

Association Between Lateral Bias and Personality Traits in the Domestic Dog (Canis familiaris)

Barnard, S., Wells, D. L., Hepper, P. G., & Milligan, A. D. S. (2017). Association Between Lateral Bias and Personality Traits in the Domestic Dog (Canis familiaris). *Journal of Comparative Psychology*, *131*(3), 246-256. https://doi.org/10.1037/com0000074

Published in:

Journal of Comparative Psychology

Document Version: Peer reviewed version

Queen's University Belfast - Research Portal:

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12 Acknowledgements

- 13 The authors would like to thank all the dog owners who volunteered to have their dogs to take part in
- 14 this study. The financial support of the BBSRC (BB.J021385/1) is gratefully acknowledged.

15 Abstract

16 Behavioural laterality reflects the cerebral functional asymmetry. Measures of laterality have been 17 associated with emotional stress, problem-solving and personality in some vertebrate species. Thus far, the association between laterality and personality in the domestic dog has been largely 18 19 overlooked. In this study we investigated if lateralised (left or right) and ambilateral dogs differed in 20 their behavioural response to a standardised personality test. The dog's preferred paw to hold a KongTM ball filled with food, and the first paw used to step-off from a standing position were scored 21 as laterality measures. The Dog Mentality Assessment (DMA) test was used to assess five personality 22 traits (e.g. Sociability, Aggressiveness) and a broader Shy-Boldness dimension. No differences 23 emerged between left and right biased dogs on any personality trait. Instead, ambilateral dogs, scored 24 using the Kong test, scored higher on their Playfulness (Z = -1.98, p = .048) and Aggressiveness (Z =25 26 -2.10, p = .036) trait scores than lateralised (irrespective of side) dogs. Also, ambilateral dogs assessed using the First-stepping test, scored higher than lateralised dogs on the Sociability (Z = -2.83, p =27 .005) and Shy-Boldness (Z = -2.34, p = .019) trait scores. Overall, we found evidence of a link 28 between canine personality and behavioural laterality, and this was especially true for those traits 29 30 relating to stronger emotional reactivity such as aggressiveness, fearfulness and sociability.

31

32 *Keywords:* canine; dog; laterality; paw preference; personality

33 **1. Introduction**

In the last two decades, a large body of research has been dedicated to the study of dog personality 34 (Barnard et al., 2016; Fratkin, Sinn, Patall, & Gosling, 2013; Gartner & Weiss, 2013; Jones & 35 36 Gosling, 2005; Ley, Bennett, & Coleman, 2008; Svartberg & Forkman, 2002). The ability to identify 37 personality traits (e.g. fearfulness, playfulness), defined as individual behavioural differences that are consistent across time and situations, has direct applications in assessing the suitability of specific 38 39 dogs as pets, e.g. to find a good match with prospective owners (Barnard et al., 2016; Dowling-Guyer, 40 Marder, & D'Arpino, 2011; Valsecchi, Barnard, Stefanini, & Normando, 2011), or selecting the most fit-for-purpose assistance, working or sporting dogs (Serpell & Hsu, 2001; Svartberg, 2002; 41 Svobodová, Vápeník, Pinc, & Bartoš, 2008). The assessment of personality traits may also help in 42 improving dog welfare by identifying individuals that are more likely to experience fear and 43 44 discomfort in a shelter or laboratory environment (Beerda, Schilder, Van Hooff, De Vries, & Mol, 1999; Haverbeke, Pluijmakers, & Diederich, 2015). Unfortunately, personality assessment methods 45 46 suffer from many limitations (Haverbeke, Pluijmakers, & Diederich, 2015; Rayment, De Groef, 47 Peters, & Marston, 2015). Surveys, for example, rely on the owners' perspective and battery tests 48 require resources, standardised protocols, trained researchers and can be very challenging, exposing 49 the dog to a wide range of potential stressors. Finding new associations between personality traits and 50 other easy-to-assess measures may provide new indicators of dogs' behavioural differences without 51 having to use time/resource consuming and challenging techniques.

52

53 In humans, affective dispositions and personality have been linked to brain hemisphere asymmetry 54 (Canli et al., 2001; Davidson & Irwin, 1999; Davidson, 1995; Hagemann et al., 1999). Davidson and 55 colleagues, for example, proposed the 'laterality-valence hypothesis', asserting that each brain hemisphere is specialized in processing different types of emotions (Davidson, 1995). Particularly, 56 negative or withdrawal-related emotions (such as fear or depression) are processed and controlled 57 primarily by the right hemisphere, while positive or approach-related emotions (such as happiness and 58 joy) are controlled mainly by the left hemisphere. In other studies, personality traits such as 59 60 Extraversion and Neuroticism have been linked with brain asymmetries. Extraversion, for example,

61 has been associated with a greater left hemisphere activity (Canli et al., 2001; Hagemann et al., 1999; 62 Howard, Fenwick, Brown, & Norton, 1992). A large body of research has demonstrated that cerebral 63 specialization is widespread among vertebrates (Rogers & Andrew, 2002; Rogers, 2010), and that the 64 left and right hemispheres process emotional and environmental information in a different way 65 (MacNeilage, Rogers, & Vallortigara, 2009; Rogers, Vallortigara, & Andrew, 2013; Vallortigara, Chiandetti, & Sovrano, 2011). Some interesting work on domestic dogs, for example, has 66 demonstrated how dogs' asymmetry in tail wagging is associated with the type of visual stimulus the 67 animals are presented with. Results are in line with Davidson's hypothesis: visual stimuli expected to 68 elicit approach tendencies were associated with a higher amplitude of tail wagging movements to the 69 right side (left brain activation), and vice-versa, stimuli expected to elicit withdrawal tendencies were 70 71 associated with a higher amplitude of tail wagging movements to the left side (right brain activation) 72 (Quaranta, Siniscalchi, & Vallortigara, 2007; Siniscalchi, Lusito, Vallortigara, & Quaranta, 2013).

73

74 Laterality has been increasingly used in non-human animal research as a predictive indicator of 75 animals' emotional processes, stress reactions and, of more interest for this study, personality traits in 76 different species (sheep: Barnard et al. 2016; dogs: Schneider, Delfabbro, & Burns, 2013; see also reviews on farm animal species: Leliveld, Langbein, & Puppe, 2013; Rogers, 2010). For example, 77 78 boldness has been positively correlated with strength of laterality in cichlids, i.e. strongly lateralised 79 fishes were quicker to emerge from a shelter when exploring an unfamiliar environment than weakly 80 lateralised animals (Reddon & Hurd, 2009). Likewise, horses assessed as right-hemisphere dominant 81 have been found to be more fearful when presented with unfamiliar stimuli than their left-hemisphere 82 dominant counterparts (Larose, Richard-Yris, Hausberger, & Rogers, 2006).

83

Limb preference (i.e. the preferred use of one hand/paw to perform a task) is associated with greater activity of the contralateral motor cortex (Versace & Vallortigara, 2015). Thus, the observation of a bias in hand (or paw) use can be considered an indicator of brain laterality (Batt, Batt, & McGreevy, 2007; Branson & Rogers, 2006; Gordon & Rogers, 2010; Hopkins & Bennett, 1994; Marshall-Pescini, Barnard, Branson, & Valsecchi, 2013). This and similar measures of behavioural laterality are
relatively easy to employ and non-invasive.

90

91 From the limited literature available, there seems to be very little support for a clear relationship 92 between personality traits and laterality in the domestic dog. A study by Branson and Rogers (2006) 93 showed that dogs with stronger paw preferences were less reactive to the sounds of thunderstorms than were those with no significant paw preference bias (i.e. ambilateral). Another study in this area is 94 the one by Schneider and collaborators (2013) which has investigated possible links between paw 95 preference and temperament traits, assessed through an owner-based survey on their pet's behaviour. 96 Their only significant result showed that lateralised dogs scored slightly higher than ambilateral ones 97 on the factor of 'stranger-directed aggression'. In their conclusions, the authors commented that the 98 99 lack of significant results might be due to the owner-based survey not being sensitive enough to reveal significant relationships with paw preference. They also stressed that, given the effect that aggressive 100 101 behaviour has on the community, this topic should be investigated further, ideally using a different 102 and more objective measurement of canine personality not vulnerable to owner bias (Schneider et al., 103 2013).

104

105 Drawing on this, the current study aimed to investigate the relationship between personality and 106 lateral bias in the dog using a purposely standardised and validated test battery. To this end, we chose 107 to assess the personality traits in dogs using the Dog Mentality Assessment (DMA) test (Svartberg & 108 Forkman, 2002; Svartberg, Tapper, Temrin, Radesater, & Thorman, 2005). The DMA was originally 109 tested on a sample of over 15,000 dogs and the factor analysis based on that sample extracted five 110 personality Playfulness, Curiosity/Fearlessness, Chase-proneness, Sociability, traits i.e. Aggressiveness and a broader Shy-Boldness dimension (Svartberg & Forkman, 2002). The DMA was 111 112 tested for reliability and validity, which are unavoidable quality requirements to ensure that the measures are meaningful, appropriate and free from random errors (Svartberg & Forkman, 2002; 113 Svartberg, 2002; Svartberg, 2005; Svartberg et al., 2005; Taylor & Mills, 2006). 114

The dogs' paw preferences were assessed using the widely used KongTM ball test (Branson & Rogers, 115 2006; Marshall-Pescini et al., 2013; Schneider et al., 2013). However, some authors reported some 116 limitations of this tool, such as the task being food-driven (Tomkins, Thomson, & McGreevy, 2010 117 Plueckhahn, Schneider, & Delfabbro, 2016). Concerns have also been raised as to whether the main 118 paw used by dogs to stabilise the KongTM ball is actually their dominant one (see Wells, Hepper, 119 Milligan, & Barnard 2016 for discussion). For these reasons, we decided to assess canine paw 120 preference using an additional measure, the First-stepping test, a tool that is reported as being quicker 121 to use than the KongTM ball test, repeatable and consistent in time (Tomkins et al., 2010). 122

123

124 It was hoped the study would shed further light on the relationship between lateral bias and 125 personality in the domestic dog and, from an applied perspective, determine whether paw preferences 126 can be used as an indicator of emotional reactivity and vulnerability to stress in a species that is 127 commonly utilised in modern day society.

128

129 **2.** Methods

130 *2.1. Subjects*

Forty privately owned pet dogs were recruited for this study among the students and staff of the School of Psychology, Queen's University Belfast, and by word of mouth. Dogs comprised 22 males (81% neutered) and 18 females (79% spayed) and included a number of different breeds and breedcrosses. The minimum age of the subjects was 12 months; the oldest dog was 13 years old (mean±SD 4.7±2.95 years).

136

137 2.2 Paw preference test

Following Branson & Rogers (2006), dogs' paw preferences were tested using a medium- or smallsized (according to dog size) Kong[™] ball (KONG Company, Golden, CO, USA), a hollow conicalshaped rubber toy (Kong, from now on). Before testing, the toy was filled with moist dog food (Pedigree chum original flavour, Waltham, UK) and frozen overnight. The toys were washed thoroughly in between tests. Dogs were food deprived for at least 4 hours before testing. After 143 allowing the dog to sniff the food-loaded Kong for a few seconds, the toy was placed on the floor 144 directly in front of the animal. The experimenter recorded the paw used by the dog to stabilize the 145 Kong. A paw use was classified as the animal having one or both paws on the Kong, regardless of 146 duration. When the animal removed its paw from the Kong and replaced one or both of its paws on 147 the object, it was scored as a separate paw use. The test was considered completed when the dog 148 reached 100 paw uses (left plus right combined). On occasion, dogs used both paws to stabilize the 149 ball; these occurrences were recorded separately and not included in the analysis.

150

151 In the First-stepping test, the first paw lifted by the dog in order to walk down a step was recorded on 50 occasions (Tomkins et al., 2010). If a dog was too small for the standard step (height 0.18 m; width 152 1.40 m), i.e. the dog jumped down instead of stepping, we used smaller steps (height 0.05 m; width 1 153 154 m). The assistant stood on the upper level of the step next to the dog and held the animal loosely on a lead. The researcher stood on the base level two meters away and facing the pair. When the dog was 155 156 standing square with its forelegs level on the step, the researcher called the dog and recorded the paw 157 lifted to step off the step. Both the assistant and researcher remained stationary while the dog stepped 158 off. To give the dog a chance to rest and drink, the task was completed over four sets of First-stepping repetitions following the sequence 15-15-10-10. Each time, the assistant alternated her position by 159 160 standing on the left or right hand-side of the dog.

161

162 2.3 Personality test

All dogs were tested using a slightly modified version of the Dog Mentality Assessment (DMA) test (Table 1). The original test includes 10 subtests, carried out in an outdoor area (Svartberg & Forkman, 2002). Due to unstable weather conditions, the test was adapted to be carried out indoors. All subtests were performed, except 'Gunshots', which was considered too stressful from an animal welfare perspective. Since previous work has shown that this variable is not associated with any personality trait extracted by a factor analysis (Svartberg & Forkman, 2002), this omission did not compromise the analysis of the personality traits scores.

	The owner was present at all times during testing, holding the dog on the leash whenever required.
172	Two experimenters (blind to the paw preference scores) tested the dogs; both were unfamiliar to the
173	dogs and were the same throughout the study.
174	
175	The dog's behavioural reactions were scored according to 32 predefined behavioural variables (as
176	described in Svartberg & Forkman, 2002). Each variable was scored from 1 to 5 according to the
177	intensity of the dog's reaction.
178	(Table 1 about here)
179	
100	
100	2.4 Data management and statistical analysis
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as during testing holding the dag on the leash whenever required

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188

190 A directional laterality index (LI) was calculated to quantify each dog's paw preference on a 191 continuum from strongly left-paw preferent (+1) to strongly right paw-preferent (-1). The LI score was calculated as (L - R) / (L + R), where R represents the number of right paws and L the number of 192 193 left paws used (Wells, 2003). A score of 0 indicates no bias, a score of ± 1 indicates that the subject 194 used the same paw throughout the trial. The directional laterality index was also used to identify any 195 population bias (non-parametric one-sample *t*-test).

from random distribution by applying a Chi-squared test.

196

197 In addition to the directional bias of lateral behaviour (i.e. left or right bias), the strength of laterality 198 has also been used as a proxy measure of hemispheric brain activity. Strongly lateralised animals show a greater activity of one hemisphere (irrespective of the side), while weakly lateralised animals do not show a significant dominance of one hemisphere over the other (i.e. ambilateral) (Rogers, 2000). The absolute value of LI, gives a measure of the strength of laterality, irrespective of the direction of paw use. A Shapiro-Wilk normality test was used to assess the distribution of LI absolute values.

204

Any effect of sex on the direction and strength of laterality was calculated using a Mann-Whitney-Utest for independent samples.

207

Associations between the Kong and First-stepping tests on the three lateral bias groups (left, right and ambilateral) were assessed using a Chi-square analysis, while the consistency between tests for both the direction and strength of laterality was assessed using Spearman's correlation test.

211

212 Following the results in Svartberg and Forkman (2002), we calculated the dogs' trait scores for the following personality traits: Playfulness, Curiosity/fearlessness, Chase-proneness, Sociability and 213 214 Aggressiveness. The dog's score (1-5) on each variable was standardized using z-scores (Svartberg et 215 al., 2005). Then, the standardized values for the representative variables of each factor (i.e. variables 216 with high loadings on a factor, according to the results in Svartberg and Forkman2002) were averaged 217 to calculate dogs' personality trait scores. For example, the trait Playfulness was calculated by averaging the standardised values of the variables #5, 6, 7, 31 and 32 from subtests 'play 1' and play 218 2' (Table 1). Table 1 shows which are the representative variables for each personality trait. In 219 220 addition, we calculated a broader Shy-boldness dimension score by averaging the scores for 221 Playfulness, Curiosity/fearlessness, Chase-proneness, and Sociability (following Svartberg et al., 2005). 222

223

To ensure that the items included in our new trait scores were measuring the same construct, we examined the internal consistency using Cronbach's alpha. For the higher Shy-Boldness dimension we calculated the item-to-total correlation using Spearman rank test.

227

A Kruskal-Wallis test for independent groups was used to determine if left-lateralised (LL), rightlateralised (RL) and ambilateral (AL) dogs differed in their standardised personality traits scores.
Post-hoc multiple comparisons, applying a Bonferroni correction (p<0.016), were carried out where
appropriate.

232

The absolute value of LI was correlated with the personality trait scores using Spearman's correlation test. Furthermore, a Wilcoxon test was used to ascertain whether there were any significant differences between lateralised and ambilateral animals on the personality trait scores. For this latter analysis, dogs defined as left- or right-lateralised, according to *z*-score calculations, were combined and categorised as lateralised (LAT), and the remaining categorised as ambilateral (AL).

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239 2.5 Ethical Note
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All methods adhered to the Association for the Study of Animal Behaviour/ Animal Behavior Society
Guidelines for the Use of Animals in Research (Association for the Study of Animal Behaviour,
2006). Ethical approval for the study was granted by the Research Ethics Committee, School of
Psychology, QUB.

244

- 245 **3. Results**
- 246 *3.1. Paw preference*

Paw preferences were not successfully recorded for three dogs using the Kong test (n = 37) and 2 dogs using the First-stepping test (n = 38). These dogs were therefore removed from the remaining analyses. Lateralisation at the individual level for both tests is reported in Table 2.

(Table 2 about here)

- 251
- 252

253 The distribution of the three paw preference categories did not differ significantly from that expected by chance, i.e. there was no population level effect (Kong: $\chi^2_{2,37} = 0.87$, p = .65; First-stepping: $\chi^2_{2,38} =$ 254 5.11, p = .08). Even when exploring the direction of laterality (using LI scores), neither test revealed a 255 population level bias (Kong: Z = .84, p = .48; First-stepping: Z = .80, p = 0.55; Figure 1). 256 257 (Figure 1 about here) 258 259 Instead, the distribution of the absolute strength of laterality was significantly skewed towards weakly 260 lateralised animals (median = |0.28|) (Shapiro-Wilk: Kong, W = .91; p = .007; First-stepping, W=0.92, 261 p = .008). 262 263 264 Direction and strength of laterality were not significantly affected by the sex of the dogs (Kong: Z_{LI} = -.87, p = .39; $Z_{|LI|} = -.84$, p = .40; First-stepping: $Z_{LI} = -.63$, p = .53; $Z_{|LI|} = -1.06$, p = .30). 265 266 Only 34.3% (n = 12) of the dogs showed a consistent paw classification between the two tests, 267 268 whereas 45.0% of dogs that had a significant individual bias (left or right) during the Kong test were 269 recorded as ambilateral on the First-stepping test. There was no significant association between the two laterality tests for the three categories of paw use ($\chi^2_{4,35} = 2.20$, p = .70) and there was no 270 correlation between tests for direction (R = -.17, p = .34) or strength (R = .19, p = .28) of laterality. 271 272 3.2. Personality assessment 273 274 After creating the personality trait scores, we checked for their internal consistency. Alpha values 275 were acceptably high for all of the five traits: Playfulness (0.93), Curiosity/Fearlessness (0.81), Chase-276 proneness (0.86), Sociability (0.72), and Aggressiveness (0.65).

277 The item-to-total correlation scores were significant ($p \le .01$) for the four traits that were averaged to

278 calculate the Boldness trait (Playfulness, Curiosity/Fearlessness, Chase-proneness and Sociability).

279 However, the correlation between the traits Aggressiveness and Shy-Boldness was not significant,

280 confirming previous results (Svartberg et al., 2005).

281

282

2 *3.3. Association between lateral behaviour and personality traits*

283 The three laterality groups (LL, RL and AL) assessed with the Kong test did not differ significantly in any of their personality scores (p > .05 for all traits). However, an overall significant relationship 284 285 emerged between laterality group and traits of Sociability (K = 8.4, p = .02) and Shy-Boldness (K = 7.3, p = .03) using the First-stepping test (Figure 2). Post-hoc comparisons showed that AL scored 286 287 consistently higher than LL dogs (Sociability: Z = -2.53, p = .011; Shy-Boldness: Z = -2.61, p = .009) 288 and AL also scored higher than RL dogs for the Sociability trait (Sociability: Z = -2.14, p = .033; Shy-Boldness: Z = -1.35, p = .18). No significant difference was recorded between left- and right-289 290 lateralised dogs for these traits (Sociability: Z = -.70, p = .48; Shy-Boldness: Z = -1.4, p = .16).

291

292

- (Figure 2 about here)
- 293

There was one negative correlation (significant after Bonferroni correction ($p \le .008$) between the dogs' strength of laterality (|LI|) scores on the First-stepping test and the personality trait of Sociability ($\rho = -.50$, p = .002, Figure 3). Increasing strength of laterality was associated with lower scores on this trait.

- 298
- 299

(Figure 3 about here)

300

301 Since the main trend seemed to be that the ambilateral dogs (AL, i.e. weakly lateralised) differed from

the other groups (LL and RL), an additional analysis was carried out to compare AL to LAT animals.

303 Ambilateral (AL) dogs (assessed with the Kong test) scored significantly higher than LAT dogs on the

traits of Playfulness (Z = -1.98, p = .048) and Aggressiveness (Z = -2.10, p = .036) (Figure 4).

305 Further, a significant difference between LAT and AL groups assessed with the First-stepping test

306	emerged for both the traits of Sociability ($Z = -2.83$, $p = .005$) and Shy-Boldness ($Z = -2.34$, $p = .019$),
307	with AL scoring higher than LAT dogs on both traits.
308	
309	(Figure 4 about here)
310	

In this study, we investigated the possible association between paw preference (assessed using two different tasks) and individual differences in personality traits (assessed using a validated and standardised test) in the domestic dog. Our main findings were that ambilateral dogs, scored using the Kong test, scored higher on their Playfulness and Aggressiveness trait scores than lateralised dogs. Also, ambilateral dogs, assessed using the First-stepping test, scored higher than lateralised dogs on the Sociability and Shy-Boldness trait scores.

318

311

4.

Discussion

319 Results from the paw preference tests revealed a significant lateral bias at the individual level (Kong 320 test 59.4% vs First-stepping test 50% lateralised dogs); there was no evidence of a population bias. 321 Previous literature reports contrasting results in this respect, with some studies showing an equal distribution of paw use between lateralised and ambilateral dogs (Marshall-Pescini et al., 2013; 322 323 Poyser, Caldwell, & Cobb, 2006; Schneider et al., 2013) and some not (Branson & Rogers, 2006; Siniscalchi et al., 2008). We also did not find a sex bias on lateral behaviour, which again is in line 324 with a number of studies (Branson & Rogers, 2006; Marshall-Pescini et al., 2013; Schneider et al., 325 2013), and in contrast with others (Poyser et al., 2006; Wells, 2003). Overall, it seems there is still the 326 327 need for further investigations to clarify the factors affecting lateral bias in dogs.

328

Analysis showed that most dogs (66%) were not consistent in their paw use between the two tasks. This is consistent with previous results by Tomkins et al. (2010) who reported that only one third of their subjects consistently used the same paw between tests (i.e. the Kong and the First-stepping test). Previous papers have also reported low consistency in lateral bias across different tasks, strengthening the hypothesis that paw preference in dogs may be task dependent (Tomkins, McGreevy, & Branson,
2010; Batt, Batt, Baguley, & McGreevy, 2008; Wells, 2003). So far very little insight has been given
on the mechanisms underlying the preferential use of one paw over the other according to task
complexity or nature of challenge, e.g. food on non-food driven, so more work is needed to explore
this further.

338

The DMA test was originally tested on a large sample of dogs and the factor analysis based on that 339 sample extracted the five personality dimensions and a higher Boldness trait that were used in this 340 study (Svartberg & Forkman, 2002). Given that each dimension was represented by several 341 342 behavioural variables, we checked for internal consistency and item-to-total correlation to ensure that our variables were measuring the same constructs. Cronbach's alpha was acceptably high for all 343 344 factors (>0.70); Aggressiveness was the lowest (0.65), but Svartberg et al. (2005) found very similar results (0.67), probably due to aggressive behaviour being very context specific (Christensen, Scarlett, 345 346 Campagna, & Houpt, 2007). The correlation between the Shy-Boldness dimension and the five 347 personality traits also confirmed that Aggressiveness was unrelated to the other traits, i.e. Playfulness, 348 Chase-proneness, Curiosity/Fearlessness and Sociability (Svartberg & Forkman, 2002; Svartberg et 349 al., 2005).

350

351 When exploring for associations between paw preference and personality traits, the analysis revealed 352 no significant effect of the direction of laterality on any of the personality traits. Our findings, instead, 353 suggested a relationship between the strength of laterality and some of the dogs' personality traits. 354 This relationship varied according to the task that was used to assess paw preference. Ambilateral 355 dogs classified using the Kong test, scored higher on both the Playfulness and Aggressiveness traits compared to lateralised dogs (including both LL and RL). The right hemisphere is specialised in 356 357 detecting and responding to novel stimuli and controlling emergency responses (e.g. fear, escape, 358 aggression), thus aggressiveness seems to be highly lateralised in a wide range of vertebrates, ranging from primates to fish (Austin & Rogers, 2014; Rogers & Andrew, 2002). However, it is also reported 359 360 that weakly lateralised animals are more likely to react in a less adaptive way to challenging 361 situations, showing distress and reacting more strongly to a threat (Branson & Rogers, 2006; 362 Dharmaretnam & Rogers, 2005). Branson and Rogers (2006), for example, found that dogs with a weaker paw preference (as assessed using the Kong Test) were more prone to distress in response to 363 loud noises than animals that were more strongly lateralised. The Aggressiveness trait in this study 364 365 was calculated on the basis of the response elicited by exposing the dog to a series of sudden and threatening stimuli, e.g. ghost test. Thus, most reactions were fear-driven and associated with a lower 366 posture and increased distance from the stimuli, which may suggest that weakly lateralised dogs were 367 368 struggling to cope with the challenging/fear-eliciting situation.

369

370 It is less clear why weakly lateralised dogs, assessed with the Kong task, were also more playful. It could be that ambilateral dogs were overall more reactive to both positive and negative emotionally-371 372 arousing stimuli. The test environment is novel and challenging, which is known to be somewhat stressful for dogs (Planta & De Meester, 2007). It is worth pointing out that the p-value for this 373 374 comparison was just below chance level (0.048). When correlating the |LI| index score (measuring the 375 strength of laterality) with the Playfulness and Aggressiveness trait, this relationship was not 376 confirmed. The |LI| index, being a continual variable, offers greater statistical power than the paw preference categories (Tomkins et al., 2010). These results should therefore be confirmed with a 377 378 larger sample size.

379

380 Paw preference classifications determined using the First-stepping test also differed significantly on 381 two personality traits: Sociability and Shy-Boldness. Again, ambilateral dogs scored higher on both of 382 these traits. The difference appeared to be mainly due to left-biased dogs scoring consistently lower 383 than right or ambilateral animals, weakly supporting the hypothesis that right-hemisphere dominance is associated with a less-bold/more-shy temperament (Hopkins & Bennett, 1994). The strong 384 385 correlation between strength of laterality and the trait of Sociability seems to support Batt et al.'s 386 (2009) finding that dogs with a weaker paw preference were more excitable when approaching an unfamiliar person than animals which were more strongly lateralised. When scoring the greeting 387 388 behaviour during the test, a higher score was given to dogs that showed 'intense greeting with

389 jumping and whining', thus describing more excitable dogs. However, another study in this area 390 employed an owner-based survey (the Canine Behavioral Assessment and Research Questionnaire, Hsu & Serpell, 2003) to define behavioural categories (Schneider et al. 2013). They found no 391 correlation between the C-BARQ subscale 'excitability' and the strength of laterality. The authors 392 393 argued that the different results might lie in the different contexts in which this trait was assessed: the 394 C-BARQ subscale refer to events that are familiar to the dog (e.g. playing with the owner in the household), whereas in Batt et al.'s (2009) study there is an element of novelty implicit in the test 395 situation. This would be in line with our findings, as our dogs were also presented with an unfamiliar 396 397 person in a novel environment. Further investigation should be carried out to get more insight on this 398 aspect.

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401 Conclusion

402 This study is the first of its kind to examine the relationship between the direct assessment of 403 personality traits in dogs and paw preference using both the Kong and the First-stepping test. We 404 found evidence of a link between canine personality, especially those traits relating to stronger emotional reactivity such as aggressiveness, fearfulness and sociability, and behavioural laterality. 405 406 Interestingly, the strongest correlation (i.e. between the strength of laterality and the Sociability trait) 407 emerged when the dogs' paw preference was assessed using the First-stepping test and not the more 408 commonly applied Kong test. The use of laterality as a proxy measure for behavioural differences in 409 animals is an area gaining increasing attention across many different species. The ease of access to 410 dog populations and the important applied outcomes of defining reliable and easy to apply measures 411 of personality (i.e. good owner-dog match, reduced welfare risk in shelters, predicting suitable working dogs) makes the dog a perfect model to further explore the link between different measures 412 413 of laterality and personality traits.

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551 Figures Captions

- 552 Figure 1 Boxplots show the LI scores variability of the three paw preference groups (left-lateralised
- 553 (LL), right-lateralised (RL) and ambilateral (AL)) for the Kong test (a) and First-stepping test (b).
- 554 Values are medians (bar within the box), upper and lower quartiles (borders of box), lowest and
- highest cases within 1.5 times the IQR (bottom and top whiskers) and outliers (circles and asterisks).
- **Figure 2** Comparison between the three laterality groups (left-lateralised (LL), right-lateralised (RL)
- and ambilateral (AL)) for the Sociability (a) and Shy-Boldness (b) traits.
- **Figure 3** Correlation between the First-stepping strength of laterality (absolute LI value) and the
- 559 personality trait score Sociability.
- 560 Figure 4 Comparison between lateralised (LAT) and ambilateral (AL) dogs for traits of Playfulness
- 561 (a) and Aggressiveness (b).