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

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1 **Association between lateral bias and personality traits in the domestic dog (*Canis familiaris*)**

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6

7 **Running title:** Lateral bias and personality in the domestic dog

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11

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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  
18 far, the association between laterality and personality in the domestic dog has been largely  
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  
21 Kong™ ball filled with food, and the first paw used to step-off from a standing position were scored  
22 as laterality measures. The Dog Mentality Assessment (DMA) test was used to assess five personality  
23 traits (e.g. Sociability, Aggressiveness) and a broader Shy-Boldness dimension. No differences  
24 emerged between left and right biased dogs on any personality trait. Instead, ambilateral dogs, scored  
25 using the Kong test, scored higher on their Playfulness ( $Z = -1.98, p = .048$ ) and Aggressiveness ( $Z =$   
26  $-2.10, p = .036$ ) trait scores than lateralised (irrespective of side) dogs. Also, ambilateral dogs assessed  
27 using the First-stepping test, scored higher than lateralised dogs on the Sociability ( $Z = -2.83, p =$   
28  $.005$ ) and Shy-Boldness ( $Z = -2.34, p = .019$ ) trait scores. Overall, we found evidence of a link  
29 between canine personality and behavioural laterality, and this was especially true for those traits  
30 relating to stronger emotional reactivity such as aggressiveness, fearfulness and sociability.

31

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

33 **1. Introduction**

34 In the last two decades, a large body of research has been dedicated to the study of dog personality  
35 (Barnard et al., 2016; Fratkin, Sinn, Patall, & Gosling, 2013; Gartner & Weiss, 2013; Jones &  
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  
38 consistent across time and situations, has direct applications in assessing the suitability of specific  
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  
41 fit-for-purpose assistance, working or sporting dogs (Serpell & Hsu, 2001; Svartberg, 2002;  
42 Svobodová, Vápeník, Pinc, & Bartoš, 2008). The assessment of personality traits may also help in  
43 improving dog welfare by identifying individuals that are more likely to experience fear and  
44 discomfort in a shelter or laboratory environment (Beerda, Schilder, Van Hooff, De Vries, & Mol,  
45 1999; Haverbeke, Pluijmakers, & Diederich, 2015). Unfortunately, personality assessment methods  
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  
56 hemisphere is specialized in processing different types of emotions (Davidson, 1995). Particularly,  
57 negative or withdrawal-related emotions (such as fear or depression) are processed and controlled  
58 primarily by the right hemisphere, while positive or approach-related emotions (such as happiness and  
59 joy) are controlled mainly by the left hemisphere. In other studies, personality traits such as  
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,  
66 Chiandetti, & Sovrano, 2011). Some interesting work on domestic dogs, for example, has  
67 demonstrated how dogs' asymmetry in tail wagging is associated with the type of visual stimulus the  
68 animals are presented with. Results are in line with Davidson's hypothesis: visual stimuli expected to  
69 elicit approach tendencies were associated with a higher amplitude of tail wagging movements to the  
70 right side (left brain activation), and vice-versa, stimuli expected to elicit withdrawal tendencies were  
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  
77 reviews on farm animal species: Leliveld, Langbein, & Puppe, 2013; Rogers, 2010). For example,  
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

84 Limb preference (i.e. the preferred use of one hand/paw to perform a task) is associated with greater  
85 activity of the contralateral motor cortex (Versace & Vallortigara, 2015). Thus, the observation of a  
86 bias in hand (or paw) use can be considered an indicator of brain laterality (Batt, Batt, & McGreevy,  
87 2007; Branson & Rogers, 2006; Gordon & Rogers, 2010; Hopkins & Bennett, 1994; Marshall-Pescini,

88 Barnard, Branson, & Valsecchi, 2013). This and similar measures of behavioural laterality are  
89 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  
94 than were those with no significant paw preference bias (i.e. ambilateral). Another study in this area is  
95 the one by Schneider and collaborators (2013) which has investigated possible links between paw  
96 preference and temperament traits, assessed through an owner-based survey on their pet's behaviour.  
97 Their only significant result showed that lateralised dogs scored slightly higher than ambilateral ones  
98 on the factor of 'stranger-directed aggression'. In their conclusions, the authors commented that the  
99 lack of significant results might be due to the owner-based survey not being sensitive enough to reveal  
100 significant relationships with paw preference. They also stressed that, given the effect that aggressive  
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 traits i.e. Playfulness, Curiosity/Fearlessness, Chase-proneness, Sociability,  
111 Aggressiveness and a broader Shy-Boldness dimension (Svartberg & Forkman, 2002). The DMA was  
112 tested for reliability and validity, which are unavoidable quality requirements to ensure that the  
113 measures are meaningful, appropriate and free from random errors (Svartberg & Forkman, 2002;  
114 Svartberg, 2002; Svartberg, 2005; Svartberg et al., 2005; Taylor & Mills, 2006).

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

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*

131 Forty privately owned pet dogs were recruited for this study among the students and staff of the  
132 School of Psychology, Queen's University Belfast, and by word of mouth. Dogs comprised 22 males  
133 (81% neutered) and 18 females (79% spayed) and included a number of different breeds and breed-  
134 crosses. The minimum age of the subjects was 12 months; the oldest dog was 13 years old (mean±SD  
135 4.7±2.95 years).

136

### 137 *2.2 Paw preference test*

138 Following Branson & Rogers (2006), dogs' paw preferences were tested using a medium- or small-  
139 sized (according to dog size) Kong™ ball (KONG Company, Golden, CO, USA), a hollow conical-  
140 shaped rubber toy (Kong, from now on). Before testing, the toy was filled with moist dog food  
141 (Pedigree chum original flavour, Waltham, UK) and frozen overnight. The toys were washed  
142 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  
152 50 occasions (Tomkins et al., 2010). If a dog was too small for the standard step (height 0.18 m; width  
153 1.40 m), i.e. the dog jumped down instead of stepping, we used smaller steps (height 0.05 m; width 1  
154 m). The assistant stood on the upper level of the step next to the dog and held the animal loosely on a  
155 lead. The researcher stood on the base level two meters away and facing the pair. When the dog was  
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  
159 repetitions following the sequence 15-15-10-10. Each time, the assistant alternated her position by  
160 standing on the left or right hand-side of the dog.

161

### 162 *2.3 Personality test*

163 All dogs were tested using a slightly modified version of the Dog Mentality Assessment (DMA) test  
164 (Table 1). The original test includes 10 subtests, carried out in an outdoor area (Svartberg & Forkman,  
165 2002). Due to unstable weather conditions, the test was adapted to be carried out indoors. All subtests  
166 were performed, except ‘Gunshots’, which was considered too stressful from an animal welfare  
167 perspective. Since previous work has shown that this variable is not associated with any personality  
168 trait extracted by a factor analysis (Svartberg & Forkman, 2002), this omission did not compromise  
169 the analysis of the personality traits scores.

170

171 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

#### 180 *2.4 Data management and statistical analysis*

181 All analyses were carried out using IBM SPSS Statistics 21.0.

182

183 Individual paw preference scores were calculated using a binomial test and converted to a  $z$ -score  
184 using the formula  $z = (L - 0.5N) / \sqrt{0.25N}$ ,  $L$  being the number of left paw uses and  $N$  the total of left  
185 and right paw uses. A  $z$ -score  $\geq 1.96$  indicates a left bias, a  $z$ -score  $\leq -1.96$  indicates a right bias; a  
186 value between these two scores indicates no lateral bias (ambilateral) (Branson & Rogers, 2006, Wells  
187 2003). The left-, right- and ambilateral paw preference classification was used to assess departures  
188 from random distribution by applying a Chi-squared test.

189

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  
192 was calculated as  $(L - R) / (L + R)$ , where  $R$  represents the number of right paws and  $L$  the number of  
193 left paws used (Wells, 2003). A score of 0 indicates no bias, a score of  $\pm 1$  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).

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

199 show a greater activity of one hemisphere (irrespective of the side), while weakly lateralised animals  
200 do not show a significant dominance of one hemisphere over the other (i.e. ambilateral) (Rogers,  
201 2000). The absolute value of LI, gives a measure of the strength of laterality, irrespective of the  
202 direction of paw use. A Shapiro-Wilk normality test was used to assess the distribution of LI absolute  
203 values.

204

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

207

208 Associations between the Kong and First-stepping tests on the three lateral bias groups (left, right and  
209 ambilateral) were assessed using a Chi-square analysis, while the consistency between tests for both  
210 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  
213 following personality traits: Playfulness, Curiosity/fearlessness, Chase-proneness, Sociability and  
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  
218 averaging the standardised values of the variables #5, 6, 7, 31 and 32 from subtests 'play 1' and play  
219 2' (Table 1). Table 1 shows which are the representative variables for each personality trait. In  
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.,  
222 2005).

223

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

227

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

232

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

238

### 239 *2.5 Ethical Note*

240 All methods adhered to the Association for the Study of Animal Behaviour/ Animal Behavior Society  
241 Guidelines for the Use of Animals in Research (Association for the Study of Animal Behaviour,  
242 2006). Ethical approval for the study was granted by the Research Ethics Committee, School of  
243 Psychology, QUB.

244

## 245 **3. Results**

### 246 *3.1. Paw preference*

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

250

251

(Table 2 about here)

252

253 The distribution of the three paw preference categories did not differ significantly from that expected  
254 by chance, i.e. there was no population level effect (Kong:  $\chi^2_{2,37} = 0.87, p = .65$ ; First-stepping:  $\chi^2_{2,38} =$   
255  $5.11, p = .08$ ). Even when exploring the direction of laterality (using LI scores), neither test revealed a  
256 population level bias (Kong:  $Z = .84, p = .48$ ; First-stepping:  $Z = .80, p = 0.55$ ; Figure 1).

257

258 (Figure 1 about here)

259

260 Instead, the distribution of the absolute strength of laterality was significantly skewed towards weakly  
261 lateralised animals (median = |0.28|) (Shapiro-Wilk: Kong,  $W = .91, p = .007$ ; First-stepping,  $W=0.92,$   
262  $p = .008$ ).

263

264 Direction and strength of laterality were not significantly affected by the sex of the dogs (Kong:  $Z_{LI} =$   
265  $-.87, p = .39$ ;  $Z_{|LI|} = -.84, p = .40$ ; First-stepping:  $Z_{LI} = -.63, p = .53$ ;  $Z_{|LI|} = -1.06, p = .30$ ).

266

267 Only 34.3% ( $n = 12$ ) of the dogs showed a consistent paw classification between the two tests,  
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  
270 two laterality tests for the three categories of paw use ( $\chi^2_{4,35} = 2.20, p = .70$ ) and there was no  
271 correlation between tests for direction ( $R = -.17, p = .34$ ) or strength ( $R = .19, p = .28$ ) of laterality.

272

### 273 3.2. Personality assessment

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 ( $p \leq .01$ ) 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 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  
284 any of their personality scores ( $p > .05$  for all traits). However, an overall significant relationship  
285 emerged between laterality group and traits of Sociability ( $K = 8.4, p = .02$ ) and Shy-Boldness ( $K =$   
286  $7.3, p = .03$ ) using the First-stepping test (Figure 2). Post-hoc comparisons showed that AL scored  
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-  
289 Boldness:  $Z = -1.35, p = .18$ ). No significant difference was recorded between left- and right-  
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

294 There was one negative correlation (significant after Bonferroni correction ( $p \leq .008$ ) between the  
295 dogs' strength of laterality (|LI|) scores on the First-stepping test and the personality trait of  
296 Sociability ( $\rho = -.50, p = .002$ , Figure 3). Increasing strength of laterality was associated with lower  
297 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  
302 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  
304 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

#### 311 **4. Discussion**

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

318

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  
322 distribution of paw use between lateralised and ambilateral dogs (Marshall-Pescini et al., 2013;  
323 Poyser, Caldwell, & Cobb, 2006; Schneider et al., 2013) and some not (Branson & Rogers, 2006;  
324 Siniscalchi et al., 2008). We also did not find a sex bias on lateral behaviour, which again is in line  
325 with a number of studies (Branson & Rogers, 2006; Marshall-Pescini et al., 2013; Schneider et al.,  
326 2013), and in contrast with others (Poyser et al., 2006; Wells, 2003). Overall, it seems there is still the  
327 need for further investigations to clarify the factors affecting lateral bias in dogs.

328

329 Analysis showed that most dogs (66%) were not consistent in their paw use between the two tasks.  
330 This is consistent with previous results by Tomkins et al. (2010) who reported that only one third of  
331 their subjects consistently used the same paw between tests (i.e. the Kong and the First-stepping test).  
332 Previous papers have also reported low consistency in lateral bias across different tasks, strengthening

333 the hypothesis that paw preference in dogs may be task dependent (Tomkins, McGreevy, & Branson,  
334 2010; Batt, Batt, Baguley, & McGreevy, 2008; Wells, 2003). So far very little insight has been given  
335 on the mechanisms underlying the preferential use of one paw over the other according to task  
336 complexity or nature of challenge, e.g. food on non-food driven, so more work is needed to explore  
337 this further.

338

339 The DMA test was originally tested on a large sample of dogs and the factor analysis based on that  
340 sample extracted the five personality dimensions and a higher Boldness trait that were used in this  
341 study (Svartberg & Forkman, 2002). Given that each dimension was represented by several  
342 behavioural variables, we checked for internal consistency and item-to-total correlation to ensure that  
343 our variables were measuring the same constructs. Cronbach's alpha was acceptably high for all  
344 factors ( $>0.70$ ); Aggressiveness was the lowest (0.65), but Svartberg et al. (2005) found very similar  
345 results (0.67), probably due to aggressive behaviour being very context specific (Christensen, Scarlett,  
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  
356 compared to lateralised dogs (including both LL and RL). The right hemisphere is specialised in  
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  
359 from primates to fish (Austin & Rogers, 2014; Rogers & Andrew, 2002). However, it is also reported  
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  
363 weaker paw preference (as assessed using the Kong Test) were more prone to distress in response to  
364 loud noises than animals that were more strongly lateralised. The Aggressiveness trait in this study  
365 was calculated on the basis of the response elicited by exposing the dog to a series of sudden and  
366 threatening stimuli, e.g. ghost test. Thus, most reactions were fear-driven and associated with a lower  
367 posture and increased distance from the stimuli, which may suggest that weakly lateralised dogs were  
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  
371 could be that ambilateral dogs were overall more reactive to both positive and negative emotionally-  
372 arousing stimuli. The test environment is novel and challenging, which is known to be somewhat  
373 stressful for dogs (Planta & De Meester, 2007). It is worth pointing out that the *p*-value for this  
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  
377 preference categories (Tomkins et al., 2010). These results should therefore be confirmed with a  
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  
384 is associated with a less-bold/more-shy temperament (Hopkins & Bennett, 1994). The strong  
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  
387 unfamiliar person than animals which were more strongly lateralised. When scoring the greeting  
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,  
391 Hsu & Serpell, 2003) to define behavioural categories (Schneider et al. 2013). They found no  
392 correlation between the C-BARQ subscale ‘excitability’ and the strength of laterality. The authors  
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  
395 household), whereas in Batt et al.’s (2009) study there is an element of novelty implicit in the test  
396 situation. This would be in line with our findings, as our dogs were also presented with an unfamiliar  
397 person in a novel environment. Further investigation should be carried out to get more insight on this  
398 aspect.

399

400

#### 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  
405 emotional reactivity such as aggressiveness, fearfulness and sociability, and behavioural laterality.  
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  
412 working dogs) makes the dog a perfect model to further explore the link between different measures  
413 of laterality and personality traits.

414

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550

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  
555 highest cases within 1.5 times the IQR (bottom and top whiskers) and outliers (circles and asterisks).

556 **Figure 2** Comparison between the three laterality groups (left-lateralised (LL), right-lateralised (RL)  
557 and ambilateral (AL)) for the Sociability (a) and Shy-Boldness (b) traits.

558 **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).