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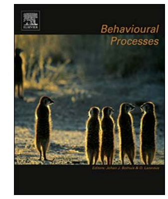

Stability of motor bias in the domestic dog, *Canis familiaris*

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ABSTRACT

This study explored the relationship between four measures of canine paw preference to establish whether the distribution, direction or strength of motor bias was consistent between tasks. Thirty-two dogs had their paw preferences tested using the *Kong ball, tape, lift paw* and *First-stepping* tests. A smaller sample were re-tested 6 months later. The distribution of the dogs' paw preferences was not significantly different from that expected by chance for the *Kong ball* and *lift paw* tests; dogs were significantly more inclined towards ambilaterality on the *tape* and *First-stepping* tests. More female dogs employed their right paw on the *lift paw* test; males were more likely to be ambilateral or left-pawed. There was no significant correlation in the direction of dogs' paw use for any tests. The *First-stepping* and *lift paw* tests were positively correlated for strength of paw use. Analysis revealed a significant correlation in direction and strength of dogs' paw use between the first and second attempts of all measures, except the *tape* test. Findings suggest that paw preference in the dog is not consistent between tasks, although stable over time. The study raises questions as to which test of paw preference is the most appropriate to employ.

1. Introduction

Lateralised motor behaviour has been studied as an observable measure of cerebral functional asymmetry for numerous years (*e.g.*, Harris, 1983; Springer and Deutsch, 1989). The most prominent manifestation of lateralised behaviour in humans is that of handedness (*i.e.*, the predominant use of one hand), with roughly 90% of people using their right hand for most activities (Annett, 1985; Porac and Coren, 1981).

Studies now suggest that cerebral functional asymmetry is not unique to humans, but may be a fundamental feature of all vertebrate, and even some invertebrate, brains (for reviews see Frasnelli et al., 2012; MacNeilage et al., 2009; Rogers, 2002; Rogers et al., 2013; Vallortigara et al., 2010; Vallortigara and Rogers, 2005). What is less clear is whether non-human species exhibit lateralisation in their limb use in a manner that approximates human handedness or whether the preferred use of a specific hand, paw or similar appendage is related to other aspects of brain asymmetry (see reviews by Corballis, 2009; Rogers, 2009; Versace and Vallortigara, 2015). Whilst there is a general consensus that individual animals may show consistent hand/paw preferences, the question of whether motor lateralisation exists at the level of the population remains controversial (see MacNeilage et al., 1987). Population-level asymmetries have been found in a number of non-human species, including primates (*e.g.* Diamond and McGrew, 1994; Laska, 1996) and humpback whales (Clapham et al., 1995), but studies on other species, for example, sheep (*e.g.*, Anderson and Murray, 2013; Morgante et al., 2010; Versace et al., 2007), horses (Austin and Rogers, 2012, 2014; Lucidi et al., 2013), cats (McDowell et al., 2016; Wells and Millsopp, 2009, 2012), and some insects (*e.g.*, desert locust, Bell and Niven, 2014; tiger spider, Ades and Ramires, 2002), point more towards motor asymmetries at the level of the individual.

The domestic dog, *Canis familiaris*, has been shown to display lateral bias in the form of paw preferences at the level of the individual (*e.g.*, McGreevy et al., 2010; Quaranta et al., 2004; Wells, 2003). Motor bias in this species has been tested using a variety of methods (for review see Siniscalchi et al., 2017), including reaching for food, removing something (*e.g.*, adhesive tape, blanket) from the body, 'giving' a paw upon request, urinary posture and walking downstairs. Whilst a range of diverse measures have been employed to assess motor bias in the dog, investigations are largely united in only using one measure of paw preference per study. Only a handful of authors have compared dogs' paw use between tests, with mixed results. Wells (2003), for example, found strong positive correlations in the direction of dogs' paw use for two out of three (giving a paw, removing a blanket from the head, reaching for food) challenges. Tomkins et al. (2010), however, found no association in the distribution, direction or strength of dogs' paw preferences between the First-step and Kong ball tests. Poyser et al. (2006) similarly found no correlation in dogs' motor bias between tests including the paw used to hold a rawhide chew and that used to touch a food-laden ball. Establishing whether dogs harbour consistent paw

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preferences is important. It has been suggested that motor bias has the potential to be used as an applied tool for assessing vulnerability to stress and welfare risk in animals (see MacNeilage et al., 2009; Rogers, 2010). Left-limbed animals, which tend to be right-hemisphere dominant, show stronger fear responses than right-limbed animals, which tend to be left-hemisphere dominant (*e.g.*, Braccini and Caine, 2009; Cameron and Rogers, 1999). Left-sided biases of aggression, reactivity to fear-inducing stimuli and vigilance behaviour have also been noted in numerous species (*e.g.*, Austin and Rogers, 2012; Denenberg, 1984; Koboroff et al., 2008; Lippolis et al., 2002, 2005; Zappia and Rogers, 1983). Thus, motor asymmetry has the potential to be used as a predictor of welfare risk. Recording accurate data on the direction and strength of an animal's motor bias is therefore important if the correct implications for welfare assessment are to be made. Categorising an animal as 'left-limbed', for example, on the basis of its performance on one paw preference test could provide misleading information on the emotional vulnerability of that individual if paw preferences are task-specific and another test might lead to the same animal being classified as 'right-limbed' or ambilateral.

The following study explores the relationship between four previously used measures of paw preference in the domestic dog in an effort to establish whether the distribution, direction or strength of motor bias is consistent or varies between tasks. A smaller sample of dogs are tested again on the same challenges 6 months later to explore for test-retest reliability. The study hopes to shed light on whether paw preference harbours any potential as an applied tool for assessing vulnerability to stress or poor welfare in the dog and determine which test/s might be the most appropriate to employ to this end.

2. Methods

2.1. Subjects

Thirty-two castrated pet dogs (18 males, 14 females) of mixed breed were recruited *via* response to an email advertising a study on paw preferences sent to pet owners in Northern Ireland, UK. Animals ranged from 1 to 10 years of age (mean age = 4.45, SEM ± 0.45years). All of the dogs were family pets living in households and whose owners had consented to them taking part in the study. None of the dogs had undergone any behavioural training, nor had any disability preventing them from completing the study.

2.2. Paw preference tests

Four previously employed tests were used to record the dogs' paw preferences

2.2.1. Kong ball test

The Kong™ ball (KONG Company, Golden, CO, USA), a hollow, conical-shaped rubber toy that moves in an erratic manner, has been widely used to assess motor asymmetry in the domestic dog (Batt et al., 2007, 2008; Branson and Rogers, 2006; Marshall-Pescini et al., 2013; Plueckhahn et al., 2016; Schneider et al., 2013; Tomkins et al., 2010; Wells et al., 2016). A medium-sized Kong ball (10.5 cm long) was used for testing. The ball has a 2.9 cm diameter hole at one end, and a smaller 1 cm diameter hole at the opposite end. Before testing, the toy was filled through the larger hole with moist dog food (Pedigree™, original flavour, Waltham Mars, UK) and frozen. Balls were washed thoroughly in-between tests.

At the start of testing, the dog was shown, and allowed to sniff, the food-loaded Kong ball. The toy was then placed directly in front of the animal. The paw used to stabilise the Kong by the dog was recorded by the Experimenter. A paw use was classified as the animal having one or both paws on the Kong ball, regardless of duration. A separate paw use was considered to have been made when the animal removed its paw from the Kong and replaced one or both of its paws on the object. On occasion, dogs used both paws to stabilise the ball; these occurrences were recorded, but testing was not considered complete until one hundred paw uses (left plus right combined) had been made by the animal, regardless of the number of times dogs employed both paws.

2.2.2. Tape test

In line with previous studies (Batt et al., 2008; Quaranta et al., 2004), a 15 mm × 50 mm piece of adhesive tape (Scotch™ tape, 3 M, UK) was stuck to the dog's nose. The tape was adhered longitudinally to the midline dorsal surface of the animal's nose, with 75% of the tape hanging over the end of the dog's muzzle. Recording commenced as soon as the tape was adhered to the dog's nose. A paw use was classified as the animal using one of its paws to attempt to remove the tape. A separate paw use was considered to have been made when the animal removed its paw from its nose. Fifty individual paw uses (left plus right combined) were recorded for each animal.

2.2.3. Lift paw test

The dog was required, upon instruction from the Experimenter, to sit and lift its paw, *i.e.*, 'give' a paw (see Wells, 2003). It was ensured that the animal was sitting symmetrically before the command to lift a paw was issued to prevent the possibility of unequal weight distribution between hind haunches influencing the dog's paw preference. The paw that was first lifted by the dog was recorded. The dog completed each paw lift in 5 blocks of 10, generating a total of 50 paw lifts per animal.

2.2.4. First-stepping test

In the First-stepping test, the first paw lifted by the dog in order to walk down a step was recorded on 50 occasions (see Tomkins et al., 2010). If a dog was too small for the standard step (height 0.18 m; width 1.40 m), *i.e.*, the dog jumped down instead of stepping, smaller steps (height 0.05 m; width 1.00 m) were employed. Experimenter 1 stood on the upper level of the step next to the dog and held the animal loosely on a lead. Experimenter 2 stood on the base level, 2 m away. When the dog was standing square with its forelegs level on the step, Experimenter 2 called the dog and recorded the paw lifted to step off. Both experimenters remained stationary while the dog stepped off. To give the dog a chance to rest, the task was completed over four sets of repetitions following the sequence 10-10-15-15. Each time, Experimenter 1 alternated her position by standing on the left or right hand-side of the dog.

2.3. Procedure

All of the dogs were required to undertake the 4 tests outlined above. To prevent over-tiring the subjects, the *Kong ball* and *tape* tests were both carried out in the dog's own home, while the *lift paw* and *First-stepping* tests were carried out on a separate day in the Animal Behaviour Centre, Queen's University Belfast. The order of testing was randomised between animals to control for potential order effects.

To explore for test-retest reliability in their expression of paw preference, a sample of available dogs (*Kong ball* n = 20; *tape* n = 16, *lift paw* n = 10, *First-stepping* n = 9) was tested again 6 months later on each of the measures. The procedure for the re-tests was exactly the same as outlined above (see 2.2).

2.4. Analysis

A series of analyses were carried out to examine the distribution, direction and strength of the dogs' paw use across the tasks and to determine the stability of the dogs' paw preferences over time.

2.4.1. Distribution of paw use

Binomial *z*-scores were calculated to determine whether the frequency of right- or left-paw use exceeded that expected by chance. An alpha value of 0.05 was adopted for all analyses. A *z*-score greater than