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Reducing Human-Directed Kennel Reactivity in Shelter-Housed Dogs

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Abstract: Many stressors have been identified for shelter dogs, and while stress is a natural physical response, exposure to shelter stressors has been implicated in poor dog welfare including the formation of maladaptive behaviors that manifest as unappealing responses toward humans. Inappropriate behavioral reactions to humans lead to longer lengths of stay in the shelter, so identifying ways to reduce these responses to human presence would not only benefit the immediate welfare of the dog but could also decrease the amount of time the dog spends in the shelter. Previous studies have shown that response-independent food paired with an auditory stimulus reduced behaviors that likely prolong time to adoption; however, these interventions used an explicit discriminative stimulus where a more easily deployed design would be effective without requiring an additional stimulus to precede the food. The purpose of the present study was to extend that work to evaluate the effect of noncontingent reinforcement on reducing behavioral reactions to humans in the presence both of the experimenter and other people. Overall, the intervention was effective at decreasing human-directed behavioral responses but did not decrease the dogs' length of stay. Changes in reactive behaviors appear to be limited to the presence of the experimenter during the first and last trials, with improvements generalizing to non-experimenters only for two behaviors: staying in the front half of the kennel and facing the kennel front. Our recommendation for shelters is that this intervention would be most effective at improving behaviors directed at a person delivering treats to the dog.

Keywords: dogs; animal shelters; animal welfare; noncontingent reinforcement

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1. Introduction

A high proportion of the dogs living in the United States are housed in animal shelters [1] and while the number of dogs being euthanized in shelters has decreased, the amount of time dogs await adoption is likely increasing [2–4]. Previous research has identified many stressors in the daily lives of dogs in animal shelters [5], including but not limited to excessive noise [6–8], spatial restrictions [9], and loss of attachment figures [10]. Although stress is a natural physical response, prolonged exposure to stressors in the shelter has been implicated in various indicators of poor welfare, such as impaired immune function [11] and the formation of maladaptive behaviors [12]. One such maladaptive behavioral pattern that may develop is undesirable reactions towards humans.

The concept of reactivity in dogs, particularly in the context of kennel environments, is not precisely defined [13]; however, it is clear that "reactivity" involves the interplay of the dog's behavior and the human's perception of what is deemed appropriate behavior. For our purposes, human-directed reactivity is defined as the dog displaying threatening and/or distance-increasing behaviors toward a human, such as lunging, biting, or orienting away from a person. Dogs are social by nature but often lack social enrichment in the shelter environment, which may lead to human interactions being perceived as high-value limited resources or discomfiting stimuli in an already overwhelming environment [14]. Behavioral responses that are perceived as extreme by passersby can occur as a result of arousal related to increased levels of adrenaline and cortisol due to exposure to uncomfortable or overly excitable situations, initiating a stress response that subsequently increases the likelihood of those behaviors [15]. People often pass by or linger in front of shelter dogs' kennels, and for those dogs that exhibit extreme human-directed behavioral responses, this repeated stimulus presentation offers many opportunities to display these behaviors, potentially contributing to an increase in their severity as the repeated presentations of humans continues throughout the dogs' stay in the shelter. Furthermore, potential adopters have a stated preference for dogs who interact calmly with them at the front of their kennel, with dogs that exhibit undesirable behaviors being less likely to be adopted [16,17]. Behavioral responses to the presence of people, such as facing away from the kennel front [18] and barking [19] have been implicated in longer lengths of stay in the shelter. Identifying ways to reduce human-directed reactivity would not only benefit the immediate welfare of the dog but would also have the potential to decrease the amount of time the dog has to spend in the shelter environment.

Thus far, the most effective interventions shown to improve shelter-dog welfare involve people spending time with dogs outside the kennels [7,20–30]. However, with shelters consistently reporting that they are understaffed [31], recommending that the dozens if not hundreds of dogs in a shelter's care be given time out of their kennels interacting with people multiple times a day places this approach outside the reach of all but the best-resourced animal shelters. While some in-kennel interventions, such as sensory stimuli (e.g., aromatherapy, pheromones, and music) and food toys, have shown benefits like reduced vocalizations and increased resting behavior [21,31–39], more research is needed to understand how these interventions interact with human presence. Moreover, these approaches may be resource-intensive, especially when human interaction is required for maximum effectiveness [40]. An ideal intervention would be brief, cost-effective, easily deployable, and not dependent on more than a few minutes of staff time a day per dog to implement.

Noncontingent reinforcement is a procedure in which an item, such as food, is dispensed to the dog independent of any specific response requirement (i.e., the dog does not need to perform a particular behavior to receive the food). Only two studies using noncontingent reinforcement have investigated shelter dogs' behavioral responses toward the presence of a person at their kennel. Both studies relied on Pavlovian conditioning procedures in which a bell or chime sound preceded the delivery of food to the dog's kennel, effectively associating a neutral auditory stimulus with an unconditioned appetitive stimulus. Protopopova and Wynne [41] showed that deployment of response-independent food treats paired with the sound of a bell when implemented for just 20 s a day over about a week led to a reduction in behaviors likely to prolong the time to adoption. However, this study only looked at the behavior of dogs while the experimenter was present and required the establishment of an explicit conditioned reinforcer or discriminative stimulus. Payne and Assemi [42] paired the sound of a door chime with the noncontingent delivery of food over several 5 min sessions a day for a week and saw a reduction in barking and overall noise level in the kennels. Although the intervention demonstrated positive behavioral changes that persisted beyond the duration of the session, the need for multiple sessions each day and the shelter staff's reluctance to use the 120 dB door chime made this intervention unsustainable. A more optimal design would be as effective as these studies without the need for an explicitly programmed stimulus preceding the delivery of food and would demonstrate that the dogs' improved behavior generalized to people other than just the experimenter passing by their kennels.

In this study, we address the utility of a noncontingent reinforcement intervention on shelter dogs' human-directed behavioral responses in order to address three research questions. First, we consider the intervention's overall efficacy; specifically, whether it is effective at decreasing human-directed behavioral responses. We hypothesize that behaviors will decrease on intervention days compared to baseline days. Second, we investigate the generalizability of the intervention's effects and explore whether the behaviors decrease similarly for the experimenter and non-experimenters (e.g., shelter staff, volunteers, and potential adopters). We hypothesize that intervention effects will generalize from the experimenter to the first non-experimenter to pass the kennel after the intervention has concluded; however, these effects may not generalize as well to a non-experimenter walking past the kennel hours after the intervention has concluded. Finally, we want to know whether dogs that receive the intervention have overall shorter lengths of stay than dogs that did not. Length of stay is a complex variable with multiple determinants [15], and consequently we hypothesize that this intervention alone may be insufficient to produce a reduction in average length of stay.

2. Materials and Methods

2.1. Settings and Subjects

Data collection for 59 dogs took place from April to June 2022 in the Phoenix, AZ area at the Arizona Humane Society Campus for Compassion (n = 19), the Arizona Animal Welfare League (n = 20), and the Maricopa County Animal Care and Control West location (n = 20). One ward of adoptable kennels was selected for participation at each shelter. Wards contained 17 to 24 kennels each, with kennels typically at full capacity. All participating dogs were eligible for adoption and visible to the public. Dogs were co-housed on a case-by-case basis, based on a history together in a home before entering the shelter or staff determination of compatibility. Single or co-housing of dogs was completely at the discretion of the shelter, and the majority of dogs were singly housed.

Dogs were housed in rows of adjacent kennels with cement walkways in front and back. Each kennel had an indoor and outdoor portion separated by a guillotine. All dogs were able to freely access either side of their kennel while the experimenter conducted the intervention. Kennels had cement floors and cement or block walls that rose approximately 75% of the way to the ceiling. The front kennel doors were made of glass or plexiglass on the top half and metal bars on the bottom half or were made entirely of metal bars or chain-link fencing and thus were transparent to light and sound. Each kennel contained a water bowl and a small plastic bed in the inside portion of the kennel. Some kennels contained bedding or toys, but this was not standard across kennels or shelters. Staff cleaned kennels and fed the dogs from 6:00 am through 10:00 am daily. Volunteers at the shelters unsystematically walked the dogs daily from 7:00 am until the shelter's closing time. The public could view dogs from 12:00 pm until the shelters closed.

For the duration of the experiment, shelter staff and volunteers were instructed to pause any enrichment in kennel or at the kennel front to control for potential associations the dogs were forming with humans approaching their kennels. The ambient temperature in the kennel walkway was recorded daily to account for potential behavioral changes due to extreme temperature fluctuations.

2.2. Baseline

The study consisted of two phases: baseline and intervention. The baseline phase took place over a span of four consecutive days, consistent with the approach used in [36]. Each dog received one trial per day unless it could not be located. This could occur if the dog was on a walk, was under medical observation, was locked in the outside half of the kennel, or a prospective adopter had asked to see it. The experimenter started the trial as long as the dog returned to its kennel while the experimenter was still present. If another person was present in front of the dog's kennel, the experimenter circled back to complete that dog's trial after all other dogs' kennels had been visited.

In the trial, the experimenter approached the kennel and then alternated between standing and crouching in front of it for approximately 20 s. This mixture of standing and crouching was used to more closely imitate the typical behavior of adopters when viewing kenneled dogs. The duration of 20 s was chosen based on the finding of [43,44] that potential adopters only looked at an individual dog for 20–70 s, as well as approximating the time it takes to approach the kennel, deliver a treat, and leave the kennel in the intervention. After the 20 s had elapsed, the experimenter moved to the next kennel and repeated this procedure until all dogs in the ward received one trial. Following the baseline trials, no edibles were given, and no further experimental procedures were carried out that day.

2.3. Intervention

The intervention phase took place over the following ten days. Each dog received one session per day consisting of ten trials unless the dog could not be located. For each trial, the experimenter approached the kennel and threw an edible treat through the front kennel fence, regardless of the dog's behavior. Some dogs moved to the front of the kennel with their head touching the chain link fence when the experimenter was within sight. Thus, if the dog was right next to the fence waiting to receive a treat, the experimenter put the treat directly into the dog's mouth. The only stimulus change that preceded the delivery of edibles was the appearance of the experimenter standing in front of the dog's kennel. After giving the dog the treat, the experimenter moved out of sight before beginning the next trial. Intertrial intervals varied between 10 s and 5 min. An edible treat consisted of one bite-size dog treat, either a Pup-Peroni® (Big Heart Pet Brands, San Francisco, CA, USA) Original Beef Flavor or Purina Puppy Chow® Salmon Flavor Puppy Training Dog Treats. Studies in humans have shown that variations in food reinforcers maintained higher response rates than constant reinforcers (e.g., [45]). Therefore, the treats in the intervention phase were alternated daily throughout the experiment.

All trials occurred between 11:00 am and 1:00 pm each day. For consistency, a single experimenter implemented both the baseline and intervention conditions, and she always wore a treat bag on her hip throughout the study. Trial-level data were recorded on a spreadsheet via a cellphone in the experimenter's hand, and it was noted whether the dog was in the indoor or outdoor half of its kennel and whether or not it ate the treat while the experimenter was present during the intervention trials.

2.4. Observation of Behavior

The in-kennel behavior of dogs was recorded continuously throughout their time in the study. Wyze cam v3 video cameras (Wyze Labs, Inc., Kirkland, WA, USA) connected to JIGA 30,000 mAh power banks (JIA Technology Co., Ltd., Essen, Germany) were mounted inside each kennel to capture an aerial view of the dogs while they were in their kennel. The recordings were stored on a microSD card within each camera, and at the start of each day, the experimenter removed the full card and replaced it with an empty one. The videos on the full card were then transferred to an external hard drive, after which the videos on the card were erased to make space for the new recordings. MicroSD cards and power banks were swapped out daily before trials began, and no dog was present in its kennel when the experimenter entered to conduct the swap.

The videos were edited to create one video per dog per day. These daily videos consisted of four segments, each corresponding to a different person type passing by the dog's kennel. The segments included the following: (1) the experimenter's first trial, (2) the experimenter's last trial (only applicable on intervention days), (3) the first non-experimenter to pass by after the last trial (i.e., the after-last-trial person), and (4) and a non-experimenter passing by at least three hours after the last trial (i.e., the hours-after-last-trial person). Capturing the dog's behavior when each type of person passed the kennel allowed us to understand if there were similar behavioral changes for the experimenter and non-experimenters.

The videos were then provided to coders, who used an ethogram derived from [18,46] to code the duration of dogs' behaviors from the 20 s before a person approached the kennel through the 20 s after the person left the kennel area (Table 1). Behaviors selected for the ethogram were those that met the criteria for human-directed reactivity, i.e., the dog displaying threatening and/or distance-increasing behaviors toward a human, such as lunging, biting, or orienting away from a person. While some of these items may be more accurately described as positions rather than discrete behaviors, for ease of collective terminology when discussing all items coded in the study, we refer to them as behaviors. All coders were trained to a criterion of >90% agreement with the experimenter on practice videos prior to independently coding study videos. Inter-observer reliability, which refers to the degree of agreement between different observers coding the same data, was assessed by randomly selecting a subset of study videos for double coding (i.e., the same videos were coded by two observers) to ensure that >90% inter-observer reliability persisted beyond the training video. A total of 114 videos (21% of all videos) were randomly selected and double-coded by 12 raters. Intraclass correlation (ICC) estimates were calculated using a single-measure, absolute-agreement, one-way random-effects model, and all videos exhibited good or excellent reliability, with the lowest ICC value being 0.92 and a 95% confidence interval ranging from 0.75 to 0.98. All analyses were conducted using SPSS (Version 29).

Table 1. Operational definitions of human-reactive behaviors.

Behavior	Operational Definition
Vocalization	Any audible vocalization of any duration including barking, growling, and howling. Mouth is open and appears to be emitting sound, but decibel levels were not measured.
Jumping	Any contact with one or more front paws on the kennel walls or fence at any time. Does not include lunging. Starts when the paw(s) leave the kennel floor, stops when the paw(s) return to the kennel floor.
Lunging	Quick diagonal forward motion of at least the neck and upward; may be accompanied by vocalization.
Biting	Any instance where the dog's teeth are observed contacting the kennel fence.
Front Half of Kennel	The majority of the dog's body is in the front half of the kennel at any time. Must include at least one full front paw in the front half of the kennel.
Back Half of Kennel	The majority of the dog's body is in the back half of the kennel at any time. Must include at least one full front paw in the back half of the kennel. Includes any instance when any part of the dog is in the outside portion of the kennel.
Facing Kennel Front	Any portion of the dog of at least the shoulders and upward is oriented toward the front half of the kennel.
Facing Kennel Back	Any portion of the dog of at least the shoulders and upward is oriented toward the back half of the kennel.
In Frame	At least some portion of the dog can be seen in the video.
Out of Frame	No part of the dog can be seen in the video.

3. Results

All dogs that were present in the experimental ward through day 10 of the study and received at least one day of the intervention were eligible for analysis. Two dogs were removed from the sample due to medical euthanasia and inconsistent kennel environments, resulting in a total of 57 behaviorally analyzed dogs. All dogs displayed one or more behavioral indicators of responding to humans passing by at some point in the study, and 91% of the analyzed dogs engaged with the intervention (i.e., ate the treats) for at least one trial on each intervention day. The average daily temperature inside the kennels during the intervention was 26 °C (range 22–28 °C).

Behavior was coded and analyzed for all four baseline days and the first four intervention days. We included only the first four days of the ten-day intervention in our analysis for two reasons. First, we aimed to have at least as many intervention days analyzed as baseline days to maintain a balanced comparison. Second, we observed attrition from day one to day ten of the intervention and thus to maximize the sample size for analysis, we chose to focus on the first four days of the intervention.

3.1. Statistical Analysis

To analyze the effect of phase (baseline vs. intervention) and person (experimenter during first and last trials vs. various non-experimenters) on the dogs' behaviors, we ran seven linear mixed-model analyses using SPSS (Version 29), with each of the following as dependent variables: percentage of time spent in frame, in the front half of kennel, facing kennel front, and jumping, as well as bites and lunges per hour and vocalizations per minute. Each behavior was calculated as a percentage of the time spent in frame, with the exception of the behavior "in frame", which was calculated as a percentage of the entire video duration. The models included fixed effects of phase, person, and their interaction, with each dog as a random effect. Model specification was as follows for each dependent variable: Behavior~Phase * Person + (1 | dog). Despite the non-normality of the residuals for our dependent variables, linear mixed-effects models are robust to violations of the normality assumption, especially with large sample sizes like ours, and non-normally distributed residuals do not significantly impact the estimation of fixed-effect coefficients or the overall validity of the model. Pairwise comparisons for the main effects of phase and person were adjusted using the Benjamini–Hochberg correction to control the false discovery rate at 5%. The pairwise comparison with the largest p-value below the Benjamini–Hochberg critical value, along with all other pairwise comparisons with p-values of higher rank, were considered statistically significant.

3.2. Main Effect of Phase

There were significant main effects of phase for facing kennel front, front half of kennel, and biting; however, pairwise comparisons were no longer significant after applying the Benjamini–Hochberg correction. There were no significant main effects of phase for in frame, jumping, lunging, or vocalizing. Statistical details, including the main effects of phase and post hoc pairwise comparisons for each behavior, are presented in Table 2.

Table 2. Main Effect of Phase.

Behavior	Main Effect of Phase (F, df, p)	Post-Hoc Pairwise Comparisons
In Frame	$F(1, 4056) = 2.678$, $p = 0.102$	No significant main effect
Front Half of Kennel	$F(1, 3460) = 4.045$, $p = 0.044$	Not significant after Benjamini–Hochberg correction
Facing Kennel Front	$F(1, 3484) = 6.826$, $p = 0.009$	Not significant after Benjamini–Hochberg correction
Jumping	$F(1, 3486) = 0.921$, $p = 0.337$	No significant main effect
Biting	$F(1, 3486) = 5.497$, $p = 0.019$	Not significant after Benjamini–Hochberg correction
Lunging	$F(1, 3473) = 0.335$, $p = 0.563$	No significant main effect
Vocalizing	$F(1, 3469) = 0.052$, $p = 0.819$	No significant main effect

3.3. Main Effect of Person

There were significant main effects of person for in frame, front half of kennel, facing kennel front, jumping, biting, and vocalizing, but there was no significant main effect of person for lunging. All post hoc pairwise comparisons were adjusted using the Benjamini–Hochberg correction. Statistical details, including the main effects of person and post hoc pairwise comparisons for each behavior, are presented in Table 3. See Figures 1–6 for a comparison of the estimated marginal means for front half of kennel, facing kennel front, jumping, biting, vocalizing, and in frame.

Table 3. Main Effect of Person.

Behavior	Main Effect of Phase (F, df, p)	Post-Hoc Pairwise Comparisons
In Frame	$F(3, 4041) = 3.862$, $p = 0.009$	More time for first-trial person than last-trial ($p = 0.012$) and after-last-trial ($p = 0.019$) people.
Front Half of Kennel	$F(3, 3431) = 5.241$, $p = 0.001$	Less time for hours after-last-trial person than first-trial ($p = 0.001$) and after-last-trial ($p = 0.002$) people.
Facing Kennel Front	$F(3, 3441) = 11.19$, $p < 0.001$	Less time for last-trial person than after-last-trial ($p = 0.005$) and hours-after-last-trial ($p = 0.006$) people. Less time for first-trial person than after-last-trial person ($p = 0.004$).
Jumping	$F(3, 3448) = 8.283$, $p < 0.001$	Less time for last-trial person than after-last-trial ($p = 0.008$) and hours-after-last-trial ($p = 0.01$) people. Less time for first-trial person than after-last-trial person ($p = 0.007$).
Biting	$F(3, 3447) = 3.734$, $p = 0.011$	Less time for last-trial person than hours-after-last-trial person ($p = 0.015$).
Lunging	$F(3, 3444) = 0.872$, $p = 0.455$	No significant main effect.
Vocalizing	$F(3, 3433) = 11.232$, $p < 0.001$	Fewer for last-trial person than first-trial ($p = 0.011$), after-last-trial ($p = 0.012$), and hours-after-last-trial ($p = 0.013$) people. Fewer for first-trial person than after-last-trial ($p = 0.014$) and hours-after-last-trial ($p = 0.018$) people.

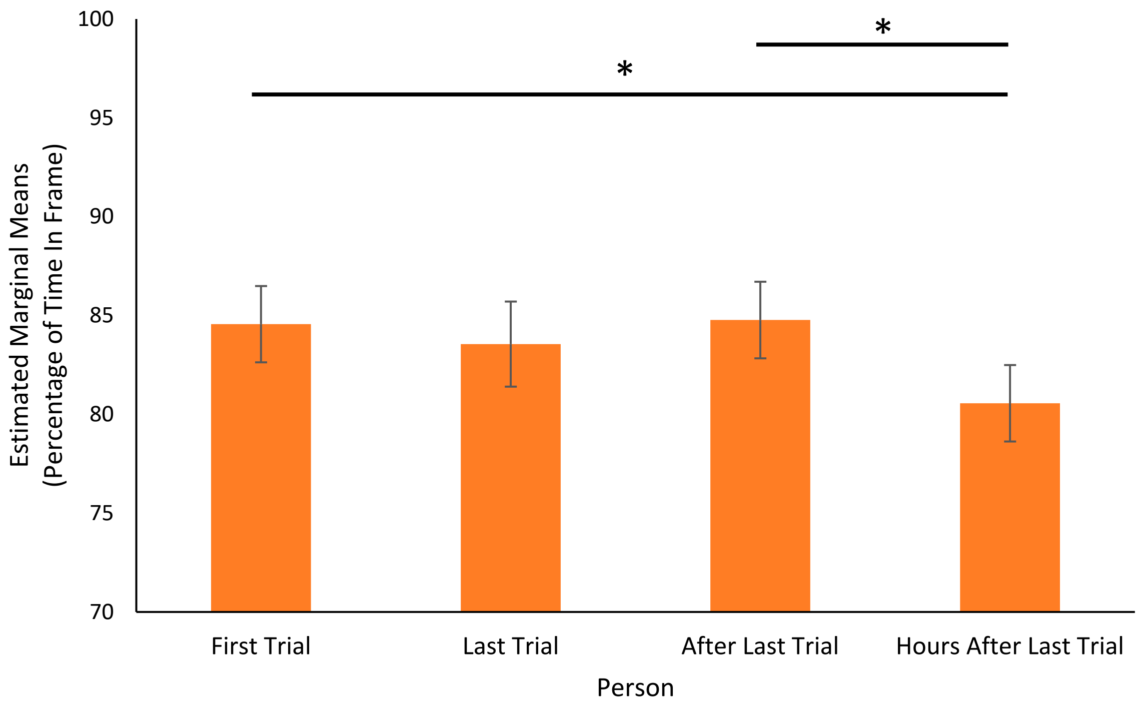

Figure 1. Main effect of person on front half of kennel. The estimated marginal means of the percentage of time dogs spent in the front half of the kennel are shown for the first-trial, last-trial, after-last-trial, and hours-after-last-trial people to walk past the dog's kennel. Percentage of time spent in the front half of the kennel was calculated as the time the dog spent in the front half of the

kennel divided by the time the dog spent in frame. Error bars show standard errors (SEs). Significant pairwise comparisons are present despite overlapping SE error bars, as these error bars are calculated based on between-subjects' data, while the pairwise comparisons are conducted using within-subjects' data. Relying on error bar overlap to determine significant differences is problematic in mixed models due to complex dependency structures between means. Instead, it is advisable to utilize model-based error bars, which provide estimates based on the learned information from the model, in conjunction with the pairwise tests for accurate interpretation. * Significant following Benjamini–Hochberg correction for multiple comparisons with false discovery rate of 0.05.

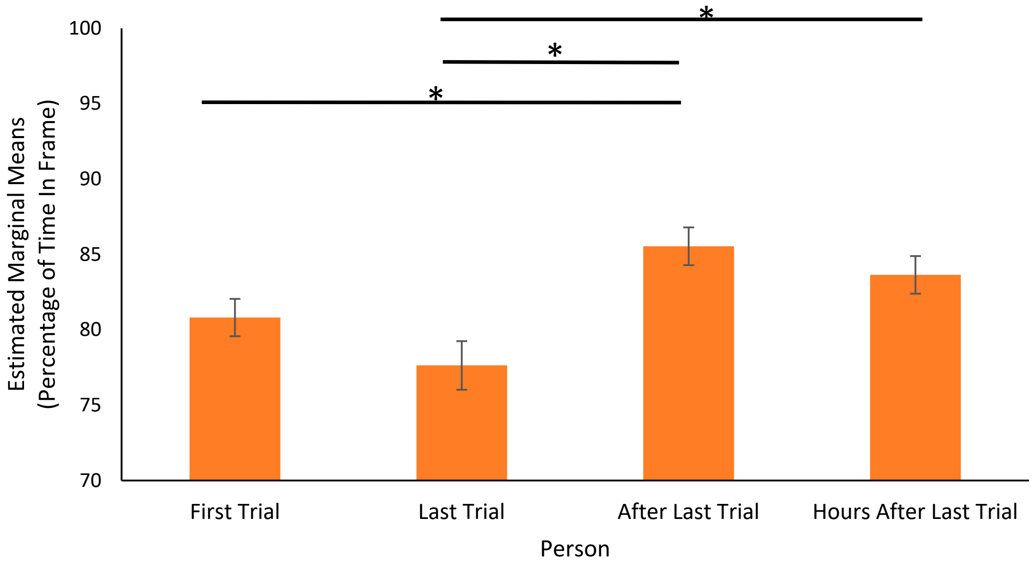

Figure 2. Main effect of person on facing kennel front. The estimated marginal means of the percentage of time dogs spent facing the front of the kennel are shown for the first-trial, last-trial, after-last-trial, and hours-after-last-trial people to walk past the dog's kennel. Other details as for Figure 1. * Significant following Benjamini–Hochberg correction for multiple comparisons with false discovery rate of 0.05.

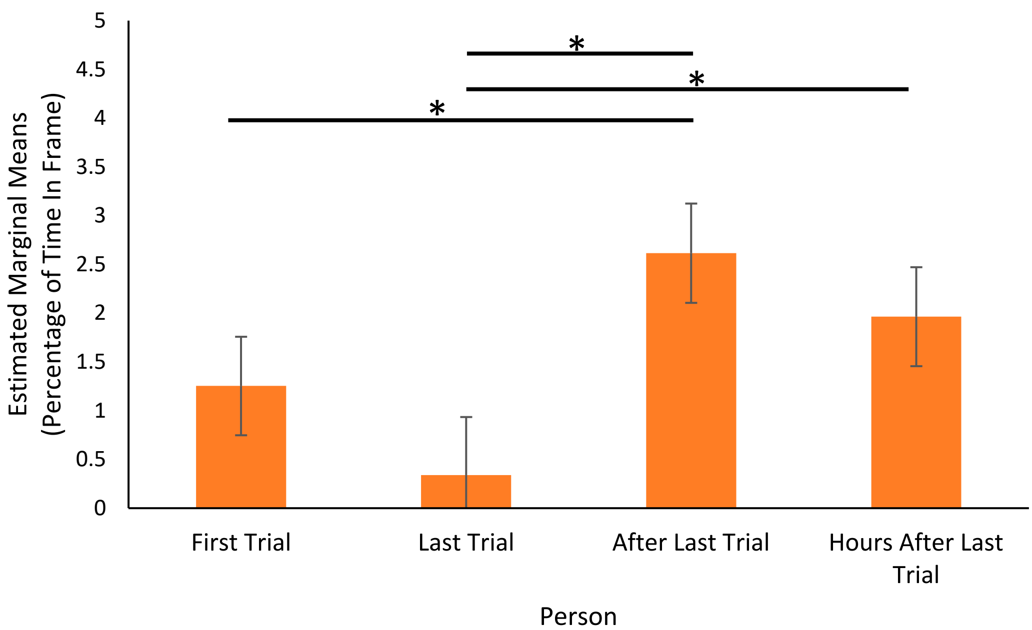

Figure 3. Main effect of person on jumping. The estimated marginal means of the percentage of time dogs spent jumping are shown for the first-trial, last-trial, after-last-trial, and hours-after-last-trial people to walk past the dog's kennel. Other details as for Figure 1. * Significant following Benjamini–Hochberg correction for multiple comparisons with false discovery rate of 0.05.

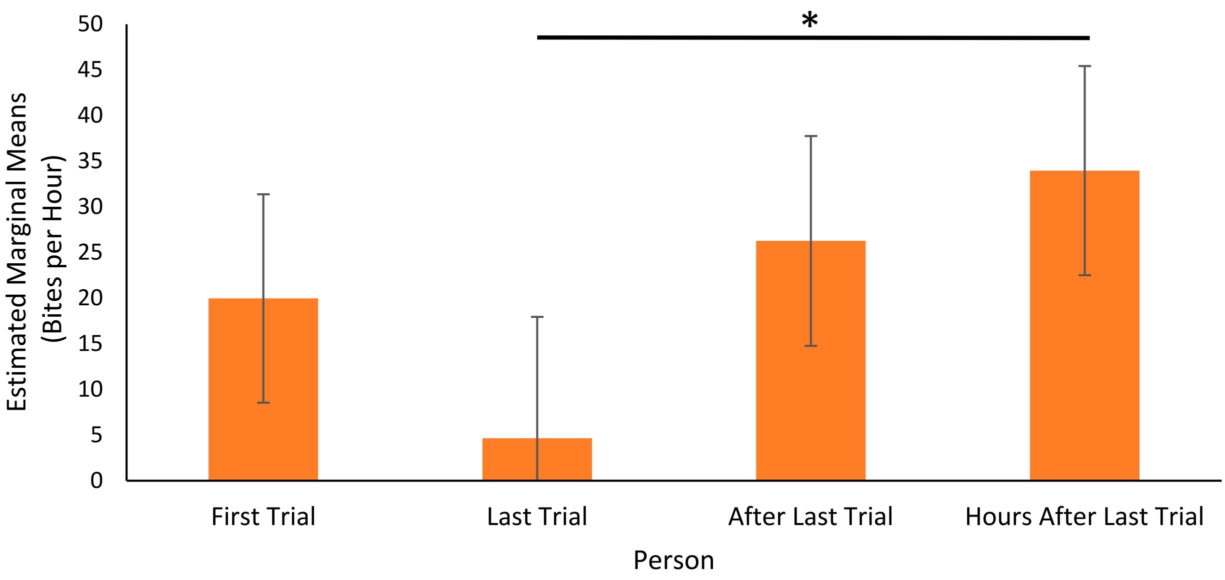

Figure 4. Main effect of person on biting. The estimated marginal means of the number of bites dogs made per hour are shown for the first-trial, last-trial, after-last-trial, and hours-after-last-trial people to walk past the dog's kennel. Bites per hour was calculated as the number of bites divided by the number of seconds the dog spent in frame, multiplied by 3600. Other details as for Figure 1. * Significant following Benjamini–Hochberg correction for multiple comparisons with false discovery rate of 0.05.

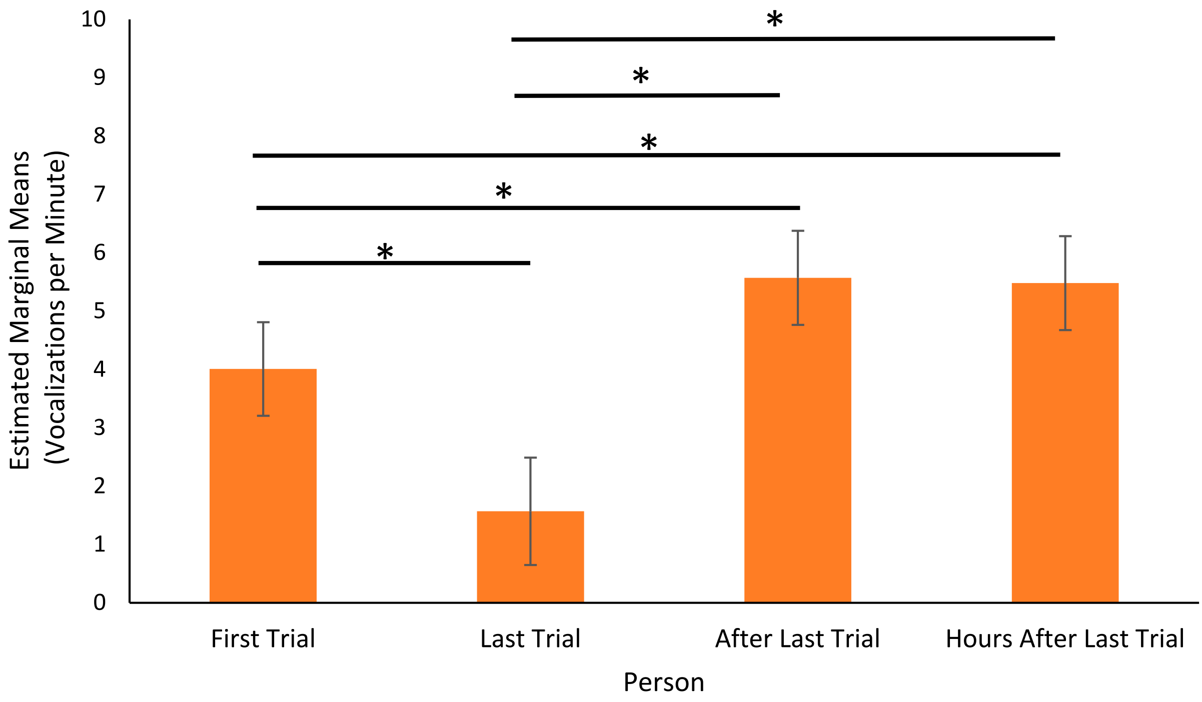

Figure 5. Main effect of person on vocalizing. The estimated marginal means of the number of vocalizations dogs made per minute are shown for the first-trial, last-trial, after-last-trial, and hours-after-last-trial people to walk past the dog's kennel. Vocalizations per minute was calculated as the number of vocalizations divided by the number of seconds the dog spent in frame, multiplied by 60. Other details as for Figure 1. * Significant following Benjamini–Hochberg correction for multiple comparisons with false discovery rate of 0.05.

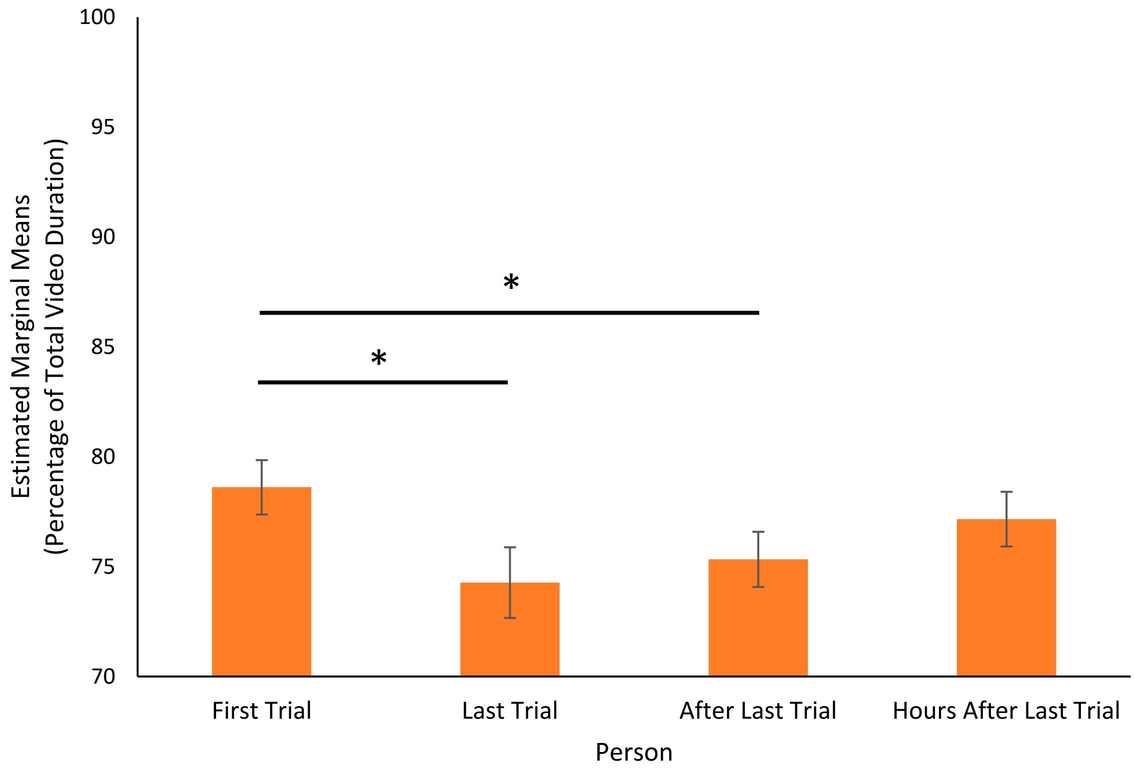

Figure 6. Main effect of person on in frame. The estimated marginal means of the percentage of time dogs spent in frame are shown for the first-trial, last-trial, after-last-trial, and hours-after-last-trial people to walk past the dog's kennel. Percentage of time spent in frame was calculated as the time the dog spent in frame divided by the total duration of the video. Other details as for Figure 1. * Significant following Benjamini–Hochberg correction for multiple comparisons with false discovery rate of 0.05.

3.4. Interaction Between Phase and Person

There were significant interaction effects for facing kennel front and biting. When analyzing interaction effects, relying on the interpretation of the 95% confidence intervals (CIs) of the estimated marginal means offers a conservative strategy, reducing the likelihood of type I errors compared to conducting numerous pairwise comparisons. Furthermore, in the case of repeated measures, model-based individual CIs are irrelevant for inferences about the mean of the differences. We tested the null hypothesis of no difference between the means by calculating CIs of the paired differences. There were no significant interaction effects for in frame, front half of kennel, jumping, lunging, or vocalizing. Statistical details, including the interaction effects and 95% CIs of the paired differences, are presented in Table 4. See Figures 7 and 8 for a comparison of the estimated marginal means for biting and facing kennel front.

Table 4. Interaction Between Phase and Person.

Behavior	Interaction Effect (F, df, p)	95% CI of Paired Differences
In Frame	$F(2, 4041) = 0.788$, $p = 0.455$	No significant interaction effect.
Front Half of Kennel	$F(2, 3431) = 0.005$, $p = 0.995$	No significant interaction effect.
Facing Kennel Front	$F(2, 3442) = 3.533$, $p = 0.029$	Less during last trial on intervention days than anyone on baseline (after last trial [3.9, 10.0]; hours after last trial [2.9, 9.1]) and intervention (first trial [3.4, 9.6]; after last trial [5.8, 11.9]; hours after last trial [2.9, 9.1]) days, except first trial on baseline days. Less during first trial on baseline days than anyone on baseline (after last trial [4.1, 10.2]; hours after last trial [3.1, 9.3]) and intervention (first trial [3.6, 9.8]; after last trial [5.9, 12.1]; hours after last trial [3.1, 9.2]) days, except last trial on intervention days.

Table 4. *Cont.*

Behavior	Interaction Effect (F, df, p)	95% CI of Paired Differences
Jumping	$F(2, 3448) = 2.509$, $p = 0.082$	No significant interaction effect.
Biting	$F(2, 3448) = 8.473$, $p < 0.001$	More toward hours-after-last-trial person on intervention days than all other people across both baseline (first trial [12.8, 64.3]; after last trial [11.7, 63.3]; hours after last trial [32.0, 83.5]) and intervention (first trial [21.4, 73.0]; last trial [32.4, 84.0]; after last trial [9.8, 61.4]) days.
Lunging	$F(2, 3446) = 0.737$, $p = 0.479$	No significant interaction effect.
Vocalizing	$F(2, 3434) = 2.456$, $p = 0.086$	No significant interaction effect.

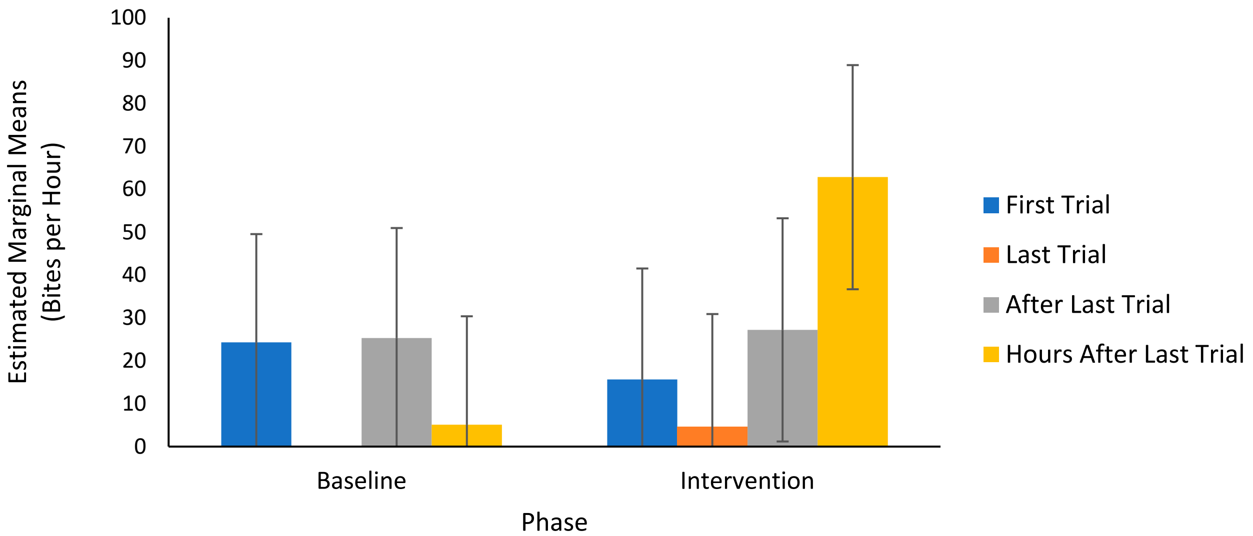

Figure 7. Interaction effect of phase by person on biting. The estimated marginal means of the percentage of time dogs spent biting are shown for the first-trial, last-trial, after-last-trial, and hours-after-last-trial people to walk past the dog's kennel in both the baseline and intervention phases. Error bars show model-based individual 95% confidence intervals. Other details as for Figure 1.

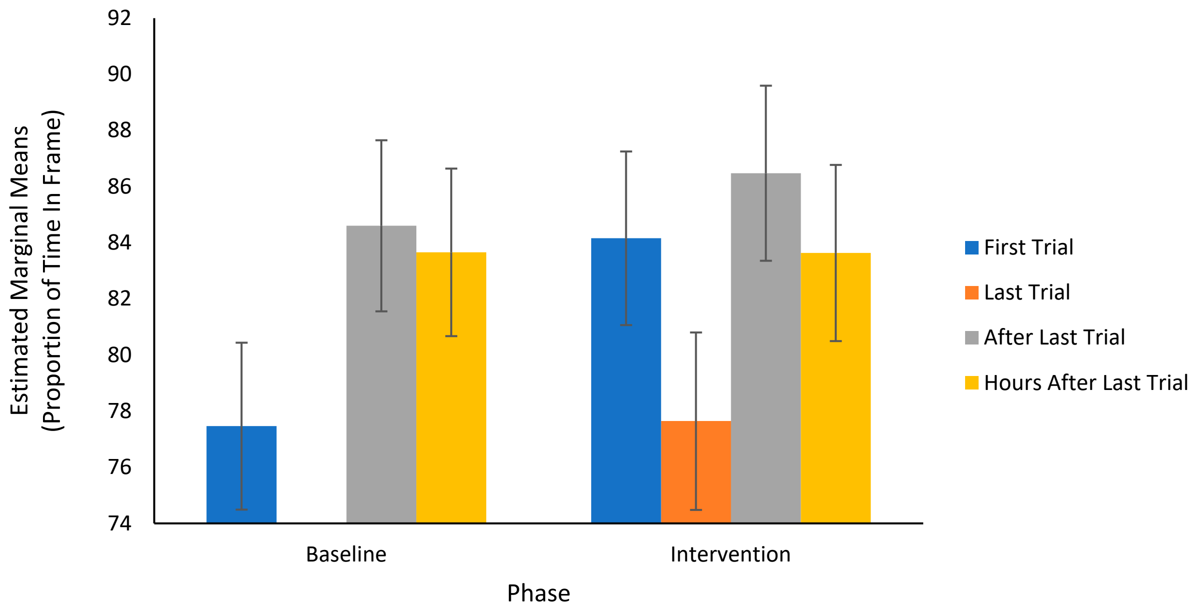

Figure 8. Interaction effect of phase by person on facing kennel front. The estimated marginal means of the percentage of time dogs spent facing the front of the kennel are shown for the first-trial, last-trial, after-last-trial, and hours-after-last-trial people to walk past the dog's kennel in both the baseline and intervention phases. Other details as for Figure 7.

3.5. Length of Stay

We compared the average length of stay for all dogs whose data were analyzed in the study to non-study dogs at the same shelter at the Arizona Animal Welfare League and the Maricopa County Animal Care and Control West location during the study time period to assess whether there was an impact of receiving the intervention on overall length of stay. A suitable comparison ward could not be determined at the Arizona Humane Society. A two-way ANOVA was conducted that examined the effect of shelter and enrollment in the experiment on length of stay. There was no significant main effect of group, $F(1, 118) = 1.195$, $p = 0.276$, or shelter, $F(1, 118) = 0.036$, $p = 0.851$, nor was there a significant group by shelter interaction, $F(1, 118) = 0.895$, $p = 0.346$ (see Figure 9). On average, non-study dogs during this time period had a length of stay of 54.3 ($SD = 6.5$) days, whereas dogs who received at least one day of intervention had an average length of stay of 66.5 ($SD = 9.1$) days. Therefore, dogs who received the intervention did not have significantly different lengths of stay than those who did not partake in the study.

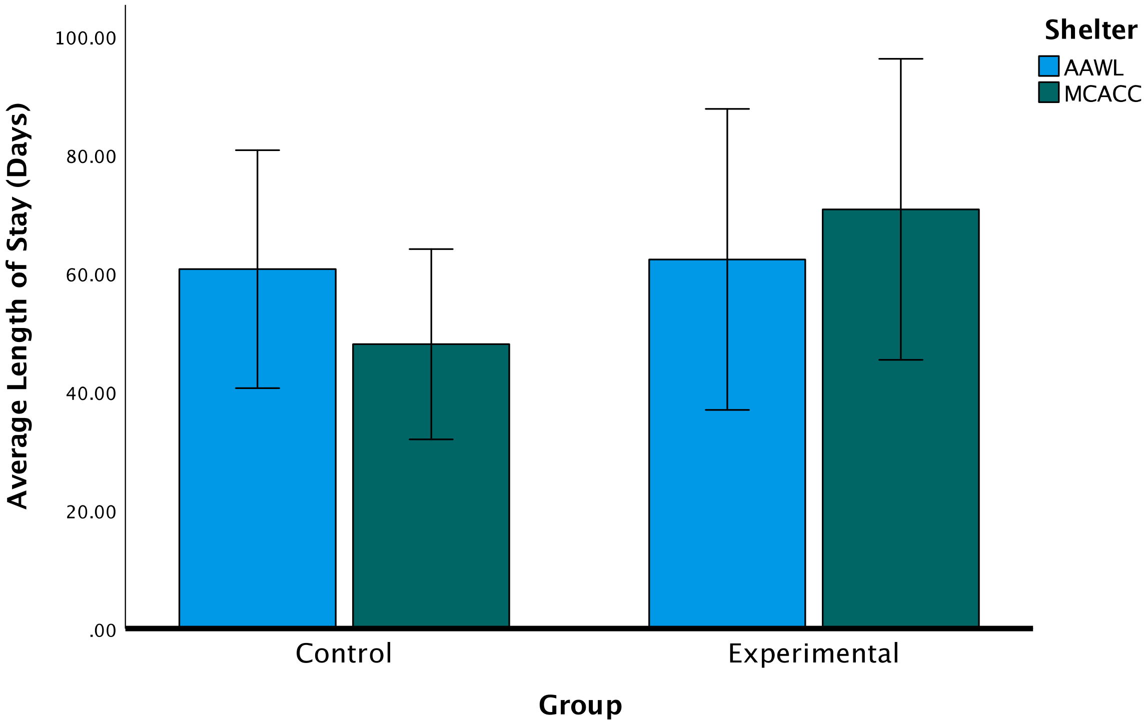

Figure 9. Length of stay for control and experimental groups. The average length of stay in days for dogs at Arizona Animal Welfare League (AAWL) and Maricopa County Animal Care and Control (MCACC) for both the control and experimental wards are shown. Error bars show 95% confidence intervals.

4. Discussion

All dogs analyzed in this study displayed inappropriate behavioral reactions to humans at least once, supporting the concern that reacting to humans is an active problem for dogs kenneled in shelters. Our noncontingent reinforcement intervention was not effective at decreasing human-directed behavioral responses independent of person type, as the frequency and amount of time dogs exhibited these behaviors was not different on intervention days compared to baseline days. However, we did see a positive effect of the experimenter on these behaviors, even if that effect did not generalize to non-experimenters.

We found limited evidence in support of the hypothesis that the intervention could cause behavioral changes in shelter dogs in the presence of any human. Changes in reactive behaviors were limited to the presence of the experimenter during the first and last trials, with improvements in behavior generalizing to non-experimenters only for the front half of kennel and facing kennel front behaviors. When considering the interaction between phase and person type, we saw that biting occurred more often toward the hours-after-last-trial person on intervention days than to any other person across both days. Furthermore, dogs spent the least amount of time facing kennel front for the first-trial person on baseline days and last-trial person on intervention days than any other person across both days.

There are a couple of possible explanations for why the inappropriate behavioral reactions to humans decreased in the presence of the experimenter. The first would be differential reinforcement of incompatible behavior, in that the consumption of the noncontingent food item was incompatible with the dog's ability to perform the undesirable behaviors (e.g., vocalizing, biting, jumping, etc.) [41]. An additional explanation could be that the consistency of the interactions with the experimenter were highly predictable for the dogs, thereby warranting less extreme behavioral responses as compared to the typically less regimented appearances by non-experimenters at their kennels [9]. The behavior of facing kennel front was exceptional in that it was the only behavior for which dogs spent more time interacting positively toward non-experimenters than the experimenter. One reason could be that, specifically on intervention days, dogs were spending the time that the experimenter was present in front of their kennel searching for and consuming the food that had been thrown into the kennel for them, which would cause them to face away from the kennel front as they pursued the treat. Another reason could again be that the predictability of the experimenter coming by the kennel meant dogs were not as attentive to front of the kennel and did not choose to orient to the kennel front because they knew what to expect (i.e., there was a habituation effect to the same experimenter tossing a treat).

The inappropriate behavioral reactions to humans may have increased in the presence of non-experimenters for several reasons. It is possible that the increase in behaviors like biting, jumping, and vocalizing toward non-experimenters stemmed from frustration when food was not provided in a context similar to one where food had regularly been presented [47]. Additionally, we saw similar percentages of time spent in front half of kennel, facing forward, jumping, in frame, and lunging behaviors toward non-experimenters as [18] found toward people lingering in front of the dogs' kennels, which may indicate that reactions to our non-experimenters were typical of the types of responses to humans at the kennel door who are not interacting with the dog.

Length of stay can be a challenging variable to identify direct causal influences for, with factors such as adoption specials, seasonality, dog's age, dog's size, and many more having an impact [18,48]. Consequently, it is unsurprising that our intervention did not decrease the dogs' length of stay.

Although [41] saw that their noncontingent reinforcement intervention successfully reduced undesirable behaviors of kenneled dogs, that study only investigated behavioral responses in the presence of the experimenter. We also saw the biggest reductions in undesirable behaviors in the presence of the experimenters but observed an absence of any impact on behavior towards non-experimenters. It is possible that the efficacy of a noncontingent reinforcement intervention is limited to the presence of the person providing the food and may not readily generalize to others. This is somewhat countered by [42], who reported a reduction in barking and overall noise level in the kennels after pairing a door chime with noncontingent food delivery over several sessions a day for a week, as their intervention effects generalized beyond the presence of the experimenter. However, they did not investigate the impact of their intervention on additional undesirable dog behaviors, and thus direct comparison of these interventions is limited. This set of studies suggests that the efficacy of a noncontingent reinforcement intervention requires the use of an explicitly programmed stimulus. However, our findings indicate that such a stimulus was not necessary to improve behavior toward the person delivering the reinforcement, suggesting the procedure may still be effective without it. Future research should explore an intervention in which all passersby provide treats, with probe trials involving individuals who do not, to reduce the risk of frustration or rebound effects when a passerby inevitably does not offer a treat.

While a limited number of studies have explored shelter dogs' behavioral responses to human presence at their kennel, several other in-kennel interventions have been investigated. Sensory stimuli like aromatherapy [32,33,39], pheromones [34,39], and music [31,36–39] have shown decreases in vocalizations and increases in resting behaviors. However, further understanding of how these interventions affect behavior in the presence of humans is necessary [19]. The use of food toys in the kennel has been found to increase activity levels and reduce locomotion and barking [21,35]. Yet, nonedible and non-destructible toys are often ignored by dogs [49–51]. Food interventions are most effective in the kennel when combined with human involvement, as [40] found that providing food-toy enrichment combined with kennel-behavior training resulted in significantly more desirable behaviors. However, this intervention, consisting of twice-daily in-kennel behavior training and a daily food toy, may be resource-intensive for many shelters. The most effective interventions for improving shelter dog welfare typically occur outside the kennel environment [7,20–30]. However, the resource demands these interventions impose on shelters highlight the need for further research into brief, cost-effective, easily deployable interventions that require minimal human interaction each day per dog to implement.

There are a few notable limitations of this study. While the food preference of each dog was not tested to identify a preferred edible, over 91% of the analyzed dogs engaged with the intervention (i.e., ate the treats) for at least one trial on each intervention day, providing support for the palatability of this intervention. Future research could examine whether or not treat preference impacts the efficacy of a noncontingent reinforcement intervention. It is challenging to enforce well-controlled studies in animal shelters that are open to the public, and videos from the dogs' kennels showed that non-experimenters occasionally provided treats to the dogs through the front of their kennels in a manner similar to the intervention, though fortunately only in fewer than 10% of non-experimenter human interactions. As such, it may not be possible to attribute changes in the dogs' behaviors solely to the intervention or person conducting the interaction. Additionally, only one experimenter was used throughout the study. While this was useful to control for differences in dogs' reactions to the experimenter as compared to non-experimenters, it is likely that multiple people would be deploying this intervention in a real-world shelter setting. Future work would do well to not only investigate the use of multiple experimenters but to also use experimenters of different sexes and with added stimuli such as wearing hats, sunglasses, using mobility assistance devices, etc.

The noncontingent reinforcement intervention utilized in this study was successful in reducing undesirable human-directed responding in kenneled shelter dogs, though these effects were primarily limited to the presence of the experimenter. Furthermore, the intervention did not contribute to a reduced length of stay for participating shelter dogs. Our recommendation for shelters would be that this intervention should not be used to improve dog welfare via a reduction in length of stay or a long-term reduction of the reactive behaviors studied here, but it may be effective at improving behaviors directed at a person delivering treats to the dog. As such, this intervention may be most helpful as a low-resource option for shelters looking to encourage potential adopters to engage with dogs in their kennels using treats to bring the dogs to display more attractive behaviors.

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Data Availability Statement: Data are available on request by qualified persons to the second author.

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