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

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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

test the feasibility, internal reliability, inter-rater reliability, temporal consistency and construct validity of the new questionnaire.

METHODS

A dog behavior questionnaire, referred to as the puppy walker questionnaire (PWQ) was developed for completion by volunteer puppy walkers (PWs). Question items (items) were sourced or created to address specific behavioral traits of relevance to guide dog owners and Guide Dogs training staff. Where possible, items were sourced from previously published questionnaires (Goddard and Beilharz, 1983; Serpell and Hsu, 2001; Hsu and Serpell, 2003; Arata et al., 2010) and a previous PW questionnaire study undertaken by Guide Dogs in 2006/2007 (unpublished data). To address content validity (Taylor and Mills, 2006; Belshaw et al., 2015) the questionnaire was refined based on feedback from a panel of volunteer PWs (n=5) regarding the questionnaires applicability to the behavior of dogs they had cared for previously. Twenty-two of the 59 items in the questionnaire were from a previously validated questionnaire known as the Canine Behaviour and Research Questionnaire (C-BARQ) (Serpell and Hsu, 2001; Hsu and Serpell, 2003), which has been validated for use in other studies (Duffy and Serpell, 2008, van den Berg et al., 2010, Nagasawa et al., 2011b, Duffy and Serpell, 2012). The C-BARQ items used were assessed for internal reliability for the Guide Dogs, UK dogs, and further reliability and validity analyses were conducted on the remaining 37 PWQ items. All items were scored using a 100mm long visual analogue scale (VAS).

SUBJECTS

PWs of dogs that turned 5 months of age during October-December, 2012 (n=311) were invited to complete the questionnaire, where possible online, with the option to request a paper version by post. Initial invitations were sent when the dogs were 21 weeks of age (1 week before 5 months). An online version of the questionnaire (hosted by SurveyGizmo.com) allowed for pseudo-randomisation of the items for each questionnaire (random within different subsections). To achieve variety in item order for the paper questionnaire, three versions were created, each with different (pseudo-random) question orders.

The questionnaire was also completed by PWs of dogs that participated in a behavior test (see Harvey et al., 2015 for details). To evaluate inter-rater reliability, when two members of the same household that were responsible for a dog attended the behavioral test, both individuals were asked to complete the questionnaire without conferring. Twenty-one PW dyads were recruited to complete the questionnaire based on our sample size estimation ($\alpha=0.05$, $\beta=0.20$, minimum - maximum acceptable coefficient = 0.30 - 0.70), according to Walter et al., (1998).

Invitations to complete questionnaires when the dogs turned 8 and 12 months old were again sent by post or email when each dog turned 34 and 51 weeks of age, respectively.

ETHICS

Participants were contacted with ethical approval from Guide Dogs, UK, and according to University of Nottingham institutional guidelines. Written informed consent was gained from each PW and participants were able to withdraw from the study at any time.

SCALE STRUCTURE AND INTERNAL RELIABILITY

Internal reliability of C-BARQ and PWQ scales, based on expected groupings of items (expected scales), were assessed using Cronbach's alpha. PWQ items were then analysed via principal components analysis (PCA), at each age in order to confirm expected scale structures or aid identification of improved structures. PCA's were conducted with eigenvalues >1 , using varimax rotation based upon a correlation matrix, and loadings of more than 0.40 were considered as salient (Budaev, 2010). If an item loaded >0.40 on more than one component (group of items identified by PCA) it was removed from the component for which it had the weakest loading. If a component showing a new scale structure was identified in more than one age group, then alpha statistics were calculated and the alpha values compared to those of the expected groupings. The grouping of items (expected or PCA component) that yielded the highest alpha value across the three sample ages was then selected as the final scale structure and mean

scores were calculated for each scale based upon the items within them (with negatively correlated items reversed using “100 minus score”). Alpha values of more than 0.6 were considered acceptable (Hsu and Serpell, 2003).

TEMPORAL CONSISTENCY AND INTER-RATER RELIABILITY

Temporal consistency of scores were examined by performing Spearman’s Rank correlations between the 5, 8 and 12 month datasets. This test examined rank order consistency and was considered acceptable if significant to $p < 0.05$ and with a correlation coefficient above 0.30. This cut-off was chosen because the mean level of temporal consistency for dogs less than 12 months of age, as revealed by a meta-analysis, is 0.34 (Fratkin et al., 2013).

Inter-rater reliability of the PWQ scales and miscellaneous items was examined using intraclass correlation coefficients (ICC’s). ICCs were calculated for each of new scale scores and miscellaneous items, using a two-way mixed model with a consistency method (Nichols, 1998). Since dogs might be expected to behave differently with different handlers (Horn et al., 2013; Kerepesi et al., 2015) significant, yet weak to moderate agreement between raters could be expected. A minimal acceptable ICC agreement coefficient was therefore a single measure ICC of > 0.30 significant at a 95% confidence interval.

CONSTRUCT VALIDITY

Scores from the 12-month questionnaire were used to assess construct validity. Predictions of positive and negative correlations between the PWQ scales and C-BARQ scales were made based on the constructs they were designed to assess. The C-BARQ scales were included in this analysis to help validate the new scales.

Spearman’s Rank correlations were performed to test expected correlations. Each predicted correlation either convergent (positive) or divergent (negative), was considered to be an individual hypotheses, which if shown to be correct would support the construct validity of the scales (i.e., that they are reflecting the construct they were intended to assess). The Improved Bonferroni procedure

was applied (Simes, 1986) to control for multiple testing, following the procedure described in Haccou and Meelis (1992).

INTERACTIONS WITH REARING ENVIRONMENT

When the dogs turned 12 months of age PWs completed an additional 11-item 'Environmental Information' survey. The survey requested details about the household in which the dog had been reared, experience of the PW and regular habits relating to the dog such as attendance at puppy training classes (see supplementary material for a copy of the survey).

The association between rearing environment and behavior scores was examined for each of the scales from the C-BARQ and the PWQ scales that were found to have acceptable levels of internal reliability and temporal consistency (a requirement for personality scores). Univariate general linear regression was initially applied with each scale score being a dependent variable and each variable from the 'Environmental Information' survey included sequentially as a fixed effect. Any independent variables that were significantly associated with a scale score to $p < 0.1$ were then analysed against the scale score via multivariate linear regression. A backwards stepwise approach was taken, followed by a forwards stepwise approach, using the ANOVA function in R to choose between models in both stages (both approaches were used to test for robustness of the models which would be indicated by convergence of results from each approach). Breed and sex were included as fixed effects in each final model and retained if significant to $p < 0.05$. This process was conducted for each scale score.

Analysis of rearing environment interactions was undertaken in R version 3.0.2 (R Core Team, 2013; R scripts available on request), with all other analysis conducted in SPSS v. 21 (SPSS Inc., Chicago, IL, USA).

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 \pm 8 days SD); 8.17 months (mean 248 days \pm 7 days SD); and 12.04 months (mean 365 days \pm 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).

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

PWQ TEMPORAL CONSISTENCY AND INTER-RATER RELIABILITY

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

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

CONSTRUCT VALIDITY

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

REARING ENVIRONMENT VS. 12-MONTH SCALE SCORES

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

For the univariate analysis, all but two of the variables from the Environmental Information survey were associated with the 12M scale scores. The two variables that had no associations with the scores were puppy class attendance and pet dogs owned previously (Table 4). Increasing PW age was associated with dogs with decreased scores for Excitability and Distractibility, and increased scores for Trainability. More children in the household was associated with increased scores on Excitability, Energy Level and Distractibility. Previous puppy walking experience of the PW was associated with reduced scores on Energy Level and Distractibility (and there was a trend towards an association with Excitability), but whether the PW had previously owned pet dogs or not was not associated with any score. Separation-related behavior scores decreased the more the dogs were allowed to play with other dogs, and if the dog was left unattended on a weekend day for between 1-2 hours compared to 0-1 hours. Finally, scores for Distractibility also decreased if the dogs were left unattended on a week or weekend day for between 1-2 hours compared to 0-1 hours. Only one association was found with General Anxiety, for which there was a trend ($p < 0.1$) for scores to decrease for each other dog they shared the household with. No associations were found between the rearing environment variables and scores for Attachment and attention seeking.

Multi-collinearity between rearing environment variables occurred for four scales (Excitability, Separation-related behavior, Trainability and Distractibility). Models were run using backwards and then forwards stepwise regressions and convergence between approaches was achieved. Use of the ANOVA function to select the best model with the least number of variables allowed for the identification of the fixed effects that explained the most variance, thus identifying only the most salient variables (Table 5). The multivariate analyses produced five models: Energy Level (3 predictors, $R^2 = 8.5\%$), Excitability (1 predictor, $R^2 = 3.4\%$), Separation-related behavior (1 predictor, $R^2 = 2.3\%$), Trainability (1 predictor, $R^2 = 3.0\%$) and Distractibility (1 predictor, $R^2 = 4.4\%$). Scores on Energy Level increased by 0.12% for each 1mm increase in ratings for frequency of meeting children, decreased by 0.58% for each puppy previously cared for by the dogs PW, and increased by 5.7% if there were other dogs in the

household. Each child in the household was associated with a 6.2% increase in scores for Excitability. For each 1mm increase in ratings for frequency of play with other dogs, scores on Separation-related behavior scale decreased by 0.06%. With regards to PWQ scales, Trainability scores increased by 0.07% for each 1mm increase in ratings for frequency of meeting children, and Distractibility scores decreased by 0.57% for each puppy previously cared for by the dogs PW.

Breed was significant in two models with the Labrador(sire) x golden retriever(dam) scoring an average of 29% (S.E. 9.8, $p < 0.01$) and 20% (S.E. 9.4, $p < 0.05$) higher than the golden retriever(sire) x Labrador(dam) for the scales Excitability and Distractibility, respectively. Sex, neuter status and sex by neuter 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

traditional Likert scales. Means of items (questions) produce scale scores which are easy to interpret based upon their names and the items within them. Together with the C-BARQ questions, these scales provide information on behavior of importance and relevance to Guide Dogs.

Three scales were reliable and would be suggested for further use in the PWQ: Distractibility, General Anxiety and Trainability. Two other scales, Body Sensitivity and Stair Anxiety were not reliable. Inter-rater reliability was acceptable for all scales, except Body Sensitivity, and for the majority of the miscellaneous items. The body sensitivity questions did not group as expected. It is feasible that 'body sensitivity', which is defined as level of responsiveness to tactile stimuli (Murphy, 1998), is a cluster of behavioral responses that have different underlying causes, e.g. fear, excitement, skin disease. This could explain the lack of reliability for these questions. Stair anxiety represented just two questions which grouped together and could have been influenced by experience, explaining the lack of test-retest reliability.

The construct validity of the PWQ was very good with 14 out of 15 *a priori* predicted correlations between the scales supported (Belshaw et al., 2015). One correlation that was in the opposite direction to that predicted was the C-BARQ scale Attachment and attention seeking, which was weakly negatively correlated with Trainability. In humans, Attachment Anxiety (characterised by questions such as: "I worry a fair amount about losing my partner") has been found to weakly negatively correlate with self-discipline (Nofle and Shaver, 2006). It is possible that the dimension measured by Attachment and attention seeking scores is similar to attachment anxiety in people. The scale did show a positive relationship with Separation anxiety, thus could be indicative of an insecure attachment style (Bowlby, 1969), which has been previously been described for dog-human dyads (Topál et al., 1998).

With respect to consistency of behavior over time, coefficients for the five PWQ scales were good, ranging from a mean of 0.47 for the 5-8 and 5-12 month scores and 0.60 for the 8-12 month scores. Animal personality can be defined as individual differences in behavioral responses that demonstrate inter-individual

consistency across time and within similar situations (Stamps and Groothuis, 2010; Uher, 2011). While consistency of behavior over time is usually weaker in developing animals (due to neurodevelopmental changes), statistically significant rank-order consistency does still occur, which is considered indicative of personality (McCrae et al., 2000; Stamps and Groothuis, 2010; Putnam, 2011; Fratkin et al., 2013). There is evidence of such rank-order consistency here. The levels of consistency found in this study exceed the expected figure of 0.34 identified in a meta-analysis of behavior scores for dogs less than 12 months of age (Fratkin et al., 2013). The high level of inter-individual consistency found here lends support to the reliability of this assessment as a measure of dog personality. The PWQ scales General Anxiety and Distractibility were comprised of items describing the same behavior in different contexts or in response to different stimuli. These scales showed high internal reliability, which could be considered as evidence of situational consistency. The PWQ scales could fit with proposed standardized categories of dog personality (Jones and Gosling, 2005). The Trainability scale fits with the category 'Responsiveness to training', General Anxiety the category of 'Fearfulness' and Distractibility the category of 'Reactivity'.

Considered together our results support the reliability of the PWQ scales, with the exception of Body Sensitivity and Stair Anxiety. Further research should focus upon investigating the predictive and concurrent criterion validity of the questionnaire scales and miscellaneous items. The C-BARQ has been shown to be significantly associated with general training outcome in five US guiding agencies, but was unable to identify specific individuals with the highest chances of being withdrawn or qualifying (Duffy and Serpell, 2012). It would be interesting to replicate this study with the PWQ scales to look for associations with success in training as a test of predictive criterion validity.

HOME REARING ENVIRONMENT

Social variables throughout development including interactions with children and other dogs were associated with behavioral scores at 12 months of age. Furthermore, previous experience of the PW was associated with scores on

Energy Level and Distractibility. Breed, but no neutering or sex effects were found on behavioral scores.

Increased scores for Energy Level (C-BARQ scale) and Trainability (PWQ) were associated with how often the dogs were allowed to interact with children. Increases in Energy Level were also associated with the presence of other dogs in the household. For Energy Level, we could hypothesise that interactions with children and other dogs may lead to a dog being more playful and energetic (the two parts of Energy Level). The presence of children in the household was associated with higher Excitability scores, which supports this hypothesis. Dogs' are able to synchronize their behavior to that of their human owners (Duranton and Gaunet, 2016) and dog behavior has been shown to be associated with aspects of their owner's personality (Kis et al., 2012) with dogs often perceived as having similar personalities to their owners (Turcsán et al., 2012). Strong social influences on dog behavioral development could be explained by the fact that dogs are one of the few non-human animals that copy the behavior of social partners through a process known as 'automatic imitation' (Range et al., 2011). Automatic imitation is a form of behavioral synchronisation controlled within areas of parietal and premotor cortex known as the "mirror neuron system" (Catmur et al., 2009). The process is thought to promote cooperation and the formation of affiliative bonds (Chartrand and Baaren, 2009). Whether such behavioral synchrony has lasting effects outside of the rearing environment is not known. These dogs have not been studied in a different environment where there is more or less access to energetic or excitable activities. Directionality of associations also requires further elucidation. For example, the association between Trainability and frequency of interaction with children could result from more obedient dogs being afforded more opportunity to interact with children.

In line with findings from Kubinyi et al. (2009), where 'calmer' dogs were associated with more experienced dog owners, we found PWs with more experience in rearing trainee guide dogs scored dogs as lower on Energy and Distractibility. Since both types of behavior are considered positive for Guide

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

Lower scores for separation-related behavior were associated with more play with other dogs. The etiology of separation-related disorders is currently poorly understood (Overall, 2013). In addition to potential hereditary factors (King et al., 2000), it is thought to develop because of a mixture of environmental factors, including traumatic or impoverished early experiences (Takeuchi et al., 2001; Flannigan et al., 2001), and the behavior and responsiveness of the owner towards the dog's needs (Konok et al., 2015). There is also evidence that it may be related to other characteristics of the dogs' personality (Konok et al., 2015), and co-morbidity can often be found with other anxiety-related behavior disorders (Overall et al., 2001). Living in a multi-dog household has not been shown to reduce the likelihood of a dog having a separation-related disorder (King, 2000, Tiira and Lohi, 2015), however our results support a particular role of interspecific play during rearing on separation-related behavior. It would be interesting to further explore whether rearing environment and interspecific play had longer-term protective effects on the development of separation-related behavior.

No associations between living with other dogs and separation anxiety were found in this study, which agrees with other studies (King et al., 2000; Tiira and Lohi, 2015). However, in one study dogs reported as generally 'fearful' have been shown to be more likely to come from single-dog households (Tiira and Lohi, 2015), and dogs that exhibited stereotypic tail-chasing have less companionship of other dogs (Tiira et al., 2012). Dogs who are thunderstorm-phobic and from single-dog households have also been reported to exhibit slower recovery of the HPA response (as measured by cortisol recovery time) following a simulated thunderstorm (Dreschel and Granger, 2005). In this study there was a trend towards a reduction in scores for General Anxiety with an increase in the number of dogs in the household, which may suggest that living with other dogs may have protective effects against developing anxiety-related behavior.

Significant breed differences were present for two scores (Excitability and Distractibility), which suggests that these scales may be heritable. Differences were not between pure breeds, but between F1 cross of Labradors and golden retrievers with different combinations of sire and dam breed. Dogs sired by a golden retriever scored on average 29% lower for Excitability, and 20% lower for Distractibility, than dogs sired by a Labrador. The importance of the sire seen here supports previous work in which effects of maternal genetics upon behavior test scores of adult German shepherd dogs were minimal (Strandberg et al., 2005). Elucidating the effects of the relative breed of the sire and dam on the behavior of F1 crossbreeds could be of relevance to the pet dog owning population in the current climate of “designer” crossbreed dogs.

Fifty-three per cent of this population of dogs had been neutered by the time they were 12 months of age, however no behavioral differences were found between neutered or intact dogs of either sex. This result is in contradiction to previous literature in which neutered adult dogs have been reported to be less calm (Kubinyi et al., 2009) and more nervous (Bennett and Rohlf, 2007) than their intact counterparts. This disparity could be explained by differences in the populations considered, which have been observed previously in working dog colonies (Pfaffenberger et al., 1976, Goddard and Beilharz, 1982, 1983) and even between different lines (i.e., gundog, show dog or pet dog) within the same breed (Lofgren et al., 2014). It is possible that behavioral differences as a result of neutering had not yet been expressed; behavioral (or social) maturity in dogs is reached between 12-24 months of age (Overall, 2013).

CONCLUSIONS

Associations were identified between home rearing environment and their scores on a behavioral questionnaire. The largest associations were social in nature, which suggests that social factors may be the most important with regards to shaping dog behavior. Results such as these may help Guide Dogs and other working dog organisations to select specific types of home environments for their puppies, which give them the best chance of matching their future environment, or in predicting the future behavioral profile of dogs by recording

key information about their rearing environment. The questionnaire used here could have utility in monitoring the behavioral development of young dogs. Combining scores from some of the C-BARQ scales with newly developed PWQ scales could give a comprehensive and reliable impression of a dog's behavior. Completed by volunteer PWs, the questions meet the psychometric requirements of reliability and construct validity. Many areas of new research have been highlighted by this study, which would improve understanding of the effects of rearing environments on development of dog behavior. Follow-up of dogs in this study could help to elucidate effects of rearing environment on guiding suitability and matching between dog and guide dog owner.

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AUTHORSHIP STATEMENT

NH conceived and designed the study and data collection tools, collected data, performed data analysis and drafted and revised the paper. PC and SB assisted with design of the data collection tools, collected data and commented on drafts and revisions of the paper. GE initiated the project, monitored the study and commented on drafts and revisions of the paper. LA oversaw the study, conceived and designed the study, monitored data collection, directed data analysis, and drafted and revised the paper.

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Table 1. Final puppy walker questionnaire scale structures based upon PCA and reliability analysis of original and PCA groupings for dogs scored assigned at three different ages: 5M (n=265); 8M (n=214); 12M (n=226). * Indicates the scale structure was changed from the expected structure due to improved internal reliability. ^A Indicates that the anchors for the 100mm VAS scale were “Really does not describe this dog” to “Really describes this dog”, whilst all remaining items were scored on a frequency scale from “Never” to “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.

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

Variable		Missing
PW age	Mean \pm S.D. = 56 \pm 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 \pm S.D. = 4.5 \pm 7.1	3
Attended puppy classes (Y/N)	Yes: 86%, No: 14%	1
Frequency of dog-dog play (0-100)	Mean \pm S.D. = 65.96mm \pm 28.68mm	4
Child meet frequency (0-100)	Mean \pm S.D. = 56.85mm \pm 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

Table 4. Results of univariate analyses of Environmental Information variables against Puppy Walker Questionnaire and C-BARQ scale scores. Coefficients for each significant variable are given, as the dependent variable is a continuous measure between 0-100 the coefficient represents the mean percentage increase or decrease in scale score associated with each unit of the variable in question. ‘.’ 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*	-	-

Table 5. Results of multivariate logistic regression analyses comparing environmental information about the environment a guide dog puppy lives in for the first year of life to scores assigned to them by their puppy walker at 12 months of age using the Puppy Walker Questionnaire (PWQ). The scoring scale for the scores is a 100mm visual analogue scale so the coefficients represent the mean percentage change in the score, associated with each unit change in the independent variable. ^a indicates a CBARQ scale and ^b 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

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