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1 **The scent of enrichment: Exploring the effect of odour and biological salience on**
2 **behaviour during enrichment of kennelled dogs**

3
4 **Short title: Scent enrichment for kennelled dogs**

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14

15 **Abstract**

16 Worldwide, millions of dogs are held in kennels for extended periods of time and may
17 experience compromised welfare. Enrichment, often using toys, is considered important to
18 minimize the negative impacts of kennelling. However, the value of this enrichment may be
19 based on various sensory facets of such toys and untangling the relative contributions is a
20 residual challenge. Therefore, improving the utility of toys as enrichment is contingent on an
21 improved understanding of the relationship between the properties of a toy and a dog's
22 interaction with it. The present study aimed to evaluate the addition of two different scents to
23 toys, both presumed to have a different level of biological salience. The behaviour and level of
24 toy engagement of 44 singly housed dogs in a rehoming centre was compared amongst no-toy
25 (NT), unscented-toy (T) and scented-toy (T+) treatments. For T+ two scents were used: rabbit
26 (T+R) and lavender (T+L). Toys were colour and type-matched for each treatment. Many of
27 the datasets were zero-inflated therefore a Hurdle analysis was used to explore the relationships
28 amongst the treatments. Non-zero inflated behavioural data were analysed using a Linear
29 Mixed Model to discern treatment effect. Dogs were significantly more likely to interact, and

30 interacted for longer, with scented toys. This was both in comparison to periods when only
31 unscented toys were present and when both scented and unscented toys were simultaneously
32 presented. However, there was no difference in response to the rabbit or lavender scented toys.
33 Provision of scent also significantly reduced stress related behaviours and increased
34 exploration. However, alterations in behaviour were not directly related to likelihood or amount
35 of toy use, suggesting the scents were altering behaviour through means other than increasing
36 physical enrichment use. These findings suggest that augmentation of toys using scents may
37 improve engagement of dogs with them, and positively affect behavioural welfare indicators
38 in the kennelled environment. The use of novel scents may therefore promote better welfare in
39 kennels irrespective of their presumed biological salience, but differing scents should be further
40 trialled.

41

42 **Keywords:** Dog; Enrichment; Olfaction; Shelter; Toy; Welfare

43

44 **1. Introduction**

45 Globally, the annual number of dogs entering shelters is likely to be vast, e.g. within the United
46 Kingdom (UK) the number exceeds 89,000 (Stavisky et al., 2012). The majority of dogs
47 entering kennels are likely to exhibit signs of distress at some point during the process
48 (Hennessy et al., 1997; Part et al., 2014; Rooney et al., 2007). Sources of stress range from
49 confinement in limited spaces; lack of complexity in kennel housing; the continuing (though
50 changing) practice of single-housing of a social animal; limited human contact, especially in
51 the most beneficial manner of prolonged petting contact; and overstimulation, particularly in
52 relation to dangerously loud levels of barking induced in a kennel environment (Taylor & Mills

53 2007). The lack of control and predictability for dogs in this environment are considered to be
54 prime sources of stress (Taylor & Mills, 2007), and are generally major factors underpinning
55 stress (Koolhaas et al. 2011). Continuing stress, and the associated behaviours, may decrease
56 the likelihood of adoption and increase time at shelter, based on public perception of dogs
57 favourable for adoption being calm but interactive (Protopopova and Wynne, 2014; Wells and
58 Hepper, 1992). This has significant implications for the long-term welfare of kennel-housed
59 dogs.

60 One means of reducing undesirable impacts of the kennelled environment might be to provide
61 enrichment. However, reports concerning enrichment for kennelled dogs are equivocal. In-
62 kennel training sessions of 20-45 minutes per dog have been shown to decrease the magnitude
63 of negative behavioural change, such as increased jumping and barking (Hennessy et al., 2002;
64 Coppola et al., 2006; Herron et al., 2014). Studies of shorter sessions of human interaction (2
65 minutes daily) were found to have no significant effect on stress (Conley et al., 2014). Dogs
66 walked for fifteen minutes one day a week were more likely to stand at the front of the kennel
67 and wag their tails in response to people, however no clear effect was found on welfare
68 measures (Normando et al., 2009). Many centres are full (Stavisky et al., 2012) meaning staff
69 may not have opportunity to apply time-consuming enrichment techniques for each dog. As a
70 result, some kennels may opt to put dogs in pens to exercise alone (Association of Dogs and
71 Cats Homes (ADCH), 2015; Royal Society for the Prevention of Cruelty to Animals (RSPCA),
72 2015). Unfortunately, a study by Cafazzo et al. (2014) found that whilst being taken for a walk
73 had a positive impact on welfare, time in a pen did not.

74 Many rescue centres use toys and chews (a subset of toys designed specifically to be chewed)
75 as a quick, easily implemented, enrichment strategy (ADCH, 2015; RSPCA, 2015). The
76 evidence for their efficacy is, however, mixed (e.g. see Wells 2004b). Some studies have
77 demonstrated small, but measurable, positive behavioural influences of a range of toys (e.g.

78 increasing activity levels) (Wells 2004a). But the most convincing studies have found evidence
79 in laboratory-housed dogs rather than rescue shelter dogs, potentially due to the relatively low
80 frequency of stimulation in the former versus the latter (Wells 2004b). More commonly, dogs
81 seem to prefer food-based enrichment to toys (Döring et al., 2016a). In addition, chews and
82 toys have been known to cause injury, cannot be used for group-housed dogs due to resource
83 guarding and do not engage all individuals (Döring et al., 2016b; Schipper et al., 2008). When
84 non-food related toys have been used the majority of dogs do not interact with them (Wells and
85 Hepper, 1992) and those that do spend relatively little time doing so (Pullen et al. 2010; Wells
86 and Hepper, 2000), nor do they have a significant impact on behaviour (Wells, 2004b; Wells
87 and Hepper, 2000). Therefore, it appears that motivation for toy-use is low, potentially in part
88 because toys do not adequately mimic the multi-component stimuli of naturally arousing
89 objects.

90 Domestic dogs have a highly developed sense of smell (Goodwin et al., 2010; Cornu et al.,
91 2011) and may, therefore, benefit from olfactory stimulation. Olfactory enrichment in canids
92 has, historically, received little attention. Dogs have been shown to respond to diffused
93 essential oils (Graham et al., 2005b) where lavender caused dogs to spend more time resting
94 and less time vocalizing whilst rosemary and peppermint resulted in more movement and
95 vocalization. Similarly, research using a limited sample of dogs, suggested that the provision
96 of plant-based compounds may be successful in reducing negative behaviours (i.e.
97 vocalization) and overall activity (vanilla, valerian, coconut and ginger) whilst promoting sleep
98 (coconut and ginger; Binks et al., 2018). Olfaction-based products, specifically designed to
99 promote behavioural change in dogs (i.e. Dog-Appeasing Pheromone (DAP)), have been
100 shown to have relatively little impact in shelters (Hermiston et al., 2018). Therefore, further
101 study of olfactory enrichment to improve the welfare of kennelled dogs seems fertile ground,
102 especially if considering other non-plant-based scents which may have greater biological

103 relevance (e.g. those associated with prey species). For example, placing Grant's gazelle
104 (*Gazella granti*) dung outside African wild dogs' (*Lycanone pictus*) enclosure led to more
105 activity and pro-social behaviour. Scented items and herb water had other effects, increasing
106 activity levels and scanning and sniffing behaviour but not reducing abnormal behaviours
107 (Price, 2010). The addition of cat urine to a toy cat did not increase the dogs' interest as
108 compared to an unscented version but did increase sniffing of a pillow which had previously
109 elicited less interest than the toy (Hoffman et al., 2017). This suggests scent can add salience
110 to items that dogs might otherwise have little motivation to interact with.

111 Previous studies have looked at scent enrichment or scent-enriched object effects on
112 behaviour/welfare in kennel-housed dogs (e.g. Binks et al. 2018; Graham et al. 2005) but the
113 present study is the first study designed to assess the impact of scent as a component of toy-
114 based enrichment for kennelled dogs. It was hypothesised that enrichment with toys would
115 have a positive behavioural impact. Furthermore, it was considered that scents applied to the
116 toys (lavender and rabbit), with the latter having the potential to be more biologically salient,
117 would have an additional and beneficial effect.

118

119 **2. Materials and methods**

120 *2.1 Subjects*

121 The study used 44 kennelled dogs that had been relinquished to Dogs Trust Darlington (UK)
122 rehoming centre from October to February 2015-16. All subjects had been at a rehoming centre
123 for at least seven days (median: 2.5 weeks, range: 7 days-5 years) and individually housed (on
124 the recommendation of the centre's behaviourist) and in their current kennel for 24h.
125 Individuals were all older than one year (modal age range 2-5 years), considered to be in good

126 health and had been neutered. Where the age of the dog was unknown, a veterinarian provided
127 an estimated range. Of the sample, 26/44 were male and the majority of dogs (32/44) were
128 crossbreeds.

129 *2.2 Daily husbandry*

130 Dogs were housed in parasol-style kennel blocks (i.e. with individual kennels radiating out
131 from a central service area) with separate indoor (3.7m²) and outdoor (5.9m²) areas. The
132 kennels were furnished with blankets, dog beds and a variety of toys. Dogs were fed at 0800h
133 and 1630h. Kennels were cleaned between 0830h and 1100h, following which dogs were taken
134 for a short walk or placed in a grass run. All trials were carried out after cleaning and before
135 the dog had been exercised.

136 *2.3 Procedure*

137 Scents were added to standard toys and the dogs' interactions compared to unscented versions.
138 Data were also collected in the absence of any toys. Rabbit (*Oryctolagus cuniculus*) and French
139 lavender (*Lavandula stoechas*) scents were selected due to them being safe for use with dogs,
140 easy to acquire and low cost.

141 Each dog took part in three treatments on the same day, with a break of at least 10 minutes
142 between them. Each treatment lasted for 20 minutes and the order was counterbalanced to avoid
143 order effects. All trials were carried out on a Wednesday when the centre was closed to the
144 public. Staff were instructed not to enter or walk directly past the kennel during a trial, but were
145 still active generally around the site. The experimenter was also out-of-view during trials, after
146 setting up the camera and placing the toys. Dogs were restricted to the outside area of their
147 kennel during test sessions, and confined to the inside area during changes of treatment.

148 Confining the dogs for short periods in this way is in line with other standard husbandry
149 procedures at the centre (e.g. cleaning).

150 The three experimental periods were: 1. 'no toys' (NT), all toys (if any were present) were
151 removed leaving no toys in the kennel; 2. 'unscented toys' (T), three differently coloured,
152 unscented toys placed in the kennel; and 3. experimental 'scented toys' (T+), three toys
153 identical to those in T of which two were additionally scented and placed in the kennel. For T+
154 10ml of lavender oil (Spa Of The World™ French Lavender Oil) was added to an orange-white
155 toy (T+L) and 10ml rabbit gland and pelt scent (National Scent Company) to a red-blue toy
156 (T+R), a blue-black toy was left unscented. Each scent was always on the same colour for
157 identification. The use of identical colours in T+ and T allowed any colour preference shown
158 in the T condition to be noted and subsequently separated from any scent preference shown in
159 T+. Toys were placed in the centre of the kennel. The order of the toys (left to right) was
160 counterbalanced between subjects to avoid side bias but was equivalent in the T and T+
161 condition for each subject. Toys were handled with disposable gloves and stored in zip-lock
162 freezer bags to prevent contamination. Toys were sterilized (soaked in Milton® and machine
163 washed at 60C°) between uses. Worn toys were thrown away and replaced as needed. The toys
164 used were knotted ropes (Dogloveit Cotton 3-Knot Braided Rope); past history of the dogs
165 with the same toys was unknown. However, most dogs had been exposed to similar toys during
166 their time at the centre therefore, due to habituation, rates of interaction are likely to be lower
167 than on initial toy introduction. In line with other experiments on scent enrichment (e.g. Binks
168 et al. 2018; Graham et al. 2005), it was not feasible to isolate non-focal animals from
169 experimental scents, therefore we cannot guarantee that all subjects perceived all scents as
170 novel. However, our results are intended for application in this real-world context, wherein
171 dogs can be expected to have had a range of previous scent and toy experiences. Most

172 importantly, we were concerned with the impact of the physical combination of the two
173 components (toy and smell), rather than an inherent response to either.

174

175 *2.4 Data collection*

176 Video cameras (GoPro Hero4 Silver) were set up on a mount at approximately 1m from the
177 dog's kennel whilst they were shut inside. Behaviour scoring began as soon as the dog moved
178 into the outside area. Behaviours associated with positive and negative affective states in
179 individually housed dogs were identified via literature review and compiled into ethograms
180 (Tables 1 and 2). Behaviours identified in the literature were discarded if they were social or
181 the literature was equivocal. State behaviour durations (Table 1) were recorded continuously
182 and event behaviours (Table 2) as a frequency. As vocalization could co-occur with any other
183 behaviour it was recorded simultaneously. Likewise, when two event behaviours co-occurred
184 both were counted. Video footage was scored using The Observer® XT version 13 (Noldus,
185 Wageningen, Netherlands). Due to logistics all videos were watched by a single observer who
186 was also the experimenter. Analysis of the videos occurred sequentially. The NT recordings
187 were able to be identified due to the absence of toys, however T and T+ could not be discerned
188 as the toys and placement of the toys were identical. Identification of the experimental period
189 (T/T+) was conducted after all data had been extracted from the recordings, thus avoiding
190 unintentional observer bias.

191

192

193 Table 1. Ethogram of state behaviours identified through review of the literature. Behaviours
 194 identified as “not analysed” are included for completeness.

Behaviour	Description	Affect	Origin*
Alert	Mostly still, may be sitting, standing or lying down but with head up. Eyes are open and moving, ears are forward and twitching/ swivelling.	Not analysed	1, 2
Vigilant	Staring at point or points, legs and face tense and may be crouched, tail tucked, trembling, whale-eye, lip licking or panting.	Not analysed	N/A
Explore	Walks with nose close to floor sniffing, sniffs objects, moves things with paws or nose to investigate underneath (excluding toy interactions).	Positive	1, 3, 2
Interact with toy	Bats around toy with paws. Picks up and flings, chews, licks, shakes, sniffs or noses. Jumps or rolls on. Each toy colour/ scent recorded separately.	Positive	1, 2
Sleep	Lying down with head rested down, can be on side, sphinx position with hips on one side, on back, partially or fully curled. Eyes are closed for more than two minutes.	Positive	4, 5
Rest	Lying down on side, sphinx position with hips to one side and head down, on back, partially or fully curled. Eyes drift open and closed.	Positive	6, 7, 5, 8
Vocalization	Whining, barking, yelping, yowling or howling.	Negative	4, 2, 8
Pace	Paces around or across kennel in a fixed route. Pattern is repeated three or more times.	Negative	9, 10, 3, 2
Wall bounce	Jumps up kennel wall two or more times, may be in the same place or different (provided other behaviours don't occur aside from crossing to new wall area).	Negative	9, 3, 2
Tail chase	Turns in a tight circle with mouth open following own tail. May chew or bite tail.	Negative	9, 3, 2
Circle	Walks or bounces in a tight circle (on the spot) two or more times.	Negative	11, 3, 2, 8
Play bounce	Similar to the play bow except chest is not so close to the floor. Front legs partially stretched out front and rump higher than head. Movement is fast and jerky.	Negative	9, 10, 3, 2
Active other	Any other active behaviour.	Not analysed	N/A

**Inactive
other**

Any other inactive behaviour.

Not
analysed

N/A

195 * Reference(s) from which the behaviour was identified: 1: Boissy et al. (2007); 2: Kiddie and
196 Collins (2014); 3: Hubrecht et al. (1992); 4: Hetts et al. (1992); 5: Part et al. (2014); 6: Beerda
197 et al. (1998); 7: Owczarczak-Garstecka and Burman, (2016); 8: Walker et al. (2009); 9: Beerda
198 et al. (1997); 10: Beerda et al. (1999); 11: Beerda et al. (2000).

199 Table 2. Ethogram of event behaviours identified as associated with stress based on literature
 200 reviewed.

Behaviour	Description	Affect	Origin*
Lip or snout lick	Lip or snout licking, lip smacking, chews or swallows nothing. Do not count if has taken a drink in the last 10 seconds.	Negative	4, 5, 2
Yawn	Wide, slow opening of the mouth may be accompanied by an exhale or whine.	Negative	3, 5
Crouch	Lowered body position, legs are bent, tail is low/ tucked (where breed appropriate) and the ears are back.	Negative	4, 5, 3, 2
Coprophagy	Eats own or others' faeces.	Negative	5, 2,
Paw lift	Raises one of forepaws and holds it there for more than two seconds.	Negative	4, 5, 6, 2
Startle	Legs flex briefly. Head and/ or body move up and back in a quick brief motion and/or moves back a few paces suddenly. May be in response to sudden sound or sight.	Negative	5, 6, 1, 2
Body shake	Shakes whole body (looks like behaviour dogs use to remove water from coat).	Negative	3, 4, 5, 6

201 * Reference(s) from which the behaviour was identified: 1: Boissy et al. (2007); 2: Kiddie and
 202 Collins (2014); 3: Beerda et al. (1998); 4: Beerda et al. (1997); 5: Beerda et al. (1999); 6:
 203 Beerda et al. (2000).

204

205 *2.5 Statistical analysis*

206 To capture rare, but important, behaviours indicative of affective state the frequencies of stress-
 207 related event behaviours (Table 2) were summed for each dog and analysed as a single total.
 208 The same was done for durations relating to the state behaviours: pacing, wall bouncing, tail
 209 chasing, circling and play bouncing (Table 1) and the total analysed as duration of abnormal
 210 repetitive behaviour. All analyses were carried out using RStudio (v1.1.456) and R (v3.3.2).
 211 (R Core Team 2016). The packages used for analyses were 'lme4' (Bates et al. 2015) and
 212 'lmerTest' (for LMM analysis, Kuznetsova et al. 2017) and 'psych' for correlation analyses

213 (Revelle 2018). The dataset and analysis code are available at
214 <https://doi.org/10.5281/zenodo.2641955>.

215 Toy use interaction was analysed across the T and T+ periods to establish the impact of scent
216 presence and scent type (T+R; T+L), including whether there was any prior preference for a
217 particular colour pre scent addition, or post scent addition for a particular scent. Due to the
218 extreme right skew in duration of toy interaction, a Hurdle type approach (i.e. a hurdle-at-zero)
219 to analysing the data was adopted (Mullahy 1986). Formally, this approach is applied to zero-
220 inflated Poisson data. It assumes that two processes operate in generating the data distribution:
221 1. A process that explains whether a non-zero count is observed or not (i.e. ‘success’ vs. ‘no
222 success’); 2. A process that explains the actual magnitude of the count, given the count is at
223 least one. This is an appropriate model here since we can assume that each dog’s decision to
224 start any kind of interaction with a toy differs from the behavioural decision to terminate that
225 interaction. Unfortunately, the durations were not generated from a Poisson-type process so we
226 deviate from the strict Hurdle approach by analysing the behavioural measure firstly as a
227 binomial outcome (behaviour observed vs. not observed). Instances where none of the
228 behaviour was observed were then excluded and the duration of behaviour analysed.

229 For other behavioural measures, either the above approach was taken (where extreme skew and
230 zero-inflation occurred) or a more straightforward Linear Mixed Model (LMM) was applied.
231 For LMMs the behavioural measure was included as the dependent variable while experimental
232 period (NT, T, T+) was included as a fixed factor and dog identity was included as a random
233 factor to control for the repeated measures. To establish whether an experimental variable has
234 a significant effect it was removed from the analysis and then the resulting model was
235 compared to the full model in a Likelihood Ratio test (comparing the relative variance
236 explained in each model against a chi-square distribution with appropriate degrees of freedom).
237 Where a significant difference occurred it was probed using planned Helmert contrasts

238 comparing the NT period with the T/T+ periods combined and then comparing solely the T+
239 with T periods. Each behavioural measure was analysed in a separate linear model. Other
240 approaches that might have combined these measures (e.g. MANOVA, PCA, discriminant
241 function analysis) were not appropriate due to extreme skew and non-independence in the data
242 structure. Assumptions were checked and transformations applied as appropriate, though the
243 data are presented as raw outcome measures in figures for clarity. Though the experiment was
244 fully counterbalanced, we were mindful that in some two-thirds of trials the NT condition
245 followed exposure to toys (i.e. there may have been a negative contrast effect). As such we also
246 examined whether this factor was significant in any behavioural aspects (it was not, all
247 $p>0.058$). We also examined the sensitivity of other statistical analyses to the inclusion of this
248 factor. Again, it did not change any of the statistical conclusions as laid out in the Results
249 section (for analyses and figures see deposited data and code).

250

251 *2.6 Ethical considerations and approval*

252 The trials were designed and timed so as not to disrupt the dogs' normal routine or compromise
253 their chances of being rehomed. The scents selected were thought to be non-aversive to dogs;
254 however, it was planned that any dog considered to be having a negative reaction to the scented
255 toys would be withdrawn from the study. In the event, no such aversion occurred. The methods
256 and scents were approved by Plymouth University's animal welfare ethical review body and
257 the veterinary and behavioural team at the rehoming centre.

258

259

260 **3. Results**

261 *3.1 Toy use*

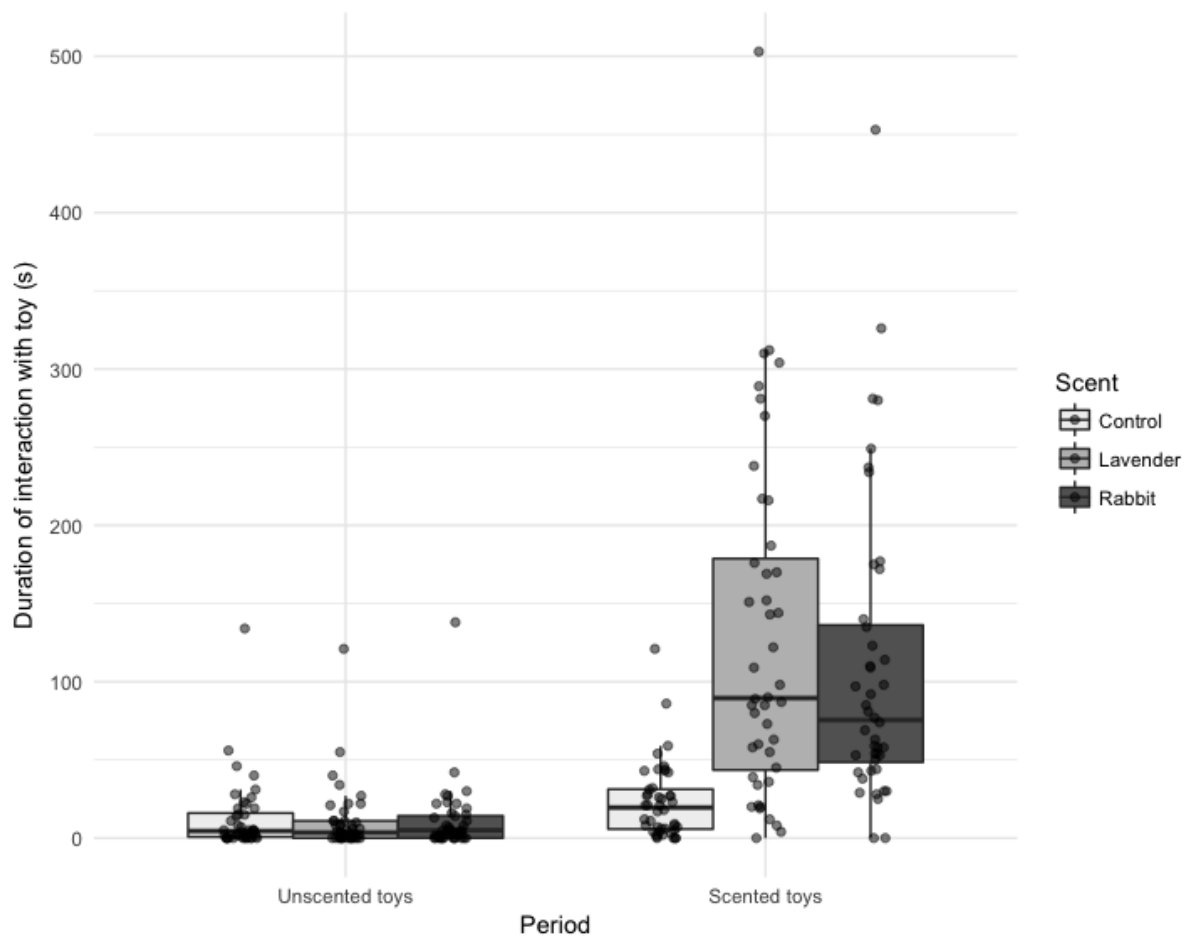
262 Table 3. Cross-tabs of one/zero on toy interaction for unscented (T) vs. scented (T+)
263 experiment periods

Treatment	Toy Colour and Scent	No toy interaction	Toy interaction
Unscented toys (T)	Blue-Black (unscented)	11	33
	Orange-White (unscented)	13	31
	Red-Blue (unscented)	12	32
Scented toys (T+)	Blue-Black (unscented)	4	40
	Orange-White (Lavender)	1	43
	Red-Blue (Rabbit)	2	42

264

265 A generalized linear mixed model (GLMM) analysis of binomial outcomes was carried out
266 where interaction with a specific toy (Yes/No) was the dependent variable; the independent
267 variables were the presence of scented toys, scent type, and a presence of scent*scent type
268 interaction. A significant effect of the presence of scents on the likelihood of dogs interacting
269 with toys was identified ($\chi^2(3) = 34.15, p < 0.001$) (Table 3). However, there was no effect of
270 scent identity ($\chi^2(4) = 2.82, p = 0.588$), nor any significant interaction of period*scent ($\chi^2(2)$
271 $= 2.74, p = 0.254$). In simpler terms, having scented toys present in the kennel increased the
272 likelihood of using both the scented and unscented toys.

273 Analysis of logged toy interaction duration using an LMM showed a significant effect of period
274 ($\chi^2(3) = 222.25, p < 0.001$), scent identity ($\chi^2(4) = 87.08, p < 0.001$) and interaction between
275 period and scent ($\chi^2(2) = 52.09, p < 0.001$) (Figure 1). Planned Helmert contrasts of the effect
276 of control vs. scented toys and lavender vs. rabbit scented toys (combining both T and T+
277 periods) were undertaken. A significant difference in the duration of interaction involving
278 control vs. scented (T+R, T+L) toys was found ($t(220) = -10.31, p < 0.001$) but not between
279 duration of interaction with T+L vs. T+R toys ($t(220) = 0.50, p = 0.619$). The interaction
280 effect was also explored using planned contrasts, the effect of T vs. T+ varied according to
281 period ($t(220) = 7.65, p < 0.001$) but not when comparing T+R with T+L ($t(220) = -0.56, p$
282 $= 0.576$). More plainly, there was no prior difference in interaction rates between differently
283 coloured toys, but the addition of any scent increased the duration of interaction significantly
284 as compared to simultaneously presented unscented toys.



285

286 Figure 1. Duration of interaction with toys (in seconds) across Unscented toys (T) and Scented
 287 toys (T+) periods. Key shows matched identity of toys used (i.e. colours of the toys were
 288 matched from T to T+).

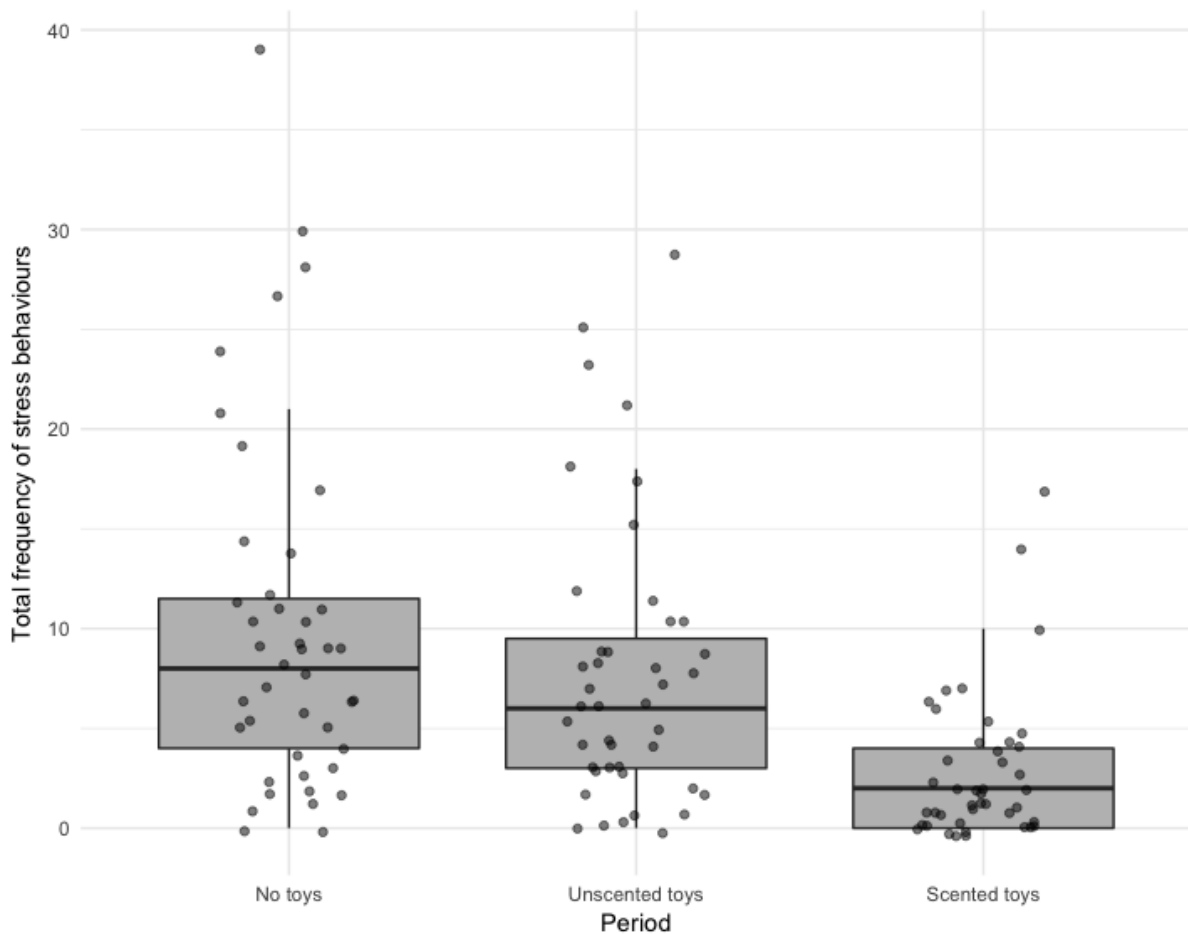
289

290

291 3.2 Stress-related behaviours

292 Experimental period significantly affected frequency of expression of stress-related event
 293 behaviours ($\chi^2(2) = 73.24, p < 0.001$; Figure 2). Planned contrasts revealed that there was a
 294 significant reduction in these behaviours when comparing NT to T and T+ combined ($t(86) =$
 295 $-7.35, p < 0.001$) and from T to T+ conditions ($t(86) = -7.85, p < 0.001$).

296



297

298 Figure 2. Change in frequency of stress-related event behaviours across three different
 299 experimental periods.

300

301 3.3 Abnormal repetitive behaviours

302 There was a significant effect of experimental period on the likelihood or not of demonstrating

303 at least some kind of abnormal repetitive behaviour ($\chi^2(2) = 32.92$, $p < 0.001$; Table 4). Planned

304 contrasts revealed a significant difference in likelihood of performing ARBs, with them being

305 less likely during T and T+ phases ($z = 3.65$, $p < 0.001$). Contrasts also showed that ARBs

306 were less likely to be performed when interacting with T+ toys vs. T toys ($z = -4.57$, $p < 0.001$).

307 However, excluding samples where zero ARBs were demonstrated revealed no significant

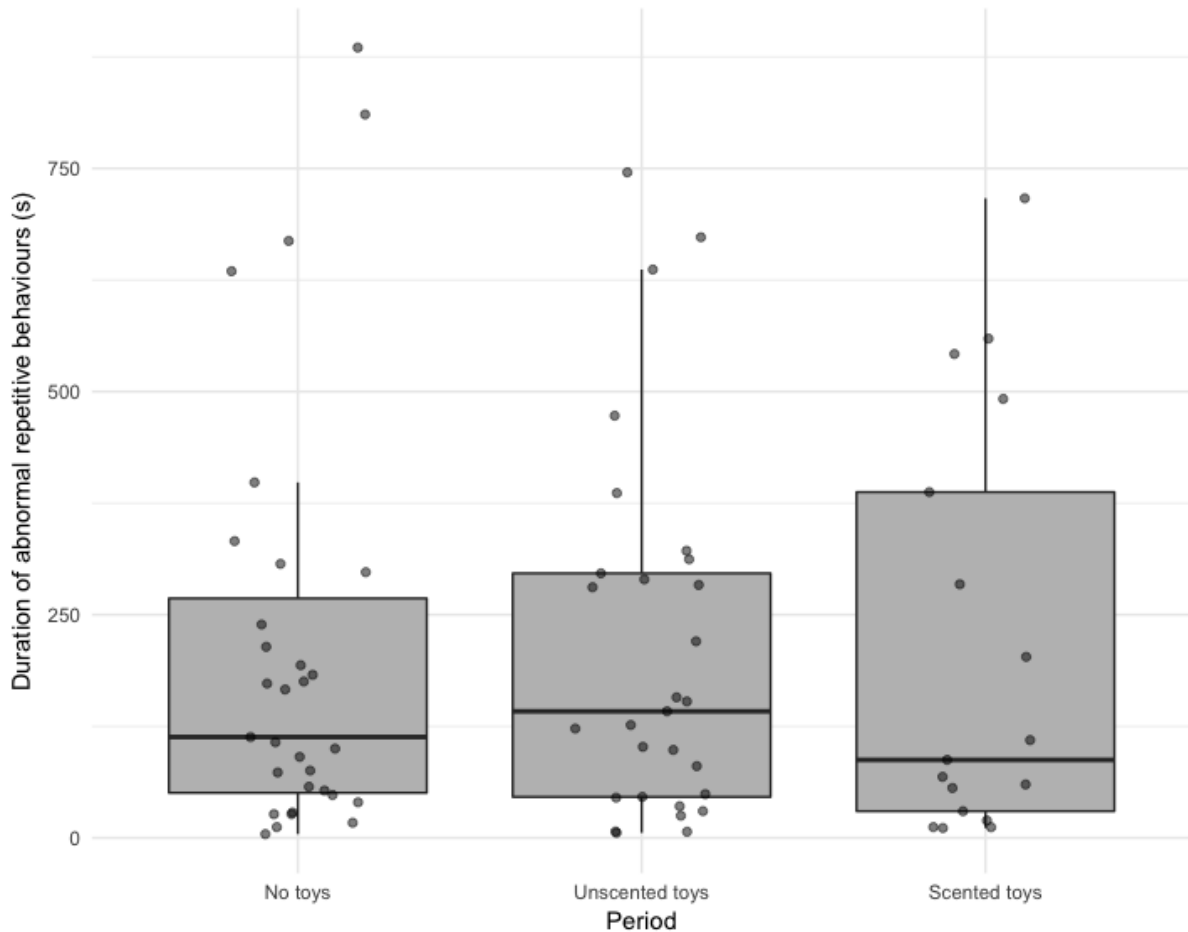
308 effect of time period on the duration of ARB performance ($\chi^2(2) = 5.39$, $p = 0.0675$; Figure 3).

309

310 Table 4. Cross-tabs of one/zero on performing abnormal repetitive behaviours (ARBs),
 311 exploration behaviour, resting, and sleeping for no toys vs. unscented toys vs. scented toys.

	ARBs		Exploration		Resting		Sleeping	
	None	Some	None	Some	None	Some	None	Some
No toys (NT)	13	31	12	31	18	26	29	15
Unscented toys (T)	15	29	11	32	18	26	34	10
Scented toys (T+)	27	17	2	41	7	37	20	24

312



313

314 Figure 3. Duration of performance of abnormal repetitive behaviours (ARBs) in seconds across
 315 the three experimental time periods.

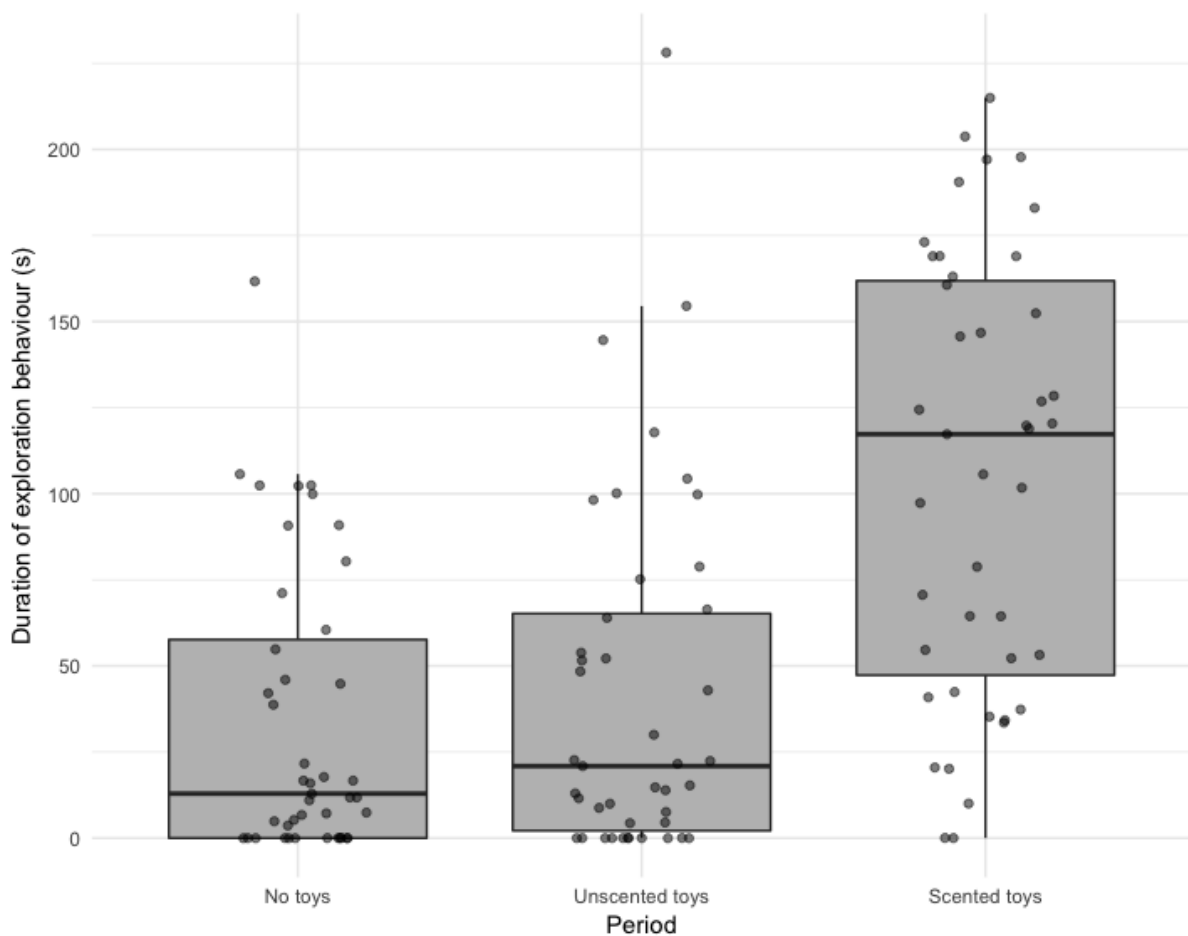
316 *3.4 Vocalization*

317 There was no significant effect of experimental period on the frequency of vocalizations ($\chi^2(2)$
 318 = 4.62, p = 0.099).

319 *3.5 Exploration*

320 There was a significant effect of period on the likelihood or not of demonstrating at least some
321 kind of exploratory behaviour ($\chi^2(2) = 15.75, p < 0.001$; Table 4). Planned contrasts revealed
322 a significant difference in the likelihood of exploration when comparing NT with T/T+ periods
323 combined ($z = -2.27, p = 0.023$) and T vs. T+ periods ($z = 2.57, p = 0.010$), likely down to
324 increased chances of exploring during periods of scented toys (Table 4). Excluding samples
325 where zero exploration was demonstrated revealed a significant effect of experimental period
326 on the duration of exploration behaviour ($\chi^2(2) = 33.31, p < 0.001$; Figure 4). Planned contrasts
327 showed that there was a significant difference in time spent exploring when comparing periods
328 of NT vs. T/T+ combined ($t(62.5) = -4.00, p < 0.001$) and when comparing T vs. T+ periods
329 ($t(64.36) = 5.21, p < 0.001$).

330



331

332 Figure 4. Duration of exploration behaviour (s), excluding interaction with toys.

333

334 *3.6 Resting*

335 There was a significant effect of period on the likelihood or not of demonstrating at least some
336 resting behaviour ($\chi^2(2) = 16.75$, $p < 0.001$; Table 4). Planned contrasts revealed a significant
337 difference in the likelihood of showing resting behaviour when comparing T+/T periods
338 combined vs. NT ($z = -2.15$, $p = 0.031$) and the T vs. T+ periods ($z = 3.03$, $p = 0.002$). Excluding
339 samples where zero resting was demonstrated revealed no significant effect of experimental
340 period on the duration of resting behaviour ($\chi^2(2) = 0.94$, $p = 0.624$).

341

342 *3.7 Sleeping*

343 There was a significant effect of period on the likelihood or not of demonstrating at least some
344 sleeping behaviour ($\chi^2(2) = 17.07$, $p < 0.001$; Table 4). Planned contrasts revealed no
345 significant difference in the likelihood of showing sleeping behaviour when comparing NT vs.
346 T/T+ periods combined ($z = -0.53$, $p = 0.599$), but there was a significant difference in this
347 likelihood when comparing T vs. T+ periods ($z = 3.36$, $p < 0.001$). Excluding samples where
348 zero resting was demonstrated revealed no significant effect of time period on the duration of
349 sleeping behaviour ($\chi^2(2) = 4.02$, $p = 0.13$).

350

351 *3.8 Relationship between toy interaction and behaviours expressed*

352 Initial analyses confirmed that the T+ phase altered the probability of interacting with toys and
353 altered the probability of various welfare-related behaviours being expressed. We followed up
354 this analysis by attempting to establish whether the actual duration of interaction with toys was

355 driving these effects, or whether in the absence of such an effect we might hypothesize that
356 scent addition simply increased arousal in some way (which increased toy interaction as a by-
357 product). A correlation analysis (using Kendall's tau) of time spent interacting with toys vs.
358 duration for all other behaviours showed that the highest correlation coefficient was |0.22| for
359 the period with scented toys (all $p > 0.15$) and |0.17| for the period with unscented toys (all $p >$
360 0.26) (periods were split due to non-independence of data). We also employed a GLMM
361 approach, using the same null models as for the main analysis above, but also including or
362 excluding toy interaction as a fixed factor. This revealed that there was no significant effect of
363 whether dogs had interacted with a toy or not on their duration or likelihood of expressing the
364 behaviours analysed in the main results section above (all $p > 0.17$).

365

366

367 **4. Discussion**

368 Our results indicate that scent-enriched toys can, and do, affect the frequency and duration of
369 welfare-indicative behaviours in kennels. When presented with scented toys dogs were more
370 likely to play with them than during equivalent periods with unscented toys. Importantly, they
371 were also more likely to play with the scented toys when presented with both scented and
372 unscented toys simultaneously (during the T+ condition). During periods of toy presentation
373 the frequency of stress-related behaviours was reduced, even more so when the toys were
374 scented. Abnormal Repetitive Behaviours (ARBs) were less likely to be expressed when toys
375 were present and were expressed at a lower frequency again when toys were scented. However,
376 the duration of ARBs was consistent across conditions, suggesting that toy play can distract
377 dogs from commencing ARBs, but cannot impact on their motivation to do so once they've
378 started performing them. The same pattern was observed for rest and sleep: dogs were more

379 likely to perform them under toy presentation conditions, but they did not necessarily change
380 how long they slept/rested for. Exploration behaviour was both more likely to occur in the
381 presence of scented toys and lasted for longer in this condition. Finally, vocalisation behaviour
382 was not affected by the presentation of toys, scented or otherwise.

383 Superficially, our results therefore look very promising, suggesting that adding scent to toys in
384 rehoming kennels might (at least in the short-term) improve welfare outcomes. However, the
385 follow-on analyses indicated that the mechanism by which this occurs is not necessarily
386 directly causal. That is, the relationship between scented toy interaction and duration of
387 behaviours indicative of improved welfare was weak, if not absent; dogs that interacted more
388 with the toys when scented did not necessarily show the greatest improvements in welfare-
389 related behaviours. There is, however, still a relationship between the presence of the scent and
390 the observed behavioural changes. This suggests that the scent enrichment may have a
391 generalised effect: both encouraging more toy use for those that are motivated to do so, and
392 generally enhancing positive welfare-related behaviour (explore, sleep) in those who are not
393 toy-motivated, but might still gain from the novel stimulus.

394 The exact means by which scent enrichments work is still uncertain. There are three potential
395 mechanisms: first, the scents may have a physiological effect. Blood tests following inhalation
396 of essential oils show increased blood serum levels of compounds found therein, suggesting
397 the potential for a pharmacological action (Kovar et al., 1987). However, Komori et al. (2006)
398 found that diffusion of various oils prolonged or shortened sleep, but not in anosmic
399 individuals. Secondly, scent enrichment may work due to neophilia, as seems to be the case
400 where non-biologically relevant scents are used (Resende et al., 2011; Yu et al., 2009). Finally,
401 evolutionary relevance of scents may trigger investigation and behavioural change (Wells and
402 Egli, 2004).

403 In our study dogs showed no preference between the lavender- and rabbit-scented toy. This
404 suggests that, unlike studies in non-canid species (e.g. Powell, 1995; Wells and Egli, 2004),
405 the value of the scented toys was in their novelty and not in the evolutionary salience of the
406 scent used. This chimes with other canine scent enrichment findings (e.g. Binks et al. 2018)
407 and, if consistently found under replication, would be useful since it would support rehoming
408 centres using a range of scents to maintain interest in toy enrichments. However, our findings
409 are at odds with general research on enrichment which suggests that appetitive unconditioned
410 stimuli are more effective at prolonging engagement and avoiding habituation (vs. novel
411 stimuli) (Tarou and Bashaw 2007). This being said, the assumption (that there is a connection
412 between the scent of common prey species and the evolution of behavioural excitability)
413 requires further exploration, in a range of species, to establish the degree to which such
414 excitability might be a product of innate vs. learned responses.

415 The present study agrees with previous work that toys are little used by dogs in kennels (Wells,
416 2004a; Wells and Hepper, 2000). However, toy use was substantially increased from a median
417 of 4s in the unscented toys condition to 53s in the scented toys condition (with the median for
418 the actual scented toys being 89.5s for lavender and 75.5s for rabbit). A crucial factor for
419 measuring enrichment success is level of engagement (Dawkins, 2004; Mellen and MacPhee,
420 2001). It has been suggested a critical aspect of welfare is whether the animal has the things it
421 wants and the animals' preferences are of paramount importance (Dawkins, 2004; Dawkins,
422 2017). Making use of an item/device suggests doing so has value to the animal and having
423 access to it improves welfare (Boissy et al., 2007; Dawkins, 2004; Yeates, 2016). The increase
424 in interest in scented toys could show that such items have an increased value to dogs compared
425 to unscented toys. However, it is important not focus too much on a 'giving animals what they
426 want' measure of welfare. Aspects that bring an animal pleasure in the short term may not be
427 what are best for their long-term welfare (Yeates, 2016). For example, dogs may select a more

428 salient, stimulating scent but the increase in arousal may increase their reactivity. Conversely,
429 a 'relaxing' scent, while having less of an impact on immediate welfare, may improve the
430 animal's ability to cope long term. More research into the behavioural effects of different scents
431 in the long term is needed.

432 Our behavioural data suggest having scented toys in the kennel may alter behaviour in a way
433 that is consistent with improved welfare, which may in turn increase the chances of adoption.
434 The addition of scent to toys encouraged their use but also encouraged exploration behaviour,
435 reduced the occurrence of stress-related behaviours and ARBs and made sleep and rest more
436 likely. Our study builds on the work of Graham et al. (2005b) by showing that dogs will choose
437 to interact with scented items when given the choice, but importantly shows that the scent may
438 have 'spill-over' effects, generally encouraging more kennel exploration and reducing stress-
439 related behaviours. Control over the environment is an important part of animal welfare (Boissy
440 et al., 2007). For this reason any enrichment should be avoidable, this is an issue within
441 olfactory enrichment as scents can permeate the whole environment (Wells, 2009). Scented
442 toys offer three advantages over the diffused scents used by Graham et al. (2005b) (though see
443 Binks et al. 2018): (a) they give the dog an option of whether to interact with the enrichment
444 or not, (b) they avoid the risk of frustration occurring at not being able to investigate the source
445 of the scent (Yeates, 2016), and (c) they can be tailored to each dog. All dogs react differently
446 to kennels (Hiby et al., 2006; Rooney et al., 2007) and their behaviour changes over time (Hiby
447 et al., 2006; Rooney et al., 2007; Wells and Hepper, 1992). Scents can have a relaxing (Shaw
448 et al., 2007) or stimulating (Lim et al., 2005) effect. Olfactory enrichment studies in other
449 species have been successful for a variety of needs such as increasing activity (Wells and Egli,
450 2004) and decreasing stereotypy (Resende et al., 2011). Scented toys are an enrichment tool
451 that allows kennel workers to select a scent type which will have the desired effect for a
452 particular dog's current needs.

453 Although adoption success was not directly measured in this study previous research has shown
454 people prefer to adopt dogs that are playful and quiet (Holland 2019; Protopopova and Wynne,
455 2014; Wells and Hepper, 1992; Wells and Hepper, 2000), both behaviours that were
456 encouraged by scented toys. Conversely, scented toys also led to an increased likelihood of
457 sleeping which people find unattractive (Wells and Hepper, 2000). Generally people prefer to
458 adopt dogs which interact with them (Protopopova and Wynne, 2014) and there is evidence
459 olfactory enrichment can increase positive social behaviour in other species, though this has
460 not been tested in canids (Powell, 1995; Rafacz and Santymire, 2014). Furthermore, people
461 show a preference for dogs at the front of their kennel. Moving a dog's bed to the front of the
462 kennel encouraged them to spend more time there (Wells and Hepper, 2000) and it is possible
463 a scented toy fixed to the kennel front would do the same. However, moving the bed meant
464 dogs used it less (Wells and Hepper, 2000) and dogs seem to prefer toys loose on the floor
465 (Pullen et al., 2010). The impact of scent enrichment (particularly when paired with toys) on
466 behaviours related to adoption success requires further study.

467 One of the most common problem with enrichment is habituation (Tarou and Bashaw 2007).
468 Research on zoo-housed felids suggests the positive effect of scent enrichment wanes over time
469 (Wells and Egli, 2004; Yu et al., 2009). However, this effect may be mitigated by changing the
470 scent being used (Gronqvist et al., 2013) as olfactory enrichment has shown to be the least
471 liable to habituation in dogs (Bowman et al., 2015; Graham et al., 2005a; Wells, 2006). Pullen,
472 Merrill and Bradshaw (2012) found that dogs habituated to toys upon repeated presentation but
473 dishabituation could be achieved by presenting the same toy with the addition of an olfactory
474 cue (saliva from a previous play session). Likewise, it is probable habituation to scented toys
475 could be prevented by the addition of a new scent at regular intervals. Future research should
476 test this hypothesis.

477 There are some clear limitations of using rehoming shelter dogs: their origin and experiences
478 are often unknown. Most importantly, their prior experience with the toys or scents could not
479 have been established. However, though prior experience can introduce bias, the use of a
480 within-subject design should have diminished any such effects. Furthermore, prior experience
481 with either toys or scents would have reduced the difference between baseline and the other
482 conditions, making a false positive result less likely. Finally, conducting the study in the ‘field’
483 improves the viability of the practical application of the results as the aim was to increase the
484 enrichment value of toys currently used by rehoming centres. The current study only looked
485 at a brief period of time because the average length of stay was seven days or fewer. As such
486 it was unable to account for the daily and longitudinal fluctuations in behaviour, which have
487 previously been noted (Hiby et al., 2006; Rooney et al., 2007; Wells and Hepper, 1992).

488 In a working shelter it is not possible to entirely remove scent traces from the environment.
489 This means that residual scent likely remained. However, every effort was taken to ensure that
490 the toys remained free from scent contamination. This being said, previous studies have
491 reasoned that even with perfect toy hygiene, scent enrichments will diffuse across multiple
492 kennels. Other studies have therefore chosen to treat subjects as ‘blocks’ and have eschewed
493 counterbalancing (reasoning that once a scent enrichment had been used in a kennel any
494 adjacent dogs had also been exposed to it) (Graham et al. 2005; Binks et al. 2018).

495 Unlike many in-shelter studies, the current work was able to ensure that all trials were carried
496 out when the centre was closed to the public, as differing visitor presence is likely to affect
497 dogs’ behaviour (Hewison et al, 2014) and is often a confounding factor in shelter-based work.

498

499 **5. Conclusion**

500 Finding an enrichment strategy that is practical for use in a busy rehoming shelter is an ongoing
501 problem. This study suggests that scented toys have the potential to be an additional tool in the
502 suite of enrichment practices. The addition of scented toys not only increased toy usage but
503 caused behavioural changes which, over time, may be indicative of improved wellbeing. The
504 effects seen were not significantly affected by the type of scent used, suggesting the value of
505 scented toys may lie in their novelty and not their biological salience. Overall, results indicated
506 that dogs in rescue kennels may benefit if commonly used toys have scents applied. Habituation
507 to toys may be avoidable if new scents are used periodically. Further research is required to
508 explore the findings presented in this paper, particularly the lack of relationship between
509 interaction with enrichment and behavioural improvements. Using a range of scents with
510 varying levels of perceived salience and exploring long-term behavioural changes and
511 adoptability may be beneficial.

512

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519

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