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## Laterality: Asymmetries of Body, Brain and Cognition

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## Behavioural responses of dogs to asymmetrical tail wagging of a robotic dog replica

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Recent evidence suggests that bilateral asymmetry in the amplitude of tail wagging of domestic dogs (*Canis familiaris*) is associated with approach (right wag) versus withdrawal (left wag) motivation and may be the by-product of hemispheric dominance. We consider whether such asymmetry in motion of the tail, a crucial appendage in intra-specific communication in all canids, provides visual information to a conspecific leading to differential behaviour. To evaluate this, we experimentally investigated the approach behaviour of free-ranging dogs to the asymmetric tail wagging of a life-size robotic dog replica. Our data, involving 452 separate interactions, showed a significantly greater proportion of dogs approaching the model continuously without stopping when the tail wagged to the left, compared with a right wag, which was more likely to yield stops. While the results indicate that laterality of a wagging tail provides behavioural information to conspecifics, the responses are not readily integrated into the predicted behaviour based on hemispheric dominance.

**Keywords:** Canids; Communication; Laterality; Robotic model.

While asymmetric behaviours have been identified in an expanding diversity of taxa, and in a variety of activities such as defence and manipulation (Bisazza, Rogers, & Vallortigara, 1998; Vallortigara, Rogers, & Bisazza, 1999), there has been little attention given to whether a left-biased versus a right-biased behaviour might have signalling value to a conspecific. Differentiating the directionality could be advantageous to the receiver if it yielded additional information about the behaviour or motivation of the sender. Apart from perceptual responses to left versus right hand use in some human cultures (McManus, 2002), we were unable to find any investigations

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into whether the direction of behavioural asymmetry would elicit different responses in a conspecific receiver.

Domestic dogs (*Canis familiaris*) are highly social animals that use a repertoire of visual and acoustical signals during intra- and inter-specific interactions (Bradshaw & Nott, 1995; Horowitz, 2009). The tail in particular is known to convey crucial information on motivational state and intent through complex interactions of its movement, position, and size (Bradshaw & Nott, 1995; Fox, 1969; Leaver & Reimchen, 2008). Quaranta, Siniscalchi, and Vallortigara (2007) recently found that dogs wag their tails asymmetrically as a function of their motivational state. Dogs demonstrated a left-biased wag towards an unfamiliar conspecific or neutral stimulus, and a right-biased wag of varying amplitudes for heterospecific stimuli (an owner, an unfamiliar human, and a cat). We hypothesised that this laterality potentially provides cues of additional signalling value to an approaching conspecific. In the current study we tested for differences in behavioural responses of dogs to the asymmetric tail wag of a life-sized robotic dog model.

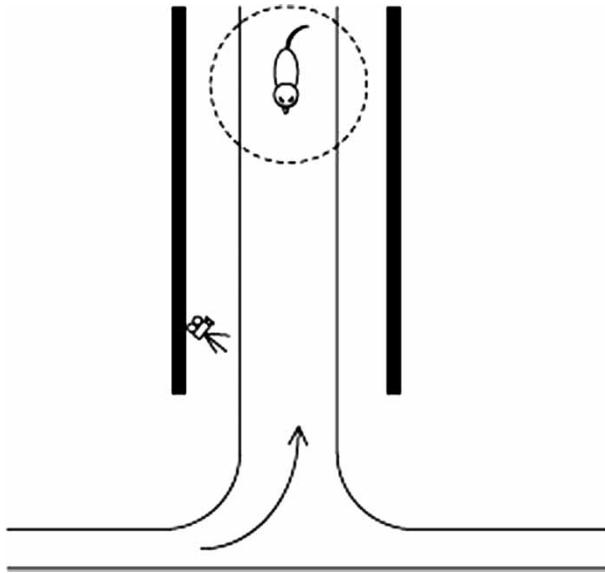
## METHOD

### Stimulus

We modified a life-size model (similar to a black Labrador retriever) previously developed to investigate communication and tail-length among dogs (Leaver & Reimchen, 2008). Manual control of the servomotor at the base of the tail was replaced with a Parallax Stamp<sup>®</sup> Microcontroller to allow manipulation of amplitude ( $\sim 0$  deg to  $\sim 45$  deg), frequency ( $\sim 2.5$ Hz), and directionality (left or right) of the wagging. To increase the visual signal of the tail, which was completely black on the original model, a 3-cm long white 'sock' was sewn over the tip, similar in appearance to white-tipped tails observed in many breeds.

### Procedure

The model was placed in an off-leash dog park in Victoria, British Columbia, in the centre of a pathway bordered on either side by dense foliage (Figure 1). We videotaped (Sony Digital 8 DCR108-TRV720) each head-on approach using a tripod positioned approximately 15 m in front of the model. The camera and tripod were placed on the left of the path and were visible to all approaching dogs. In 2008 we videotaped 80 interactions encompassing 76 different dogs, but excluded 6 interactions (4 repeat visits, 2 model malfunctions). To evaluate the possible effects of proximity, we scored



**Figure 1.** Schematic for position and alignment of robotic dog in field setting. Dotted line = 1.5 m circle. Arrow = approach direction of dogs. Solid bars = dense foliage.

behaviour of the dogs when they were approaching and secondly when they were close ( $<1.5$  m) to the model. At the onset of the 2008 trials, a 1.5-m radius rope circle centred at the model was videotaped, removed, and subsequently digitally overlaid on the video to allow assessment of distant and proximate approach behaviour. We categorically scored approach speed (slow walk, fast walk, run), head position (down, horizontal, up), tail tip position (down, horizontal, up), and tail base position (down, horizontal, up). Tail tip and tail base scores were strongly correlated (outside,  $r = .65$ ,  $p < .001$ ; inside,  $r = .55$ ,  $p < .001$ ); we evaluated only the former. Approach speeds outside and inside the 1.5-m radius were also strongly correlated ( $r = .37$ ,  $p < .01$ ); we examined only the former. Additionally, we scored whether dogs stopped during their approach to the model, and if they did, whether they resumed their approach. We analysed these scores using Pearson chi-squared to determine whether they differed based on the laterality of the model's tail motion. We observed no instances in which the robotic dog was approached aggressively.

To evaluate whether the classification of behaviour was repeatable, an observer unfamiliar with this experiment scored 45 of the 74 encounters analysed. Associations that were not significant in our classification also lacked significance when re-scored. Results that were significant in the initial

classification had trends in the same direction but with reduced levels of significance concurrent with the smaller sample size.

Extending from the results in 2008, we videotaped encounters with 435 different dogs in 2009, of which 57 encounters were excluded (model ignored, interference from humans) leaving 378 useable interactions. For these, we scored whether dogs stopped or were continuous in their approach to the model, as this was the major behavioural difference observed in the first field experiment. We also recorded presence or absence of any barking during the approach. Dogs were categorised into one of three size categories estimated from the video: large (haunch higher than model's head), medium (haunch higher than model's chest), small (haunch lower than model's chest). These data were analysed using Pearson chi-squared to determine whether they differed based on the laterality of the model's tail motion.

## RESULTS

The relative tendency of free-ranging dogs to stop during their approach was influenced by the directionality of model's tail wag (Table 1). For the 74 trials in 2008, with a left wag, 56% dogs approached the model without stopping compared with 31% with the right wag (Pearson  $\chi^2_1$ ,  $p = .03$ ). Speed, head position, and tail tip position of approaching dogs were also evaluated outside and inside the circle but there were no significant effects.

TABLE 1  
Approach behaviour of free-ranging dogs to lateralised tail motion of life-size model dog replica

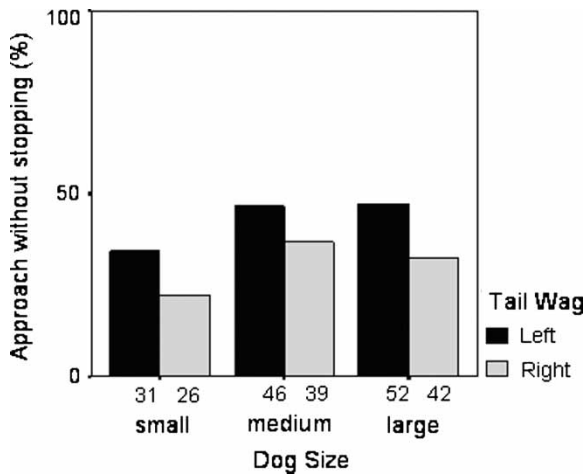
<i>Data period</i>	<i>Tail direction</i>	<i>Approach behaviour</i>			
		<i>No-stop</i>	<i>Stop</i>	<i>Total</i>	
2008	Left wag	22	17	39	$\chi^2_1 = 4.66, p = .031$
	Right wag	11	24	35	
2009 (full data)	Left wag	74	124	198	$\chi^2_1 = 3.94, p = .047$
	Right wag	50	130	180	
2009 (restricted*)	Left wag	53	76	129	$\chi^2_1 = 4.37, p = .037$
	Right wag	30	77	107	

Values show number of dogs exhibiting continuous (no-stop) versus interrupted (stop) during approach to model. \*Exclude trials where additional dogs were present.

Replicated trials in 2009 were concordant with the first trials. Of 198 left wag and 180 right wag trials, 37.4% and 27.8% respectively approached the model without stopping (Pearson  $\chi^2_1, p = .04$ ). We further restricted our analyses and excluded 142 trials where owners or additional dogs were present as this might modify the behaviour of the approaching dog. Results for the smaller dataset were similar. Of 129 trials with left wags, 41.1% of the dogs approached continuously while of 107 trials with right wags, 28.0% approached continuously (Pearson  $\chi^2_1, p = .03$ ). We partitioned these data among size classes of dogs and the same trend occurred in small, medium, and large dogs (Figure 2). A total of 15% of the dogs barked at the model during the interrupted approach with no significant differences (Pearson  $\chi^2_1 = 1.0, p = .3$ ) to the left- versus right-biased wag on the robotic model.

### DISCUSSION

Our study using a robotic dog model, which appeared lifelike and regularly deceived both human and dog (Leaver & Reimchen, 2008), demonstrates that the directionality of the tail wag leads to differential approach behaviour of dogs. Our results, based on over 450 separate interactions, show replicated responses for dogs of different sizes. The use of the robotic model for this study on laterality has advantages compared with bi-directional interactions among actual dogs, as it allow explicit signals to



**Figure 2.** Frequency of continuous approaches to robotic model by free-ranging dogs for tail wag asymmetry and size class of dog. Values below bars show number of separate trials.

be presented without any correlated associations that could confound interpretations (Young, 2007).

Quaranta and colleagues (2007) observed a right-biased wag for positive stimuli and a left-biased wag for unfamiliar or neutral stimuli, possibly the consequence of left-hemisphere bias (right wag) for positive approach behaviours and anterior right-hemisphere bias (left wag) for potential withdrawal behaviour or with neutral stimulation (see also Davidson, 2004; Siniscalchi, Quaranta, & Rogers, 2008). Extending from this and the known importance of tail motion in canid communication (Fox, 1969), we thought that dogs would approach the model with a right-biased tail wag more continuously and confidently than for the left-biased wag, yet we observed the opposite, with dogs interrupting their approach at a higher frequency to the right-biased wag. The stop response during the approach appeared to us as a more cautious approach than the continuous approach to the left wag. Possibly these differences originate when dogs are presented with a signal that would otherwise be positive (right wag) yet are not accompanied by additional reciprocal visual or acoustic responses (for example, Siniscalchi et al., 2008) of the robotic model.

This study represents some of the first experimental evidence that a conspecific receiver can evaluate directionality of a lateralised behaviour in a sender and subsequently modify a resulting interaction. Perhaps the ability to respond to behavioural asymmetries is not unexpected given the acute sensory capabilities in a diversity of vertebrate and invertebrate taxa that allow detection of subtle morphological asymmetries in conspecifics (Moller & Pomiankowski, 1993; Swaddle & Johnson, 2007; Uetz & Smith, 1999). Whether the differential responses of approaching dogs to the lateralised tail motion is a legacy of prior experience with other dogs or a heritable behavioural predisposition to respond according to the tail asymmetry is unknown. If our results are confirmed and are representative, they suggest additional complexity in interpreting intra- and inter-specific interactions given that lateralised behaviour is present across a diversity of taxa (Bisazza et al., 1998; Meguerditchian & Vaclair, 2009). For example, do predators respond differentially to specific eye use of the prey, given the general right hemisphere (left eye) preference for monitoring threats (for example, Vallortigara et al., 1999)? The results also address the continued cultural practice of tail docking in dogs, which would further compromise communication repertoires both for the signaller and receiver (Leaver & Reimchen, 2008).

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