Reducing barking in a Brazilian animal shelter: A practical intervention

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Abstract
Barking is a common problem in animal shelters. Loud noise is an irritant and stressful to both humans and other animals. In the present study, we tested a positive reinforcement intervention using food delivery with 70 dogs at a municipal animal shelter in Pirassununga, state of São Paulo, Brazil. The experiment consisted of three conditions with three daily phases: pre-intervention (A1), intervention (B), and post-intervention (A2). The intervention consisted of the experimenter (ALB) entering the building in which dogs were housed, stopping at each of its 12 kennels, and delivering food to the dogs after they had ceased barking. After the first study condition with its single experimenter, we conducted two other conditions to test the generalization of the intervention with novel stimuli. In Condition 2, the experimenter was accompanied by a student; and in Condition 3, the experimenter was with the same student and a shelter employee. Continuous sound levels (Leq dB) and duration of barking were measured pre- and post-intervention throughout the study's three conditions as well as the amount of time needed to carry out the intervention each day. We found that, on average, both Leq dB and barking duration reduced following the intervention with a decrease in both measures from the beginning to the end of the study. Furthermore, intervention implementation time shortened across the study's conditions, with less than three minutes needed for the intervention to be carried out in Condition 3. In total, our findings suggest that this barking reduction protocol (BRP) is an effective and low effort intervention that reduces dog barking in the animal shelter. When considering the many issues that compromise the daily lives of shelter dogs, this intervention may be a useful tool in changing dogs' barking behavior in response to people and improve their welfare as they await adoption.

Abbreviations
ALB: Ana Lucia Baldan
BRP: Barking Reduction Protocol

Keywords: animal welfare; barking; training; noise reduction; bioacoustic; *Canis familiaris*

1. Introduction

Excessive barking is an often-reported problem in animal shelters (Titulaer et al., 2013). Barking is a species-specific canine behavior (Yin & McCowan, 2004) and occurs in interactions with humans and other dogs (Pongrácz et al., 2010). In shelters and homes, dogs are dependent upon humans, yet the level of social isolation that dogs experience in the animal shelter is significant (Hennessy et al., 1997). Due to the lack of social interaction amongst many other stressors (Gunter et al., 2019), it is likely that dogs have poor welfare while living under these conditions (Mellor et al., 2020).

One of the most apparent welfare concerns in the shelter is excessive noise. Dogs' sensitivity to sound is around 20 dB (decibels) at frequencies of 4000–8000 Hz (Lipman & Grassi, 1942; Barber et al., 2020). The upper limit of their hearing is better than humans; but at lower frequencies, humans and dogs are likely similar. Sound levels in the shelter have been measured to be greater than 90 dB, and at times, recorded as high as 125 dB (Sales et al., 1997; Coppola, Enns & Grandin, 2006; Scheifele et al., 2012; Venn, 2013). According to the World Health Organization, long exposure to noise levels of 50 dB or above is potentially harmful to mammalian ears (Kryter, 1994). Research by Scheifele and colleagues (2012) found that exposure to kennel noise over a six-month period resulted in hearing loss for the dogs. Peak sound pressure levels (peak decibel value over the measuring period in a linear curve) tend to be low and constant overnight but can increase in the early morning and vary according to shelter routines (Payne & Assemi, 2017).

Modifications to shelter policy, such as prohibiting people from kennel areas, or changing the design of kennels by obscuring dogs' visual contact with passersby, have been shown to reduce dogs' barking successfully. When potential adopters met dogs outside of kennel areas instead of viewing them within, noise levels within the shelter were reduced by over 10 dB, when compared to pre-intervention levels measured at the same time of day when potential adopters were allowed access (Hewison et al., 2014). Beesley and Mills (2010) found that dogs' barking in response to a novel person more quickly habituated and there were fewer barking bouts when the bottom portion of their kennel front was obscured by glazing. Thus, it seems that changes to the environment can influence shelter dog barking.

Dog barking is a behavior that has been shown to be modifiable through training. In their study of over 100 shelter dogs, Herron, Madden, and Lord (2014) found that an intervention consisting of both in-kennel enrichment and training, including reinforcing the dogs for not barking, increased the proportion of dogs that were quiet in their kennels. Protopopova and Wynne (2015) demonstrated that interventions using either classical or operant conditioning can reduce undesirable in-kennel behaviors, such as barking. Payne and Assemi (2017) observed that daily pairings of a door chime with food reduced kennel noise by 15 dB. Often in these studies, the experimenter was the sole individual paired with food, and whether dogs can generalize this behavior to the presence of staff members or members of the public remains to be evaluated. Most recently, a multi-experimenter design using a classical conditioning pairing of food in a veterinary hospital setting indicated promising results, if only descriptive in nature (Zurlinden et al., 2022).

While the negative impacts of barking on shelter dog welfare is evident, the effect of barking on adoptions is less clear. In an attempt to better understand people's preferences when acquiring a new dog, Wells and Hepper (1992) deployed a questionnaire, which included photographs of barking and non-barking dogs, and found that participants rated dogs that were not barking as more desirable than dogs that were. Nevertheless, finding evidence of a causal relationship with training interventions or barking in the kennel and dogs' likelihood of adoption has been elusive. When shelter dogs received a multi-faceted intervention, which included being reinforced for non-barking when a person passed by their kennel (in addition to being provided reinforcement for coming to the front of the kennel, sitting, and not jumping), more dogs exhibited desirable behaviors than dogs that did not receive the intervention (Herron et al., 2014). Yet trained dogs in the aforementioned study were not more likely to be adopted than non-trained dogs, despite barking less often. In a Florida animal shelter, morphologically preferred dogs that barked more often had surprisingly

shorter lengths of stay, and no difference was found between barking behavior and the lengths of stay of morphologically non-preferred dogs (Protopopova et al., 2014).

The present study aims to understand how a training intervention influences the barking behavior of dogs living in a Brazilian shelter, specifically the duration and sound levels in the presence of people. In Brazil, dogs are not singly housed in the animal shelter, which is a common practice in the United States, but live communally with other dogs. Thus, the suitability of a food-based intervention in this environment was also of interest to the authors.

2. Methods

2.1 Subjects and housing

This study was carried out in Pirassununga municipality in the state of São Paulo, Brazil at a municipal animal shelter supported by a non-governmental organization, *Ajuda para animal*. Animals arrived at the shelter as strays from the surrounding community or abandoned by their owners. On a typical day, the shelter cares for approximately 300 animals (100 cats and 200 dogs) in brick and concrete buildings.

The building that was utilized for this study has no physical sound-reducing or abatement materials. All dogs living in the building, 70 in total, participated in the study: 36 neutered males and 34 spayed females between the ages of 6 months and 8 years (precise ages are unable to be determined as most dogs arrive as strays to the shelter). Throughout the study, the sample remained the same, except for four dogs that were added on Days 2 and 3 of Condition 1.

The dogs lived in 12 kennels (5 x 2 m^2), with half of the kennels on each side of a central corridor, and 4-6 dogs living in each kennel. (Figure 1). Chain-link kennel doors face the building's central corridor (Figure 1). Daily, the animals' kennels are cleaned, and the dogs are fed afterward. A dry kibble is provided on the floor of each of the kennels for all dogs to eat.

Typically, dogs do not leave their kennels and reside in them 24 hours a day; however, concurrent with the present study, another study was also conducted investigating factors of dog adoption and return. In this tandem study, half of the dogs (35 out of 70) that were enrolled in the present study were provided 20-minute interactions in the morning by the experimenter (ALB), after morning data collection in the present study had concluded. No more than three dogs within a single kennel participated in the tandem study.

2.2. Pre-training, training, & post-training phases

The Barking Reduction Protocol (BRP) was implemented in three phases: A1, B, and A2 across three conditions. Phases A1 and A2 lasted approximately one minute each, and B ranged from two to seven minutes, depending on the dogs' behavior (see below). The BRP occurred in the morning after the employees opened the shelter at 7:00 am. Phase A was a pre-training period, during which the dogs' barking response was measured prior to receiving the intervention for that day. The experimenter (ALB) entered the central corridor, walked past the 12 kennels, and left the building for one minute (Figure 1). During this phase, she did not make visual or physical contact with the dogs.

In Phase B, the experimenter returned to the central corridor and applied the intervention throughout the building. She stopped and stood in front of each kennel, making soft eye contact with the dogs (as an adopter would), and remained in that position until all dogs in the kennel stopped barking. Once this occurred, a sound (stimulus) was produced by a clicker, a device operated with a button that makes a clicking sound when pressed. Following the click, the dogs were reinforced with food (rolled Petitos® cut into small pieces). Upon completing the intervention with that kennel, the experimenter walked to the adjacent kennel across the corridor and repeated training until all dogs in the building's 12 kennels had received the intervention. The experimenter then left the building for one minute, after which she re-entered the central corridor and carried out Phase A2. The experimenter's behavior in Phase A2 was the same as in Phase A1.

In all the phases, audio recording began before and ended after the opening and closing of the building's gate (Figure 2).

Repetitions of Phases A1, B, and A2 occurred each day, excluding weekends and days in which institutional demands of the shelter did not allow for the experiment. In Condition 2, a student accompanied the experimenter in order to simulate a potential adopter walking alongside a shelter employee viewing the dogs. During Condition 3, the same student and a shelter employee accompanied the experimenter to shape the dogs' behavior further. In both Conditions 2 and 3, the individuals moved from kennel to kennel together. The group would remain in front of each kennel, making eye contact with the dogs until the barking ceased. Once they quieted, the experimenter pressed the button on the sound apparatus and delivered food, and the group moved to the next adjacent kennel (as in Condition 1).

Each condition's data collection period was based on the dogs' behavior by measuring the duration of their barking pre- and post-intervention each day. Specifically, the number of days in the duration of dogs' barking which the duration of dogs' barking during in Phase A2 needed to be shorter than that in Phase A1. In Condition 1, a 10-day criterion of daily, shorter durations was used. The experimenter carried out Condition 1 of the BRP protocol over 12 days; however, a recording error occurred on June 30th, and no audio data was collected. As such, 11 days of data are described. The length of Conditions 2 and 3 was determined by our criterion of four days in which shorter durations of barking occurred in A2 than A1. Conditions 2 and 3 measured the dogs' resilience to changes in stimuli presentation, specifically the generalization of the trained non-barking behavior in the presence of additional people. The number of days that passed, without data collection, between Conditions 1 and 2 and Conditions 2 and 3 were 3 and 5 days, respectively (Figure 3).

2.3 Data preparation: Barking duration and sound pressure level

Audio recordings were made using a TASCAM DR-40 (TEAC Corporation, Santa Fe Springs, CA). The handheld recorder was placed in a bag and carried by the experimenter in order to capture the sound in the shelter corridor that a potential adopter might experience. Duration of recordings varied according to the phase in which it belonged. The typical length of Phase A1 and A2 recordings was the time needed for the experimenter to move through the building corridor. Recordings made in Phase B were the longest in duration as BRP training occurred during this phase. Regardless of phase, recordings were standardized, such that the sound of the corridor gates opening and closing marked the beginning and end of each recording (Figure 2).

Sound editing and analysis were performed in Raven Pro 1.6.4 (K. Lisa Yang Center for Conservation Bioacoustics, 2023) and Audacity 3.0 (Muse Group, Renton, WA, USA). Recordings were processed using a Hann window with 50% overlap and 512 fast Fourier transform (FFT) size. We adopted the metric of equivalent continuous sound pressure level, or Leq (dB re 1 μPa), to represent the variation in sound levels as a function of time. This is a common method to describe sound levels varying in duration within noise pollution studies, such as those examining human or other animals' hearing and vocalizations (Estabrook et al., 2016; Gentry et al., 2018; Sultana et al., 2020; Monticelli et al., 2022).

Leq sound levels are a single decibel value, accounting for the total sound energy within that phase of the study. While these values are akin to a phase average, it is not an arithmetic average because decibels are a logarithmic value. Acoustical measurements in spectrograms (frequency over time graphs) are taken from a square drawn with the cursor, where the horizontal sides determine the spectral band (until 5kHz in this study) and the vertical sides set the time interval to be considered. Barking durations were defined by the initiation of barking and its cessation, with barking having not occurred for more than 10s. The Leq values that are produced are negative numbers, and are not absolute, since they are relative to an arbitrary reference through comparison between measurements in sound recordings made with the same recording equipment and settings, where the highest amplitude corresponds to zero.

2.4 Data Analysis

To more easily interpret Leq dB values, the lowest negative value obtained during data collection was used as reference value to transform Leq values into positive values for analysis, such that the lowest reference value became 0 and our largest transformed Leq value was the positive equivalent of that lowest negative value.

To understand the intervention's effect on sound levels, transformed Leq values were examined using a mixed linear model with the variables of condition (1, 2, or 3), phase (A1 and A2), and a condition-by-phase interaction. Day and intercept were included as random effects with condition, phase, and a condition-by-phase interaction as fixed effects. The method of Restricted Maximum Likelihood (REML) was used for estimating parameter values. In a second mixed linear model, all analysis characteristics previously described remained the same except that barking duration was the model's dependent variable.

To explore the time needed to carry out the intervention over the course of the study, a one-way analysis of variance was used to examine the duration of Phase B across conditions. When post hoc comparisons were conducted as part of our analyses, a Sidak correction was utilized to reduce the likelihood of false positives when multiple comparisons were made. A statistical significance level of $p < 0.05$ was utilized throughout.

2.5 Ethical Approval. This project was approved by the Ethics Committee on the Use of Animals of Faculdade de Filosofia Ciências e Letras de Ribeirão Preto under the number 19.1.984.59.0 (10/01/2019).

3. Results

Data from 19 days of data collection at the animal shelter resulted in 38 measures of barking duration (s) and 38 Leq dB values for Phases A1 and A2. The lowest Leq value, -55.05, representing the lowest total sound energy obtained for a phase, was used as a reference value (0) to transform Leq measures into positive values for interpretation. Durations of barking, transformed Leq values, and time spent carrying out the intervention in Phase B are presented in Table 1.

To understand the intervention's effect on barking duration, we used a mixed linear model to uncover any effects of condition, phase, or a condition-by-phase interaction. With this model, only the main effects were significant. The main effect of phase was significant, $F(1, 23.40) = 18.87$, $p < .001$, demonstrating that the length of time dogs spent barking changed between the study's pre- and post-intervention phases. Specifically, dogs barked for longer in Phase A1 ($M = 34.16$, $SE = 2.69$) than in Phase A2 ($M = 22.67$, $SE = 4.46$). The main effect of condition was also significant, $F(2, 23.40) = 8.06$, $p < .002$, showing that barking duration changed across the study's three conditions as well. In post hoc comparisons, dogs barked for a shorter amount of time ($p < .001$) in Condition 3 ($M = 14.26$, $SE = 4.54$) than in Condition 1 ($M = 37.29$, $SE = 2.74$). The comparison between Condition 1 and Condition 2 ($M = 22.67$, $SE = 4.46$) was not significant ($p = .108$) nor between Condition 2 and 3 ($p = .478$) (Figure 4).

To uncover any change caused by the intervention in Leq values, we employed a mixed linear model to detect an effect of condition, phase, or a condition-by-phase interaction. With this model, both main effects were significant but not the interaction. The main effect of phase was significant, $F(1, 21.66) = 18.27$, $p < .001$, demonstrating that Leq levels in the building changed between the pre- and post-intervention phases of the study. Specifically, values in Phase A1 ($M = 30.44$, $SE = 1.15$) were higher than in Phase A2 ($M = 17.95$, $SE = 2.69$). The main effect of condition was also significant, $F(2, 21.66) = 6.07$, $p = .008$, indicating that Leq levels changed across the study's three conditions. In post hoc comparisons, values in Condition 3 ($M = 16.68$, $SE = 2.85$) were significantly lower than in Condition 1 ($M = 27.75$, $SE = 1.72$) ($p = .009$) and Condition 2 ($M = 28.15$, $SE = 2.85$) ($p = .028$) while levels measured in Condition 2 did not significantly differ from Condition 1 ($p = .999$) (Figure 5). Taken together with barking duration, these results suggest an increasing effect of the intervention on both sound levels and duration of barking over time.

To examine the time needed to train the dogs during the intervention phase of the study, we used a one-way analysis of variance to compare its duration in Conditions 1, 2, and 3. Phase B varied from 436s to 140s with an average of 114.38s (SD = 68.77). In the analysis, we found a significant difference in the average duration of Phase B across the study's conditions, $F(2, 16) = 8.21$, $p = 0.04$. Specifically, the intervention took the shortest amount of time (p = 011) to carry out in Condition 3 (M = 163.25, SE = 7.89) as compared to Condition 1 (M = 262.27, SE = 18.72). Additionally, training time in Condition 2 (M = 174.50, SE = 5.11) was shorter than in Condition 1 (p = .024). No significant difference in phase duration was found between Conditions 2 and 3 (p = .985) (Figure 6).

4. Discussion

In this investigation, we tested the effectiveness and generalization of an intervention designed to reduce dog barking in a Brazilian municipal animal shelter by measuring the overall sound level in one building, and length of time dogs spent barking prior to and following the intervention across multiple experimental conditions. We found that the average continuous sound level and duration of barking in the building reduced post-intervention and across the study's conditions, with a significant decrease in decibels and duration of barking in Phase A2 compared to Phase A1, and in Condition 1 with a single experimenter compared to Condition 3 with the experimenter, student, and shelter employee. Lastly, the amount of time needed for the experimenter to train dogs using the Barking Reduction Protocol shortened, despite the increasing number of individuals walking the shelter's corridor with the experimenter in the study's second and third conditions.

Our study adds to a handful of previous studies that have attempted to modify the barking behavior of dogs in shelters and kennels (Protopopova & Wynne, 2015; Payne & Assemi, 2017; Pengilly, 2020; Zurlinden et al., 2022). However, to our knowledge, this publication is the first to examine dogs' ability to generalize a non-barking response to other individuals beyond the study's experimenter as well as use multiple measures to evaluate intervention efficacy. Similar to the results in the aforementioned studies, we found that the BRP when applied with a single experimenter was effective in reducing dogs' barking, both in terms of its duration and loudness. Moreover, we were able to demonstrate that the inclusion of a student (Condition 2) and then student and shelter employee (Condition 3) did not lead to an incalcitrant recurrence of the dogs' barking behavior, but, in fact, dogs at the end of each condition spent less time barking, their sound level was lower (except in Condition 2), and the time needed to train them decreased.

While we did find that our intervention reduced sound levels in the shelter building and dogs spent less time barking, we did not directly explore which components of the intervention produced the observed results. Certainly, our results align with those from prior studies (Protopopova & Wynne, 2015; Payne & Assemi, 2017; Pengilly, 2020; Zurlinden et al., 2022) in which food was used to decrease barking, but it is also possible that habituation could have played a role in our observed results. Dogs have been shown to habituate to a novel noise within 1–6 trials (Martin et al., 1976). In the present study, the experimental person(s) walked the building's corridor three times in less than 10 minutes. As such, it is possible that by the third trial, the dogs simply habituated to the novelty of the experimenters, producing a reduction in barking sound levels and duration simply by their repeated presentations.

In their study, Protopopova & Wynne (2015) conducted one experimental session per day and used responding during a probe trial, which was the first trial of each session, as their dependent variable. They reported a decrease in undesirable behavior across days in that first probe trial. While habituation within a day is possible, it is less likely that habituation occurred across days in this study, especially when other humans would have walked through the kennels in between sessions or during days in which data collection did not occur, producing a dishabituation effect. As such, this suggests that the Pavlovian effects of pairing a human with food might have been a critical feature of the intervention. Given that the current procedure is very similar to that of Protopopova & Wynne (2015), we suspect that similar behavioral principles are at

play. We also saw an across-day improvement in dB levels, even in Phase A, which would have been comparable to the probe session of Protopopova & Wynne (2015). Nonetheless, future research should explore the potentially separate impacts of habituation and food delivery with the BRP.

As noted, this study is the first to assess generalization of a barking reduction intervention to other experimenters in the animal shelter. Considering the applied nature of the research question, this is a critical measure to include since novel people walking through shelters is common. Identifying if and what procedures are effective in producing generalization would enhance the intervention's utility. In the current study after observing an effect of one person, we introduced a second person in Condition 2. Given the change in stimulation, we were not surprised to find that the sound level and duration of barking increased again in the first trial of Condition 2. Nevertheless, barking rapidly decreased again in the condition's second trial (see Table 1). Furthermore, we did not observe a rebound of barking transitioning from Condition 2 to 3. Taken together, this suggests that while dogs were able to discriminate between one and two individuals in the experiment's second condition, they potentially generalized more readily when an additional individual was added in Condition 3.

Stokes and Baer (1977) identified seven strategies for generalization. While many scientists may opt for the train-and-hope method (Stokes & Baer, 1977), in the current study we utilized a technique akin to multiple exemplar training. With this technique, a novel stimulus is presented. If generalization to the novel stimulus is not observed (similar to the barking we saw in Trial 1 of Condition 2), the animal is then trained with that stimulus until criteria, after which we present another novel stimulus, and so on. This testing-training continues until generalization to a novel stimulus is observed. We, in fact, saw generalization after training on two exemplars.

Nevertheless, our stimulus presentation differed slightly from typical multiple exemplar training, in which exemplars are presented separately from one another (e.g., Brino et al., 2014; Marzullo-Kerth et al., 2011), in that the prior stimulus (ALB) was also present with the novel stimulus (student and shelter employee), which might have facilitated generalization, similar to programming common stimuli, another strategy identified by Stokes and Baer (1977). Considering these aspects, it would be especially useful in future studies to investigate the dogs' behavior to a novel human unaccompanied by the previously trained person to further elucidate how many human exemplars are needed in training to ensure adequate generalization by shelter dogs.

In Brazil, dogs are offered for adoption to the public, but little time is dedicated to interactions with people (Travnik & Baldan, 2022). In order to view adoptable dogs, potential adopters must enter buildings where the dogs are housed and walk their corridors. In these situations, barking occurs in response to the novel presence of humans, and barking initiated by one dog can cause others to react (Petak, 2013). As in many shelters, dogs' auditory responses can be loud, particularly for an indoor environment; and it is likely they are disruptive to both people and other dogs (Sales et al., 1997; Titulaer et al., 2013; Jarosińska et al, 2018). Momentary increases in noise within kenneled environments can influence dogs' behavior, including increases in tongue flicking, lip licking, paw lifting, body shaking, and low body posture (Beerda et al., 1997; Beerda et al., 1998). When behavioral interventions have provided reductions in barking and concomitant noise levels, such as by Hewison and colleagues (2014), dogs' behavior also improves. Dogs spend more time in sedentary behaviors, less time locomoting in their kennel, and exhibit fewer incidents of repetitive behaviors (Hewison et al., 2014). Thus, we might infer that an intervention, such as the current investigation, that reduced the duration of barking in the shelter and the loudness of that barking, may also positively affect dogs' behavior beyond vocalizations.

Changing the barking behavior of dogs in shelters and reducing noise may influence not only their proximate welfare, but their distal welfare as well. Observationally, Coppola et al. (2006) reported that sound levels in the shelter impacted viewing by potential adopters, reducing time spent in kenneling areas.

When one considers the amount of time a visitor may spend at a single dog kennel, including those that they pass by, dogs may have just 20s with a person considering adoption (Wells & Hepper, 2001; Protopopova & Wynne, 2015). As such, it is possible that when the sound levels of shelter buildings improve following an intervention like the one described here, potential adopters may increase the amount of time they spend viewing dogs. Nevertheless, it remains to be understood if additional time spent in kenneling areas of animal shelters would lead to the adoption of more homeless dogs.

The decreasing amount of time needed to implement the BRP, under three minutes in Condition 3 for a building housing 70 dogs, supports the intervention's feasibility. Previously, Protopopova and Wynne (2015) reported that their response-independent intervention required approximately 20s per dog and their response-dependent intervention, in which the experimenter differentially reinforced other behavior that was undesired (including but not limited to barking), 120s per dog. It is likely that the number of dogs housed together in our study influenced the amount of time (7.5 minutes at its longest) needed for the intervention to be carried out. Typically, 4-6 dogs were living in a kennel versus a majority being singly housed as was the case in other publications (Protopopova & Wynne, 2015; Payne & Assemi, 2017; Pengilly, 2020; Zurlinden et al., 2022). While this novel feature allows for our findings to be applied to more real-life sheltering situations in which dogs are co-housed, the lack of food aggression anecdotally observed may not generalize to other populations. Differences in the shelter's housing conditions, husbandry practices, or social instability (due to high turnover rates within the kennels) may influence the prevalence of food aggression amongst co-housed dogs; and as such, we recommend that such differences be experimentally assessed prior to BRP implementation.

Protopopova and Wynne (2015) found a reduction in dogs' undesirable behaviors, including being at the back of the kennel, out of sight, or facing away from the front of the kennel, as a result of their interventions. When evaluating the present study's outcomes, it is possible that training also influenced the dogs' location and positioning within the kennel, although it was not directly measured. During our intervention trials, the experimenter would wait until all dogs ceased barking within a kennel and then deliver a treat to each dog in the kennel. Considering the study's repeated trial design, in conjunction with the observed success of the BRP in reducing barking, it is likely that dogs approached the front of the kennel in anticipation of reinforcement when the stimuli (experimenters) were present. A similar anticipatory response by shelter dogs to human interaction interventions has been previously observed (Bergamasco et al., 2010; Valsecchi et al., 2007; Normando et al., 2006). When dogs move or face away from the front of their enclosures when visited by a person, their lengths of stay in the shelter tend to be longer (Protopopova et al., 2014), suggesting that an intervention like the BRP may benefit dogs' distal welfare as well.

When considering limitations of our study not previously discussed, it is possible that the dogs may have responded differently had the intervention occurred at other times throughout the day. Sales et al. (1997) found daily fluctuations in barking, and Hewison et al. (2014) reported that the barking levels depended upon human traffic. Thus, it would be worthwhile to explore whether this intervention would continue to show the same reductions if implemented in the afternoon, such as when there is more potential adopter activity in the building or if modifications to produce the same behavioral effect would be needed. Beyond issues of generalization to times of day with different environmental stimulation, dog barking is likely enhanced by social facilitation. That is, if one dog barks, other dogs are more likely to bark. More dogs engaged in barking, barking for longer durations or causing greater sound pressure levels, could impact the efficacy of the intervention.

Regarding our experimental design, Condition 2 commenced after 10 non-consecutive days of reduced barking in Phase A2 as compared to A1, while Conditions 2 and 3 ceased after four days. Additional days of data collection in all of the study's conditions, yielding more data points and behavioral stability (e.g., a criterion of consecutive days of reduced duration in barking), would demonstrate even stronger experimental control and strengthen inferential conclusions (Cooper et al., 2020). Thus, future studies

should utilize longer and varied lengths of conditions, such as in multiple baseline designs and changing criterion designs (Cooper et al., 2020).

Additionally, data collection was undertaken in only one building at the municipal animal shelter in São Paulo. As such, replication amongst the shelter's other buildings would have been informative in understanding the generalizability of our results within the same population of dogs. Moreover, while multiple experimenters were included to explore the generalization of dogs' responses to additional stimuli, the primary experimenter (ALB) applied the intervention throughout the study. As in any experiment in which the intervention is carried out by a single individual, it is unknown if another primary experimenter would have achieved similar results.

Conclusion

The intervention tested in this study, a Barking Reduction Protocol, had both an immediate and cumulative effect on dogs' behavior in the animal shelter. We found that sound pressure levels and barking duration reduced following the intervention (from Phase A1 to A2) with a decrease in both measures from the Condition 1 with a single experimenter to the end of the study in which the experimenter was accompanied by two additional persons. Moreover, the intervention time shortened across the study, with less than three minutes needed in Condition 3 for the training of 70 dogs. Due to the low effort nature of this intervention and its inexpensive cost, the BRP can likely be implemented by many shelters to change the behavior of their kenneled dogs in response to people and improve canine welfare.

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Captions

Table 1. Duration of barking and transformed Leq values in pre-intervention (A1) and post-intervention (A2) phases in Conditions 1, 2, and 3, and duration of walking during the intervention phase (B)

Figure 1. Study building and its central corridor and kennel doors.

Figure 2. Schematic representation of the BRP experimental phases: Phase A1 (pre-training), B (training), and A2 (post-training). Dogs' barking varied in sound levels and duration within each phase.

Figure 3. The three conditions of BRP protocol application. Condition 1 included only the experimenter and lasted 12 days (11 days of data was collected). Condition 2 was administered with both the experimenter and a student to simulate the browsing behavior of potential adopters. This condition was carried out over four days. Condition 3 included both the experiment, student, and a shelter employee and lasted four days.

Figure 4. Boxplots of barking duration (s) in pre- (A1) and post- (A2) intervention phases across the study's three conditions.

Figure 5. Boxplots of transformed Leq dB levels in pre- (A1) and post- (A2) intervention phases across the study's three conditions.

Figure 6. Boxplots of intervention duration (s) across the study's three conditions.

Table 1. Duration of barking and transformed Leq values in pre-intervention (A1) and post-intervention (A2) phases in Conditions 1, 2, and 3, and duration of walking during the intervention phase (B)

		Barking Duration (s)		**Transformed Leq** (dB)		**Phase Duration** (s)
Condition	**Day**	A1	A2	A1	A2	B
1	1	43.45	36.83	42.03	32.57	450
	2	50.58	33.33	35.8	23.05	250
	3	41.65	22.19	31.36	31.84	220
	4	44.10	24.98	31.52	27.24	280
	5	55.64	33.44	33.9	24.38	270
	6	50.81	33.23	32.31	29.88	227
	7	35.62	0	28.95	0.15	240
	8	39.6	0	30.83	13.65	250
	9	56.69	19.65	32.73	23.85	266
	10	32.81	52.21	26.78	30.22	200
	11	44.25	0.43	30.61	16.79	246
Condition 1 Mean (SD)		45.02 (7.72)	23.30 (17.17)	32.44 (3.97)	23.06 (9.68)	262.27 (62.08)
2	12	35.59	38.36	35.97	30.13	183
	13	33.72	14.84	35.54	32.5	180
	14	32.42	2.06	30.74	31.53	160
	15	24.37	0	23.72	5.08	175
Condition 2 Mean (SD)		31.53 (4.94)	13.82 (17.63)	31.49 (5.70)	24.81 (13.19)	262.27 (62.08)
3	16	27.16	0	30.24	0.33	168
	17	21.32	16.74	25.46	20.89	140
	18	37.00	0	32.13	0	170
	19	11.83	0	21.71	2.65	175
Condition 3 Mean (SD)		24.33 (10.55)	4.19 (8.37)	27.39 (4.71)	5.87 (10.02)	163.25 (15.78)

Note. Data collection days are numbered continuously despite the intervals of days between them in which data collection did not occur.

Figure 1

Figure 2

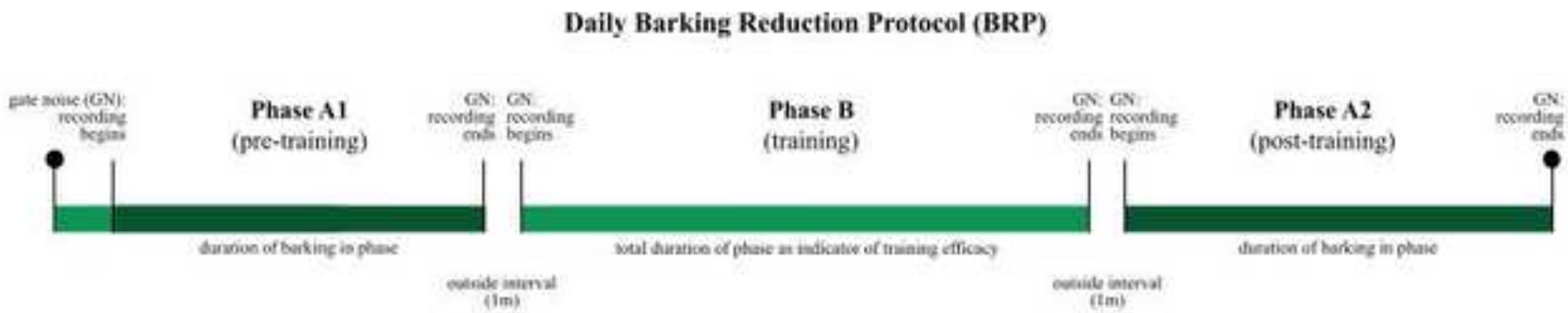
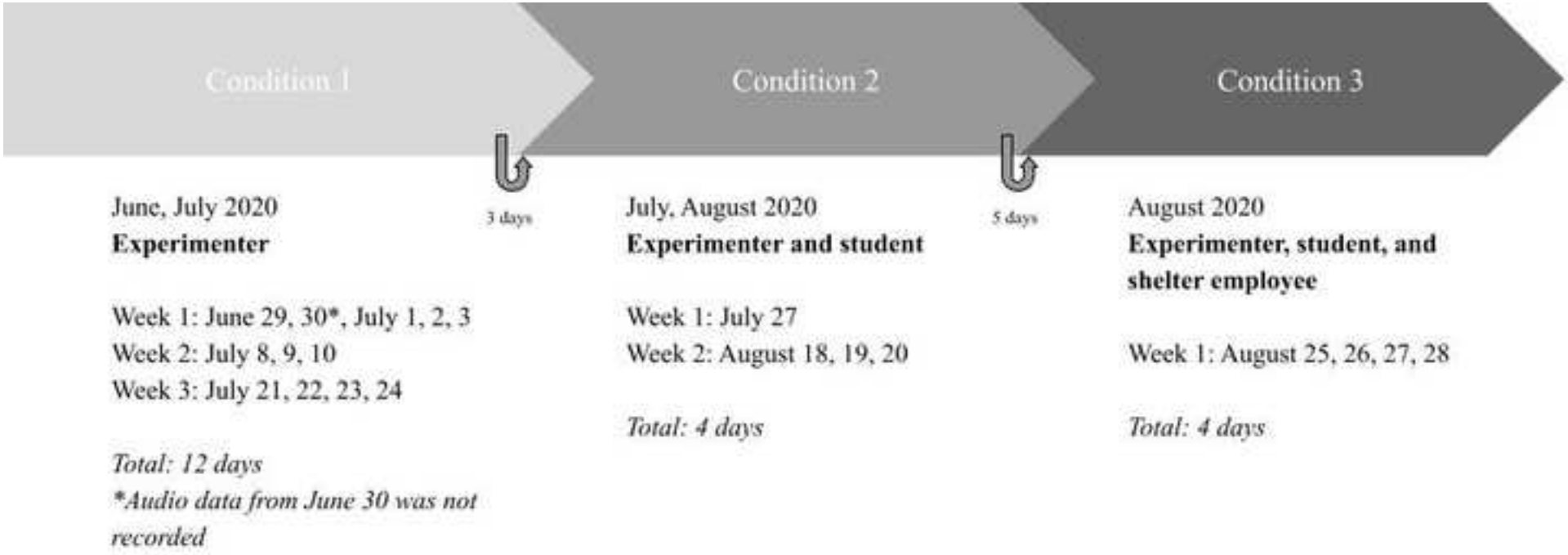


Figure 3



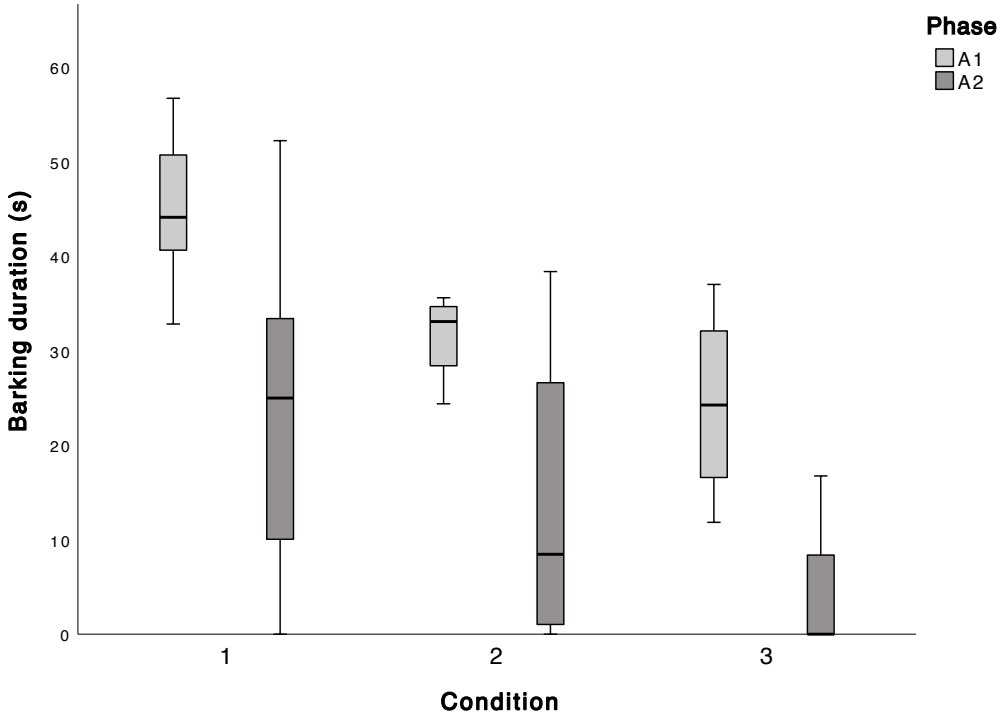


Figure 5