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Owner-Implemented Functional Analyses and Reinforcement-Based Treatments for Mouthing in Dogs

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Abstract

The most effective behavioral interventions are function based, which requires the identification of the behavioral function. A functional analysis is conducted to isolate and identify the environmental variables maintaining target behavior, and this method is effective across species. In domesticated dogs, mouthing is a common behavior and is considered problematic by many people. However, mouthing is not always simple to treat with standard interventions without identifying the function of the dog's mouthing. Without efficacious interventions, undesirable behavior in companion animals may result in reduced welfare, an increased likelihood of relinquishment, or an increased probability of euthanasia. The purpose of this study was to provide a clinical demonstration of an owner-conducted functional analysis to identify the contingencies maintaining mouthing behavior in dogs and apply the results to owner-implemented function-based interventions to reduce mouthing. Identified functions included attention and tangibles, and owner-implemented interventions were successful at reducing mouthing in all three dogs.

Keywords
Behavior, Functional analysis, Puppy, Biting, Problem behavior, Training, Mouthing

Introduction

Companion animals commonly engage in behavior considered problematic to their owners (Gazzano et al., 2008; Salman et al., 2000), and problem behavior is a common cause of animal abandonment and euthanasia (Patronek et al., 1996a, 1996b; Patronek & Dodman, 1999; Reisner et al., 1994; Shore, 2005). Animal behavior professionals are available to assist families with their pets' problem behavior through behavioral assessments and interventions; however, few assessments have been scientifically validated in the pet population to identify the behavioral function. As a result, indirect or subjective assessments are typically used to hypothesize the variables maintaining animal problem behavior. For example, a typical behavioral consultation begins with collecting owner reports of the behavior and antecedent/consequent variables (Casey & Bradshaw, 2008; Landsberg et al., 2013; Reisner et al., 2007). The initial meeting may include relatively brief direct, descriptive evaluations of the animal and its behavior by the consultant, either in person or via video recording, plus a possible recommendation for medical assessment (Horwitz, 2018; Sueda & Malamed, 2014). Based on these brief indirect and direct assessments, an intervention protocol is developed. After several weeks of applying the intervention, most consultants will again rely on indirect, subjective owner assessments or brief direct assessments to evaluate success (Horwitz, 2018; Landsberg et al., 2013; Sueda & Malamed, 2014) and will modify the treatment protocol in the absence of success.

Although indirect and descriptive assessments are commonly used in animal behavior consulting to develop hypotheses of behavioral function, these assessment types have been shown to be less accurate than experimental assessments (Iwata et al., 2013; Kahng et al., 1998; Lerman & Iwata, 1993; Mace & Lalli, 1991; Piazza et al., 2003; Smith, 1995; St. Peter et al., 2005; Thompson & Iwata, 2007) and have not been validated in animals. For human behavior problems, behavioral function is typically assessed using the functional analysis, which can elucidate the maintaining variables for various behavioral topographies (Iwata et al., 1994a; Iwata, Pace, Cowdery, & Miltenberger, 1994b; Smith et al., 1993). Common behaviors assessed by the functional analysis include aggression (Hagopian et al., 2013; Thompson et al., 1998), destructive behavior (Bowman et al., 1997), and other behaviors harmful to the individual or others (Ing et al., 2011; Piazza et al., 1996). Although the functional analysis has been used to assess human behavior for decades and is often part of a comprehensive treatment plan for human problem behavior, there has been less translation into the animal behavior field.

More recently, studies have assessed the validity of the functional analysis on animal behavior. The first published human-to-animal translational study demonstrated the validity of the functional analysis to identify positive reinforcement in the form of attention as the function of self-injurious behavior in a single olive baboon, and the results informed an efficacious, function-based intervention (Dorey et al., 2009). Further functional analyses were performed in captive wild animals to identify the function of human-directed problem behavior in a chimpanzee (Martin et al., 2011), aggression in a black-and-white ruffed lemur (Farmer-Dougan, 2014), and self-injurious feather plucking in a black vulture (Morris & Slocum, 2019). Functional analyses in companion dogs have identified the function of jumping on people (Dorey et al., 2012; Pfaller-Sadovsky et al., 2019), canine stereotypic behavior (Hall et al., 2015), food guarding (Mehrkam et al., 2020), and various problem behaviors in shelter dogs (Winslow et al., 2018), and function-based interventions were implemented. However, previous studies did not incorporate reversals during intervention assessments (i.e., they used an A-B design), which does not permit the validation of changes in problem behavior as a result of the intervention.

These earlier studies suggest that the functional analysis can identify the contingencies maintaining animal problem behavior. However, although most studies used research team members as the experimenters engaging with the canine participants during the functional analysis, switching the owner into the experimenter role in one study resulted in different behavioral frequencies (Hall et al., 2015), suggesting that analyses may need to incorporate owners into the experimenter role to maximize accuracy. Importantly, owners were successful at implementing interventions after behavioral skills training (Pfaller-Sadovsky et al., 2019), thereby supporting the successful integration of owners into the treatment process. Overall, although function-based treatments for animals have been published, a comprehensive clinical application involving assessment, treatment, and caregiver training has not yet been described.

"Mouthing" is thought to be a common behavior problem in pet dogs (Gazzano et al., 2008) and was previously operationally defined as the "dog places teeth on person regardless of force" (Protopopova & Wynne, 2014, p. 111). Mouthing is considered a problem behavior because it can result in damage to human skin through bruising, scratches, or open wounds (Waite et al., 2021) and because it may be highly aversive to owners and other people given its potential for topographical and functional overlap with "biting" (Coppinger et al., 1987; Guy et al., 2001; Oxley et al., 2019; Shabelansky & Dowling-Guyer, 2016). The Centers for Disease Control and Prevention (CDC) lists a variety of zoonotic diseases that may be spread from dogs to humans via any skin wound caused by a dog's mouth, even those as minor as a scratch (CDC, 2020).

A study on 46 Italian dogs suggested that 37% of the dogs aged 11–18 months engaged in mouthing (Gazzano et al., 2008), and a larger study surveying U.S. dog owners indicated that 45% of respondents' dogs engaged in mouthing (Waite et al., 2021). Mouthing was significantly more prevalent in younger dogs than older dogs, and over 80% of dogs under 1 year old mouthed. Specifically, puppies experiencing tooth development are hypothesized to mouth more often (Horwitz, 2018), potentially to access automatic reinforcement. Teething in puppies occurs at 2–7 months of age and is a result of permanent teeth erupting from the gums (Arnall, 1960; Geiger et al., 2016). This developmental process potentially causes physical discomfort, which could establish the reduction in discomfort as an automatic negative reinforcer. Similarly, parents of human children perceive that infants in the teething phase are more likely to bite and suck on objects, engage in abnormal gum rubbing, and be more irritable (Macknin et al., 2000; Memarpour et al., 2015). Nevertheless, assumptions regarding the function of mouthing in young dogs should be evaluated with a functional analysis to examine whether mouthing may be maintained by socially mediated consequences, because interventions developed on hypotheses rather than assessment outcomes may not effectively reduce mouthing.

A variety of colloquial recommendations exist to reduce mouthing frequency. These include yelping when mouthed to mimic other puppies in the litter, giving the dog a time-out, ignoring the dog when it mouths (Seksel, 2008), and giving the dog a chew toy as a distraction. However, the functions of mouthing in dogs are unknown, as no published applications of a functional analysis have been performed on the behavior. Further, no interventions for mouthing have been empirically validated. This is problematic, given that interventions that do not address the maintaining contingencies risk inefficacy or, worse, reinforcement of the problem behavior (Iwata, Pace, Cowdery, & Miltenberger, 1994). The fact that many dogs continue to engage in mouthing into adulthood (Gazzano et al., 2008; Waite et al., 2021) suggests that the commonly recommended interventions may not be widely effective and that use of a functional analysis to identify the function of mouthing in dogs is necessary to develop efficacious treatments. Further, even when owners hypothesize the function of mouthing behavior, they may engage in interventions that are contraindicated for that function (Waite et al., 2021), thereby maintaining or worsening the dog's mouthing behavior. This indicates an additional need for identification of function-based interventions that owners can successfully implement.

The study was divided into two parts focusing on functional analyses and function-based treatment protocols for mouthing. The purpose of Experiment 1 was to provide a clinical application of a functional analysis for dog mouthing behavior, and the purpose of Experiment 2 was to combine the functional analysis results with owner feedback to develop interventions that can be successfully implemented by owners to reduce canine mouthing. Secondary outcomes included describing the procedures used to train alternative behaviors, as well as measuring owner fidelity at performing functional analyses and interventions.

Method

Participants, Setting, and Materials

Dogs living with their owners within the greater Milwaukee, Wisconsin, area were recruited via flyers at shelters, dog training businesses, veterinary clinics, and online canine-focused groups. Participants were eligible for enrollment if their dog frequently engaged in mouthing behavior on the owner. Dogs had to be at least 10 weeks old, have been living in the home for a minimum of 1 month, have their sight and hearing intact, and have proof of rabies vaccinations. For safety purposes, dogs were excluded if they had ever engaged in behaviors that the owners described as "aggressive," including snarling, snapping, lunging, growling, or biting behavior not related to play (Borchelt, 1983; Radosta-Huntley et al., 2007) or had a history of mouth contact that produced open wounds on human skin requiring medical intervention within the last 3 years. Participating owners were at least 18 years old. All procedures performed in this study were approved by the institutional review board for the protection of human subjects and the institutional animal care and use committee.

Owners were first screened via an online survey for inclusion/exclusion criteria, and the remaining eligible participants were contacted via phone to discuss the study. Of the 29 owners who were screened online, 19 were eligible and submitted their contact information. All eligible owners were contacted. After the study and study requirements were described to the owners, six owners were interested in enrolling their dogs in the study. Three dog–owner pairs completed the study. Two dogs dropped out of the study because they did not engage in mouthing during early sessions, and one dog dropped out due to a lack of owner availability. All dog names presented here were changed to ensure the confidentiality of humans and animals.

Bubbles was a 6-month-old female goldendoodle acquired directly from a breeder at 8 weeks old from two litters of 15 puppies. She frequently engaged in mouthing on both of her owners at home, and the behavior was especially frequent when the owners were sitting on the couch in their living room or wearing clothing with loose fabric, such as the belt on a bathrobe. Mouthing started almost immediately upon adoption. At the time of enrollment, the behavior was producing bruises, and the owners reported that mouthing was increasing in severity. Bubbles's assessment was performed in the owners' living room with the male owner.

Wilbur was a male golden retriever aged 4.5 months at the time of enrollment. He was acquired directly from a breeder at 8 weeks from a singleton litter (a litter with only one puppy). He frequently engaged in mouthing on his female owner since his introduction to the home. Although the mouthing behavior was typically gentle, he still had deciduous teeth, which are sharper than adult teeth (Fulton et al., 2014) and can easily scratch human skin. Wilbur's assessment was performed inside the living room of his home with his owner.

Oliver was a 5-month-old male mixed-breed dog acquired from a local shelter at the age of 8 weeks from a litter of four. He did not mouth on the male owner but frequently engaged in mouthing on his female owner, including placing his mouth on her arms and legs or tugging on her clothes, typically in the backyard of the home. This behavior started almost immediately upon adoption. Although he only weighed 20 lb (0.45 kg), his mouthing behavior produced some bruising and broken skin not requiring medical attention. His owners reported that they frequently engaged in tug games with Oliver during which both owner and dog simultaneously pulled on a toy. Because most of Oliver's mouthing occurred in the backyard on his female owner, his assessment and intervention were both performed in the backyard with his female owner.

Sessions occurred in the setting in which the owner reported the highest frequency of mouthing. Bubbles's assessment and intervention were performed in her living room, Oliver's was in his backyard, and Wilbur's was in his living room. The owner conducted each condition with their dog. A researcher also was present during the functional analysis and interventions to provide verbal instructions, offer feedback, and video record the session.

Due to the reported high frequency of mouthing, owners wore protective equipment in the form of padded cloth armguards and, if applicable, shin guards during sessions of assessment and treatment. Protective equipment for owners was chosen because it does not appear to interfere with functional analysis outcomes (Oropeza et al., 2018) and may increase the social validity of conducting the assessment despite high rates of mouthing. To assist with discrimination between the conditions of the functional analysis, five pairs of armguards were dyed different colors known to be discriminable by dogs, including white, gray, black, yellow, and blue (Neitz et al., 1989; Pretterer et al., 2004). Each color was consistently paired with a specific functional analysis condition within and across dogs. White armguards were paired with ignore, gray with attention, black with play, yellow with demand, and blue with tangible.

Owners identified toys and demands for inclusion in functional analysis conditions. Owners selected toys with which their dog frequently played for inclusion in the toy play condition, and the putatively most preferred toy (based on owner report) was included in the tangible condition. Demands to which the canine participants consistently complied according to their owners, as well as small edibles used during training, were included in the demand condition.

Response Measurement, Interobserver Agreement, and Procedural Integrity

The primary dependent variable was mouthing on an owner, defined as the dog's teeth or inner lips making contact with human skin or clothing. Contact solely by the tongue (licking) was excluded. This definition is similar to, but more comprehensive than, the definition proposed by Protopopova and Wynne (2014) in that it includes contact with owner clothing, which many owners identify as part of the behavior. Because the duration of each dog's mouthing was unique, with some dogs making brief contact and some grabbing on for long durations, partial-interval recording was used to measure the behavior. Videos of each session were scored using partial-interval recording with 10-s intervals across each 5-min session. Mouthing data were converted to a percentage by dividing the intervals in which mouthing occurred by the total number of intervals in the session and multiplying by 100.

Trained observers collected interobserver agreement data for mouthing behavior on 35.9% of assessments. Agreement for the functional analysis was calculated by dividing the number of intervals with agreements by the total number of intervals tested. Mean agreement for mouthing during the functional analysis was 95.9% (range 86.7%–100%) for Bubbles, 95.8% (range 80%–100%) for Wilbur, and 96.7% (range 86.7%–100%) for Oliver.

Data were also collected on procedural integrity during 100% of functional analysis sessions to examine whether the owner made errors of omission, errors of commission for problem behavior, or errors of commission for other behavior. Omission errors were defined as the owner failing to provide programmed reinforcement within 3 s of the target behavior. Commission errors for problem behavior occurred when the owner provided unprogrammed reinforcement for mouthing behavior. Commission errors for other behavior were defined as the owner providing unprogrammed reinforcement for a nontarget response. Total errors were calculated using partial-interval recording by dividing the total number of intervals with errors by the total number of intervals. Integrity data are reported as the percentage of intervals in which the owner implemented the assessment or intervention procedures as described in the protocol and did not make any of the previously described errors.

During the functional analysis, integrity was 95% (range 76.7%–100%) for Bubbles's owner, 95.3% (range 76.7%–100%) for Wilbur's owner, and 99% (range 90%–100%) for Oliver's owner. Errors of omission never occurred, and errors of commission for problem or other behavior were relatively rare. Interestingly, commission errors of other behavior were most likely to occur during the attention condition, wherein noncontingent attention was provided by Bubbles's and Wilbur's owners during an average of 14% and 9.3% of intervals, respectively. These commission errors typically occurred when the dog engaged in desirable behavior, to which the owner provided encouraging statements (e.g., "Good girl!" or "You're so cute!") or petting.

Experiment 1: Functional Analysis of Dog Mouthing Behavior

Method

A functional analysis was conducted for each dog. Conditions included ignore, attention, toy play, demand, and tangible, and each condition was conducted at least five times for each dog. Conditions were typically presented in a consistent order, unless noted otherwise, and alternated in a multielement design with no more than 10 sessions per day. Each session was 5 min in duration. The fixed order maximized the use of sequence effects by taking advantage of programmed, consistent establishing operations (EOs; Hammond et al., 2013; Iwata et al., 1994c). Specifically, a fixed-order sequence can contrive an EO for the putative reinforcer tested in the following condition, thereby increasing the likelihood of the behavior during relevant conditions.

Ignore

The owner was present but did not interact with their dog nor provide any attention contingent on mouthing or any other behavior. Extended ignore sessions were conducted in a final phase of Wilbur's functional analysis to examine whether mouthing decreased across repeated sessions in which no socially mediated consequences for behavior were provided. This condition was included to evaluate whether mouthing may be maintained by automatic reinforcement.

Attention

The owner withdrew their attention from the dog. Contingent on mouthing, the owner provided attention. The topography of attention provided by the owner was consistent with how the owner typically interacted with the dog following mouthing, and there was no required minimum interval length. For example, Oliver's and Bubbles's owners said "no" and pushed Oliver or Bubbles away contingent on mouthing, whereas Wilbur's owner laughed, talked to Wilbur, and gently played with Wilbur's mouth and paws for approximately 10 s. This condition evaluated whether mouthing was maintained by social positive reinforcement in the form of owner attention.

Toy Play (Control)

The owner provided their typical attention and played with their dog. Interactions included vocal attention (e.g., high-pitched praise, such as "You're such a good girl!" or other statements to/about the dog, such as "Go get it" when a toy was thrown), petting, and playing with toys (e.g., squeaking, shaking, or throwing toys). Contingent on mouthing, the owner neither responded nor changed their behavior and continued the activity. Available toys were chosen by owners based on their interpretation of the dog's preference. This condition served as the control, as toys and owner attention were consistently available and presented, respectively, and mouthing did not produce any consequences.

Demand

The owner continuously presented previously trained prompts to the dog (e.g., sit, down, stay, shake). Contingent on a correct response by the dog, the owner delivered a small edible. If the dog did not respond correctly, the owner continued to present the prompt approximately every 3 s. Contingent on mouthing, the owner removed the demand by turning away and ignoring the dog for 20 s from the first mouthing response. This condition tested whether mouthing was maintained by social negative reinforcement.

Tangible

Toys were selected for inclusion based on the owner's nomination of the dog's putatively most preferred toy. The session started by removing all toys to contrive an EO for toys. The owner then provided access to a preferred toy for 20 s contingent on mouthing by holding the toy in front of the dog's face and allowing the dog to take the toy. After 20 s, the owner attempted to retrieve the toy. At the time of retrieval, if the dog did not release it, the owner allowed the dog to keep the toy in order to avoid social attention in the form of a tug game. The owner was then asked to retrieve the toy when possible during the session, such as when the dog was distracted. To ensure reinforcers were available for every instance of mouthing, the owner had access to two similar toys (e.g., two fox-shaped tug toys). If the canine participant mouthed while already in possession of a toy, the owner gave the dog the second toy and concomitantly attempted to retrieve the first toy.

For both Bubbles and Wilbur, toys were easily retrieved when necessary. In contrast, Oliver often engaged in tug games and would not release the toy. Whenever his owner reached down to pick up a toy at the end of a reinforcement interval, he consistently lunged toward the owner's hand and mouthed the owner or grabbed the toy for which the owner was reaching, resulting in further toy access when the owner released the toy to avoid tug games. As a result, Oliver had access to at least one toy outside of reinforcement intervals (unscheduled abolishing operation), meaning he still had the toy after the owner was supposed to take it away, for an average of 55.7% of the duration of tangible sessions.

Results

The functional analysis included 25–31 sessions per dog, for a total of 125–155 min over 4–6 days. The functional analysis was conducted over a 2- to- 7-week period, based on the owners' availability for appointments.

Figure 1 shows the results of Bubbles's functional analysis. Bubbles engaged in high levels of mouthing behavior in the attention condition, suggesting that mouthing was maintained by positive reinforcement in the form of attention. When Bubbles's owner provided a higher magnitude of physical attention (forceful shoving away), the intensity of Bubbles's behavior increased with barking, jumping, and rapid lunging, suggesting the topography of owner attention may impact behavior (e.g., Kodak et al., 2007). Although Bubbles also engaged in elevated levels of mouthing behavior in the ignore condition, it is possible that Bubbles did not discriminate the contingencies arranged in the attention versus ignore conditions, both of which contrived an EO for attention and had identical procedural arrangements except for the consequence for mouthing. An extended ignore condition was not conducted due to time limitations; thus, automatic reinforcement was not ruled out as a potential function of Bubbles's mouthing. Mouthing remained low in the demand, tangible, and toy play conditions.

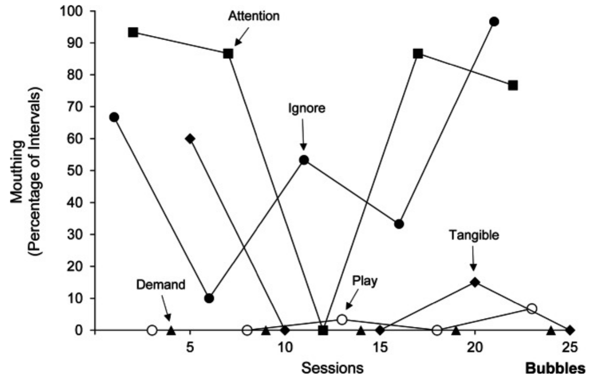

Figure 1. The Percentage of Mouthing During Bubbles's Functional Analysis

Figure 2 shows the results of Wilbur's functional analysis. Wilbur consistently engaged in high levels of mouthing during the attention condition, whereas the behavior decreased or remained low in other conditions after repeated exposures. Levels of mouthing were similarly low in the tangible and toy play conditions, and mouthing did not occur in the demand condition. Although Wilbur's mouthing was elevated in early ignore sessions, levels of mouthing decreased over time, and an extended ignore session (10 min) resulted in substantial decreases in mouthing.

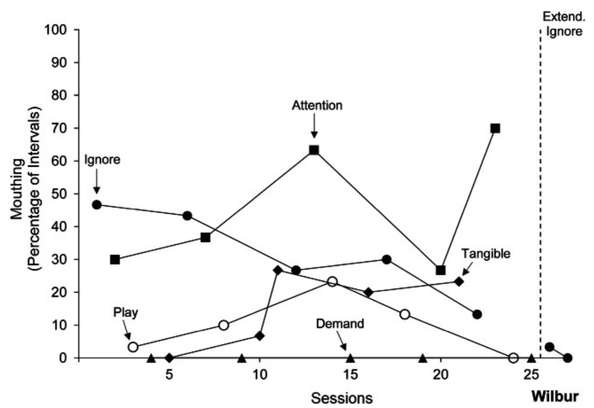

Figure 2. The Percentage of Mouthing During Wilbur's Functional Analysis

Figure 3 shows Oliver's functional analysis results. Oliver engaged in mouthing during a high percentage of intervals in the attention, ignore, and tangible conditions. In the attention condition, when the magnitude of the owner's physical attention increased (e.g., occasional forceful shoving of Oliver), Oliver's mouthing became much more intense (quickly lunging) and he engaged in other behavior (e.g., barking), suggesting potential differences in the quality of types of attention as reinforcers (e.g., Kodak et al., 2007). During the tangible condition, Oliver engaged in mouthing during 33.3%–100% of EO-present intervals. Oliver's owner was unable to remove the tangible item during some intervals. During reinforcement intervals and following reinforcement intervals when the owner could not remove the tangible item due to Oliver's tugging behavior, Oliver frequently engaged with the toy in his possession. However, if the owner reached for a nearby toy, Oliver would leave his current toy in order to mouth or grab the toy for which the owner was reaching. Oliver had near-zero levels of mouthing in the toy play condition. Although Oliver mouthed during some demand intervals, 51.8% of this mouthing occurred during the interdemand interval (i.e., abolishing operation interval, although this interval also contrived an EO for attention because the owner turned away from Oliver during breaks). These data suggest that Oliver's mouthing was maintained by social positive reinforcement in the form of attention and access to tangible items. Oliver initially engaged in high levels of mouthing in the ignore condition; however, levels of mouthing decreased with additional exposure to the contingencies in the condition. Although the researcher was in the backyard with the owner, Oliver never mouthed on the researcher during the functional analysis.

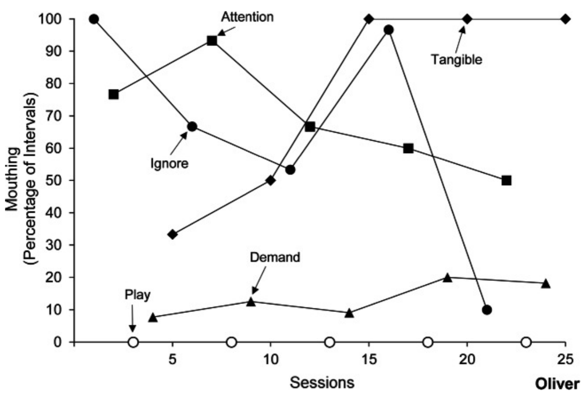

Figure 3. The Percentage of Mouthing During Oliver's Functional Analysis. *Note.* Extend. Ignore = extended ignore

Experiment 2: Function-Informed Interventions for Mouthing Behavior

Method

Response Measurement, Interobserver Agreement, and Procedural Integrity

In addition to the dependent variables included in Experiment 1, dependent variables during the intervention included down-stay and/or sit-stay for Bubbles and Oliver, as these were the behaviors incorporated as alternative or incompatible behaviors during differential reinforcement procedures. Stay behaviors required holding a specific body position for a set duration. Down-stay is when a dog lies in sternal recumbency and was defined to be when a dog's elbows, abdomen, and rear pasterns were touching the ground. Sit-stay was defined as the dog's rear pasterns and rump in contact with the ground. Data collectors scored the latency to sit behavior near a toy for Bubbles during training after her owner set down a toy, partial-interval recording of down-stay behavior for Oliver during intervention sessions, and the duration of sit and down-stay behaviors for Oliver during postintervention delay fading.

Trained observers collected interobserver agreement data for mouthing behavior for 59.1% of treatment sessions, alternative behavior in 34.7% of training trials, and alternative behavior in 35.7% of intervention sessions. Agreement for intervention sessions was calculated by dividing the number of intervals with agreements by the total number of intervals tested. Agreement for duration or latency of alternative behaviors during intervention training sessions was calculated by dividing the smaller duration by the larger duration for each interval and multiplying by 100, and then dividing the sum of all intervals by the total number of intervals, multiplied by 100. Mean agreement for mouthing during treatment was 96.1% (range 83%–100%) for Bubbles, 97.8% (range 93.3%–100%) for Wilbur, and 100% for Oliver. Mean agreement for the alternative behavior during treatment was 92.2% (range 90%–93.3%) for Bubbles and 93.2% (range 86%–100%) for Oliver. Mean agreement for intervention training sessions was 94.4% (range 45.1%–99.7%) for Bubbles and for Oliver's delay-fading sessions was 83.4% (range 51.9%–99%). Only three instances of agreement were below 70% during training, and these were related to the occurrence of short-duration behavior, which increases the relative amount of error (e.g., 2 s for one observer vs. 3 s for another).

Procedural integrity data for training and intervention sessions were collected and scored as described in Experiment 1. During the intervention training sessions and intervention sessions, procedural integrity was 97.9% (range 83.3%–100%) for Bubbles, 96.3% (range 83.3%–100%) for Wilbur, and 99.7% (range 98%–100%) for Oliver. During training and intervention sessions, similar to the functional analysis sessions, errors of commission of other behavior were the most common error, and errors of omission never occurred.

Procedure

Based on the results of each dog's functional analysis and each owner's needs, an individualized intervention was developed to address the function(s) of mouthing. Each intervention session was 5 min. An A-B-A-B reversal design was used to evaluate the effects of the intervention on mouthing with baseline (A) and intervention (B) sessions. Owners conducted all baseline and intervention sessions. Toys used during intervention sessions were those identified by owners as highly preferred and able to be used in dog–owner interactions (e.g., tug toys for tug games or balls for throwing).

Baseline

Owners provided the reinforcer associated with the highest levels of problem behavior from the functional analysis contingent on mouthing. The attention condition from the functional analysis served as the initial baseline for Oliver and Wilbur, whereas an attention baseline was conducted for Bubbles. The one-session reversal following intervention with each dog was conducted in an identical manner to the attention condition in the functional analysis (e.g., Cooper et al., 2007; Kodak et al., 2004).

Treatment

Bubbles's intervention included differential reinforcement of alternative behavior (DRA) with extinction (EXT) to gain access to a tug game or ball throw with concomitant vocal or physical owner attention. The alternative behavior consisted of Bubbles picking a toy up from the ground, bringing the toy within a 0.3-m radius of the owner, and sitting within a 0.3-m radius of the owner. This intervention was chosen because it ensured that Bubbles's alternative behavior was acceptable to the owners and had the potential to be salient to the owner at moments when the owners were not already attending to Bubbles, such as when they were sitting on the couch and reading. Contingent on Bubbles engaging in the alternative behavior, the owner immediately provided brief praise, picked up the toy, and engaged in a tug or ball throw with the toy and Bubbles for 15 s. To establish the DRA, Bubbles underwent alternative-behavior training using multiple-prompt fading. Bubbles had already learned to sit in response to the owner's vocal/visual prompts while the owner was standing. Training began with the owner putting the toy on the ground several feet away, standing up, then providing several vocal and visual prompts for "sit" by saying "sit" and raising his hand, respectively. Contingent on sitting behavior, the owner engaged in 15 s of a tug game or ball throwing with Bubbles. These prompts were faded by decreasing the frequency of each per trial and reducing the movement associated with the physical prompt. Training ended with the owner sitting normally and facing forward on the couch while not looking at Bubbles (as in the attention and ignore conditions of the functional analysis) and Bubbles engaging in the alternative behavior without any prompting. Any mouthing resulted in no attention from the owner.

Wilbur's intervention included a multiple (MULT) schedule, and all sessions were 5 min in duration. During the noncontingent reinforcement (NCR) schedule in initial training, Wilbur had 60 s of continuous access to toys and frequent owner attention, and any mouthing behavior resulted in EXT. During the 60-s EXT schedule, the owner began by turning away, crossing her arms, and saying "Not now." All subsequent behavior by Wilbur was ignored until the end of the session, and Wilbur continued to have noncontingent access to toys. If mouthing occurred at the end of the EXT component of the MULT, a 10-s changeover delay was used to prevent a transition to NCR in close temporal proximity to mouthing (Schwartz et al., 1975). Together, these resulted in a (MULT NCR 60/EXT 60) schedule. Following training, the intervals for each condition increased to 150 s (MULT NCR 150/EXT 150) because of the owner's need to signal the unavailability of attention reinforcement while they performed work tasks throughout the day. This MULT was selected as an intervention because Wilbur's owner often worked from home and required intervals without disruption by Wilbur.

Oliver's intervention included differential reinforcement of incompatible behavior (DRI) with EXT, during which the owner prompted Oliver to engage in a 5-s stay. Contingent on Oliver staying in a down position for 5 s, his owner provided attention and tangible access in the form of 15 s of a tug game with a toy and vocal attention. Following attention and tangible access, the owner tried to retrieve the toy, stopped providing attention, and prompted another stay behavior. Contingent on mouthing, Oliver's owner continued to withhold attention and tangible items. Because Oliver's behavior generally occurred in the backyard, this intervention was designed to allow Oliver's owners to walk through the backyard from their detached garage to the house without problem behavior.

Because Oliver's owner needed to be able to walk through the backyard, longer duration stay behaviors were trained after the initial analysis. A changing-criterion design was used with delay fading, wherein the topography and duration of incompatible responses were modified across criteria. If Oliver's behavior met the criterion two sessions in a row, the duration criterion was increased or the topography changed. However, if Oliver's behavior did not meet the criterion two sessions in a row, the criterion was decreased to the previous step. Criteria included holding a stay for 5, 8, 12, 15, 20, 23, and 25 s. Phases included down-stay behavior, then sit-stay behavior, then sit-stay while the owner walked around. The terminal criterion for intervention was for Oliver to remain in the sit-stay position for at least 20 s while his owner walked around the yard, as this would allow his owner enough time to enter and cross the backyard, briefly enter the house, and return with a toy to provide reinforcement (e.g., tug game and attention).

Results

Figure Figure44 shows the results of Bubbles's treatment (top panel) and alternative-behavior training (bottom panel). Bubbles engaged in high levels of mouthing during the initial attention baseline. After alternative-behavior training, there was an immediate reduction in Bubbles's mouthing behavior and high levels of the alternative (sit with toy) behavior during DRA with EXT. The reversal to baseline showed high levels of mouthing. Following the reintroduction of treatment, Bubbles's mouthing reduced to low levels and the alternative behavior reversed to high levels. Although the researcher was in the same room as the owner, Bubbles never mouthed on the researcher.

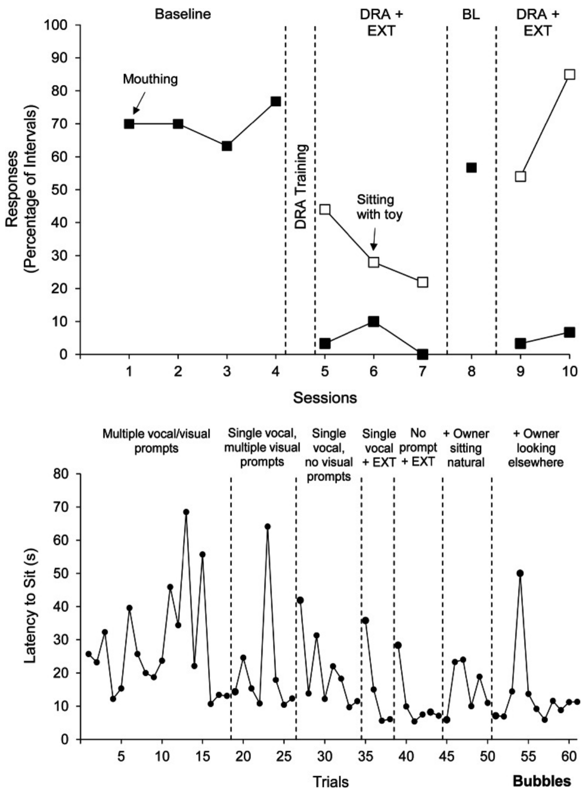

Figure 4. The Percentage of Mouthing and Alternative Behaviors During Bubbles's Function-Based Treatment (Top Panel). *Note.* The bottom panel shows the secondary behavioral measure of latency to sit during DRA training for Bubbles. BL = baseline; DRA = differential reinforcement of alternative behavior; EXT = extinction

Figure 5 shows the results of Wilbur's treatment. During intervention training (MULT NCR 60/EXT 60), Wilbur's mouthing behavior only occurred once during the EXT schedule, and mouthing remained low during NCR. During MULT NCR 150/EXT 150, Wilbur frequently engaged with his owner and toys during the NCR schedule. However, during the EXT schedule when no owner attention was available, he stopped engaging with toys or his owner and lay down. He showed delays to reengage with his owner during subsequent NCR schedules. This lack of reengagement was evident during the reversal to baseline session. Although mouthing behavior occurred in the return to baseline, it did not increase to preintervention levels. Additional baseline sessions could have been conducted to further test the behavior reversal; however, the owner was pleased with the low levels of mouthing behavior produced during treatment and concerned about additional baseline sessions.

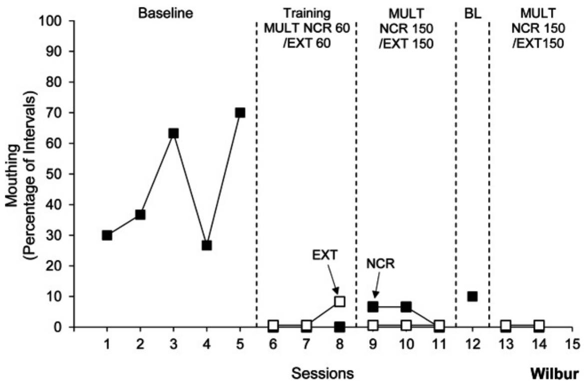

Figure 5. The Percentage of Mouthing During Wilbur's Function-Based Treatment. *Note.* Data from the attention condition of the functional analysis are duplicated in the initial baseline phase of treatment. BL = baseline; MULT = multiple schedule; NCR = noncontingent reinforcement; EXT = extinction

Oliver's treatment was developed to address attention and tangible reinforcers for mouthing and included DRI with EXT. His functional analysis attention sessions served as his initial baseline for the treatment phase, during which he occasionally engaged in the incompatible behavior of lying down. In all treatment sessions, Oliver did not engage in mouthing, and his lying-down behavior increased (Figure 6, top panel). However, during the reversal to a baseline attention condition, mouthing occurred during 80% of intervals. Mouthing decreased to zero levels and his lying-down behavior increased to previously observed levels following the reintroduction of treatment. These data indicate that Oliver's treatment was highly successful in reducing his mouthing and increasing the incompatible behavior of lying down.

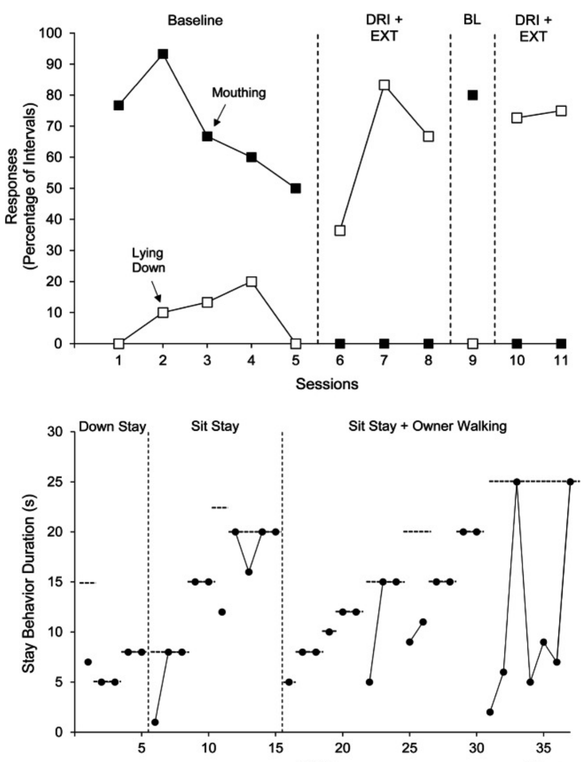

Figure 6. The Percentage of Mouthing and Incompatible (Lying Down) Behaviors During Function-Based Treatment (Top Panel) and the Duration of Stay Behavior During Delay Fading for Oliver Postintervention (Bottom Panel). *Note.* Data from the attention condition of the functional analysis are duplicated in the initial

baseline phase of treatment. BL = baseline; DRI = differential reinforcement of incompatible behavior; EXT = extinction

Following the successful intervention, Oliver was trained using delay fading of the reinforcer to increase the duration of lying down and then sitting behavior (Figure (Figure6,6, bottom panel). Lying down was originally used as the incompatible behavior because it is potentially more effortful for the dog to leave a lying position than a sitting position, thereby increasing the likelihood of successfully remaining in a down position for longer durations. However, during delay fading, sitting replaced lying down as the incompatible behavior because the conditioned prompt for the down behavior required the owner to bend directly in front of Oliver and hold the prompt position in order to occasion continuation of the down behavior. Therefore, conditioning Oliver to remain in a down position while the owner stood up and moved around would require both prompt fading and delay fading. As a result, substituting the sit behavior, which could already be prompted from a standing position and at a distance, was deemed more efficient. Oliver was able to successfully complete a 20-s sit-stay behavior, thus allowing the owner to walk from her detached garage through the backyard to her house without mouthing occurring. Oliver did not achieve success for 25 s, potentially because of fatigue (25 trials had occurred in the previous hour) due to time constraints. Several weeks after training, the owner reported that Oliver continued to sit-stay while the owners walked through the backyard from their garage to the house.

Discussion

Results from these participants suggest that the owner-conducted functional analysis identified the function(s) of mouthing, and owner-implemented, function-based treatments resulted in reduced levels of mouthing for all three dogs. These results indicate several successful interventions for reducing undesired mouthing behavior in dogs. Further, each intervention was chosen based on the dog's unique context, which likely contributed to the success of the protocol and owner engagement in conducting the intervention during the study and thereafter. For example, DRA was programmed for Bubbles that included teaching Bubbles an appropriate response to signal to her owner for access to attention with tangibles in the form of a tug game or ball throw. A salient alternative behavior that was acceptable to the owner was trained because Bubbles often mouthed on her owners when they were not attending to her, such as when they were sitting on the couch and watching television or reading the newspaper. If the behavior chosen was not salient, the owner was unlikely to provide the functional reinforcer, thereby setting up EXT contingencies potentially resulting in a reversal to high levels of mouthing as seen in the baseline reversal session. The salience of the sitting behavior was increased by including the requirement for Bubbles to hold a toy. Although more salient behaviors could have been chosen, such as barking or pawing at the owner, these behaviors may not be socially acceptable to owners because of the intrusiveness, thereby requiring some compromise in the level of saliency for the alternative behavior. For Oliver, DRI was chosen because the intervention needed to allow the owner to walk from their detached garage through the backyard to the house, which only required around 20 s. The DRI for Oliver was an ideal choice because he could maintain a sit-stay for at least 20 s, which allowed the owner to walk through the yard, open the house door, pick up a tug toy, and provide Oliver with the functional reinforcer. Further, Oliver's owner was willing to provide the functional reinforcer in the context of being in the backyard.

These results also show the clinical application of these procedures because owners were successfully incorporated directly into assessment and treatment, consistent with previous studies (Hall et al., 2015; Pfaller-Sadovsky et al., 2019), and owner participation with researcher supervision resulted in relatively few errors. Owner errors were rare and only consisted of errors of commission. Further, the commission errors typically occurred after a desirable nontarget behavior (e.g., the owner provided attention when the dog sat still and looked up at the owner). Thus, errors reinforcing the mouthing behavior were uncommon during treatment, which is important given the detrimental effects of commission errors for problem behavior (St. Peter Pipkin et al., 2010). These low levels of errors of omission and commission of other behavior are consistent with the error patterns emitted by parents providing behavioral interventions to their children (Arkoosh et al., 2007). Additionally, the intervention's success, despite some errors, is consistent with previous studies demonstrating problem behavior can be successfully reduced with high integrity for reinforcement of appropriate or nontarget behaviors (Arkoosh et al., 2007). Although incorporating owners into assessment and treatment sessions requires significant owner effort (>2.5 hr across several days) and includes some level of error, owner inclusion can ensure the results are specific to the unique context of the home environment and offers an opportunity for the owner to practice appropriate, new responses to behavior during supervised treatment delivery.

The owner-conducted functional analysis in Experiment 1 showed differentiated levels of responding across conditions and thereby identified functions of the mouthing behavior in all three dogs. Attention was a functional reinforcer for mouthing in all three dogs, and mouthing was also maintained by access to tangible items for one dog (Oliver). Oliver's data suggest interaction effects in which two reinforcers are complementary. The presence of one reinforcer (attention) increased the value of the other reinforcer (tangibles). During conditions with toys, Oliver often attempted to tug on toys that were in his owner's hand/reach and would ignore a toy in his possession to grab a toy held by his owner. This indicates the value of the toy increased when paired with the owner's attention. This is similar to complementary reinforcers for humans, wherein the value of play on a playground structure may be increased when other kids are playing along (i.e., social interactions are available during play). Additionally, the functional analysis results informed successful interventions through the removal of reinforcers for mouthing and programming of DRA or DRI. Each intervention was additionally informed by the owner's feedback regarding preferred alternative behaviors. Bubbles and Oliver received differential reinforcement with EXT, and Wilbur was exposed to a MULT schedule with a changeover delay to signal periods of reinforcement versus EXT.

Although it is possible that mouthing initially occurs in dogs during teething to reduce discomfort, similar to the perceived initial function for human children (Memarpour et al., 2015), contact with other reinforcers during this period may result in a transfer of function and maintenance of the behavior into adulthood. Nevertheless, the participants in the current study were puppies, and the functional analysis identified that all three participants' mouthing behavior was maintained by socially mediated consequences. Thus, our results identified several potential behavioral functions and are consistent with the human literature indicating that interventions should be function specific and not based on assumptions regarding putative function or following rigid protocols that do not account for differences between individuals.

This study successfully used and slightly modified the standard conditions from the human functional analysis literature (ignore, attention, play, demand, tangible), which have also been successfully employed in previous canine functional analyses (Dorey et al., 2012; Mehrkam et al., 2020; Pfaller-Sadovsky et al., 2019). To date, canine functional analyses using standard conditions differ from the human methods in that no moderately preferred toy is provided during the attention condition (Dorey et al., 2012; Mehrkam et al., 2020; Pfaller-Sadovsky et al., 2019). The presence of a preferred toy during the attention condition may mask attention-maintained behavior, although it can also aid discrimination of automatically maintained behaviors (Ringdahl et al., 2002; Roscoe et al., 2008). Although the inclusion of a specific toy may assist with discrimination between conditions, the procedural variation without the condition-specific toy is likely a closer representation of the typical antecedent arrangement for the dog population when owner attention is diverted. In contrast, presentation of a moderately preferred toy is a practice matching common human parenting strategies during attention diversion (e.g., a parent encourages their child to watch TV while they make an important call). Additionally, although the standard functional analyses have been useful for identifying behavioral functions in humans, dogs may have behavioral functions unique from humans due to their distinctive learning histories and physiology (Hall et al., 2015; Winslow et al., 2018). For example, dogs who have gone through training classes will typically have a history of edibles presented contingent on complying with demands; therefore, vocal demands may not be aversive for this dog subpopulation due to their potential training history. In order to account for these potentially unique functions, future studies could include the use of formalized, descriptive observations by dog owners or caregivers to inform subsequent individualized test conditions (Iwata et al., 2013).

Although owners can be successfully integrated into assessments and treatment evaluations, the inclusion of the owner potentially limits the length or number of sessions available. Extended conditions were not performed for Oliver and Bubbles, and functional analysis results were used in place of a treatment baseline for Wilbur and Oliver, even though behavioral trends could have been further elucidated by additional sessions. For example, Bubbles's ignore condition had high levels of mouthing, and completing extended sessions of the ignore condition could have provided further clarification. However, owner time was limited, and mouthing duration and intensity were typically very high; thus, further extension to the analysis was not a socially valid option for the owners. Additionally, owner considerations limited the length of reversals during intervention to a single session, which may somewhat limit the demonstration of experimental control if the behavior does not reverse during that session. This was the first canine functional analysis and treatment study to include reversals during the intervention, which can further demonstrate experimental control. Although reversals to baseline for Bubbles and Oliver showed high levels of mouthing and provided a demonstration of experimental control over the behavior, the reversal for Wilbur was weak. Additional baseline sessions with Wilbur would have clarified the permanence of the behavior change. However, the owner was averse to conducting more than one baseline reversal session. Nevertheless, the purpose of the study was to provide a clinical demonstration of effective, owner-implemented assessment and treatment conditions to reduce mouthing, which was accomplished with the current procedures despite some compromise to highly controlled conditions.

A limitation of Experiment 1 was the length of time some dogs had access to a tangible item during the tangible condition. For example, Oliver engaged with toys when they were accessible, but if his owner reached to pick up that toy or another toy nearby, Oliver lunged toward and grabbed the toy being picked up or mouthed his owner. This resulted in the owner frequently releasing the toy to Oliver to avoid engaging in tugging. These behaviors suggest that toy access functioned as a reinforcer, but that engagement in a game of tug with the owner was likely a more valuable, competing reinforcer, making it difficult to retrieve toys in order to contrive abolishing operation intervals within the tangible sessions. It is also possible that the tangible items only functioned as reinforcers if they were combined with attention. In future studies, researchers might consider conducting an additional data-informed synthesized contingency condition in which attention and tangibles are combined if the dog's behavior suggests that combined contingencies may maintain problem behavior (e.g., Hanley et al., 2014).

Another limitation of Experiment 1 was the sole use of the multielement design for the functional analysis. Although a multielement design allows for the testing of multiple conditions relatively efficiently, it carries the risk of weak discrimination between conditions. For example, results for Bubbles suggested the attention and ignore conditions may not have been discriminable. Even though the armguard colors potentially assisted with discrimination, the conditions may share EOs and discriminative stimuli (e.g., the owner is present and looking away from the dog), which could result in similar outcomes across conditions. In order to further clarify multielement functional analysis results suggesting multiple control, design modifications such as reversal or pairwise designs can be used (Iwata & Dozier, 2008). Alternatively, if there are limitations to isolating the functions, such as time constraints imposed by the incorporation of the owner, it may be possible to use synthesized treatments to address multiple reinforcers or increase the efficacy of consequences for appropriate, alternative behavior.

Overall, these results add to the literature on the use of functional analyses to identify function-based treatments for companion animals (Dorey et al., 2012; Feuerbacher & Wynne, 2016; Hall et al., 2015; Mehrkam et al., 2020; Winslow et al., 2018) by providing a clinical demonstration of owner-implemented assessment and treatment conditions. Owners implemented procedures with high levels of integrity, which resulted in the reduction of mouthing behavior. In addition, the use of a functional analysis in place of inferring behavioral function may increase the probability of intervention efficacy and reduce the temporal and financial effort required to test various interventions based on hypothesized functions. However, further clinical demonstrations across populations and behaviors should be performed.

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Authors' Contributions

All authors contributed to the study conception, design, and conduct.

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Data Availability

Not applicable.

Code Availability

Not applicable.

Declarations

Conflicts of interest/Competing interests

The authors declare that they have no conflicts of interest.

Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the University of Wisconsin–Milwaukee Human Research Protection Program (July 25, 2017, 17.308). Approval was also granted by the University of Wisconsin–Milwaukee Institutional Animal Care and Use Committee for animal research (May 22, 2017, 16-17 #21).

Consent to participate

Informed consent was obtained from all individual human participants included in the study.

Consent for publication

Consent for publication for de-identified data was obtained from all individual human participants included in the study.

Footnotes

Research Highlights

• Canine mouthing behavior can be multiply maintained.

• Interventions targeting the function of mouthing behavior can substantially reduce mouthing on people.

• Owners can conduct canine functional analyses and interventions with high levels of treatment integrity.

• Owners can be successfully incorporated into testing the function of mouthing behavior and delivering interventions to reduce its behavioral frequency.

Publisher's Note

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