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EDITED BY

Linda Jane Keeling,
Swedish University of Agricultural Sciences,
Sweden

REVIEWED BY

Dalia Perkumiene,
Vytautas Magnus University, Lithuania
Stephanie Clark,
Consultant, Bentonville, AR, United States

*CORRESPONDENCE

Lina S. V. Roth
✉ lina.roth@liu.se

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Behavior, long-term stress and relationship to owner in relinquished dogs

Cornelia Sulonen¹, Jenny Löf¹, Per Jensen¹, Karolina Lasses²,
Elvar Theodorsson³, Helena Quist⁴ and Lina S. V. Roth^{1*}

¹IFM Biology, Linköping University, Linköping, Sweden, ²Hundstallet Stockholm, Stockholm, Sweden, ³Department of Biomedical and Clinical Sciences, Division of Clinical Chemistry and Pharmacology, Linköping University, Linköping, Sweden, ⁴Department of Health, Medicine and Caring Sciences, Division of Society and Health, Linköping University, Linköping, Sweden

Dog ownership gained popularity during the pandemic. However, there was also a corresponding increase in the number of dogs being relinquished and rehomed. The rehoming procedure is known to be stressful to the dog, but the short- and long-term effects still need to be better understood. This study aimed to enhance our understanding of the short- and long-term challenges dogs encounter during the rehoming process by combining behavioral and physiological measures. The study included 20 relinquished dogs from a Swedish shelter and 30 rehomed dogs, comparing them to 33 control dogs that have been with their owner since leaving the breeder as puppies. All participants performed an unsolvable problem task, eye-contact test, and memory test and hair samples were obtained to analyze cortisol concentrations. Furthermore, dog owners (of rehomed and control dogs) completed a questionnaire assessing their perceived human-dog relationship. These owner-dog dyads also participated in a behavioral synchronization test. The result indicated that shelter dogs had the shortest eye-contact duration in both an eye-contact test and an unsolvable problem task, but there was no difference between the three groups in the short-term memory test or in stress-related behaviors. Analysis of hair cortisol concentrations in the dogs revealed that the shelter dogs had higher long-term stress levels than rehomed dogs, but they did not differ significantly from control dogs. Both rehomed and control dogs synchronized their behavior with their owner, but, interestingly, the owners of rehomed dogs reported a higher emotional closeness to their dogs than owners of control dogs. Consequently, despite the observed short-term effects during the rehoming procedure, this study suggests that rehomed dogs can adapt to their new life and develop a strong relationship with their owner.

KEYWORDS

animal welfare, behavioral synchronization, contact-seeking behavior, human-dog relationship, hair cortisol concentration, rehomed dogs, shelter dogs, short-term memory

1 Introduction

Dogs are popular as companion animals, and increasingly so during the Covid 19 pandemic. But despite their popularity, many dogs are being abandoned or relinquished to dog shelters yearly (Marston and Bennett, 2003). In Sweden, there are over one million registered dogs, and at the same time, 1828 dogs were reported to have changed owners only during January 2023 (statistics from Swedish Board of Agriculture, 2023). Common reasons for relinquishment are lifestyle and accommodation issues; the owner having too many dogs, or behavior problems (Miller et al., 1996; Salman et al., 1998; Scarlett et al., 1999; Wells and Hepper, 2000; Hawes et al., 2020; Eagan et al., 2022).

Dogs that are relinquished to a dog shelter are exposed to several stressors, such as a novel and unpredictable environment and noise, and they are often placed in a socially isolated environment, which contributes to an increase in the dog's stress level (Hennessey et al., 1997; Jones et al., 2014; van der Laan et al., 2022). Indeed, rehomed dogs or dogs that have lived in dog shelters for any period can suffer from acute and long-term stress, which can be measured behaviorally and physiologically (Beerda et al., 1997; Rooney et al., 2007). Behaviors such as lip-licking, paw-lifting, yawning, and body shaking are commonly used as stress indicators (Beerda et al., 1997; Jones et al., 2014), but stress can also affect cognitive abilities such as impaired memory performance, attention, and problem-solving skills (Luine et al., 1994; González-Martínez et al., 2013; Chapagain et al., 2018). Therefore, behavioral tests could effectively be used to assess stress levels and screen different types of cognitive decline (Chapagain et al., 2018).

Besides behavioral responses, which could serve as an early sign of stress, assessments linked to welfare can also benefit from physiological indicators. An increasingly non-invasive method to physiologically measure long-term stress is analyzing the cortisol concentration in hair (Roth et al., 2016; Heimbürge et al., 2018). Interestingly, some breed groups have been shown to synchronize their hair cortisol concentration (HCC) with their owner (Sundman et al., 2019), showing the owner's great influence on their dog. In addition, we have found associations between the dog's HCC and the owner's perceived human-dog relationship (Höglin et al., 2021), which suggest that the relationship quality is linked to the welfare of the dog. Interestingly, Powell et al. (2022) reported that 22% of the rehomed shelter dogs were returned within a few months, many due to the lack of perceived bond to the dog. Indeed, the dog-owner relationship is important during the rehoming procedure. In this present study, our aim was to investigate the behavior, long-term stress, and human-dog relationship in dogs currently rehoming, as well as those that have already been rehomed. This research can contribute to a better understanding of the challenges and adjustments dogs face during the rehoming process and also, the importance of the dog-owner relationship in these situations (Höglin et al., 2021; Powell et al., 2022). By setting more reasonable expectations for rehomed dogs, there will hopefully be positive effects on both dog and human welfare, thereby reducing the risk of the dog being repeatedly relinquished.

In our recent study (O'Riordan and Roth, 2023), citizen science was used to assess behavior and cognitive abilities in rehomed dogs and dogs bought directly from the breeder. In this study, a more controlled assessment was conducted, and importantly, dogs that lived in one of the largest dog shelters in Sweden were also included. Hence, the current study aimed to compare contact-seeking behavior, short-term memory, and stress levels in dogs that are relinquished and live in a shelter, dogs that are rehomed and live with their new owner, and compare those to control dogs that have lived with their owner since it left its breeder. Standardized behavioral tests were performed, and hair samples from the dogs were obtained to assess long-term stress levels. In addition, dog-owner dyads were also tested in behavioral synchronization, and the owner completed a relationship questionnaire. We hypothesized shelter dogs to have higher long-term stress level, and show more stress-related behaviors and less contact-seeking behaviors, while the rehomed dogs have recovered and are similar to the non-rehomed dogs.

2 Methods

2.1 Animals

Privately owned dogs of various breeds were recruited using social media or personal contact. The study included 33 dogs of the age of 4.67 years \pm 0.5 that had been bought directly from the breeder (and not rehomed since then; 10 females and 23 males). This group is referred to as the control group. The study also included 30 rehomed dogs of the age of 5.80 years \pm 0.6 (13 females and 17 males) and to be part of this group the dogs have had to change owner after it left the breeder. The group of rehomed dogs was included in the study to investigate the long-term effects of the rehoming procedure. All dog owners were informed about the study and signed a consent that they voluntarily participated in this study. In addition, 20 dogs living at the dog shelter Hundstallet in Stockholm, Sweden were included in the study. The shelter consisted of four corridors housing 16 dogs each. The dogs had separate indoor and outdoor kennels and they could see each other when they were in their outdoor kennel. All kennels were cleaned in the morning and feeding took place around 08:00–09:00 and around 16:00–17:00. The dogs were taken out on walks two to three times a day depending on staff and volunteer availability. The group of shelter dogs was included to study the more immediate stress effects of the rehoming process. The included shelter dogs consisted of 7 females and 13 males, and their mean age was 3.85 years \pm 0.5 (for more information about the dogs, see Supplementary Table 1. Dog information).

2.2 General experimental procedure

The experiments took place in September and October 2021 and were performed in the same order for all dogs. All dyads were tested separately. When the dog-owner dyad (control and rehomed

dogs) arrived at Linköping University in the southeast of Sweden, the owner was informed about the tests and asked to sign a consent form. Then, the human-dog dyad started with the behavioral synchronization test before they went indoors in a nearby empty room and performed the Unsolvable Problem Task (UPT), memory test, and eye contact test. Lastly, a hair sample from the dog was obtained for later HCC analysis to reveal the long-term stress level of each dog.

The shelter dogs were tested in October 2021 in the dog shelter Hundstallet, in Stockholm, Sweden. All dogs were tested separately, with a well-familiar female caretaker assuming the role of the owner in all tests. The shelter dogs started with the UPT, then the memory test, the eye contact test, and the hair collection. The behavioral synchronization test was not performed with the shelter dogs due to time and space restrictions and the lack of an owner.

2.3 Behavioral synchronization test

The behavioral synchronization test was adapted from Duranton et al. (2017) and previously described in detail in Heurlin et al. (2024). First, the owner was asked to walk their dog on a loose leash in a clockwise direction inside the test arena (6 x 10 m) to allow the dog to acclimatize to the novel surroundings. Then, the owner was instructed to bring their dog to the starting area connected to the test arena. The dog's leash was removed, and the owner was again given verbal instructions and received a printed walking and standing schedule (Supplementary Figure 1A. Synchronization schedule). The experimenter started the test when the owner and the dog had left the starting area, and the owner was standing still in the first position. The synchronization test lasted one minute, including 15 s when the owner was standing still and 15 s when the owner was walking, which then was repeated, resulting in a total of 60 s. The test was recorded with a camcorder (Canon Legria) for later analysis with a predetermined ethogram (Table 1) in the software Observer XT 13 (Noldus).

2.4 Unsolvable Problem Test – UPT

The UPT was performed in an empty room in a 3 x 3 m enclosed test arena using fence. For the shelter dogs, tests were performed in a room of similar size at the dog shelter, with the same sized 3 x 3 m test arena (using a fence). Before the UPT started, a motivation test was conducted to ensure sufficient food motivation in the dogs. This was achieved by presenting a treat three times on a plate constructed in the same way as the test device but without a lid. The test device (Supplementary Figure 1B. UPT device), measuring 55 x 25 cm, consisted of three plates covered in transparent lids with odor holes. These plates were mounted on a solid base. While the two lids on the sides could be easily moved to provide access to treats underneath, the third in the middle remained immobile (but looked the same).

The test duration was 3 min, described in detail by Persson et al. (2015). The test leader put down the test device in the front end of the test area before she went back behind the camera. The owner (or

TABLE 1 Ethogram for Behavioral synchronization test and Unsolvable Problem Task (UPT).

Behavior	Description	Test
Physical contact to either owner/handler, experimenter, or test set-up.	The dog is in physical contact with owner/handler, experimenter or test-set-up.	UPT
Proximity to either owner/handler, experimenter.	The dog's head is within its own body length of owner/handler, or experimenter.	Both
Eye contact with owner/handler or experimenter.	The dog's nose is pointing towards the owner's/handler's or experimenter's head.	Both
Solved the first problem	The dog opens the first lid and eats the treat	UPT
Moving	The dog front paws are moving more than 5 cm in any direction.	Both
Exploring	The dog's nose within 10 cm of the ground or any other physical object excluding the test set-up.	Both
Orientation	The dog's chest is pointed in the same direction as the owner's hips, within 45° to either direction. ¹	Behav. Synk.
Lip licking	Snout licking with tongue visible.	UPT
Yawning	The dog opens mouth widely.	UPT
Vocalizing	The dog is barking, whining, howling or growling.	UPT
Body shaking	The dog shakes any part or entire body from side to side.	UPT
Paw lifting	The dog lifts one of its paws off the floor.	UPT
Tail wagging	Repetitive wagging movements of the tail.	UPT

¹Wanser, S.H., MacDonald, M., Udell, M.A. (2021) Dog-human behavioral synchronization: family dogs synchronize their behavior with child family members. *Anim. Cogn* 24:747–752.

a familiar female handler for the shelter dogs) and female experimenter (unfamiliar to the dog) stood passively facing the test device throughout the test. If the dog did not open any of the two lids within 60 seconds, the experimenter and the dog owner would approach the test device, open the solvable lids halfway, and then return to their original positions. The test was recorded with a camcorder (Canon Legria) for later analysis with a predetermined ethogram (Table 1) in the software Observer XT 13 (Noldus).

If a dog was afraid of the fence surrounding the test arena, it was removed for that dog. For that reason, one control dog and one rehomed dog were out of sight during parts of the test and, therefore, had shorter durations of observed behaviors during this test.

2.5 Memory test

Two cups were placed on the ground on either side of the experimenter. Each cup consisted of two stacked cups with a treat

hidden in between to control for odor cues. In the starting position, the owner, and the dog faced the experimenter (and the cups) at 2–3 meters. Before the Memory test started, one warmup test was performed where the dog witnessed only one cup being baited and was then immediately allowed to approach the cup.

During the actual test, the experimenter lifted one of the two cups (either the left or right cup) to let the dog see it was empty before putting it back down on the ground. The experimenter then picked up the other cup and placed a food treat underneath while the dog watched. Then the owner was instructed to leave the room for one minute with the dog. After this delay, the dog and the owner returned to the starting position, and the owner was asked to release the dog. The test was recorded with a camcorder (Canon Legria) to analyze the dog's choice. If the dog picked the baited cup, it was scored as the correct choice; if it chose the empty cup, it was scored as the wrong choice; and if the dog did not pick a cup within 30 seconds, it was scored as no choice and removed from the analysis.

2.6 Eye-Contact Test

During the eye-contact test, the owner-dog dyad was positioned in the middle of the indoor testing area, facing each other. The owner was instructed to stand passively and quietly and to show the dog a treat to get the dog's attention. The owner then held the treat next to her/his face, and eye-contact duration was assessed. Eye contact was defined as the dog facing the owner's face. The duration ended if the dog broke eye contact for more than 3 seconds within the maximum time of 90 seconds. Before the actual test, a warmup test was performed, where the owner held a treat next to her/his face for only 10 seconds before giving the treat to the dog. The test was recorded with a camcorder (Canon Legria) for later analysis.

2.7 Hair cortisol

The samples were obtained after the tests and did not affect dogs' performance. Approximately 0.5 grams of hair was cut from the neck as close to the skin as possible and then stored in room temperature until preparation and cortisol extraction (Roth et al., 2016). About 4–8 mg of hair was cut into small pieces and frozen with liquid nitrogen for 2 minutes; after this, it was pulverized with beads in a TissueLyser for 2 minutes. 1 ml of methanol was added to each test tube, and the tubes were put in a tube shaker overnight at room temperature. 0.8 ml of the methanol supernatant was removed from the tubes; following this, the tubes were evaporated in a Speed-Vac. The remaining pellets were dissolved in 200 μ L RIA buffer. From this solution, 50 μ L was then taken, and 100 μ L of primary antibody (Anti-cortisol rabbit antibody) was added. After incubation (48 h), 100 μ L of radioactive conjugated cortisol was added to each tube before another incubation (24 h). Then 75 μ L of SAC-CEL (Solid phase second anti-rabbit antibody coated cellulose suspension) was added to all samples. The reaction was stopped after 30 minutes by adding 2 mL of water, and the samples were centrifuged for 15 minutes (3000 rpm; 4 °C). The water was removed using a decanting tool, and the tubes were placed in a

gamma counter (PerkinElmer 2470 Wizard2), which gave measures in CPM and nmol/L, later converted into pg of cortisol per mg of hair. Samples were run in duplicates for validity.

2.8 Questionnaire – Owner perceived relationship

Owners completed The Monash Dog-Owner Relationship Scale (MDORS) developed by Dwyer et al. (2006) to investigate the owner perceived dog-owner relationship. The questionnaire was completed by the owners via online forms and consisted of a 28-items resulting in three subscales: Dog-owner interaction, Perceived emotional closeness, and Perceived costs.

2.9 Data analysis

The behaviors in the synchronization test were analyzed using a generalized linear mixed model (GLMM; normal distribution) after visual inspection of the Q-Q plots. Dog group (control and rehomed dogs), sex, age, phase, and the interaction between phase and group were treated as fixed effects.

In the UPT, the test interaction and latency to open the first lid and stress-related behaviors were analyzed using a generalized linear model (GLM; normal distribution) after visual inspection of the Q-Q plots. Dog group (control, rehomed, and shelter dogs) and sex were treated as fixed factors and age as a covariate. To compare the contact-seeking behaviors between the tree groups in the UPT, Kruskal Wallis tests were used since the data was not normally distributed according to the Q-Q plots. Pairwise comparisons were then corrected using the Bonferroni correction for multiple tests. Similarly, to test the dog group's preference for owner or stranger, Wilcoxon Signed Rank test was used for each group.

In the eye-contact test, eye contact duration of the shelter dogs, rehomed dogs and control dogs was tested using GLM (normal distribution) after visual inspection of Q-Q plots. Dog group (control, rehomed, and shelter dogs) and sex were treated as fixed factors and age as a covariate. Tukey post hoc test was used to test differences between the three groups. In the memory test, the choices made by the dogs (correct or wrong choice) was tested groupwise using chi-square test. Hair cortisol concentrations (HCC) were analyzed using Kruskal Wallis tests after visually inspecting the Q-Q plots that revealed a non-normal data distribution. Pairwise comparisons of groups were adjusted by the Bonferroni correction for multiple tests.

Lastly, the MDORS results were normally distributed according to Q-Q plots and analyzed with GLM. Dog group (control and rehomed dogs) and sex were treated as fixed factors and age as a covariate.

The statistical analysis was performed using the software SPSS (version 28). In the text, results are reported using mean \pm SE, and p-values less than 0.05 were judged as significant and less than 0.1 as a trend. For easier comparisons, all behavioral results are shown as boxplots, and for details about the data and the statistical tests, see [Supplementary Table 2](#). Experimental data.

3 Results

3.1 Behavioral synchronization test

The behavioral synchronization test was performed on rehomed dogs (N = 29) and control dogs (N = 31) to study the activity and behavioral synchronization between the dog and the owner.

Most behaviors were affected by phase, that is, if the owner was walking or standing still (Figures 1A–G). In the walking phase, the dogs exhibited increased movement compared to the standing still phase (p < 0.001). Moreover, they were more in the same direction as the owner (p < 0.001) and showed longer eye-contact duration in the walking phase compared to the standing still phase (p = 0.024). On the other hand, the dogs showed more exploratory behavior (p <

0.001) during the standing still phase, and overall, the rehomed dogs tended to explore more than the control group (p = 0.078). Human proximity was, however, not affected by phase (p = 0.15), but the interaction phase and group revealed a tendency (p = 0.078).

The only sex difference found was that, during the whole test, the females tended to move more (p = 0.070) and tended to show an increased duration of eye contacts (p = 0.084) than the males. Age did not significantly affect any of the analyzed behaviors (p > 0.2). Hence, these results suggest that control and rehomed dogs behaved alike and synchronized their moving behavior with their owner.

Mean total owner proximity during the whole test (1 min) was 38.8% ± 3.5 for control dogs and 37.5% ± 4.1 for rehomed dogs. The control dogs spent 31.2% ± 3.3 of the time in the same direction as the owner and the same numbers for rehomed dogs were 25.5% ± 2.9. Total eye-contact duration was 11.0% ± 1.9 for control dogs and

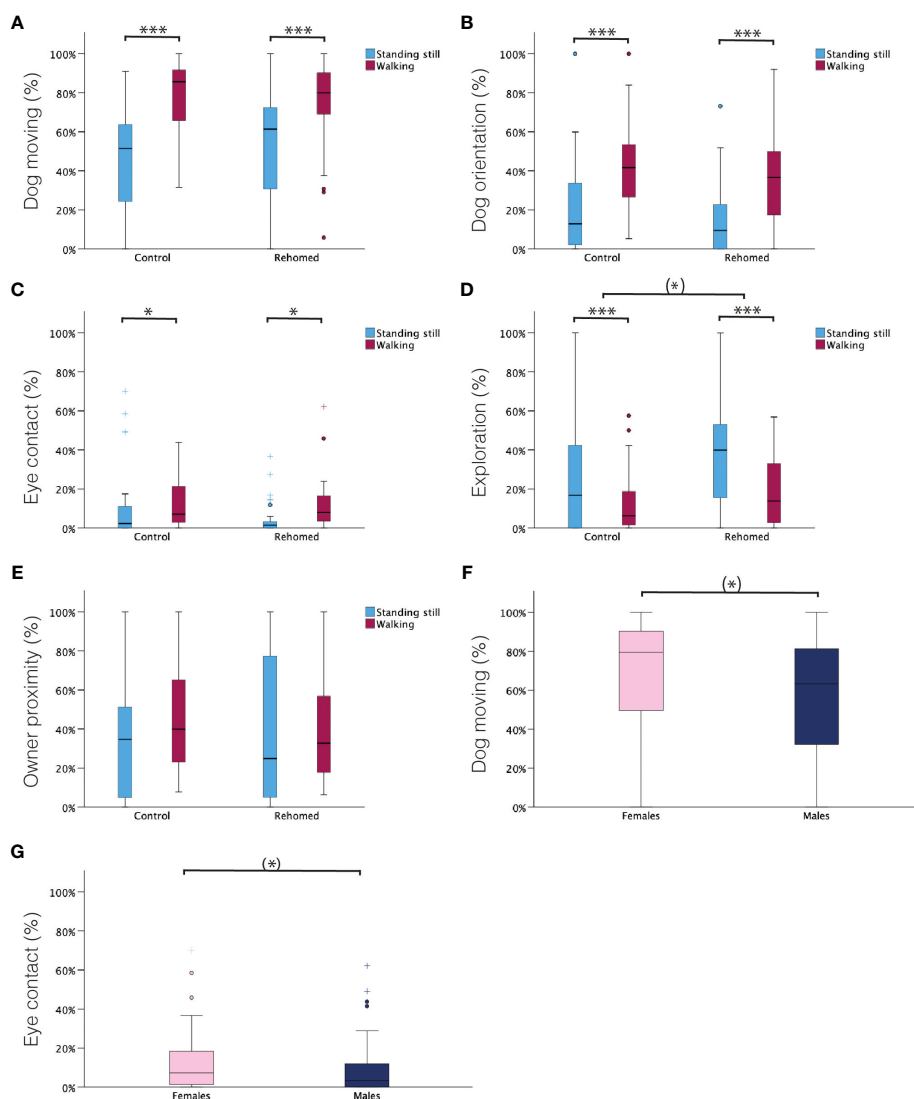


FIGURE 1 Boxplots of the control and rehomed dogs' (A) moving duration, (B) orientation, (C) eye-contact duration, (D) exploration, and (E) owner proximity during the standing still phase (blue) and walking phase (dark red) in the synchronization test, and for females (pink) and males (dark blue) for (F) the dogs' moving and (G) eye-contact duration. Circles indicate outliers and + indicate extreme outliers (three times the interquartile range from a quartile). (*) p < 0.1, *p < 0.05, *** p < 0.001.

8.6% ± 1.6 for rehomed dogs. Lastly, the control and rehomed dogs explored 19.9% ± 3.3 and 28.9% ± 3.2 of the time, respectively.

3.2 Unsolvable problem test

All but one rehomed dog passed the food motivation test before the UPT. Hence, The UPT was performed by 20 shelter dogs, 29 rehomed dogs, and 33 control dogs to assess the dogs' problem-solving abilities, contact-seeking behavior, and stress-related behaviors. The number of lip-licking, paw-lifting, body shaking, and yawning were summed into a total stress-related behavioral category. All groups showed a similar number of stress-related behaviors (Figure 2A; $p = 0.20$), and there was no effect of age ($p = 0.74$) or sex ($p = 0.16$).

Test setup interaction duration was similar between groups ($p = 0.21$; control dogs: 107.3 s ± 7.9, rehomed dogs: 85.1 s ± 10.5, shelter dogs: 92.4 s ± 11.9), and again, there were no effects of sex ($p = 0.73$) and age ($p = 0.60$). Four dogs (one female and three males) did not manage to open any of the lids (hence, did not eat the treats) and were assigned 180 seconds in the latency to solve the task. Still, there was no effect of dog group ($p = 0.53$), age ($p = 0.47$), or sex ($p = 0.37$) in the latency to open the first lid and eat the treat (Figure 2B).

Comparing the contact-seeking behaviors between the three groups (Figures 2C–F) showed only differences in eye-contact-

seeking behavior towards the owner/handler ($H = 8.01$, $p = 0.018$) and proximity to the unfamiliar experimenter ($H = 8.85$, $p = 0.012$). Pairwise comparisons revealed that control dogs gazed significantly longer duration towards their owner compared to the duration shelter dogs gazed at their familiar handler ($p = 0.017$). In contrast, the shelter dogs showed longer experimenter proximity duration than control dogs ($p = 0.013$). The dog groups were similar in their eye-contact duration towards the experimenter ($H = 1.56$, $p = 0.46$), owner/handler proximity ($H = 2.90$, $p = 0.23$), physical contact with owner/handler ($H = 0.72$, $p = 0.70$) and experimenter physical contact ($H = 3.08$, $p = 0.21$). Only 25 of the 82 dogs, equally distributed between groups, had physical contact with their owner/handler during the UPT.

Comparing the dogs' preference for their owner/handler or an unfamiliar experimenter showed that control dogs had longer eye-contact duration towards their owner than towards the experimenter ($Z = -4.05$, $p < 0.001$). Still, proximity and physical contact with their owner and the experimenter was similar ($Z = -1.50$, $p = 0.13$ and $Z = -0.88$, $p = 0.38$ respectively). Similarly, the rehomed dogs showed longer eye-contact duration towards their owner than with the experimenter ($Z = -2.48$, $p = 0.013$) but they also seemed to prefer their owner over the experimenter in proximity ($Z = -2.54$, $p = 0.011$) and physical contact ($Z = -2.05$, $p = 0.040$). Shelter dogs revealed similar eye-contact duration ($Z = -0.40$, $p = 0.69$), and proximity ($Z = -0.48$, $p = 0.63$) towards the handler and the experimenter, but they

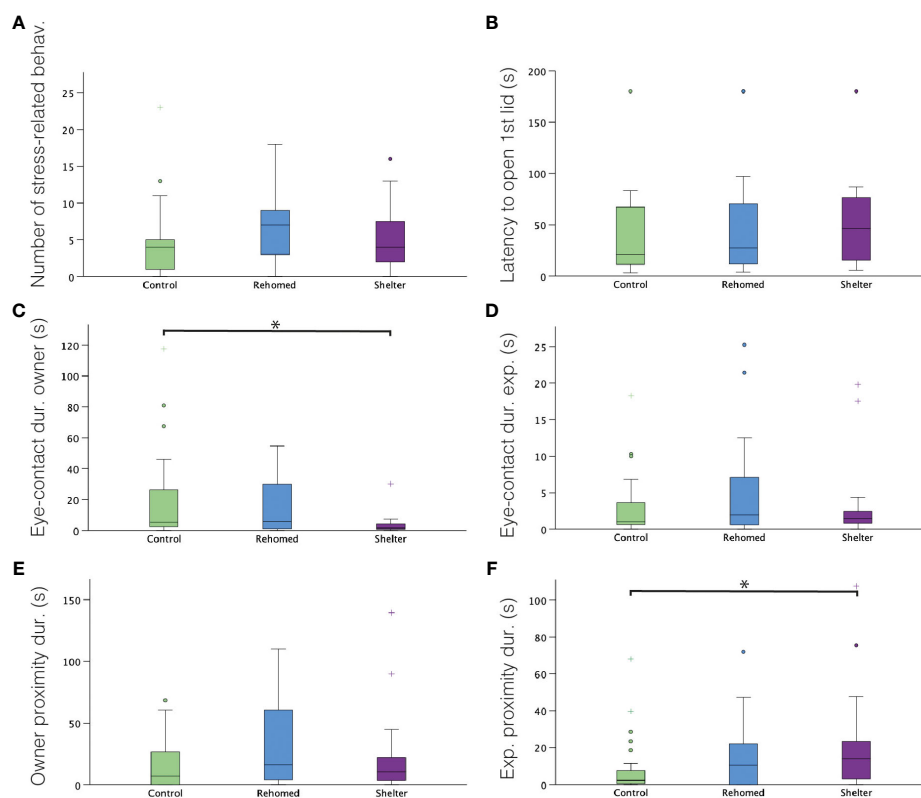


FIGURE 2 Boxplots of the control dogs' (light green) rehomed dogs' (blue) and shelter dogs' (deep purple) (A) stress-related behaviors, (B) latency to open the 1st lid, (C) eye-contact duration towards the owner and (D) the unfamiliar experimenter, and (E) proximity towards owner and (F) experimenter, during the UPT. Circles indicate outliers and + indicate extreme outliers (three times the interquartile range from a quartile). * $p < 0.05$.

were more in physical contact with the experimenter than with the familiar handler ($Z = -1.98$, $p = 0.048$).

3.3 Eye-contact test

The eye-contact test was performed on shelter dogs ($N = 20$), rehomed dogs ($N = 30$) and control dogs ($N = 33$). There was an effect of group on the eye-contact duration (Figure 3A; $p = 0.002$) and Tukey *post hoc* test revealed that shelter dogs had shorter duration than both rehomed ($p = 0.002$) and control dogs ($p = 0.007$). Control dogs and rehomed dogs did not differ in duration ($p = 0.84$). Age ($p = 0.33$) and sex ($p = 0.99$) was not linked to the eye-contact duration.

3.4 Short-term memory test

The short-term memory test was performed on shelter dogs ($N=20$), rehomed dogs ($N=30$) and control dogs ($N=33$). When the dogs that did not make any choice at all were excluded (1 control, 3 rehomed, and 2 shelter dogs), all groups performed better than chance. Control dogs made 75% correct choices ($X^2(1, N = 32) = 8.00$, $p = 0.005$), rehomed dogs 78% correct choices ($X^2(1, N = 27) = 8.33$, $p = 0.004$) and shelter dogs also achieved a 78% success rate ($X^2(1, N = 18) = 6.56$, $p = 0.018$). There was no difference between groups ($H = 0.07$, $p = 0.97$).

3.5 Hair cortisol concentration as a measure of long-term stress

Long-term stress was assessed using HCC in shelter dogs ($N = 15$), rehomed dogs ($N = 23$) and control dogs ($N = 31$). HCC differed significantly between the groups (Figure 3B; $H = 8.17$, $p = 0.017$) where shelter dogs revealed significantly higher HCC than rehomed dogs ($p = 0.017$). Control dogs, with three extreme outliers, did not differ from the other groups. If recent shelter dogs were removed (eight dogs with less than one month stay; hence the hair sample would not represent the stay at the shelter),

there was still a group difference ($H = 7.05$, $p = 0.029$) and still a difference between rehomed and shelter dogs ($p = 0.043$).

3.6 Questionnaire – Owner perceived relationship

The questionnaire MDORS assessing the owner perceived relationship was completed by 31 control dogs and 30 rehomed dogs (Figure 4). The subscale Dog-owner interaction was not affected by dog group ($p = 0.70$), age ($p = 0.64$) or sex ($p = 0.56$). However, the subscale perceived emotional closeness was significantly higher in rehomed dogs than control dogs ($p = 0.006$) and there was a tendency that male dogs scored higher than females on this subscale ($p = 0.065$). Age had no effect on the subscale perceived emotional closeness ($p = 0.20$). The third subscale, perceived cost was not affected by dog group ($p = 0.20$), age ($p = 0.56$) or sex ($p = 0.32$).

4 Discussion

With an increasing number of dogs being relinquished and rehomed, this study aimed to compare short and long-term effects in shelter dogs and rehomed dogs, comparing them to non-rehomed control dogs. The goal is to enhance our understandings of the challenges faced by relinquished. Encouragingly, according to our results, dogs appear to adapt well and while rehomed dogs exhibited the lowest long-term stress levels, their owners reported the strongest perceived emotional bond.

The rehoming procedure is a stressful period for the dog, and in this study, shelter dogs were found to have higher HCC than rehomed dogs. However, they did not differ significantly from the control dogs. van der Laan et al. (2022) recently found a significant HCC increase during the dogs first six weeks at the shelter. With time, cortisol levels seem to decrease, which suggests that the dogs adapt to the new environment (Hennessey et al., 1997; van der Laan et al., 2022). The shelter dogs in our study varied largely in how long they had been at the shelter (from one day to one year), but most had been there for more than one month, which could explain why

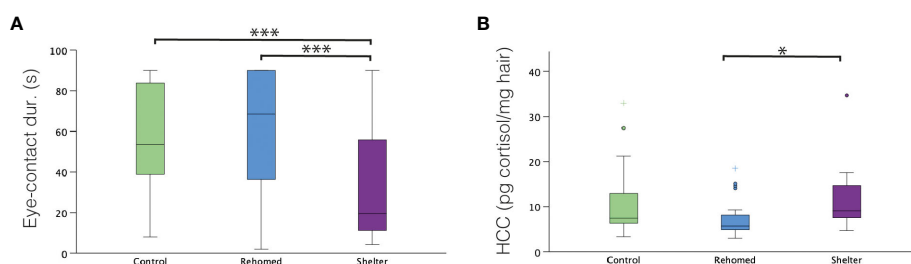


FIGURE 3

Boxplots of the (A) eye-contact duration in the eye-contact test, and (B) HCC (pg cortisol/mg hair) for control dogs (light green), rehomed dogs (blue), and shelter dogs (deep purple). Circles indicate outliers and + indicate extreme outliers (three times the interquartile range from a quartile) but two extreme HCC outliers (70.5 and 72.8 pg/mg) are omitted for clarity in the figure. * $p < 0.05$, *** $p < 0.001$.



they did not differ from the control dogs in HCC. Still, the rehomed dogs exhibited lower HCC than shelter dogs, suggesting they have adapted well to their new life.

Interestingly, in this study, owners of rehomed dogs reported a closer emotional bond with their dogs compared to the control dog owners. Indeed, these owners have chosen to take care of relinquished dogs with various previous experiences, which might suggest a strong dedication to the dog and its well-being. Owners who do not perceive a strong relationship with their dog or who have had too high expectations on the dog's behavior risk returning the dog to the shelter (Powell et al., 2022). Therefore, in our study, there might be a bias, as we may have primarily recruited only successfully rehomed dogs with strong dog-owner relationships. Also, the rehomed dogs in the UPT to gaze more toward the owner and were closer to the owner than the stranger, which was not the case for the control dogs. The rehomed dog's contact-seeking behavior towards the owner might also add to the owner's perceived emotional bond, but this is speculative and would need further investigation. Nevertheless, shelter dogs have been found to form bonds with unfamiliar humans quickly, and it is suggested that the time spent in shelters, with limited human social contact, may enhance this ability (Gácsi et al., 2001). If that is true, then when rehomed, the dog would easily form a strong bond with its new owner, aligning with the results from the rehomed dogs in this study.

In addition to measuring contact-seeking behavior, the UPT assesses the dog's persistence, which was similar between the groups in our study, and the dog's problem-solving skills. The latter is suggested to decline with age (González-Martínez et al., 2013), along with cognitive abilities (Chapagain et al., 2020). However, in our study, the dog group or age did not affect the latency to succeed. Therefore, our UPT results do not suggest any cognitive decline regarding problem-solving skills resulting from rehoming. However, we did not study the same individual during the rehoming process, so the results should be interpreted cautiously.

Sustained eye contact in dogs has been inversely linked to cognitive dysfunctions (Hoel et al., 2021), and it is easy to test. In the eye-contact test in this study, the shelter dogs exhibited the shortest duration. This observation might indicate a cognitive decline in the shelter dogs. However, an alternative explanation

could be that they were tested with a familiar handler rather than an owner, as with the rehomed and control owner-dog dyads. Hence, for future studies, a better comparison may involve testing all dogs with a stranger. Interestingly, the control and rehomed dogs showed similarly high eye contact durations. Hence, if affected during the rehoming procedure, the rehomed dogs seem to recover. That result differs from our recent study (O'Riordan and Roth, 2023), where rehomed dogs gazed significantly shorter toward their owner than non-rehomed dogs. However, in O'Riordan and Roth (2023), the owners performed, and video recorded the tests in the dog's home environment, which might have affected the results. When comparing the durations in these two studies the rehomed dogs show similar results while it was the control dogs that were better in keeping the eye-contact in their home environment (O'Riordan and Roth, 2023) than the control dogs in the present study in an unfamiliar room at the university. Hence, it would be interesting to investigate whether new environments affect the contact-seeking behavior in rehomed and non-rehomed dogs differently, but that is outside the scope of this study.

In the short-term memory test, all groups succeeded to a similarly high degree, which also differs from the findings in O'Riordan and Roth (2023), where rehomed dogs performed better than non-rehomed dogs. However, in this study, the owners/handlers were asked to leave the room for 1 minute, potentially influencing the results, as no dog could maintain eye contact with the baited cup during that time. Still, the shelter dogs' high success rate in the current memory test suggests that the rehoming process does not reduce their short-term memory ability.

Being synchronized in behavior is important in social animals as it could improve group cohesion. Between individuals, the synchronization might reflect on the relationship quality (see review Duranton and Gaunet, 2016). Indeed, pack-living dogs and wolves do not show behavioral synchronization with a familiar handler (Heurlin et al., 2024), while companion dogs living with their owner do (Duranton et al., 2017; Heurlin et al., 2024). In this study, the behavioral synchronization test was performed on rehomed and controlled dogs, and both groups synchronized with their owner in their movement pattern. Hence, they moved more and were in the same direction as their owner when the owner was walking compared to when the owner was standing still. Also, like the

companion dogs in Heurlin et al. (2024), the dogs in the current study showed longer eye contact duration towards the owner when the owner was walking compared to when the owner stood still, and when the owner stood still, the dogs spent more time exploring.

One limitation of this study is that there were slightly more male dogs, and the shelter dogs were slightly younger than the other groups. However, age and sex of the dogs did not have a significant effect on our results. Another limitation with the study is, as mentioned before, the absence of follow-up with the same dog throughout the rehoming process. Instead, the results from the shelter dogs were interpreted to reflect the short-term effects, while those from the rehomed dogs were considered to reflect the long-term effects of the rehoming process. Also, it is acknowledged that research studies may primarily attract the interest of dedicated and enthusiastic dog owners, potentially limiting the generalizability of the findings. We recognize that some relinquished dogs are repeatedly rehomed highlighting the variability in the success of rehomed dog-owner relationships and there is still a need to further explore strategies that can improve the overall success rate of rehoming these dogs.

In conclusion, while dogs may experience stress during the rehoming process, those that are successfully rehomed dogs demonstrate a remarkable ability to adapt and form strong relationships with their new owners. It is important to note, however, that these conclusions are drawn from dog owners who volunteered for research studies and may be particularly dedicated to their dogs.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Ethics statement

The animal studies were approved by Linköping Ethical Committee, Dnr 6065/2019. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent was obtained from the owners for the participation of their animals in this study.

Author contributions

CS: Conceptualization, Data curation, Investigation, Methodology, Software, Writing – original draft, Writing – review

& editing. JL: Conceptualization, Data curation, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. PJ: Conceptualization, Writing – original draft, Writing – review & editing. KL: Writing – original draft, Writing – review & editing. ET: Methodology, Writing – original draft, Writing – review & editing. HQ: Methodology, Writing – original draft, Writing – review & editing. LR: Conceptualization, Data curation, Formal analysis, Methodology, Software, Supervision, Visualization, Writing – original draft, Writing – review & editing, Investigation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fanim.2024.1384155/full#supplementary-material>

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