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Social rearing environment influences dog behavioral development

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1 **Social rearing environment influences dog behavioral development**

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12

14 **ABSTRACT**

15 Early life experiences are known to influence behavior later in life. In dogs,

16 environmental influences of early home rearing could be exploited to improve

17 the chances of developing adult behavior most suited to the adult environment.

18 For working dog organisations, such as Guide Dogs, suitable adult behavior is

19 important to ensure dogs can fulfil their role as guides for people with visual

20 impairment.

21 Here we test the hypothesis that dogs' home rearing environment will influence

22 behavioral development. To investigate this hypothesis, carers of potential guide

23 dogs (puppy walkers) completed a questionnaire, termed the Puppy Walking

24 Questionnaire (PWQ), about the dog's behavior at 5, 8 and 12 months of age. An

25 additional 11 questions were answered about the home environment at the last

26 assessment. Since no questionnaire existed which measured behavior most

27 relevant to Guide Dogs, questions from an existing questionnaire (C-BARQ) were

28 combined with additional questions. Thus, a subsidiary aim of the study was to

29 test the reliability of the PWQ for measuring behavioral development of potential

30 guide dogs.

31 The PWQ, scored on a 100mm visual analogue scale, grouped into five new

32 scales: Trainability, Distractibility, General Anxiety, Body Sensitivity, and Stair

33 Anxiety, with four C-BARQ scales: Excitability, Separation-related behavior,

34 Attachment and attention seeking and Energy Level. For each reliable scale,

35 multivariate linear regression identified significant predictors from the home

36 environmental questions.

37 The results suggest that home rearing environment is indeed important for

38 behavioral development: 9 out of 11 environmental variables were significant

39 predictors of behavioral scores. Those environmental variables that appeared

40 most important were social in nature. Dogs were scored as higher in Energy

41 Level, Excitability and Distractibility if they had been raised in a home with

42 children, lower on Energy Level and Distractibility the more experience of puppy

43 walking their carer had, and lower on Separation-related behavior the more they

44 had been able to play with other dogs. These findings have implications for

45   matching between dogs' early and later home environments. Follow-up of dogs

46   in this study could help to elucidate effects on guiding suitability and matching

47   between dog and guide dog owner.

48 **INTRODUCTION**

49 For many species, the period of time before individuals' reach maturity is crucial

50 in developing their future behavior. In dogs, experiences between 3-12 weeks of

51 age (the "socialization period") are known to play a vital role in shaping adult

52 behavioral development and the various effects of experience at this age are well

53 documented (Scott and Fuller, 1965). In humans and rats, experiences during

54 adolescence (the period of sexual maturation; Crone, 2009) can have life-long

55 impacts upon an individual's behavior as the mammalian neural network and

56 endocrine system is still developing during this stage (McCrae et al., 2000, Sisk

57 and Zehr, 2005, Crone, 2009, McCormick and Mathews, 2010). In both working

58 and pet dogs, knowledge of early environmental influences on behavior, after 12

59 weeks of age could assist in matching dogs to later environments. For working

60 dogs, such information could help with the selection of environment, or in

61 predicting and managing future behavior. For non-free-living dogs, the typical

62 rearing environment is a human home environment.

63 The domestic dog's adolescence is thought to occur between 6-9 months of age

64 in males, and 6-16 months in females (Anderson, 1970; Pineda and Dooley,

65 2003), whilst behavioral and social maturity is reached between 12-14 months

66 of age (Overall, 2013). Despite the potential importance of experience upon

67 behavioral development during this stage, little is known about the effects of a

68 dog's environment between 3-24 months of age upon the behavior of adult dogs.

69 From the few studies that have been conducted, factors such as hours left

70 unattended has been shown to be associated with behavior scores on a

71 standardized behavior test (Foyer et al., 2013). Additionally, the number of

72 people in the household, prior experience of dog ownership and amount of

73 training experience received was associated with 'trait' scores from a

74 questionnaire (Bennett and Rohlf, 2007). Further research is required in order to

75 confirm these findings, and to dissect the relative influences of genetic and

76 environmental factors on different behavior traits.

77 Behavioral profiles of working dogs require regular assessment to determine

78 suitability to training programs, decide upon appropriate training regimes and,

79 for assistance dogs, to match them with their future owners. As such, a greater

80 understanding of how environmental factors influence dog development could

81 be of great value to working dog organizations. Guide Dogs, UK breed the

82 majority of their own dogs (Asher et al., 2013), and have guidelines to try and

83 standardize the amount of social and environmental exposure (socialization and

84 habituation) and training their dogs receive. As such, trainee guide dogs may

85 represent an excellent model for elucidating the relative effects of experience

86 and genetics upon adult personality and behavior.

87 A previous study of guide dog behavior has demonstrated that behavioral

88 questionnaires can be associated with training outcome (Duffy and Serpell,

89 2012). To be of best use to guide dog organisations questionnaires should be

90 able to identify specific individuals with the highest chances of being withdrawn

91 from the training programme and those with the highest chances of successfully

92 completing training (qualifying). To date, there is no questionnaire that can

93 deliver this information for Guide Dogs, UK, and so there is scope for a

94 behavioral questionnaire designed specifically for guide dog behavior, which

95 may be better able to make such distinctions. For Guide Dogs, a crucial decision

96 point for trainee dogs occurs at 12-14 months of age, because the financial

97 investment increases as dogs' progress to a more formal training programme at

98 this age. Volunteers who live with and train a dog for its formative period are

99 able to provide an accurate impression of a dog's likelihood of qualifying as a

100 guide dog (Batt et al., 2009), supporting the rationale for developing a behavioral

101 development questionnaire to be answered by volunteers caring for trainee

102 guide dogs prior to entry to more formal training.

103 The aim of this study was to test the hypothesis that a dog's rearing environment

104 between the ages of 2-12 months of age will influence its behavioral

105 development. A questionnaire method was selected in order to achieve this aim

106 in a manner relevant to the study population of trainee guide dogs. To provide a

107 profile of behavior of most relevance to guide dogs, a combination of existing

108 questions and newly developed questions were required. Thus, a subsidiary aim

109 of this study was to develop a reliable questionnaire to be completed by

110 volunteer trainee guide dog carers (puppy walkers). Specifically, we aimed to

111 test the feasibility, internal reliability, inter-rater reliability, temporal

112 consistency and construct validity of the new questionnaire.

113 **METHODS**

114 A dog behavior questionnaire, referred to as the puppy walker questionnaire

115 (PWQ) was developed for completion by volunteer puppy walkers (PWs).

116 Question items (items) were sourced or created to address specific behavioral

117 traits of relevance to guide dog owners and Guide Dogs training staff. Where

118 possible, items were sourced from previously published questionnaires

119 (Goddard and Beilharz, 1983; Serpell and Hsu, 2001; Hsu and Serpell, 2003;

120 Arata et al., 2010) and a previous PW questionnaire study undertaken by Guide

121 Dogs in 2006/2007 (unpublished data). To address content validity (Taylor and

122 Mills, 2006; Belshaw et al., 2015) the questionnaire was refined based on

123 feedback from a panel of volunteer PWs (n=5) regarding the questionnaires

124 applicability to the behavior of dogs they had cared for previously. Twenty-two

125 of the 59 items in the questionnaire were from a previously validated

126 questionnaire known as the Canine Behaviour and Research Questionnaire (C-

127 BARQ) (Serpell and Hsu, 2001; Hsu and Serpell, 2003), which has been validated

128 for use in other studies (Duffy and Serpell, 2008, van den Berg et al., 2010,

129 Nagasawa et al., 2011b, Duffy and Serpell, 2012). The C-BARQ items used were

130 assessed for internal reliability for the Guide Dogs, UK dogs, and further

131 reliability and validity analyses were conducted on the remaining 37 PWQ items.

132 All items were scored using a 100mm long visual analogue scale (VAS).

133 SUBJECTS

134 PWs of dogs that turned 5 months of age during October-December, 2012

135 (n=311) were invited to complete the questionnaire, where possible online, with

136 the option to request a paper version by post. Initial invitations were sent when

137 the dogs were 21 weeks of age (1 week before 5 months). An online version of

138 the questionnaire (hosted by SurveyGizmo.com) allowed for pseudo-

139 randomisation of the items for each questionnaire (random within different

140 subsections). To achieve variety in item order for the paper questionnaire, three

141 versions were created, each with different (pseudo-random) question orders.

142   The questionnaire was also completed by PWs of dogs that participated in a

143   behavior test (see Harvey et al., 2015 for details). To evaluate inter-rater

144   reliability, when two members of the same household that were responsible for a

145   dog attended the behavioral test, both individuals were asked to complete the

146   questionnaire without conferring. Twenty-one PW dyads were recruited to

147   complete the questionnaire based on our sample size estimation ($\alpha=0.05$, $\beta=0.20$,

148   minimum - maximum acceptable coefficient = 0.30 - 0.70), according to Walter et

149   al., (1998).

150   Invitations to complete questionnaires when the dogs turned 8 and 12 months

151   old were again sent by post or email when each dog turned 34 and 51 weeks of

152   age, respectively.

153   ETHICS

154   Participants were contacted with ethical approval from Guide Dogs, UK, and

155   according to University of Nottingham institutional guidelines. Written informed

156   consent was gained from each PW and participants were able to withdraw from

157   the study at any time.

158   SCALE STRUCTURE AND INTERNAL RELIABILITY

159   Internal reliability of C-BARQ and PWQ scales, based on expected groupings of

160   items (expected scales), were assessed using Cronbach's alpha. PWQ items were

161   then analysed via principal components analysis (PCA), at each age in order to

162   confirm expected scale structures or aid identification of improved structures.

163   PCA's were conducted with eigenvalues >1, using varimax rotation based upon a

164   correlation matrix, and loadings of more than 0.40 were considered as salient

165   (Budaev, 2010). If an item loaded >0.40 on more than one component (group of

166   items identified by PCA) it was removed from the component for which is had

167   the weakest loading. If a component showing a new scale structure was

168   identified in more than one age group, then alpha statistics were calculated and

169   the alpha values compared to those of the expected groupings. The grouping of

170   items (expected or PCA component) that yielded the highest alpha value across

171   the three sample ages was then selected as the final scale structure and mean

172 scores were calculated for each scale based upon the items within them (with

173 negatively correlated items reversed using "100 minus score"). Alpha values of

174 more than 0.6 were considered acceptable (Hsu and Serpell, 2003).

175 TEMPORAL CONSISTENCY AND INTER-RATER RELIABILITY

176 Temporal consistency of scores were examined by performing Spearman's Rank

177 correlations between the 5, 8 and 12 month datasets. This test examined rank

178 order consistency and was considered acceptable if significant to $p < 0.05$ and

179 with a correlation coefficient above 0.30. This cut-off was chosen because the

180 mean level of temporal consistency for dogs less than 12 months of age, as

181 revealed by a meta-analysis, is 0.34 (Fratkin et al., 2013).

182 Inter-rater reliability of the PWQ scales and miscellaneous items was examined

183 using intraclass correlation coefficients (ICC's). ICCs were calculated for each of

184 new scale scores and miscellaneous items, using a two-way mixed model with a

185 consistency method (Nichols, 1998). Since dogs might be expected to behave

186 differently with different handlers (Horn et al., 2013; Kerepesi et al., 2015)

187 significant, yet weak to moderate agreement between raters could be expected. A

188 minimal acceptable ICC agreement coefficient was therefore a single measure

189 ICC of >0.30 significant at a 95% confidence interval.

190 CONSTRUCT VALIDITY

191 Scores from the 12-month questionnaire were used to assess construct validity.

192 Predictions of positive and negative correlations between the PWQ scales and C-

193 BARQ scales were made based on the constructs they were designed to assess.

194 The C-BARQ scales were included in this analysis to help validate the new scales.

195 Spearman's Rank correlations were performed to test expected correlations.

196 Each predicted correlation either convergent (positive) or divergent (negative),

197 was considered to be an individual hypotheses, which if shown to be correct

198 would support the construct validity of the scales (i.e., that they are reflecting the

199 construct they were intended to assess). The Improved Bonferroni procedure

200 was applied (Simes, 1986) to control for multiple testing, following the

201 procedure described in Haccou and Meelis (1992).

202 INTERACTIONS WITH REARING ENVIRONMENT

203 When the dogs turned 12 months of age PWs completed an additional 11-item

204 'Environmental Information' survey. The survey requested details about the

205 household in which the dog had been reared, experience of the PW and regular

206 habits relating to the dog such as attendance at puppy training classes (see

207 supplementary material for a copy of the survey).

208 The association between rearing environment and behavior scores was

209 examined for each of the scales from the C-BARQ and the PWQ scales that were

210 found to have acceptable levels of internal reliability and temporal consistency (a

211 requirement for personality scores). Univariate general linear regression was

212 initially applied with each scale score being a dependent variable and each

213 variable from the 'Environmental Information' survey included sequentially as a

214 fixed effect. Any independent variables that were significantly associated with a

215 scale score to $p<0.1$ were then analysed against the scale score via multivariate

216 linear regression. A backwards stepwise approach was taken, followed by a

217 forwards stepwise approach, using the ANOVA function in R to choose between

218 models in both stages (both approaches were used to test for robustness of the

219 models which would be indicated by convergence of results from each

220 approach). Breed and sex were included as fixed effects in each final model and

221 retained if significant to $p<0.05$. This process was conducted for each scale score.

222 Analysis of rearing environment interactions was undertaken in R version 3.0.2

223 (R Core Team, 2013; R scripts available on request), with all other analysis

224 conducted in SPSS v. 21 (SPSS Inc., Chicago, IL, USA).

225

RESULTS

Of the 311 PWs contacted, 192 agreed to participate in the study and completed the questionnaire at least once, which represented a 61% response rate. Including the dogs that participated in the behavior test, a total of 276 (130 male/146 female) dogs had at least one completed questionnaire. There were 265 questionnaires completed for dogs of 5 months (43% online: 57% on paper), 214 on 8-month-old dogs (37%: 63%) and 226 on 12-month-old dogs (37%: 63%). The dogs were from eight different breeds or crossbreeds (Sire x Dam): golden retriever x Labrador (n=105); Labrador (n=65), golden retriever (n=30), Labrador x golden retriever crossbreed (n=29), golden retriever x German shepherd dog (n=24), German shepherd dog (n=16), Labrador x golden retriever (n=5), Labrador x Labrador crossbreed (n=2). Age of the dogs at the time of questionnaire completion was: 5.17 months (mean 157 days ± 8 days SD); 8.17 months (mean 248 days ± 7 days SD); and 12.04 months (mean 365 days ± 12 days SD). A total of 224 out of the 226 PWs that completed the 12-month (12M) PWQ also completed and returned the 'Environmental Information' survey. At the time of the 12M PWQ completion 105 dogs (47%) were sexually intact and 119 (53%) had been spayed or castrated.

SCALE FORMATION AND INTERNAL RELIABILITY

Following the PCA and internal reliability analyses of the PWQ items, only one scale was found to have optimal internal reliability in the expected structure: Distractibility (see Supplementary Table 2 for PCA loadings). The six items from the scale designed to assess 'environmental anxieties' (General Anxiety) separated into two components in PCA for each age group. The new component contained the two items relating to anxious or uneasy behavior on stairs, so this was named Stair Anxiety. Two of the four items created to assess 'body sensitivity' loaded together in all three PCA's and met the requirements of acceptable internal reliability so became the scale Body Sensitivity. Two expected scales (items grouped as they were designed to) had best internal reliability when merged (Trainability and Attentiveness in addition to one additional miscellaneous item) (Table 1 & 2).

257   Internal reliability of the C-BARQ scales was acceptable (>0.60) for all scales.

258

259   PWQ TEMPORAL CONSISTENCY AND INTER-RATER RELIABILITY

260   Consistency of scores over time (temporal consistency), as measured by
261   Spearman's correlations, showed that inter-individual consistency was higher
262   than expected for most scales (Table 2). Bivariate correlation coefficients ranged
263   from a minimum of 0.18 (Stair Anxiety comparing 5-12M) to a maximum of 0.66
264   (Distractibility comparing 5-8M and General Anxiety comparing 2-12M). All
265   coefficients were >0.40, excepting those for Stair Anxiety which was least
266   consistent between ages. Consistency was good to high for the majority of the
267   miscellaneous items (see supplementary Table 3), with the strongest
268   correlations comparing 5-8M (mean 0.47) and the weakest comparing 5-12M
269   (mean 0.32).

270

271   Four of the five scales had acceptable inter-rater reliability with single measure
272   ICC coefficients of >0.30 (Table 2). Only Body Sensitivity was below the
273   minimum accepted level for inter-rater reliability. Of the miscellaneous items, 5
274   out of 10 achieved acceptable levels of inter-rater reliability (see supplementary
275   Table 3).

276

277   CONSTRUCT VALIDITY
278   Fourteen out of fifteen predictions made about relationships between scales of
279   the PWQ and C-BARQ were supported with significant correlations in the
280   predicted direction (see supplementary table 4). All of these supported
281   correlations had coefficients of above 0.30 and nine of above 0.40.

282

283   REARING ENVIRONMENT VS. 12-MONTH SCALE SCORES

284   Based upon the reliability results discussed above, all of the C-BARQ scales
285   (Attachment and attention seeking, Separation-related behavior, Excitability and
286   Energy Level) and three of the PWQ scales (Trainability, General Anxiety and
287   Distractibility) were included in this analysis (descriptive statistics for the 11
288   Environmental Information variables are presented in Table 3).

289   For the univariate analysis, all but two of the variables from the Environmental

290   Information survey were associated with the 12M scale scores. The two variables

291   that had no associations with the scores were puppy class attendance and pet

292   dogs owned previously (Table 4). Increasing PW age was associated with dogs

293   with decreased scores for Excitability and Distractibility, and increased scores

294   for Trainability. More children in the household was associated with increased

295   scores on Excitability, Energy Level and Distractibility. Previous puppy walking

296   experience of the PW was associated with reduced scores on Energy Level and

297   Distractibility (and there was a trend towards an association with Excitability),

298   but whether the PW had previously owned pet dogs or not was not associated

299   with any score. Separation-related behavior scores decreased the more the dogs

300   were allowed to play with other dogs, and if the dog was left unattended on a

301   weekend day for between 1-2 hours compared to 0-1 hours. Finally, scores for

302   Distractibility also decreased if the dogs were left unattended on a week or

303   weekend day for between 1-2 hours compared to 0-1 hours. Only one association

304   was found with General Anxiety, for which there was a trend ($p<0.1$) for scores

305   to decrease for each other dog they shared the household with. No associations

306   were found between the rearing environment variables and scores for

307   Attachment and attention seeking.

308   Multi-collinearity between rearing environment variables occurred for four

309   scales (Excitability, Separation-related behavior, Trainability and Distractibility).

310   Models were run using backwards and then forwards stepwise regressions and

311   convergence between approaches was achieved. Use of the ANOVA function to

312   select the best model with the least number of variables allowed for the

313   identification of the fixed effects that explained the most variance, thus

314   identifying only the most salient variables (Table 5). The multivariate analyses

315   produced five models: Energy Level (3 predictors, $R^2= 8.5\%$), Excitability (1

316   predictor, $R^2= 3.4\%$), Separation-related behavior (1 predictor, $R^2=2.3\%$),

317   Trainability (1 predictor, $R^2= 3.0\%$) and Distractibility (1 predictor, $R^2= 4.4\%$).

318   Scores on Energy Level increased by 0.12% for each 1mm increase in ratings for

319   frequency of meeting children, decreased by 0.58% for each puppy previously

320   cared for by the dogs PW, and increased by 5.7% if there were other dogs in the

321 household. Each child in the household was associated with a 6.2% increase in

322 scores for Excitability. For each 1mm increase in ratings for frequency of play

323 with other dogs, scores on Separation-related behavior scale decreased by

324 0.06%. With regards to PWQ scales, Trainability scores increased by 0.07% for

325 each 1mm increase in ratings for frequency of meeting children, and

326 Distractibility scores decreased by 0.57% for each puppy previously cared for by

327 the dogs PW.

328 Breed was significant in two models with the Labrador(sire) x golden

329 retriever(dam) scoring an average of 29% (S.E. 9.8, p<0.01) and 20% (S.E. 9.4,

330 p<0.05) higher than the golden retriever(sire) x Labrador(dam) for the scales

331 Excitability and Distractibility, respectively. Sex, neuter status and sex by neuter

332 status interactions did not have a significant effect on any 12M scale score.

DISCUSSION

In testing the hypothesis that the home rearing environment for dogs will influence behavioral development, we found many associations between home environment and behavior. Nine of the eleven environmental variables measured were associated with one or more behavioral scales. The environmental variables with the largest effect size referred to factors of the dog's social environment.

In measuring behavior, it was necessary to develop new questions focused on behavior of most importance to Guide Dogs. A new composite questionnaire (PWQ) for regular completion by volunteer puppy walkers (PWs) was developed for assessing behavior of juvenile guide dogs. In addition to the four scales adapted from an already validated questionnaire, the C-BARQ (Excitability, Energy level, Attachment and attention seeking, and Separation-related behavior; Hsu and Serpell, 2001; Serpell and Hsu, 2003), five new scales were identified: General Anxiety, Trainability, Distractibility, Body Sensitivity, and Stair Anxiety. Three of these scales (Distractibility, General Anxiety and Trainability) reached acceptable levels of internal reliability, inter-rater reliability and construct validity. High between individual correlations in these scale scores between 5, 8 and 12 months of age (temporal consistency) suggest that these scales may be measuring dog personality traits.

DEVELOPMENT OF QUESTIONNAIRE

The PWQ was developed to be reliable and feasible for routine application. Taylor & Mills (2006) state that behavior assessments should be easy and efficient to implement, taking less than 30 minutes to complete. The PWQ and additional C-BARQ questions take approximately 15-20 minutes to complete and require little to no expert knowledge or guidance to complete. Also in accord with best practice (Taylor and Mills, 2006; Belshaw et al., 2015) the PWQ was developed in consultation with the users of the questionnaire, puppy walkers (volunteers who care for trainees guide dogs from 6-8 weeks to 12-14 months of age) and the organisation Guide Dogs, UK. The visual analogue scale (VAS), which was used to score questions, allows for a wider range of responses than

364 traditional Likert scales. Means of items (questions) produce scale scores which

365 are easy to interpret based upon their names and the items within them.

366 Together with the C-BARQ questions, these scales provide information on

367 behavior of importance and relevance to Guide Dogs.

368 Three scales were reliable and would be suggested for further use in the PWQ:

369 Distractibility, General Anxiety and Trainability. Two other scales, Body

370 Sensitivity and Stair Anxiety were not reliable. Inter-rater reliability was

371 acceptable for all scales, expect Body Sensitivity, and for the majority of the

372 miscellaneous items. The body sensitivity questions did not group as expected. It

373 is feasible that 'body sensitivity', which is defined as level of responsiveness to

374 tactile stimuli (Murphy, 1998), is a cluster of behavioral responses that have

375 different underlying causes, e.g. fear, excitement, skin disease. This could explain

376 the lack of reliability for these questions. Stair anxiety represented just two

377 questions which grouped together and could have been influenced by

378 experience, explaining the lack of test-retest reliability.

379 The construct validity of the PWQ was very good with 14 out of 15 *a priori*

380 predicted correlations between the scales supported (Belshaw et al., 2015). One

381 correlation that was in the opposite direction to that predicted was the C-BARQ

382 scale Attachment and attention seeking, which was weakly negatively correlated

383 with Trainability. In humans, Attachment Anxiety (characterised by questions

384 such as: "I worry a fair amount about losing my partner") has been found to

385 weakly negatively correlate with self-discipline (Noftle and Shaver, 2006). It is

386 possible that the dimension measured by Attachment and attention seeking

387 scores is similar to attachment anxiety in people. The scale did show a positive

388 relationship with Separation anxiety, thus could be indicative of an insecure

389 attachment style (Bowlby, 1969), which has been previously been described for

390 dog-human dyads (Topál et al., 1998).

391 With respect to consistency of behavior over time, coefficients for the five PWQ

392 scales were good, ranging from a mean of 0.47 for the 5-8 and 5-12 month scores

393 and 0.60 for the 8-12 month scores. Animal personality can be defined as

394 individual differences in behavioral responses that demonstrate inter-individual

395 consistency across time and within similar situations (Stamps and Groothuis,

396 2010; Uher, 2011). While consistency of behavior over time is usually weaker in

397 developing animals (due to neurodevelopmental changes), statistically

398 significant rank-order consistency does still occur, which is considered indicative

399 of personality (McCrae et al., 2000; Stamps and Groothuis, 2010; Putnam, 2011;

400 Fratkin et al., 2013). There is evidence of such rank-order consistency here. The

401 levels of consistency found in this study exceed the expected figure of 0.34

402 identified in a meta-analysis of behavior scores for dogs less than 12 months of

403 age (Fratkin et al., 2013). The high level of inter-individual consistency found

404 here lends support to the reliability of this assessment as a measure of dog

405 personality. The PWQ scales General Anxiety and Distractibility were comprised

406 of items describing the same behavior in different contexts or in response to

407 different stimuli. These scales showed high internal reliability, which could be

408 considered as evidence of situational consistency. The PWQ scales could fit with

409 proposed standardized categories of dog personality (Jones and Gosling, 2005).

410 The Trainability scale fits with the category 'Responsiveness to training', General

411 Anxiety the category of 'Fearfulness' and Distractibility the category of

412 'Reactivity'.

413 Considered together our results support the reliability of the PWQ scales, with

414 the exception of Body Sensitivity and Stair Anxiety. Further research should

415 focus upon investigating the predictive and concurrent criterion validity of the

416 questionnaire scales and miscellaneous items. The C-BARQ has been shown to be

417 significantly associated with general training outcome in five US guiding

418 agencies, but was unable to identify specific individuals with the highest chances

419 of being withdrawn or qualifying (Duffy and Serpell, 2012). It would be

420 interesting to replicate this study with the PWQ scales to look for associations

421 with success in training as a test of predictive criterion validity.

422

423 HOME REARING ENVIRONMENT

424 Social variables throughout development including interactions with children

425 and other dogs were associated with behavioral scores at 12 months of age.

426 Furthermore, previous experience of the PW was associated with scores on

427   Energy Level and Distractibility. Breed, but no neutering or sex effects were

428   found on behavioral scores.

429   Increased scores for Energy Level (C-BARQ scale) and Trainability (PWQ) were

430   associated with how often the dogs were allowed to interact with children.

431   Increases in Energy Level were also associated with the presence of other dogs

432   in the household. For Energy Level, we could hypothesise that interactions with

433   children and other dogs may lead to a dog being more playful and energetic (the

434   two parts of Energy Level). The presence of children in the household was

435   associated with higher Excitability scores, which supports this hypothesis. Dogs'

436   are able to synchronize their behavior to that of their human owners (Duranton

437   and Gaunet, 2016) and dog behavior has been shown to be associated with

438   aspects of their owner's personality (Kis et al., 2012) with dogs often perceived

439   as having similar personalities to their owners (Turcsán et al., 2012). Strong

440   social influences on dog behavioral development could be explained by the fact

441   that dogs are one of the few non-human animals that copy the behavior of social

442   partners through a process known as 'automatic imitation' (Range et al., 2011).

443   Automatic imitation is a form of behavioral synchronisation controlled within

444   areas of parietal and premotor cortex known as the "mirror neuron system"

445   (Catmur et al., 2009). The process is thought to promote cooperation and the

446   formation of affiliative bonds (Chartrand and Baaren, 2009). Whether such

447   behavioral synchrony has lasting effects outside of the rearing environment is

448   not known. These dogs have not been studied in a different environment where

449   there is more or less access to energetic or excitable activities. Directionality of

450   associations also requires further elucidation. For example, the association

451   between Trainability and frequency of interaction with children could result

452   from more obedient dogs being afforded more opportunity to interact with

453   children.

454   In line with findings from Kubinyi et al. (2009), where 'calmer' dogs were

455   associated with more experienced dog owners, we found PWs with more

456   experience in rearing trainee guide dogs scored dogs as lower on Energy and

457   Distractibility. Since both types of behavior are considered positive for Guide

458 Dogs, it would suggest that guide dog organisations should invest in retaining

459 PWs.

460 Lower scores for separation-related behavior were associated with more play

461 with other dogs. The etiology of separation-related disorders is currently poorly

462 understood (Overall, 2013). In addition to potential hereditary factors (King et

463 al., 2000), it is thought to develop because of a mixture of environmental factors,

464 including traumatic or impoverished early experiences (Takeuchi et al., 2001;

465 Flannigan et al., 2001), and the behavior and responsiveness of the owner

466 towards the dog's needs (Konok et al., 2015). There is also evidence that it may

467 be related to other characteristics of the dogs' personality (Konok et al., 2015),

468 and co-morbidity can often be found with other anxiety-related behavior

469 disorders (Overall et al., 2001). Living in a multi-dog household has not been

470 shown to reduce the likelihood of a dog having a separation-related disorder

471 (King, 2000, Tiira and Lohi, 2015), however our results support a particular role

472 of interspecific play during rearing on separation-related behavior. It would be

473 interesting to further explore whether rearing environment and interspecific

474 play had longer-term protective effects on the development of separation-related

475 behavior.

476 No associations between living with other dogs and separation anxiety were

477 found in this study, which agrees with other studies (King et al., 2000; Tiira and

478 Lohi, 2015). However, in one study dogs reported as generally 'fearful' have

479 been shown to be more likely to come from single-dog households (Tiira and

480 Lohi, 2015), and dogs that exhibited stereotypic tail-chasing have less

481 companionship of other dogs (Tiira et al., 2012). Dogs who are thunderstorm-

482 phobic and from single-dog households have also been reported to exhibit

483 slower recovery of the HPA response (as measured by cortisol recovery time)

484 following a simulated thunderstorm (Dreschel and Granger, 2005). In this study

485 there was a trend towards a reduction in scores for General Anxiety with an

486 increase in the number of dogs in the household, which may suggest that living

487 with other dogs may have protective effects against developing anxiety-related

488 behavior.

489   Significant breed differences were present for two scores (Excitability and

490   Distractibility), which suggests that these scales may be heritable. Differences

491   were not between pure breeds, but between F1 cross of Labradors and golden

492   retrievers with different combinations of sire and dam breed. Dogs sired by a

493   golden retriever scored on average 29% lower for Excitability, and 20% lower

494   for Distractibility, than dogs sired by a Labrador. The importance of the sire seen

495   here supports previous work in which effects of maternal genetics upon

496   behavior test scores of adult German shepherd dogs were minimal (Strandberg

497   et al., 2005). Elucidating the effects of the relative breed of the sire and dam on

498   the behavior of F1 crossbreeds could be of relevance to the pet dog owning

499   population in the current climate of "designer" crossbreed dogs.

500   Fifty-three per cent of this population of dogs had been neutered by the time

501   they were 12 months of age, however no behavioral differences were found

502   between neutered or intact dogs of either sex. This result is in contradiction to

503   previous literature in which neutered adult dogs have been reported to be less

504   calm (Kubinyi et al., 2009) and more nervous (Bennett and Rohlf, 2007) than

505   their intact counterparts. This disparity could be explained by differences in the

506   populations considered, which have been observed previously in working dog

507   colonies (Pfaffenberger et al., 1976, Goddard and Beilharz, 1982, 1983) and even

508   between different lines (i.e., gundog, show dog or pet dog) within the same breed

509   (Lofgren at al., 2014). It is possible that behavioral differences as a result of

510   neutering had not yet been expressed; behavioral (or social) maturity in dogs is

511   reached between 12-24 months of age (Overall, 2013).

512

513   CONCLUSIONS

514   Associations were identified between home rearing environment and their

515   scores on a behavioral questionnaire. The largest associations were social in

516   nature, which suggests that social factors may be the most important with

517   regards to shaping dog behavior. Results such as these may help Guide Dogs and

518   other working dog organisations to select specific types of home environments

519   for their puppies, which give them the best chance of matching their future

520   environment, or in predicting the future behavioral profile of dogs by recording

521 key information about their rearing environment. The questionnaire used here

522 could have utility in monitoring the behavioral development of young dogs.

523 Combining scores from some of the C-BARQ scales with newly developed PWQ

524 scales could give a comprehensive and reliable impression of a dog's behavior.

525 Completed by volunteer PWs, the questions meet the psychometric requirements

526 of reliability and construct validity. Many areas of new research have been

527 highlighted by this study, which would improve understanding of the effects of

528 rearing environments on development of dog behavior. Follow-up of dogs in this

529 study could help to elucidate effects of rearing environment on guiding

530 suitability and matching between dog and guide dog owner.

531

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Tables

694 **Table 1.** Final puppy walker questionnaire scale structures based upon PCA and reliability analysis of

695 original and PCA groupings for dogs scored assigned at three different ages: 5M (n=265); 8M (n=214); 12M

696 (n=226). * Indicates the scale structure was changed from the expected structure due to improved internal

697 reliability. **A** Indicates that the anchors for the 100mm VAS scale were "Really does not describe this dog" to

698 "Really describes this dog" , whilst all remaining items were scored on a frequency scale from "Never" to

699 "Almost Always".

Scale	Item Wording	Direction	Scale
Trainability*	Attention can be attracted easily but it loses interest soon	-	Attentiveness
	Attention can be easily distracted	-	Attentiveness
	Needs obedience commands repeating to get a response	-	Trainability
	Seems like it doesn't listen even if it knows someone is speaking to it	-	Trainability
	Fidgets all the time	-	Trainability
	Is attentive to you ᴬ	+	Attentiveness
	Will look at you when you talk to it directly in the home environment	+	Attentiveness
	Is self-controlled and calm ᴬ	+	Misc.
	Stay's/Wait's' when instructed to	+	Trainability
	Learns new things quickly	+	Trainability
	Will respond immediately to the recall command while off lead	+	Trainability
	Is responsive to/focussed on you whilst playing retrieve games	+	Trainability
Body Sensitivity*	Is uneasy with being physically handled/groomed	+	Body Sensitivity
	Attempts to move away when you start to groom it	+	Body Sensitivity
Distractibility	Pulls (including lunging) towards unfamiliar dogs	+	Distractibility
	Is motivated towards/distracted by food on the ground and or on tables/shelves	+	Distractibility
	Shows interest (attempts to greet, sniffs, wags tail) when directly approached by children or member of the public	+	Distractibility
	Shows interest (attempts to greet, sniffs, wags tail) when passing children or members of the public	+	Distractibility
	Shows interest (attempts to greet, sniffs, wags tail) when encounters other dogs	+	Distractibility
General Anxiety*	Is obviously disturbed by loud or unexpected sounds	+	General Anxiety
	Is spooked by odd or unexpected things or objects	+	General Anxiety
	Is anxious or uneasy in new situations	+	General Anxiety
	Backs away from or is reluctant to pass objects on the street (such as collecting boxes, bin bags or children's ride-on toys)	+	General Anxiety
Stair Anxiety*	Appears uneasy on closed stairs	+	General Anxiety
	Appears uneasy on open or unusual stairs	+	General Anxiety
Miscellaneous	Appears uneasy or uncomfortable when putting on Guide Dog equipment (including collars)	NA	Body Sensitivity
	Tucks tail under, flattens ears, whines or trembles when being physically handled/groomed	NA	Body Sensitivity
	Attempts to steal food	NA	Misc.
	When settled this dog reacts quickly to disturbances	NA	Misc.
	Is initially excitable (jumps up; barks; coughs etc.), but quickly settles	NA	Misc.
	Likes to carry objects in their mouth	NA	Trainability
	Returns directly to you if startled or frightened	NA	Misc.
	Jumps up on people (stands to place front paws on persons chest/legs)	NA	Misc.
	Plays by itself	NA	Misc.
	Is the first to initiate play with you	NA	Misc.

Tables

Table 2. Reliability statistics for PWQ scales. Cronbach's alpha statistics are provided for internal reliability at each age and mean across the ages, Spearman's correlations between ages are provided for temporal consistency and Intra-Class Correlation coefficients (ICCs) are provided for inter-rater reliability.

Scale	Internal reliability				Temporal consistency (n=176)			Inter-rater reliability (n=21)
	5M (n=265)	**8M** (n=214)	**12M** (n=226)	**Mean**	**5-8M**	**8-12M**	**5-12M**	**ICC**
Body Sensitivity [3]	0.58	0.73	0.67	0.66	0.56**	0.60**	0.46**	0.20
Distractibility [2]	0.75	0.76	0.74	0.75	0.66**	0.61**	0.61**	0.48**
General Anxiety [3]	0.68	0.75	0.75	0.73	0.49**	0.66**	0.55**	0.44*
Stair Anxiety [3]	0.77	0.79	0.89	0.82	0.19*	0.59**	0.18*	0.33*
Trainability [3]	0.71	0.62	0.78	0.70	0.47**	0.52**	0.57**	0.38*

Note: Numbers in superscript indicate the final scale structure decision: [1] PCA analysis confirmed the original structure, so original structure retained (did not occur here); [2] PCA or Cronbach's analysis identified a new structure with reduced internal reliability, so original structure retained; [3] PCA or Cronbach's analysis identified a new structure with improved internal reliability, so original structure changed.

700

701 **Table 3. Demographic characteristics** of the 11 items from the Environmental Information survey
702 (n=224).

Variable		Missing
PW age	Mean ± S.D. = 56 ± 12	3
Other dogs in household	None: 70%, one: 28%, two: 3%	0
Number of adults in household	One: 14%, two: 60%, three: 14%, four: 11%, more than four: 1%	1
Number of children in household	None: 82%, one: 8%, two: 6%, three: 4%	0
Pet dogs previously owned (Y/N)	Yes: 84%, No: 15%	1
Pups walked previously	Mean ± S.D. = 4.5 ± 7.1	3
Attended puppy classes (Y/N)	Yes: 86%, No: 14%	1
Frequency of dog-dog play (0-100)	Mean ± S.D. = 65.96mm ± 28.68mm	4
Child meet frequency (0-100)	Mean ± S.D. = 56.85mm ± 29.68mm	4
Average hours unattended weekend day	<1: 38%. 1-2: 36%, 2-3: 18%, 3-4: 5%, 4-5: 1%, >5: 0%	4
Average hours unattended weekday	<1: 20%. 1-2: 43%, 2-3: 27%, 3-4: 8%, 4-5: 0%, >5: 0%	4

703

704 **Table 4. Results of univariate analyses of Environmental Information variables against Puppy**
705 **Walker Questionnaire and C-BARQ scale scores.** Coefficients for each significant variable are given,
706 as the dependent variable is a continuous measure between 0-100 the coefficient represents the mean
707 percentage increase or decrease in scale score associated with each unit of the variable in question. '.'
708 $p<0.1$, *$p<0.05$, **$p<0.01$, , '-' indicates no significance.

Variable	CBARQ Excitability	CBARQ Energy Level	CBARQ Separation-related behavior	CBARQ Attachment and attention seeking	Distractibility	Trainability	General Anxiety
Age of PW	-0.21*	-	-	-	-0.25*	0.13 .	-
Number of other dogs in household	-	5.78*	-	-	-	-	-3.78 .
Number of adults in household	-	-2.47 .	-	-	-	-	-
Number of children in household	4.13**	4.12*	-	-	3.71*	-	-
Pet dogs previously owned (Y/N)	-	-	-	-	-	-	-
Number of pups previously walked	-0.31 .	-0.48*	-	-	-0.68**	-	-
Puppy class frequency	-	-	-	-	-	-	-
Frequency of dog-dog play (0-100)	-	0.10*	-0.06*	-	-	-	-
Child meet frequency (0-100)	-	0.13**	-	-	-	0.08*	-
Unattended weekend day	-	-	-3.70*	-	-8.23*.	-	-
Unattended weekday	-	-	-	-	-8.11*	-	-

709

710

711

712 **Table 5.** Results of multivariate logistic regression analyses comparing environmental information about

713 the environment a guide dog puppy lives in for the first year of life to scores assigned to them by their

714 puppy walker at 12 months of age using the Puppy Walker Questionnaire (PWQ). The scoring scale for the

715 scores is a 100mm visual analogue scale so the coefficients represent the mean percentage change in the

716 score, associated with each unit change in the independent variable. [a] indicates a CBARQ scale and [b]

717 indicates a new PWQ scale.

Scale	Mean	Independent variable	Coefficient	SE	*P*
Energy Level [a]	71.5	Child meet frequency (0-100)	0.12	0.04	0.005
		Number of other dogs in household	5.66	2.44	0.021
		Number of pups walked previously	-0.58	0.19	0.002
Excitability [a]	27.7	Children in the household (count)	6.20	1.96	0.002
Separation-related behavior [a]	10.3	Frequency of dog-dog play (0-100)	-0.06	0.02	0.015
Distractibility [b]	54.4	Number of pups walked previously	-0.68	0.21	0.001
Trainability [b]	74.0	Child meet frequency (0-100)	0.07	0.03	0.006

718

HIGHLIGHTS

- A composite questionnaire for juvenile guide dog behavior is described and evaluated
- Reliable scoring scales were identified that could represent dog personality 'traits'
- Associations were identified between rearing environment and questionnaire scores
- Factors related to the dog's social environment were most associated with the 'trait' scores