

Behavioural responses of *Canis familiaris* to different tail lengths of a remotely-controlled life-size dog replica

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Summary

The tail of dogs and allies (Canidae) is important for intraspecific communication. We used a life-sized dog model and varied the tail length and motion as an experimental method of examining effects of tail-docking on intraspecific signaling in domestic dogs, *Canis familiaris*. We videotaped interactions of 492 off-leash dogs and quantified size and behaviour of approaching dogs to the model's four tail conditions (short/still, short/wagging, long/still, long/wagging). Larger dogs were less cautious and more likely to approach a long/wagging tail rather than a long/still tail, but did not differ in their approach to a short/still and a short/wagging tail. Using discriminant analyses of behavioural variables, dogs responded with an elevated head and tail to a long/wagging tail model relative to the long/still tail model, but did not show any differences in response to tail motion when the model's tail was short. Our study provides evidence that a longer tail is more effective at conveying different intraspecific cues, such as those provided by tail motion, than a shorter tail and demonstrates the usefulness of robotic models when investigating complex behavioural interactions.

Keywords: Canidae, dog behaviour, intraspecific communication, robotic model, tail-docking.

Introduction

Within Canidae, the tail has multiple functions including balance (Wada et al., 1993) and visual signaling (Tembrock, 1968; Fox, 1971; Prince, 1975; Bradbury & Vehrencamp, 1998). Studies of canid species from different

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habitats (open desert and dense forest) have found the tail to be important for intraspecific signaling in different visual environments (Kleiman, 1972). Specific colourations and patterns such as a contrasting tip likely evolved to improve intraspecific communication with the tail (Tembrock, 1968; Fox, 1969, 1971; Orotolani, 1999).

Information is communicated with the tail through changes in its height and motion (Tembrock, 1968). Higher tail positions are associated with confidence and/or aggression, while a lowered tail position may be a neutral signal or reflect fear and/or submission (Tembrock, 1968; Fox, 1971; Kleiman, 1972; Prince, 1975; Bradbury & Vehrencamp, 1998). Wagging the tail may show excitement, comfort and relaxation, or submission if the tail is also lowered (Fox, 1969; Kleiman, 1972; Prince, 1975). The importance and complexity of these signals increases with a group's sociability (Fox, 1975).

Although domestic dogs, *Canis familiaris*, have diverged morphologically and behaviourally from ancestral wolves, *Canis lupus* (Goodwin et al., 1997), the position and motion of a domestic dog's tail still provides information regarding motivational states including friendliness, playfulness, fear, submission, dominance and aggression (Fox, 1969; Morton, 1992; Bradshaw & Nott, 1995; Wansborough, 1996; Coren, 2000). Like wild canids, a domestic dog can express emotional state and social status with its tail.

The tail is commonly docked in approximately one third of all recognized breeds of domestic dogs for a variety of historical and contemporary reasons (Morton, 1992; Wansborough, 1996; Bennett & Perini, 2003). As the tail is important for intraspecific interactions, there is concern that tail-docking reduces the ability of a dog to effectively communicate with others (Morton, 1992; Wansborough, 1996; Coren, 2000; Bennett & Perini, 2003). However, the behavioural effects of tail-docking have not yet been well-studied (Bennett & Perini, 2003).

Evaluating the effect of tail length in encounters between dogs is challenging because of the tremendous complexity and variability present in dog interactions. Ideally, a comparison among dogs of the same breed but with, and without, a docked tail would be most informative. However, in traditionally docked breeds there are few instances of full-tailed individuals. Even if sufficient numbers of the latter could be identified, the interpretations on tail length would remain ambiguous given the social history and individual differences that exist among dogs. To address some of these challenges, we used

a remotely-operated, life-sized model of a dog with which we could experimentally manipulate tail length and motion as a standard stimulus. The use of robotic models as tools to study behaviour is expanding (Knight, 2005). Standard stimuli provided by a robot allow investigation of body position and motion that were previously untestable (Young, 2007). We videotaped and quantified the interaction of off-leash dogs to this model under different conditions of tail length and motion to test the effectiveness of signals conveyed by short and long tails. Even though multiple aspects of body language influence visual signaling in real dogs (Fox, 1971; Prince, 1975; Bradshaw & Nott, 1995; Coren, 2000; Aloff, 2005), we only varied aspects of the tail in our experiment.

We hypothesize that the response of dogs will vary with model tail condition. More specifically, given the prevalence of tail condition in family Canidae as a major signaling trait, we predict dogs will approach a short-tailed model dog replica more cautiously than a long-tailed replica due to the reduced availability of social cues and we expect caution to be accentuated in the smallest dogs as the consequences of misinterpretation are potentially more costly.

Methods

We used a life-sized model dog composed of a black synthetic fur-like material covering a wire frame and cotton-stuffed body. The model had a shoulder height of 50 cm, a head height of 62 cm, a body length of 80 cm, an appearance similar to that of a Labrador Retriever, and a standing body position (Figure 1). While the signals conveyed by the tail and body position may have conflicted in some trials, consistency was necessary to isolate the effect of length and motion on the tail's signal. A servomotor (Futaba[®] S3003) was mounted within the wire frame at the base of the tail, which allowed the tail to be remotely manipulated by use of a control (Futaba[®] T2DR). Attached to this structure was a 5-cm post on which the tail was mounted. We used a short (9 cm) or long (30 cm) tail (Figure 1). Because the long tail was flexible, the simulated motion appeared to us to resemble that of a loose, wagging tail of a real dog. The tail was positioned approximately 10 degrees posterior to the vertical. During wagging trials, the lateral motion of the tail (45 degrees either direction) was remotely controlled and maintained at approximately one cycle per second. When in operation, the motor made an audible

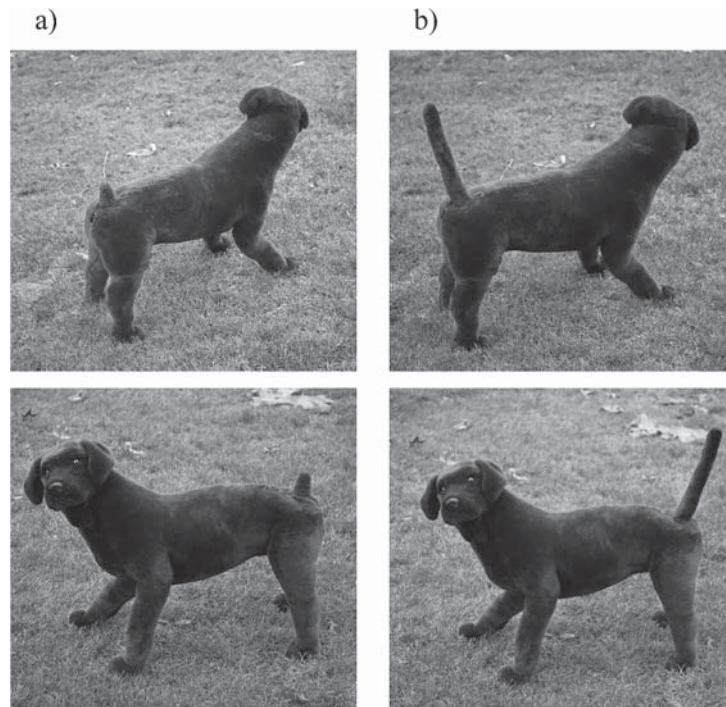


Figure 1. Artificial model of a dog, approximately 50 cm at the shoulder, comprised of a black synthetic fur covering a wire frame and cotton-stuffed body. Both the 9 cm short (a) and 30 cm long (b) tails were mounted to a post attached to a servo motor with that motion could be remotely controlled. The approach frequency and behavioural variables of off-leash dogs were recorded in response to four possible model physical conditions: short/still tail, short/wagging tail, long/still tail and long/wagging tail. Head and body position of the model were a consequence of the metal frame within and could not be modified.

noise that could be heard by an observer 10 m away. We used four model tail conditions: short/still, short/moving, long/still and long/moving.

The model dog was positioned in areas of high off-leash domestic dog activity in Victoria, British Columbia, Canada. A digital video camera (Sony Digital 8 DCR-TRV720) was positioned 10 m away from the model with a camera height of 1.3 m. A 1.5-m radius circle of rope was laid out around the model, recorded on video and then removed prior to the trials. This was later used to enable the scoring of variables outside and inside a 1.5-m perimeter without interfering with the actual approach of dogs. The size of the rope loop resulted in a circle with a radius of two model body lengths centered on the model. For every dog that came within 20 m, the encounter was video-

taped and transferred into digital format for subsequent computer playback. We video-taped a total of 556 separate encounters by dogs. However, 64 of these encounters were repeat visits that were excluded from analysis.

In playback of the 492 video-taped dogs we visually separated individuals into five size categories (top of dog's head below model's stomach, dog's shoulder below model's shoulder, same size, dog's shoulder higher than model's shoulder but not higher than top of model's head, and dog's shoulder higher than top of model's head). The first two and last two categories were respectively grouped into a 'smaller' and 'larger' size category resulting in three size categories for analysis: smaller than model (152 dogs), same size as model (65 dogs) and larger than model (275 dogs). When the data were partitioned for model-tail condition, numbers for the 'same size' size class were low and in these cases, we made comparisons only for the 'smaller' and 'larger' dogs.

We evaluated the response of dogs in three ways:

1. Their activity during the approach sequence of the encounter (Do they approach the model? Approach without stopping? Resume approach if they stop? Contact and sniff the model?).
2. Their behaviour during the approach as measured by individual behavioural variables such as head position, tail position and movement which were scored categorically inside and outside the 1.5-m perimeter (Table 1).
3. A multivariate measure of behaviour of dogs that contacted the model. The discriminant analysis identified the relative combination of variables that best differentiates the four model tail conditions. We used this measure because of the presumed correlations that exist between the multiple behavioural traits. Although the data used to create the multivariate assessment are categorical, they are all incremental (Table 1).

Some variables known to be important indicators of behaviour such as ear position (Fox, 1969; Schilder & van der Borg, 1993; Bradshaw & Nott, 1995; Coren, 2000) and signs of stress, such as tongue flicking (Schilder & van der Borg, 1993; Aloff, 2005), were not scored due to low video resolution. Furthermore, not all of the behavioural variables included in this study could be scored for every encounter. This was due either to occasional visual obstruction by owners or other dogs, or insufficient video resolution. To

Table 1. Summary of the categorical behavioural variables recorded for dogs approaching the artificial dog model that were used in the discriminant analysis. All, except speed of approach, were scored both outside and inside a 1.5-m radius around the model. Note that the categorical options are incremental.

Variable	Categorical options
Speed of approach (outside)	- Slow walk - Trot - Run
Position of tip of tail (outside/inside)	- Down, below horizontal - Flat and in line with the spine - Up, above horizontal but not past vertical - Curled over back - Unknown (not included)
Position of base of tail (outside/inside)	- Down, below horizontal - Flat and in line with the spine - Up, above horizontal - Unknown (not included)
Head position (outside/inside)	- Head below shoulders - Head in line with shoulders - Head above shoulders - Head held high up with neck vertical
Tail motion (outside/inside)	- Still - Slow wag (between 0 and 1 cycle/s) - Fast wag (more than 1 cycle/s)

create the discriminant analysis variable, we included only those encounters ($N = 238$) for which all of the behavioural variables could be scored.

To estimate repeatability of the behavioural classifications, forty randomly chosen video trials were rescored 12 months after original classification. Overall repeatability was 87%. Of the 364 rescored values, 41 differed by one categorical level and 1 differed by two levels. Repeatability ranged from a low of 75% for 'tail movement outside 1.5 m' to a high of 94% for 'approach speed outside 1.5 m'. The former had low contribution to the loadings of the multivariate classification.

The accumulation of scent, the sound of the motor, and model realism were potential methodological issues in this experiment. First, no effort was made to clean the model between trials and we assume that there was a gradual accumulation of new scents on the model. However, on each observation

day over the study, we cycled through each of the four tail conditions and infer that any additional scents would equally influence all tail conditions. Second, although the servomotor was audible when the tail was in motion, we do not feel it acted as an attractant as dogs contacted the rear of the model (where the motor was located) equally during still and wagging trials. Finally, based on the general behaviour of approaching dogs, we are confident that our model was viewed as realistic. In particular, of all dogs that contacted the model, 72% first contacted the tail region, as is prevalent in typical dog interactions (Tembrock, 1968; Bradshaw & Nott, 1995).

SPSS version 11.5 was used for all statistical analyses. A *G*-test and contingency tables were used to examine differences in the categorical data. Frequencies presented are derived from the contingency tables. A discriminant analyses was used to construct a multivariate behavioural classification to identify potential group differences and ANOVA was employed for subsequent comparisons.

Results

There were differences in the approach sequence of the three size classes of dogs. Larger dogs were more likely to approach the model ($G_2 = 28.5$, $p < 0.01$), approach continuously ($G_2 = 6.7$, $p < 0.04$), resume their approach if they did stop ($G_2 = 5.2$, $p < 0.08$), and to contact the model if they had not yet broken off their approach ($G_2 = 14.31$, $p < 0.01$) (Figure 2).

Differences were present in how the approach sequence varied with model tail condition. Only two aspects of the approach sequence, likelihood to 'approach' and 'approach continuously', varied with model tail condition. These results were seen in larger dogs ($G_3 = 8.1$, $p = 0.05$ and $G_3 = 11.0$, $p = 0.01$ for comparisons of the 'approach' and 'approach continuously' data among the four categories of model tail condition, respectively) but not smaller dogs ($G_3 = 6.0$, $p = 0.11$ and $G_3 = 4.1$, $p = 0.26$ for comparisons of the 'approach' and 'approach continuously' data among the four categories of model tail condition, respectively). More specifically, larger dogs approached the long/wagging tail most often (91.4%), the long/still tail least frequently (74.4%), and approached the short/still and the short/wagging tail equally (82.2% and 85.2%, respectively). For the 'approach continuously'

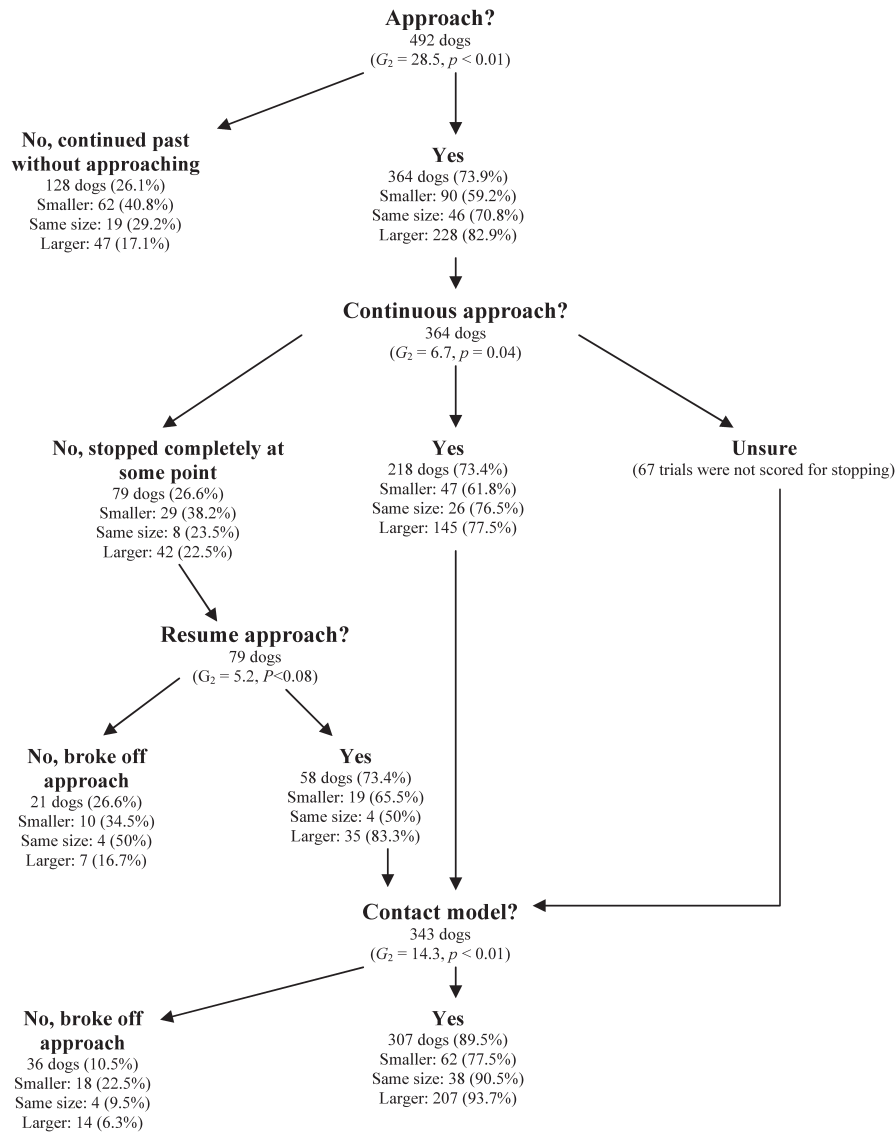


Figure 2. Approach sequence for all trials. Under each choice (e.g., ‘Approached?’) is a G -test identifying significant differences in the choices made by the three size classes. Under each ‘yes’ or ‘no’ option is the number and percent of dogs that followed that option. Below that is the number and percent of dogs within each size class that chose that option. Note: 67 trials did not have ‘Continuous approach?’ scored and were, therefore, not included in the G -test for this analysis. However, these 67 trials still recorded data for ‘Contacted model?’ and were included for this level of analysis.

Table 2. Relative contributions to the behavioural discriminant analysis variable with the highest three loading variables in boldface.

Variable	Loading
Speed of approach (outside)	-0.024
Position of tip of tail (outside)	0.882
Position of base of tail (outside)	-0.162
Head position (outside)	-0.318
Tail motion (outside)	0.240
Position of tip of tail (inside)	-0.639
Position of base of tail (inside)	-0.045
Head position (inside)	1.011
Tail motion (inside)	-0.202

data, larger dogs were more likely to stop completely at some point during their approach when the model's tail was short (30.2% stopped) compared to long (15.8% stopped; $G_1 = 4.7$, $p = 0.03$).

We compared the nine different behavioural variables of approaching dogs (Table 1) to the four model tail conditions. Only 'head position inside 1.5 m' of the approaching dogs varied significantly ($G_3 = 10.9$, $p = 0.01$) in response to model tail condition. During their approach, head position above the dog's shoulder occurred 49% for the short/still condition, 40% for the short/wagging condition, 38% for the long/still version and 63% for the long/wagging version. We examined a multivariate behavioural index for dogs that contacted the model. 'Head height inside 1.5 m', 'tail tip height outside 1.5 m', and 'tail tip height inside 1.5 m' contributed most to the canonical loading of which 'head height inside' and 'tail tip outside' loaded positive and 'tail tip inside' loaded negative (lower tail position) (Table 2).

The canonical variate of behaviour showed differences in the response of dogs to model tail condition. Dogs responded similarly to the short/still and short/wagging tail (ANOVA: $F_{1,109} = 0.1$, $p = 0.72$), but displayed significantly higher canonical values when contacting the long/wagging tail compared to the long/still tail (ANOVA: $F_{1,123} = 16.4$, $p < 0.01$). This trend is seen in the smaller size class (ANOVA: $F_{1,25} = 0.8$, $p = 0.39$ and ANOVA: $F_{1,18} = 4.1$, $p = 0.06$ for the short/still vs. short/wagging and long/still vs. long/wagging comparison, respectively), same size as model size class (ANOVA: $F_{1,9} = 0.5$, $p = 0.51$ and ANOVA: $F_{1,14} = 7.5$, $p = 0.02$ for the short/still vs. short/wagging and long/still vs. long/wagging comparison, respectively), and larger size class (ANOVA: $F_{1,71} = 0.0$, $p = 0.95$ and

ANOVA: $F_{1,87} = 10.4$, $p < 0.01$ for the short/still vs. short/wagging and long/still vs. long/wagging comparison, respectively) (Figure 3). The differences between the responses of the three size classes to model tail condition were not significant (2-way ANOVA: $F_{\text{size}:1,224} = 1.2$, $p = 0.29$).

Discussion

We hypothesized that dogs would approach a model dog with a short tail more cautiously than a model with a long tail due to the reduced availability of social cues and we expected caution to be accentuated in the smallest dogs. Our results support expectations on body size as smaller dogs behaved more cautiously towards the model. Larger dogs were more likely to make decisions that resulted in an encounter with the model in all aspects of the approach sequence. An increase in caution for smaller body size is reasonable (Parker, 1974), and may explain why the smaller size class did not show any response to different model tail conditions when we examined their approach sequence. Perhaps the greater caution exhibited by the smaller dogs obscured any behavioural subtleties at this broad level of analysis.

Larger dogs displayed differences in the approach sequence according to model tail condition. For 'approaching continuously' data, larger dogs stopped more often when the tail was short versus long. As the efficacy of a visual signal is related to its visibility (Bradbury & Vehrencamp, 1998), it may be that larger dogs had a harder time interpreting the 'intentions' of the model when the tail was short. Similarly, the likelihood of 'approaching' results can be interpreted in terms of signal efficacy. Larger dogs approached a long/wagging tail more than a long/still tail, which is not surprising given the meaning of the respective signals (Tembrock, 1968; Fox, 1969, 1971; Kleiman, 1972; Prince, 1975; Bradbury & Vehrencamp, 1998), but responded equally to the short/still and short/wagging tail. It appears that the signals communicated by differences in tail motion were most effectively conveyed when the tail was long.

All three size classes of approaching dogs also showed higher multivariate indices in response to the long/wagging tail compared to the long/still tail, but showed similar values when approaching the short/still and short/wagging tail. The highest loading variable in the discriminant analysis, and the only variable that showed any significant responses to model tail condition, was greater 'head height inside 1.5 m'. Increases in head height are

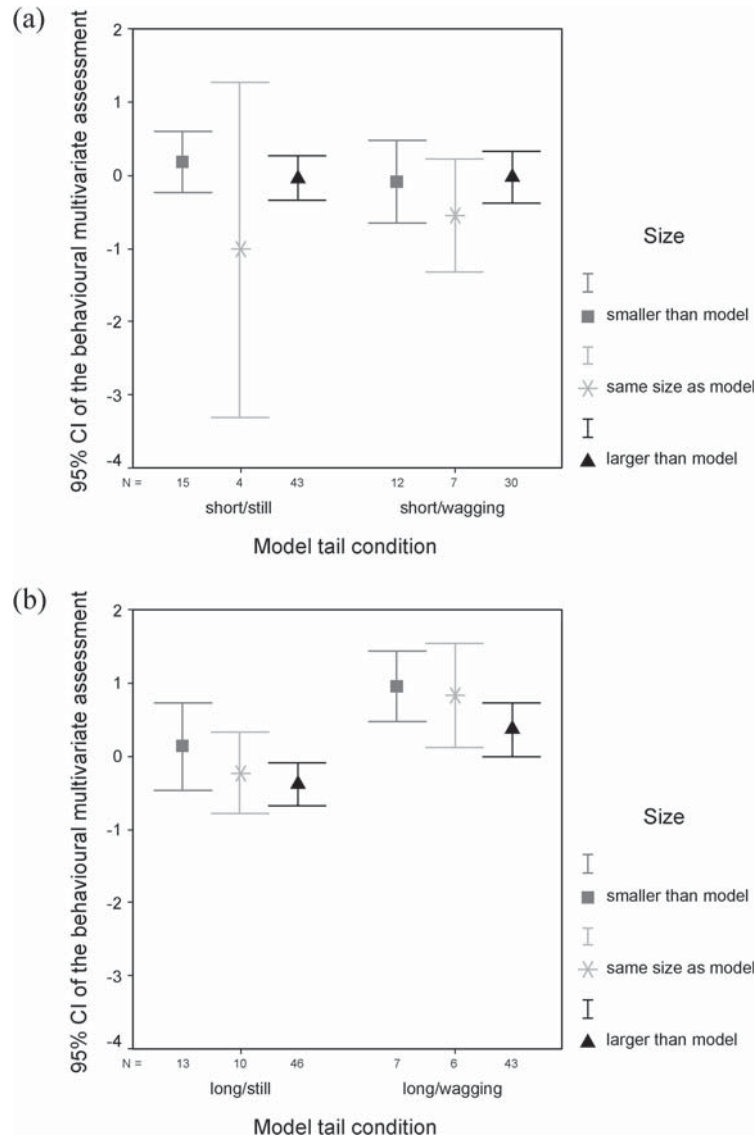


Figure 3. Mean values and 95% confidence intervals of a multivariate behavioural index representing the response of approaching and contacting dogs to the motion of an artificial model's tail when the model's tail was (a) short and (b) long. Higher values of the behavioural index primarily represent a dog whose head was high inside 1.5 m, tail was high outside 1.5 m, and tail was lower inside 1.5 m. Values are clustered according to the size of the contacting dog compared to the model (smaller, same size, or larger than model). Values on x-axis indicate number of approaching and contacting dogs.

associated with increasing levels of confidence and dominance in dogs (Fox, 1971; Bradshaw & Nott, 1995; Galae & Knol, 1997; Bradbury & Vehrencamp, 1998). The next highest loading variable, greater 'tail tip height outside 1.5 m' is also indicative of confidence (Tembrock, 1968; Fox, 1971; Kleiman, 1972; Prince, 1975; Bradshaw & Nott, 1995; Galae & Knol, 1997; Bradbury & Vehrencamp, 1998; Coren, 2000). However, as the third highest loading variable was a lower 'tail tip height inside of 1.5 m', the discriminant analysis variable may not be a clear measure of confidence. Nonetheless, this discriminant analysis variable reflects a dog's behaviour and it varied with respect to model tail motion, but only when the model's tail was long.

We had predicted that the difference in behavioural response to the model would simply vary with model tail length and expected that dogs would approach a short tail more cautiously due to the lack of social cues. We found some evidence to support this — larger dogs were more likely to stop completely during their approach when the model's tail was short — but more frequently we observed differences in response to tail length when we examined the dogs' response to model tail motion. Larger dogs were more likely to approach the long/wagging tail compared to the long/still tail, but did not differentiate between the short/still and short/wagging tail. Furthermore, in the discriminant analysis variable values of all size classes, dogs responded more positively to long/wagging tail compared to the long/still tail, but did not differentiate between the short/still and short/wagging tail. Our results, thus, provide evidence that the signal communicated by tail motion is most effectively conveyed when the tail is long.

The reduced ability to interpret social cues signaled by a short tail's motion could have behavioural implications for dogs with docked tails. Although there are visual signals in addition to the tail that indicate motivational state (Fox, 1971), our results are consistent with the hypothesis that docking a dog's tail may impair intraspecific communication. It has been suggested that dogs with docked tails may be more frequently involved in aggressive encounters because of the increased chance of social misunderstanding (Morton, 1992; Wansborough, 1996; Coren, 2000; Bennett & Perini, 2003). Previously, only anecdotal evidence from Coren (2000), who noted a higher proportion of dogs with docked tails were involved in aggressive encounters compared to dogs with full tails, was available to evaluate the potential behavioural effects of tail-docking. Although our results do not directly demonstrate any link between docking and an increase of aggression,

we do provide evidence that tail-docking may impair intraspecific communication.

Additionally, our study demonstrates the potential use of a model for studying interactions between members of a socially complex species. Although our model does not provide the large numbers of social cues that socially complex animals use, it defines specifically the attributes of individual signals such as the tail length and tail motion. Like Göth & Evans (2004), our model appeared to elicit appropriate social responses and, similar to both Patricelli et al. (2002) and Göth & Evans (2004), our experiment provides information on intraspecific signaling. Recent evidence (Quartana et al., 2007) that the directionality of tail wagging reflects a dog's motivational state offers additional context to the application of these robotic techniques. The use of robots in behavioural studies is increasing (Knight, 2005), and they offer numerous advantages by providing a standard stimulus in highly variable situations (Young, 2007).

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References

- Aloff, B. (2005). Canine body language: a photographic guide. — Dogwise, Wenatchee, WA.
- Bennett, P.C. & Perini, E. (2003). Tail docking in dogs: a review of the issues. — *Aust. Vet. J.* 81: 208-218.
- Bradbury, J.W. & Vehrencamp, S.L. (1998). Principles of animal communication. — Sinauer Associates, Sunderland, MA.
- Bradshaw, J.W.S. & Nott, H.M.R. (1995). Social and communication behaviour of companion dogs. — In: *The domestic dog, its evolution, behaviour and interactions with people* (Serpell, J., ed.). Cambridge University Press, Cambridge, p. 116-130.
- Coren, S. (2000). How to speak dog. — The Free Press, New York, NY.
- Fox, M.W. (1969). The anatomy of aggression and its ritualization in Canidae: a developmental and comparative study. — *Behaviour* 35: 243-258.
- Fox, M.W. (1971). Behaviour of wolves, dogs, and related canids. — Jonathan Cape, London.
- Fox, M.W. (1975). Evolution of social behaviour in canids. — In: *The wild canids* (Fox, M.W., ed.). Van Nostrand Reinhold, New York, NY, p. 429-437.
- Galae, S. & Knol, B.W. (1997). Fear-motivated aggression in dogs: patient characteristics, diagnosis and therapy. — *Anim. Welfare* 6: 9-15.

- Goodwin, D., Bradshaw, J.W.S. & Wickens, S.M. (1997). Paedomorphosis affects agonistic visual signals of domestic dogs. — *Anim. Behav.* 53: 297-304.
- Göth, A. & Evans, C.S. (2004). Social responses without early experience: Australian brush-turkey chicks use specific visual cues to aggregate with conspecifics. — *J. Exp. Biol.* 207: 2199-2208.
- Kleiman, D.G. (1972). Social behaviour of the Maned Wolf (*Chrysocyon brachyurus*) and Bush Dog (*Speothos venaticus*): a study in contrast. — *J. Mammal.* 53: 791-806.
- Knight, J. (2005). When robots go wild. — *Nature* 434: 954-955.
- Morton, D. (1992). Docking of dogs: practical and ethical aspects. — *Vet. Rec.* 131: 301-306.
- Orotolani, A. (1999). Spots, stripes, tail tips and dark eyes: predicting the function of carnivore colour patterns using the comparative method. — *Biol. J. Linn. Soc.* 67: 433-476.
- Parker, G.A. (1974). Assessment strategy and the evolution of fighting behaviour. — *J. Theor. Biol.* 47: 223-243.
- Patricelli, G.L., Uy, J.A.C., Walsh, G. & Borgia, G. (2002). Sexual selection: male displays adjusted to female's response.— *Nature* 415: 279-280.
- Prince, J.H. (1975). Languages of the animal world. — Thomas Nelson, New York, NY.
- Quartana, A., Siniscalchi, M. & Vallortigara, G. (2007). Asymmetric tail-wagging responses by dogs to different emotive stimuli. — *Curr. Biol.* 17: R199-R201.
- Schilder, M.B.H. & van der Borg, J.A.M. (1993). Training dogs with help of the shock collar: short and long term behavioural effects. — *Appl. Anim. Behav. Sci.* 85: 319-334.
- Tembrock, G. (1968). Land mammals. — In: *Animal communication* (Sebeok, T.A., ed.). Indiana University Press, Bloomington, IN, p. 359-373.
- Wada, N., Hori, H. & Tokuriki, M. (1993). Electromyographic and kinematic studies of tail movement in dogs during treadmill locomotion. — *J. Morphol.* 217: 105-113.
- Wansborough, R.K. (1996). Cosmetic tail docking of dogs. — *Aust. Vet. J.* 74: 59-63.
- Young, E. (2007). Undercover robots lift lid on animal body language. — *New Sci.* 193: 22-23.
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