, n = 70, p = 0.007). Higher scores of Separation-related behaviour at 5 months of age were associated with entering puberty earlier when controlling for confounds (R=-0.295, n=70, p = 0.014), but were not associated without control for confounds (R=-0.115, n = 70, p = 0.343). General anxiety was not associated with timing of puberty without (R=-0.048, n=70, p=0.691) or with control for confounds (R=-0.134, n=67, p=0.271).

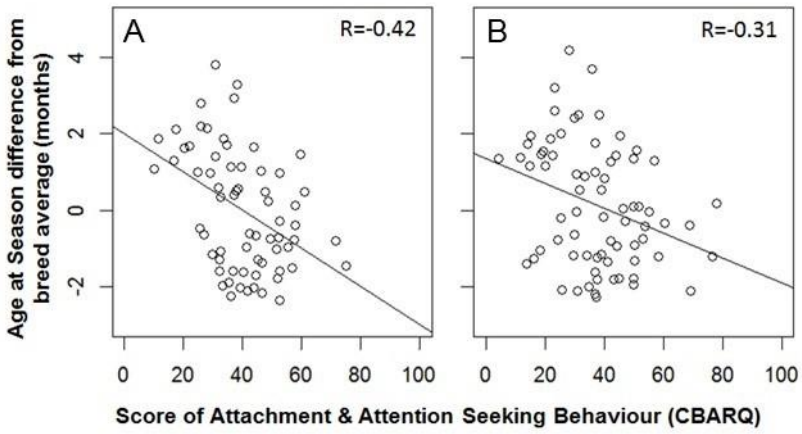

Figure 1. Negative association between insecure attachment behaviour measured by caregivers at 5 months and puberty end (first proestrus) relative to breed norm, based on: A) partial correlation controlling for confounds of shared parentage and diet type; B) correlation with no control for confounds. Attachment and attention seeking was scored on a 100 mm visual analogue scale, with a higher score indicating an insecure attachment.

Adolescent-phase conflict behaviour

To investigate adolescent-phase conflict behaviour, we observed and scored obedience response of 93 dogs (41M: 52F, breeds and cross breeds of: Golden & Labrador retrievers) to an established command given by a caregiver and a consistent stranger in a controlled setting [19] (complete Methods Details ESM). We predicted that dogs would be less obedient during adolescence, demonstrating an adolescent-phase of conflict with their primary caregiver. Reduced responsiveness to well-established command ('sit') was considered as a proxy for reduced obedience. The population of dogs were sampled at pre-adolescent (n=82 aged 5 months) and adolescent (n=80 aged 8 months, of which 69 were tested at both time points) time periods. Dogs responded less to the 'sit' command during adolescence, but only when the command was given by their caregiver, not a stranger (the caregiver and stranger were the same people at both time points). The odds of repeatedly not responding to the sit command were higher at 8 months compared to 5 months for the caregiver (Odds Ratio= 2.14, 95% Confidence Interval=1.46-3.11, Z= 2.01, P= 0.044). However, the response to the 'sit' command improved for the stranger between the 5 and 8 month tests (OR = 0.40, 95% CI =0.25-0.63, Z=1.96, P= 0.049).

Further evidence of a transitory adolescent-phase of disobedience confirming these findings was also found in data collected from a larger cohort of dogs (n=285, 135M:150F, breeds and cross breeds of: Golden retriever, Labrador retriever & German Shepherd Dogs) using the scale of 'Trainability' from two validated guide dog behaviour questionnaires completed by dog's main caregiver [20], and a trainer less familiar to the dogs [18]. Trainability was a mean of VAS scores to five questions (e.g. "This dog…Refuses to obey commands, which in the past it was proven it has learned", "Responds immediately to the recall command when off lead"). Caregivers assigned lower scores of 'Trainability' to dogs around adolescence (8 months), than pre-adolescence (5 of age) and post-adolescence (12 months). For caregivers

there was a 5 to 8-month decrease (cross-classified random effects GLM: Z = -4.46, p<0.001) and a 5 to 12-month increase in Trainability on the questionnaire scale (Z = 13.76, p<0.001, Fig. 2a). In contrast, the dog's trainers reported an increase in Trainability when adolescent (5 to 8-month increase: Z = 5.42, p<0.001, Fig. 2c).

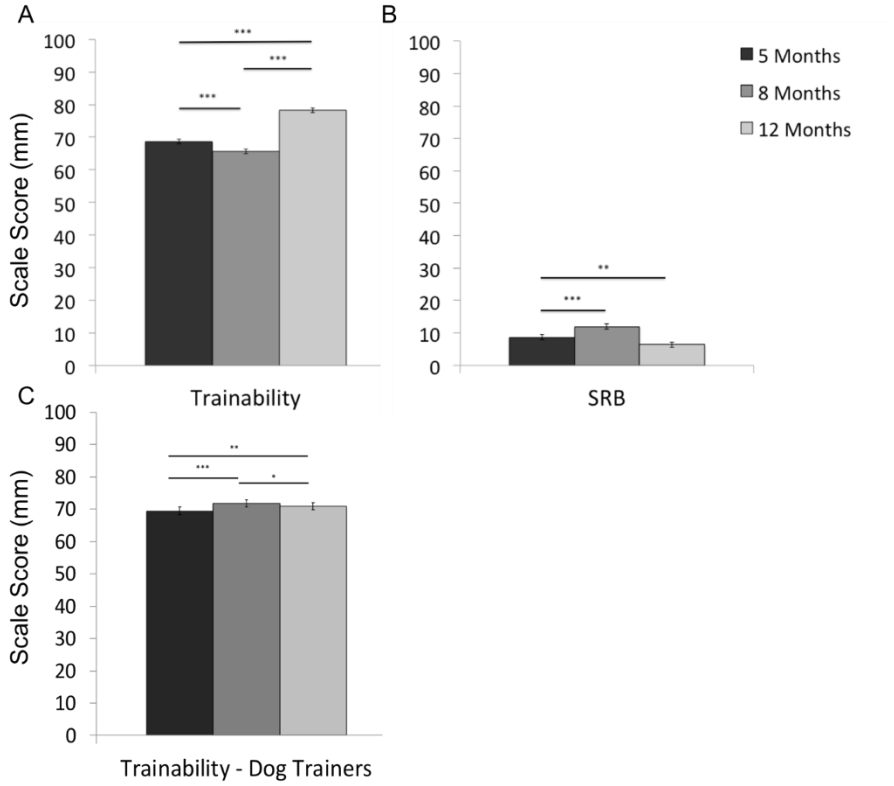

Figure. 2. Scores for A) Trainability (higher is more 'trainable') and B) Separation-related behaviour (SRB, from C-BARQ where higher scores indicate more separation-related behaviour displayed), as scored by dog caregivers (puppy walkers) when dogs were aged 5, 8 and 12 months. Scores for C) Trainability when scored by the dogs training supervisor when dogs were aged 5, 8 and 12 months. * P <0.05. ** P < 0.01. *** P < 0.001. Error bars represent SE ± 1.

Adolescent-phase conflict behaviour and attachment

Questionnaires completed by dog caregivers were used to investigate whether adolescent conflict behaviour was associated with dog-caregiver attachment. Mirroring the transitory

adolescent-phase of conflict, was a phase of higher scores for Separation-related behaviour towards the caregiver. Scores for Separation-related behaviour were 36% higher at adolescence (8 months) than pre- (5 months) and post- (12 months) adolescence (5-8 month increase GLM: $Z = 4.11$, $p<0.001$ and 5-12 month decrease GLM: 0.77, $Z = 3.02$, $p<0.01$, Fig. 2b). Increased Separation-related behaviour at 8-months was associated with lower obedience (Trainability score) to their caregiver at 8-months of age (random effects GLM: $R= -0.516$, $t = -10.37$, $p<0.001$), but not at 5 or 12 months. Scores of Attachment and attention seeking did not change with age, but they were correlated with Trainability at 8 months of age only ($R=-0.298$, $t=-4.31$, $p<0.001$).

Discussion

The strength of attachment between humans and dogs is made possible by dogs piggybacking on human mechanisms for bonding with children [1-2]. Here, we find evidence to suggest that the human-dog attachment may in turn influence dog behaviour and reproductive physiology during puberty. Specifically, our results find an association between earlier puberty and an insecure attachment to a human caregiver. This replicates correlational findings from human adolescents who enter puberty earlier if they do not have strong attachments to parental figures [12]. Additionally, we found when dogs reached puberty, they were less likely to follow commands given by their caregiver, but not by others. The socially specific nature of this behaviour in dogs (reduced obedience for their caregiver only), suggests this behaviour reflects more than just generalised hormonal, brain and reward pathway changes that happen during adolescence. In parts of this study, the ‘other’ person was a Guide Dog trainer who may have been more capable of getting a dog to perform a command, however the results are consistent with parts of the study when the ‘other’ person was an experimenter without experience of dog training. We also find the reduction in

obedience to the caregiver and not an 'other' person to be specific to the dog's developmental stage and more pronounced in dogs with insecure attachments, which is not easily explained by differences in dog training ability between the caregiver and other.

We find support for the prediction that conflict behaviour is associated with less secure caregiver attachments during an adolescent-phase, because behaviour indicative of insecure or anxious attachments was only associated with obedience at an age which corresponds with adolescence. A weakness of this study is that puberty was not measured in all dogs, rather it was assumed based on existing knowledge of pubertal timing in relevant breeds (noting that age groupings would need to be reconsidered for different breeds). Further when puberty was measured, our definition of the onset of puberty in females (first proestrus) was reductionist as some bitches may not have entered a complete cycle. We cannot preclude the possibility that a small minority of dogs were incorrectly classified as pubertal, however this would be more likely to lead to a type II rather than type I error.

Research in rats and humans shows that adolescence is a sensitive period for development in mammals due to extensive reorganization of the brain's neural circuitry (see [21] or an overview). The possibility that puberty is a sensitive period in dogs warrants further investigation, particularly as experiences at this time could have long-term impacts on behaviour. A sensitive period around puberty is proposed in grey literature (e.g. within dog training literature), however to our knowledge this is the first study to provide empirical support for this.

Reproductive development is known to be influenced by social relationships in a wide range of species [22], but this study highlights the possibility for cross-species influences on

196 reproductive development. Like human adolescents, we find dogs' attachment behaviour to
197 their caregivers is associated with the age at which puberty starts. It is likely that the
198 caregiver's behaviour influences the dog's attachment to them [23], indeed correlations have
199 been found between human and dog attachments [24–26]. Understanding the specific
200 behavioural influences on more secure attachments is an area for future study.
201
202 Our findings support dogs as a potential model species for studying puberty in humans. This
203 is a particularly important area of study because early puberty is associated with more risky
204 behaviour, earlier death, repeat offending, narcotics abuse and mental health
205 problems [27]. Experimental studies of human puberty or attachment are not
206 ethically possible but may be considered in dogs. Such studies could elucidate the casual link
207 between attachment and pubertal timing, along with other aspects of adolescence. It will be
208 important to confirm our results in future studies, because it is possible the similar results
209 could arise from different explanatory mechanisms in dogs compared to humans.
210
211 We found that dogs displaying behaviour indicating they are stressed by separation from their
212 main caregiver were also increasingly disobedient towards that same person. This finding
213 emulates human research, where increases in conflict with parents during adolescence has
214 been associated with insecure attachments [28]. An alternative explanation for our results is
215 that some dogs received poorer training both in obedience and in being separated from their
216 caregiver, however our sample of trainee guide dogs are provided with standardised training
217 to gradually introduce dogs to being left alone.
218
219 In humans, conflict between parents and adolescents is proposed to function to test and
220 potentially re-establish secure attachments [29]. A lack of secure attachments during
221 childhood [30] and adolescence [31] is associated with earlier reproduction. In dogs it is

possible that the attachment to a caregiver acts as a cue of environmental quality, where the caregiver is the main source of survival. In this case attachment could have an evolutionary function to mediate between life history strategies that favour roaming and early reproduction, versus continued human care and delayed reproduction.

In most dogs it seems that adolescent-phase disobedient behaviour exists, but does not last. Unfortunately, the welfare consequences of adolescence-phase behaviour could be lasting because this corresponds with the peak age at which dogs are relinquished to shelters [32,33]. Welfare could be also be compromised if problem behaviour results in use of punishment-based training methods [34] or causes caregivers to disengage, as it does in humans [35]. It is hoped these issues could be avoided if dog owners were made aware that (as in humans) problem behaviour during adolescence could be just a passing phase.

Acknowledgments: This study would not have been possible without: Peter Craigon, Kathleen Gallagher, Caroline McMillian, David Griffiths, Sue Richardson, Logan Anderson, Sarah Miller, Barry Cahill, David Hurst, Rachel Moxon, Simon Blythe, and the trainers, caregivers and dogs who participated. Thanks to Alan McElligott, Rachel Moxon and four reviewers for insightful comments on the manuscript.

Data are available on the ncl.data repository [36].

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