Relationship Between Paw Preference Strength and Noise Phobia in *Canis familiaris*

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The authors investigated the relationship between degree of lateralization and noise phobia in 48 domestic dogs (*Canis familiaris*) by scoring paw preference to hold a food object and relating it to reactivity to the sounds of thunderstorms and fireworks, measured by playback and a questionnaire. The dogs without a significant paw preference were significantly more reactive to the sounds than the dogs with either a left-paw or right-paw preference. Intense reactivity, therefore, is associated with a weaker strength of cerebral lateralization. The authors note the similarity between their finding and the weaker hand preferences shown in humans suffering extreme levels of anxiety and suggest neural mechanisms that may be involved.

Keywords: noise phobia, lateralization, paw preference, dog, fear

Functional asymmetries of the cerebral hemispheres have been identified in a number of vertebrate species using various methods, including brain lesions, monocular testing, and turning biases (summarized by Rogers & Andrew, 2002). Observations of hand, or paw, preference have also been used as an indicator of hemispheric asymmetry, particularly in primates (Hopkins & Bennett, 1994) but also in lower vertebrates (Bisazza, Cantalupo, Robins, Rogers, & Vallortigara, 1997). Preferred use of one hand, or paw, is associated with greater activity of the contralateral motor cortex and is presumed to recruit activity in other regions of that hemisphere (Yousry et al., 1995). As demonstrated in primates, use of one hand induces changes in the size and distribution of movement representations in the contralateral motor cortex (Nudo, Jenkins, Merzenich, Prejean, & Grenda, 1992). We know, in humans, that repeated movement of the fingers of one hand increases the blood flow to the contralateral hemisphere (Halsey, Blauenstein, Wilson, & Wills, 1979), which reflects greater neural activity in that hemisphere. Papousek and Schulter (1999) showed that the strength of right-handedness in humans is related to patterns of asymmetrical hemispheric activity, measured by electroencephalogram. Using functional magnetic resonance imaging in humans, it has been shown that strongly lateralized subjects exhibit cortical activation of the primary and supplementary motor area contralateral to the hand being moved to grasp an object, whereas the ipsilateral hemisphere was more active in ambilateral subjects (Nakada, Fujii, & Kwee, 2004).

Hand preference, in animals, is associated with temperament and the type of behavior expressed in novel contexts: Marmosets (Cameron & Rogers, 1999) and chimpanzees (Hopkins & Bennett, 1994) with a left (L)-hand preference to pick up and hold food have been shown to interact with novel objects less readily than those with a right (R)-hand preference. Moreover, positive correlations have been shown between left-handedness and levels of submissive behavior and the incidence of receiving aggression in male rhesus macaques (Westergaard et al., 2003), although we note that the same authors identified the opposite relationship in female rhesus macaques (Westergaard et al., 2004). A relationship has also been found between the use of one hand and the expression of emotion in humans: Schiff and Lamon (1994) found that contractions of the L hand led to the expression of negative emotions such as sadness, whereas contraction of the R hand led to the expression of positive emotions such as a feeling of well-being.

Because L-pawed animals generally seem to show behavior patterns consistent with the known functions of the right hemisphere and R-pawed animals show behavior patterns consistent with the known functions of the left hemisphere, our initial hypothesis was that L-pawed dogs might be more fearful of loud noises than R-pawed dogs.

Measurement of physiological parameters has also identified asymmetrical (right hemisphere) control of the hypothalamic-pituitary-adrenal axis in humans (Henry, 1997; Spivak, Segal, Mester, & Weizman, 1998), rhesus macaques (Buss et al., 2003), and rodents (Betancur, Neveu, Vitiello, & Le Moal, 1991; Sullivan & Gratton, 2002). The sympathetic-adrenomedullary axis is also considered to be under the dominant control of the right cerebral hemisphere (Adamec & Morgan, 1994; Wittling, 1997). In general, therefore, the right hemisphere is associated with the expression of intense, often negative, emotions and the control of the hormonal states that accompany these emotional states (Davidson, Marshall, Tomarken, & Henriques, 2000).

However, because recent research has described the advantages of being strongly lateralized compared to weakly lateralized (Rogers, Zucca, & Vallortigara, 2004), we also considered the possi-

bility that the canine behavioral disorder of noise phobia might be associated with weak or absent paw preference. The main finding on which we based this idea was that nonlateralized chicks are unable to perform two tasks simultaneously (discriminating pebbles from grain and being vigilant for a predator), whereas lateralized chicks can perform both tasks well (Rogers et al., 2004). The nonlateralized chicks also made more distress calls in response to seeing the predator (Dharmaretnam & Rogers, 2005), indicative of elevated fear responsiveness.

Noise phobia involves the expression of excessive fear in response to a sound stimulus (Shull-Selcer & Stagg, 1991). Dogs with noise phobia are said to display a level of fear that is relative to the intensity of a sound (Overall, 2002). For instance, low-grade fear responses might include pacing, panting, and staying close to the owner; as the intensity of the stimulus increases, the dogs may exhibit more extreme responses and even sustain physical injuries while attempting to flee by digging or jumping through glass windows (Voith & Borchelt, 1985). The phobic response may also involve freezing for long periods of time (Murphree, Dykman, & Peters, 1967; Voith & Borchelt, 1985). In fact, there is considerable variation in the responses of noise-phobic dogs to particular sounds (Beerda, Schilder, van Hooff, & de Vries, 1997). Although no specific data are available on the prevalence of noise phobia in the domestic dog population, it is not uncommon and it is generally accepted that all dog breeds and both sexes are susceptible to noise phobias (Overall, Dunham, & Frank, 2001; Voith & Borchelt, 1985).

Of relevance to our study of lateralization and noise phobia, Watson, Clark, and Tellegen (1988) reported that less lateralized humans are more prone to experience maladaptive levels of anxiety than are more strongly lateralized individuals. There are also reports of a higher proportion of less lateralized individuals presenting with psychosis (Chapman & Chapman, 1987), schizophrenia (Crow, 1997), alexithymia, and post traumatic stress disorder (PTSD; Parker, Keightley, Smith, & Taylor, 1999; Spivak et al., 1998; Zeitlin, Lane, O'Leary, & Schrift, 1989). Given that alexithymia and PTSD are associated with the expression of extremely intense emotions, they may provide a comparison with noise phobia in the dog, as suggested by Overall (2000) and Thompson and Shuster (1998). Because human patients with alexithymia and PTSD have been found to show a higher incidence of ambilaterality and that this has been linked to impaired interhemispheric communication (Parker et al., 1999), we thought that investigating the relationship between noise phobia and brain lateralization in dogs might extend our understanding of the relationship between brain activity and emotional behavior.

We categorized dogs as L-pawed, R-pawed, or ambipreferent (A) using a new test that avoided the lengthy procedures used in previous studies (Quaranta, Siniscalchi, Frate, & Vallortigara, 2004; Tan, 1987; Wells, 2003). In addition, we assessed their reactions to thunderstorms and fireworks.

Method

Subjects

Access to 48 healthy adult dogs (*Canis familiaris*; 24 male and 24 female) was obtained through veterinary practices in Geelong, Victoria, Australia. All of the dogs had been neutered surgically. Their ages ranged from 2 to 15 years (mean $\pm$ *SEM* = 6.7 $\pm$ 1.69 years), and the group was a mixture of pure and crossbred dogs of small, medium, and large body size.

Paw Preference Testing

Each dog was visited at its owner's home by the observer (N. J. Branson) and presented with a Large Classic Kong, which is a hollow, 10-cm long, conical shaped, firm rubber tube with a 10-mm hole at one end and a 25-mm hole at the other end (Kong Company, Golden, CO). Although none of the dogs were specifically food deprived, most had not eaten for 12–18 hr before being presented with the Kong. To encourage paw use, we filled the Kong with chicken and rice sausage meat and presented it to each dog on a flat surface. The dog's use of the L or R forepaw or both forepaws together (B) to hold the Kong while eating its contents was recorded until a total of 100 L plus R scores had been collected from each dog (i.e., irrespective of the number of B scores). A single score of L or R paw use was recorded irrespective of how long a paw remained on the Kong. The intervening events separating scores of paw use included moving the paw(s) from the Kong and then replacing it on the Kong shortly after it had been moved from the Kong, and performing another unrelated behavior between holding the Kong with the paws. If the dog pushed the Kong with the nose so that it came to rest against a foreleg or if it rolled against a foreleg, no score of paw use was recorded. To prevent any form of social reward (verbal or tactile) from affecting the dog's performance on the task, the observer ensured no interaction took place during testing.

The average time to collect these data was 30 min per dog. For 36 (75%) of the dogs, this was achieved in one scoring session. The remaining 12 dogs required a second 30-min scoring session applied a week later. Repeat measures of 100 paw scores collected 6 months after the first scores were also recorded for 26 of the dogs in this study, selected randomly from the total group of 48. The second test was performed to check whether dogs expressed the same paw preference on both tests.

A third test involving measurement of paw preference on a natural task was applied to another, randomly selected, subsample of 15 dogs. Scores were collected while the dog held down a bone while chewing it. This test was conducted 9 months after the first Kong test. Each dog was presented with a raw beef bone approximately 30 cm long, and the unimanual (L and R) and bimanual (B) forepaw use to hold the bone was recorded until a total of 100 L plus R paw uses had been collected for each dog. As for the Kong task, L or R paw use was recorded when a paw was placed or replaced on the bone to hold it in position to allow the dog to chew it.

Questionnaire Rating Responses to Fireworks and Thunderstorms

The dog owners were asked to complete a questionnaire to grade their opinion of each dog's responses to thunderstorms and fireworks. Owners were required to respond with either a "yes" or a "no" to questions asking whether their dog displayed any of the following listed behavioral types: shaking of the body, dilated pupils, panting, salivating, urinating, defecating, ears back, corners of the mouth retracted down and back, tail between the legs, running away, hiding, seeking attention, or barking. Each yes response was allocated a score of 1, and the total for each dog was used to generate a response index, henceforth referred to as the *questionnaire noise score*. The highest possible score was 13, and the lowest score was 0. All 48 dogs were assessed using this procedure.

Response to Playback of Fireworks and Thunderstorms

An audio recording of the sounds of thunderstorm and fireworks (Sound Design Studios, 2000) was played to a subsample of 31 dogs (also selected at random from the larger group) in their home environment. These experiments were also performed 9 months after the first Kong test. To

balance the procedure for any possible order effect, we played the thunderstorm first to 16 of the dogs and played the fireworks first to 15 of the dogs. Each sound was played for 2 min at a volume of 80–100 db (measured with a Precision Sound Level Meter, Type 2206, Brüel & Kjær, Nærum, Denmark at 1 m from the speakers in a soundproof room). A 5-min interval was allowed between each playback. The observer (unaware of the questionnaire noise score at the time) recorded the dog's response to the playback using a scoring sheet ranking the responses as listed above for the questionnaire.

The same subsample of 31 dogs was tested again 2 months after this experiment in the same manner but this time including a playback of white noise as well as the fireworks and thunderstorm, the order of presentation being random. All three sounds were played at an intensity of 80 dbA for 2 min, and there was a 5-min interval between each presentation. This second test was given to see whether the pattern of responses might remain the same even though habituation might occur and whether the dog's noise reactivity would generalize to white noise.

Experiments were conducted in accordance with the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes* (National Health and Medical Research Council, 1997) and were approved by the University of New England Animal Ethics Committee.

Statistical Analysis

The first 100 L or R paw scores were used to calculate a binomial z score for each dog to determine whether the paw preference differed significantly from chance. The formula used to calculate this was $z = (R - 0.5N)/\sqrt{(0.25N)}$, where R signifies the number of R paw uses and N signifies the sum of L plus R paw uses. Dogs with a positive z score value ≥ 1.96 were R-pawed, those with a negative z score value ≥ 1.96 were L-pawed, and the remainder were ambilateral, A (showing no paw preference). The use of both paws together was also determined as a percentage of the total number of unimanual (L plus R) plus bimanual (B) scores. The values for %B were arcsine transformed prior to statistical analysis to meet parametric assumptions.

A handedness index (HI) was also calculated for each dog (L − R/L + R); hence a score of 1.0 represents exclusive use of the L paw and −1.0 exclusive use of the R paw. The absolute value of HI is the strength of paw preference with the highest possible value of 1 indicating the exclusive use of either the L or R paw. The lowest possible HI score is 0 indicating equal use of the L and R paws.

For all statistical tests, Minitab 13.1 (Minitab Inc., State College, PA) was used, and the results were considered significant if $p \leq .05$. A Ryan–Joiner test on the questionnaire noise scores ($p > .10$) and a Levene's test for equal variance ($p = .85$) found no evidence to suggest that the data were not normally distributed. Paw preference classifications (L, A, or R) and sex were compared with regard to the questionnaire noise score using the generalized linear model (GLM) procedure for analysis of variance (ANOVA). Post hoc testing was performed using Tukey's tests. The group effect size is given by the statistic omega-squared (w_2) for all fixed-effect ANOVAs and by partial eta-squared (η_p^2) for the repeated measures ANOVAs.

Results

Paw Preference

The z-score calculations of data collected on the 48 dogs tested on the Kong test identified 21 dogs as being significantly L-pawed, 16 as significantly R-pawed, and 11 as ambilateral. There was a significant negative correlation between %B and the strength of paw preference determined when only one paw was used at a time, $r(48) = -.44$, $p < .002$: Dogs with weaker paw preferences

determined from unilateral scores used both paws together (%B) more often than dogs with stronger paw preferences.

The alternation of L and R paw use was analyzed using the Wald–Wolfowitz runs test to identify whether or not each dog's use of the L and the R paw was in bouts. No significant runs were found for any dog ($p > .05$).

Repeat Paw Preference Testing

To ascertain whether the Kong paw preference was a stable individual characteristic, we applied a repeat Kong test of paw preference to a subsample of 26 dogs, 6 months after the first test: Pearson correlation of the HI scores, $r(26) = 0.9$, $p < .001$ (see Figure 1A). There was also a positive and statistically significant correlation between the HI determined in the first Kong test and HI determined for holding the bone, $r(15) = 0.96$, $p < .001$ (see Figure 1B). Hence, the measure of paw preference was a stable characteristic of the dogs.

Relationship Between Paw Preference and Questionnaire Noise Score

The scores obtained by the questionnaire were analyzed by GLM with the variables paw preference (L, A, R) and sex. There was a significant main effect of paw preference, $F(3, 47) = 4.42$, $p = .02$, $\omega_2 = 0.1$, but no significant effect of sex, $F(1, 48) = 3.08$, $p = .09$, $\omega_2 = .04$, and no significant interaction between sex and paw preference, $F(2, 48) = 0.55$, $p = .58$, $\omega_2 = 0.08$. Post hoc Tukey testing found a significantly greater questionnaire noise score for ambilateral dogs compared with L-pawed dogs, $t(30) = -2.85$, $p = .02$, and R-pawed dogs, $t(25) = -2.53$, $p = .04$ (see Figure 2). There was no significant difference between the scores for L- and R-pawed dogs, $t(35) = 0.19$, $p = .98$.

The scores for the strength of paw preference were correlated with the questionnaire noise score, and a significant negative relationship was found, $r(48) = -.34$, $p = .02$. The correlation between %B and questionnaire noise score was not significant, $r(48) = .11$, $p = .52$.

Relationship Between Questionnaire Scores and Measured Reactivity to Playback of Sounds

The mean reactivity scores determined in the first test in which sounds (thunderstorm and fireworks) were played correlated positively with the owner-derived questionnaire noise score, $r(31) = 0.8$, $p < .001$ (see Figure 1C). A GLM analysis with the variables paw preference (L, R, ambilateral) and treatment (thunderstorm vs. fireworks sounds, as repeated measures) revealed that paw preference had a significant main effect on the reactivity to the sounds of thunderstorm and fireworks, $F(2, 30) = 9.58$, $p = .001$, $\eta_p^2 = 0.41$ (see Figure 3). Treatment (thunderstorm vs. fireworks) had no significant main effect, $F(1, 30) = 0.01$, $p = .75$, $\eta_p^2 = 0.004$, and there was no significant treatment by paw preference interaction, $F(2, 28) = 1.0$, $p = .38$, $\eta_p^2 = 0.07$. An a posteriori Tukey's test showed that there was no difference between L- and R-pawed dogs, and that both L- and R-pawed dogs differed from ambilateral dogs ($p < .05$).

A significant main effect of paw preference was also identified in the second playback test, $F(2, 29) = 6.26$, $p = .006$, $\eta_p^2 = 0.32$
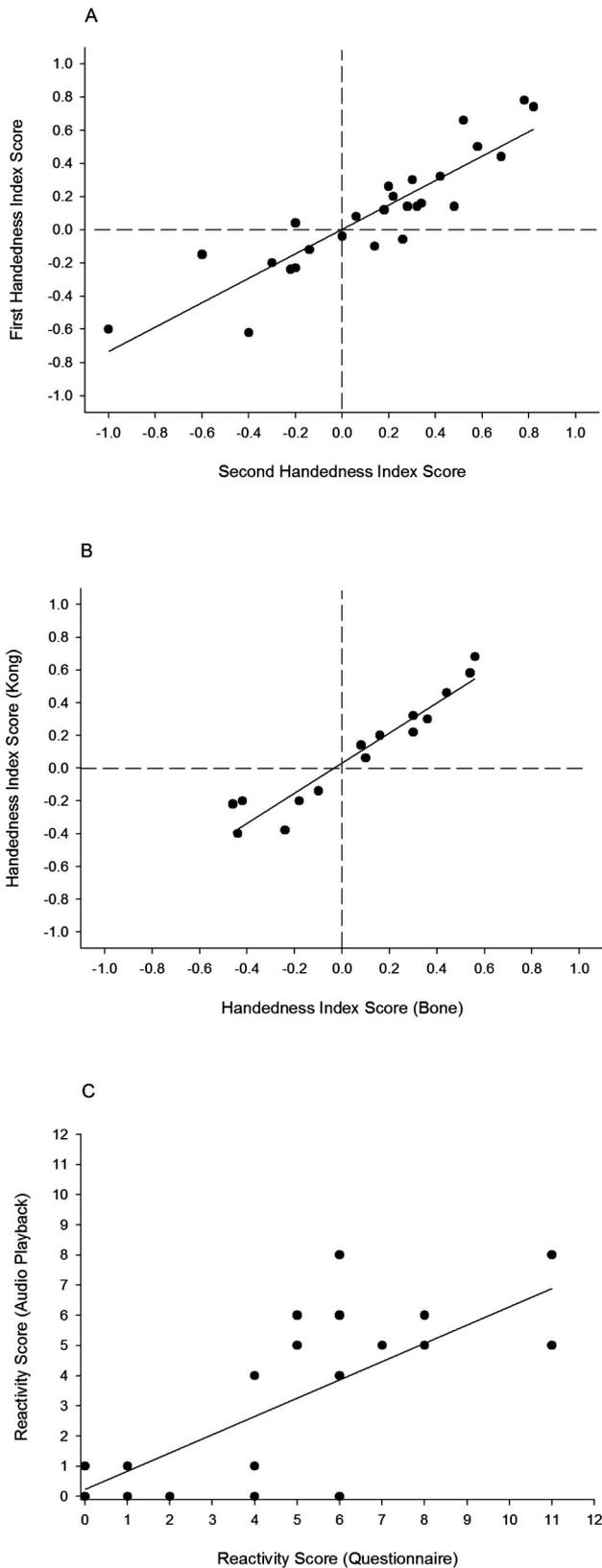
Figure 1. Data for the significant correlations discussed in the text. A: Scores for direction of paw preference on two occasions separated by 6

(see Figure 3), using the mean score for reactivity to thunderstorm and fireworks. An a posteriori Tukey's test identified a significant difference between the scores for the L-pawed and ambilateral dogs ($p < .001$) and between scores of the R-pawed and ambilateral dogs ($p < .001$) but no significant difference between L- and R-pawed dogs ($p = .59$).

The reactivity scores obtained in the second playback test were also analyzed separately for each sound stimulus using GLM. There was no significant effect of treatment (thunder, fireworks, or white noise), $F(2, 29) = 2.04$, $p = .14$, $\eta_p^2 = 0.07$, and no significant interaction between treatment and paw preference, $F(4, 86) = 0.61$, $p = .66$, $\eta_p^2 = 0.04$ (see Figure 4). This suggests that the dogs responded as much to the white noise as to the sound of fireworks and the sounds of a thunderstorm. However, this result may be misleading because the majority of dogs did not respond to white noise. Those that did respond (6 out of 31) responded quite strongly: note the high variability of responses to white noise shown in Figure 4.

There was a positive correlation between the responses given to fireworks and thunderstorms in the first playback test and the repeat of this test, $r(31) = .66$, $p < .001$. However, the reactivity of the dogs was lower in the second test than in the first test: fireworks, $t(31) = 3.7$, $p = .001$; thunderstorms, $t(31) = 3.95$, $p = .001$ (see Figures 3 and 4). Nevertheless, the same pattern of responses was recorded for both playback experiments.

Discussion

The distribution of paw preferences of the dogs tested was 44% L, 33% R, and 23% ambilateral. Although there were more L-pawed dogs in the population, there was no obvious population bias. This result is consistent with two other studies also showing no population bias for paw preference in domestic dogs (Quaranta et al., 2004; Wells, 2003). However, one finding that differs between these latter two studies and our study was that we did not find an association between sex and paw preference. Wells (2003) found that lateralized behavior was sex related, with male dogs being more inclined to use the L paw and female dogs more inclined to use the R paw. Quaranta et al. (2004) also found that male dogs were more likely to be L-pawed, and female dogs showed a nonsignificant trend to use their R paw. Wells (2003) and Quaranta et al. (2004) included only sexually entire dogs in their sample, whereas we tested surgically neutered dogs. Although the effect of surgical neutering on paw preference has not been investigated, the pattern of these results suggests that sex hormone status may be influential.

months for 26 dogs. In both cases, the preferences were determined using the Kong test. There was a strong positive correlation between the two data sets, indicating that this measure of paw preference is a stable individual characteristic. B: Scores for handedness index determined on the first Kong test and when the dog was eating a bone ($N = 15$). Note the strong positive correlation. C: Mean reactivity scores determined for each dog in the first test involving playback of the sounds of a thunderstorm and fireworks plotted against the reactivity score obtained from the questionnaires completed by the owners. The correlation is positive and significant.
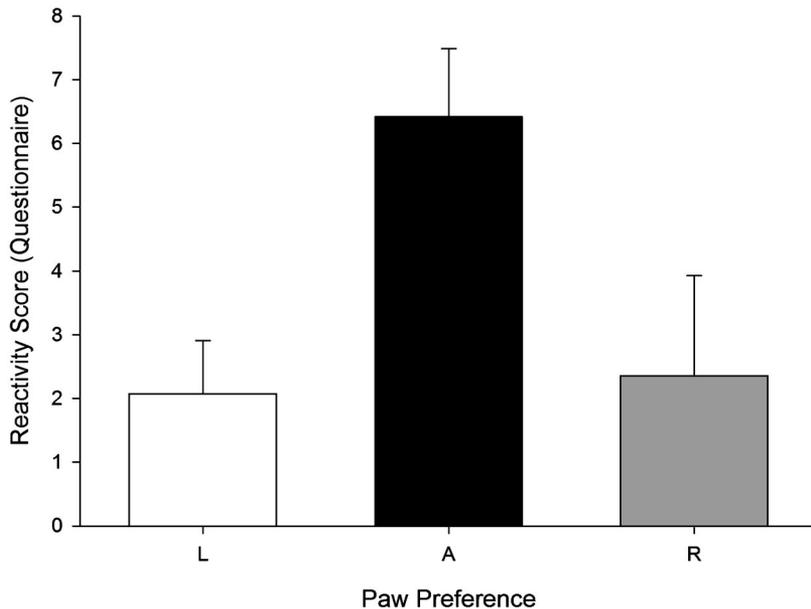
Figure 2. Data for the mean (and 95% confidence interval) score of noise reactivity determined from the questionnaires completed by the owners for each paw preference group: L-paw preferring group (L) is represented as the white bar, the ambilateral group (A) by the black bar, and the right-paw preferring group (R) by the gray bar. It can be seen that the reactivity to thunderstorms and fireworks is much higher in the ambilateral group.

We found that the scores of L and R paw use to hold the Kong were not influenced by runs or bouts and also that the paw preference measure was a repeatable individual characteristic. Strong positive and statistically significant correlations were found between the paw preference scores on the first and second Kong tests, separated by 6 months, and also between scores on the Kong tests and in the test using a bone, demonstrating a likely relevance to naturalistic behavior.

The paw preferences were associated with reactivity to noise. Ambilateral dogs had higher scores of reactivity to thunderstorms
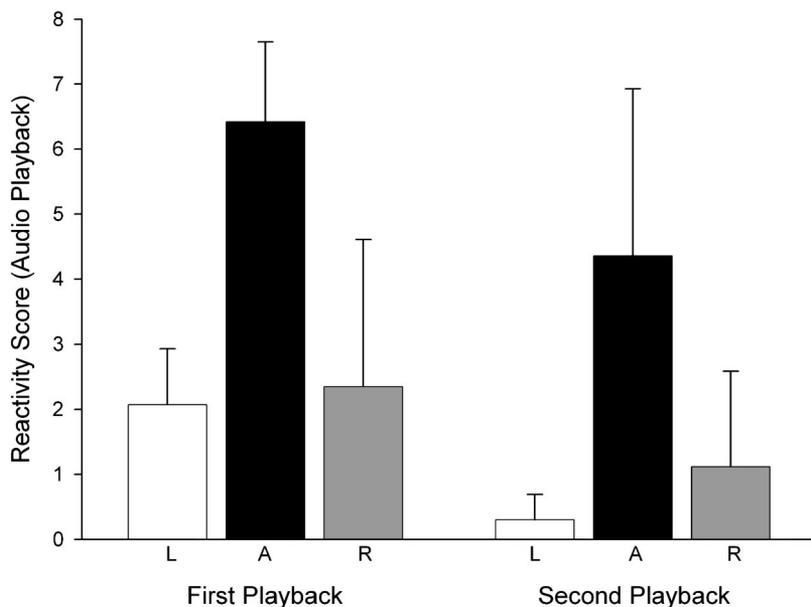

Figure 3. The mean (and 95% confidence interval) thunderstorm and fireworks audio playback scores (white noise is not included) plotted for each paw preference group. Note that the same pattern of greater reactivity in the ambilateral group (A) compared with the left-paw (L) and right-paw (R) preferring groups is seen for both playback tests. The reactivity was lower to the second playback compared with the first.
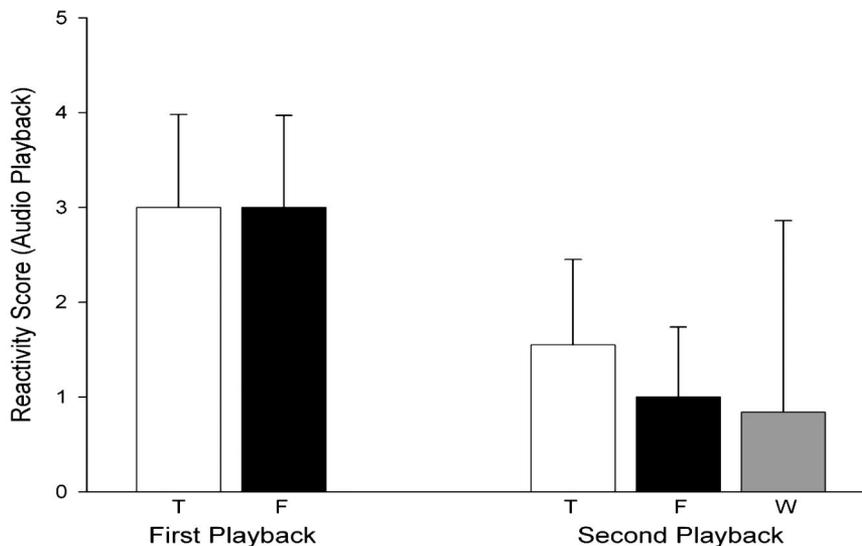
Figure 4. The mean (and 95% confidence interval) results of the two playback experiments showing the differences in reactivity to the different sounds. T refers to thunderstorm, F to fireworks, and W to white noise. The scores for all dogs are presented, irrespective of the paw preference. Note that reactivity to both the thunderstorm and fireworks is equivalent in playback tests. The dogs' reactivity was lower in playback Test 2, and there was no significant difference in reactivity to any of the sounds. Nevertheless, the larger variability to white noise should be noted: Most dogs did not react to white noise.

and fireworks, as rated by their owners, than either L- or R-pawed dogs. Consistent with this, a significant negative correlation was found between the owner's score for sound reactivity and the strength of paw preference. The latter result confirms that, independent of the criteria used to group dogs as L-pawed, ambilateral, or R-pawed, dogs with weaker paw preference show greater reactivity to thunderstorms and fireworks. Hence, the results do not support the first hypothesis that L-pawed dogs might be more reactive to these sounds but support our second hypothesis of greater reactivity in dogs with weaker hemispheric lateralization.

The playback experiments were designed to provide an objective measure of the dogs' reactions to acoustic stimuli. Although differences exist between a playback of a sound recording and the actual events of thunderstorms and fireworks, this technique has been used to categorize the reactivity of dogs to sounds (Crowell-Davis, Seibert, Sung, Parthasarathy, & Curtis, 2003) and to desensitize and countercondition dogs with noise phobia (Overall, 2002). We found a positive and statistically significant correlation between the owner-rated reactivity scores and the measured reactivity in the playback experiments. Our results for playback showed a significant association between paw preference and the scores for reactivity to the sounds of thunderstorms and fireworks. Ambilateral dogs reacted more strongly to hearing these sounds than did L- or R-pawed dogs.

The scores in the second playback experiment were lower than those for the first playback, showing that a degree of habituation occurred despite the fact that 60 days separated these two tests. In the only (published) study available for comparison, Crowell-Davis et al. (2003) did not record any difference between the dog's response to a first and second playback of thunderstorm sounds and fireworks when the presentations were separated by 120 days. It may be relevant that our playback experiments were carried out

in the dog's home environment, whereas the study by Crowell-Davis et al. took place at a veterinary clinic.

Despite the lower reactivity scores in our second playback test, the relationship between the reactivity score and paw preference was the same as determined in the first test. Hence, the consistent relationship identified between paw preference and reactivity to sound, measured by owner report and by the two playback tests, provides substantial evidence of weaker paw preference being associated with greater sound reactivity.

In the first playback experiment, there was no significant difference between the dogs' responses to playback of the sound of either a thunderstorm or fireworks. In the second experiment the dogs were tested with the sounds of thunderstorms, fireworks, and white noise, all at the same intensity. Figure 4 shows a nonsignificant trend for the reactivity to playback of the thunderstorm sounds to be higher than that for fireworks and also for white noise. Playback for white noise was its first presentation, compared with repeat playback of the other two sounds, which might suggest that the dogs were less reactive to it than to thunderstorms and fireworks. Also, the reactivity to white noise was more variable than to the other two sounds: Most dogs made no response to the white noise but some dogs, particularly in the ambilateral group, reacted strongly to it. In fact, white noise played at a sound intensity similar to that used in our experiment has been found to stimulate the hypothalamic-pituitary-adrenal axis in dogs (Engeland, Miller, & Gann, 1990).

We also scored simultaneous use of both paws (%B) to hold the Kong. A significant negative correlation was found between %B and the strength of unimanual paw use (absolute value of HI): Dogs with a weaker preference were also more likely to use both paws together. However, there was no significant relationship between %B and reactivity to noise, likely because of the corre-

lation between %B and strength of paw preference being mild rather than strong.

The issues we addressed in this study were whether (a) the presence or absence of lateralization or (b) a lateralized bias to prefer the L or R paw is associated with the expression of extreme reactivity to noise, and our results supported the first hypothesis. As mentioned in the introduction, other studies have identified behavioral differences between lateralized and nonlateralized individuals. Of these studies, one of the most relevant for comparison with our results showed that chicks that are nonlateralized for processing visual information produce more distress calls in response to seeing a simulated predator than do lateralized chicks (Dharmaretnam & Rogers, 2005). It seems possible that nonlateralization of neural functions may be associated with intense emotional responses to a broad range of stimuli. One way of inhibiting an intense emotional response to a disturbing stimulus is to shift attention to another, less disturbing stimulus, and, from research on chicks (Rogers et al., 2004), it seems that a lateralized brain is able to do this more successfully than a nonlateralized brain.

Here we note that dogs exhibit behavioral disorders that may be homologous to some psychiatric disorders in humans (Overall, 2000; Thompson & Shuster, 1998) and that, as well as showing an increased incidence of ambilaterality, PTSD patients show a bidirectional interhemispheric transfer deficit (Parker et al., 1999; Zeitlin et al., 1989). Noise phobia in dogs might depend on a similar central nervous system mechanism, although absence of asymmetry at the level of the amygdala may be as important as at the cortical level, given the role of the amygdala in emotion (Baas, Aleman, & Kahn, 2004). The antecedent events to noise phobia and ambilaterality would be interesting to determine because it is known, in rodents, that early experience (handling and an enriched environment) has a long-term impact on lateralized brain function (Denenberg, 1981) and the direction of paw preference (Tang & Verstynen, 2002).

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