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Canine research

It is mine! Using clicker training as a treatment of object guarding in 4 companion dogs (*Canis lupus familiaris*)

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ABSTRACT

Aggressive behaviors in companion dogs are a serious problem to owners, which often result in important physical and emotional damage on the victims. Aggressive incidents frequently happen during human-dog interactions (i.e., reaching toward the dog or petting it) while the dog is engaging with a preferred item (e.g., a toy, sock, or shoe). The present study investigated whether a clicker-training approach, backward chaining, could decrease the frequency of category II (e.g., ears flattened and/or hovering over the object) and category III (e.g., staring and/or stiffening up) behaviors by establishing an alternative target response of *releasing preferred item on cue*. Four dogs were exposed to the intervention using a nonconcurrent multiple-baseline single-case experimental design. Each dog experienced a total of 14 conditions, including baseline conditions (i.e., rates of preferred item release on request before any training), treatment conditions (i.e., different steps of the backward chaining procedure, such as *release* or *place, sit*), and probe conditions (i.e., same procedure as baseline but conducted after varying steps during treatment condition). Success rates of the target response more than doubled in all dogs after implementation of the backward-chaining procedure, ranging from 2% to 85%. Rates for category II responses showed an important reduction in 3 of the 4 dogs ranging from 39% to 55%. In the case of category III aggressive responses, there was a reduction in frequency relative to baseline rates ranging from 58% to 69% across all dogs. During follow-up probes conducted 3 months after the intervention ended, average rates of category II behaviors decreased by 23% for the dog in human-dog dyad 1 and 35% for the dog in dyad 2, whereas rates of category III responses reverted back to baseline levels in dogs in dyads 01 (D01) and 02 (D02). Success rates during follow-up probes more than doubled for dog D01 from 2% to 45% and reverted to baseline levels for D02. Overall, the present study showed that backward chaining is an effective procedure to teach dogs to release a highly preferred item on cue and importantly reduce category II and III behaviors, at least short term. Considering the scarcity of studies on the effectiveness of backward chaining in aggression-related behaviors, further research could extend these promising findings, including determining whether ongoing maintenance training would extend this effect, and addressing the present study's limitations (e.g., using a refined categorization of aggressive responses).

Introduction

Aggression in companion dogs (*Canis lupus familiaris*) is " … a serious health problem that inflicts considerable physical and emotional damage on victims and incurs immeasurable hidden costs to communities" (American Veterinary Medical Association, 2001). Several studies conducted in Europe and North America indicate that most dogs engaging in aggressive behaviors were either owned by the victim or the victim's family or were otherwise familiar to the victim (Cornelissen and Hopster, 2010), and some sort of interaction with or close to the dog took place before the aggressive incident happened (Arhant et al., 2016; Rosado et al., 2009). However, these studies do not further specify if any of the investigated aggressive incidents involved preferred items, for example toys, sticks, or bowls that the dog may have tried to guard from the victim. Guy et al. (2001a) and Lindsay (2005) reported that human interactions, such as reaching toward, leaning over,

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snuggling, petting, or playing tug while the dog is engaging with the preferred item, may result in the display of aggressive responses. In their large-scale study (n = 3226), Guy et al. (2001b) stated that approximately 20% of dogs showed aggressive behaviors while in the possession of a preferred item. This type of undesired behavior, typically labeled as object guarding, is accompanied by physiological arousal (e.g., tense body posture, dilated pupils) and may co-occur with an underlying anxiety that preferred items will be removed when the dog is approached (Landsberg et al., 2013; Lindsay, 2005). In an important effort to de-escalate the situation, owners may often inadvertently negatively reinforce tense body posture, growling, barking, lunging, snapping, or biting by backing away when the dog engages in 1 or more of these responses (Landsberg et al., 2013).

Jacobs et al. (2017) found that dog owners have difficulties identifying canine behaviors indicating stress and/or threat (e.g., stiffening up, freezing, growling, and snarling) but reliably identified overt aggressive responses (i.e., snapping or biting) in a resource-guarding situation using edibles. Landsberg et al. (2013) reported that dogs that engage in these undesired responses typically have not been taught to expect reinforcement for relinquishing a preferred item on cue. Accordingly, recommended treatment of this problematic behavior includes teaching retrieving and releasing an item on cue by using positive reinforcement procedures as shown in the "Protocol for desensitizing and counter-conditioning dogs to relinquish objects" (Overall, 2013), for instance.

One possibility to teach a dog to retrieve and deliver an object on cue is chaining. This procedure involves breaking down a task into its component parts via a task analysis, and sequentially teaching each individual component to mastery level via prompting and differential reinforcement (Slocum and Tiger, 2011). One version of this procedure—backward chaining—involves teaching the final step of the task analysis first—releasing the item—followed by progressive teaching of earlier components, such as placing the item in the owner's hand (Slocum and Tiger, 2011). Backward chaining entails that reinforcement is delivered when the learner performs the final behavior in the sequence at the predetermined criterion level (Cooper et al., 2007). As more and more of the earlier steps are added to the training process, all previously taught steps and the current step need to be accurately completed to produce reinforcement (Slocum and Tiger, 2011). The sequence proceeds backward through the chain until all the steps in the task analysis have been introduced in reverse order and practiced cumulatively (Cooper et al., 2007). This general process is the same for human and nonhuman learners, depending on the tasks that are to be taught and species-specific limitations.

Despite the proven efficacy of backward chaining as an intervention for undesired behaviors in human and nonhuman learners (Erickson, 2013; Hagopian et al., 1996; Jerome et al., 2007; Nosik and Williams, 2011), this approach has not been systematically tested for treating aggressive behaviors in companion dogs. This gap in the literature, together with an inherent advantage of the procedure, leads to the decision of implementing backward chaining in the present study. Backward chaining entails that the learner receives the most training (and reinforcement) in the final task sequences of the chain first (Grant and Evans, 1994), which were the most relevant in the present study, as they involved a hypothesized antecedent for the undesired aggressive responses, namely the approach of a human hand.

Overall, the aim of the research reported here was to investigate the efficacy of using backward chaining to increase the frequency of alternative responses—delivering and releasing the preferred item to the presented hand of the owner—with the expectation that this process could result in a decrease in the frequency of category II (e.g., hovering over object and/or ears flattened) and category III (e.g., staring and/or stiffening up) behaviors. See Table 1 for definitions.

Table 1
Topographical description of canine responses when the owner tried to remove the preferred item from the dog

Summary label	Topographical description	Categories
Lifting paw	The dog was sitting or standing when the weight was shifted to either front leg, whereas shoulder, elbow, and carpal joints of the second leg were bent. This resulted in an upward movement, lifting the leg off the ground. Lifting paw could be shown simultaneously with turning head or body away and ears back	I
Nose licking	The dog licks the upper part of its muzzle with a quick out and in motion of the tongue, with or without touching the nose (Beerda et al., 1998; Tod et al., 2005; Rooney et al., 2007; Snider, 2007)	
Turning head or body away	The dog either turned only the head away from the stimulus or its whole body. The dog could be in any position (i.e., sitting, standing, or lying).	
Yawning	The dog opened its muzzle while emitting a single expulsion of air (Snider, 2007; Cafazzo et al., 2014). The yawn could be audible or inaudible	
Ears flattened	Muscles of the ears were retracted caudally, resulting in ears lying against the side of the head. An instance was counted when the ears moved from neutral position caudally	II*
Hovering over object	Hovering occurred when the dog was looking at the stimulus while lowering the head horizontally over the object and holding it there for a specified amount of time. It could have been combined with ears flattened. Usually the dog was lying down while emitting this behavior. An instance was recorded when the dog placed the head approximately 3 cm or closer toward the object on the ground and held it there for 3 seconds. The instance ended when the dog returned the head to vertical position	
Growling	Low guttural vocalization, mouth either closed or narrowly open (Prato-Previde et al., 2003; Snider, 2007). An instance was recorded when the sound became audible and ended when the sound ceased	III*
Snarling	Upper lips were pulled proximally and caudally, whereas lower lips were pulled distally and caudally, resulting in visibility of upper and lower incisors and canine teeth (Feddersen-Petersen, 2008). Snarling was counted when the dog started curling the lips and ended when the lips went back to neutral position	
Staring with sclera visible	The eyes were wide open, and the sclera became visible. The head was held still while gaze was directed and focused on the threat (Feddersen-Petersen, 2008). An instance was recorded when the eyes widened and the sclera became visible. It ended when a head movement away from the stimulus occurred	
Stiffening up	The dog was standing, sitting, or lying when muscles became rigid and joints were stiffening	
Biting	Rapid opening and closing of jaws with contact of clothing or skin (Jacobs et al., 2017)	IV
Snapping	Rapid opening and closing of jaws in the air without contact of clothing or skin (Jacobs et al., 2017)	

These responses were classified into categories I, II, III, and IV, which were added for measuring purposes. Dogs may also have shown category I behaviors; however, only responses belonging to higher behavioral categories, namely category II and III, were recorded as indicated by asterisks (*). Dogs displaying category IV responses would have been excluded from participating in the study, if brought forward.

Method

Participants

Participants were 4 human-dog dyads living in private households in a 25-km radius around the village of Puchberg am Schneeberg, Lower Austria, Austria.

Dyad 01 (D01) consisted of a castrated 9-year-old golden retriever male, who was one of the first author's companion dogs, and the first author's husband who trained and handled the dog for the duration of the study. The dog had a shoulder height of 60 cm and weighed approximately 30 kg. This dog had approximately 9 years of experience with clicker training. His preferred item was a tennis ball.

Dyad 02 (D02) consisted of an 11-month-old intact female Belgian shepherd cross, who had a shoulder height of 50 cm and weighed approximately 19 kg, and her male owner. This dyad was already familiar with training using an event marker, but so far had only used a vocal event marker (Brav), which was followed by food or play. The concept of clicker training was new to them. Her preferred item was a plush toy.

Dyad 03 (D03) consisted of a 2-year-old intact female border collie, who had a shoulder height of 50 cm and weighed approximately 20 kg, and her male handler. This dog had a diagnosis of stereotypic behavior (i.e., shadow and light chasing, excessive licking of the floor, and repetitive pacing) by a veterinary practitioner (written diagnosis available on request from the first author). Dog D03 had lived with the first author and her husband since March 2016 as a foster dog. The handler of D03 was the first author's husband, who was also the new formal owner of the dog. This dog had approximately 6 months of experience with clicker training. Her preferred item was a plush toy.

Dyad 04 (D04) consisted of an 18-month-old intact male Austrian Pinscher, who had a shoulder height of 50 cm and weighed approximately 17 kg, and his female owner. This dyad had approximately 4 months of experience with clicker training. His preferred item was a play rope.

The decision of including dogs D01 and D03 in the present study was reached because those breeds (i.e., golden retriever and border collie) are both abundant in most countries (Asher et al., 2011; Coppinger and Coppinger, 2014; Serpell and Duffy, 2014), and including these was thought to benefit generality of the study. To maximize control for the potentially confounding variable of the second dog being a competing reinforcer, the dogs were put into different rooms for the duration of the interventions to separate them from each other. In addition, the timing of the onset of the study was different for both dogs (i.e., dog D01 was already in the 3-month break when dog D03 initiated intervention).

Setting and materials

Table 1 displays topographical definitions of responses that may lead to aggression in companion dogs. Ordering of the summary labels of the responses was based on the *Ladder of aggression* by Shepherd (2009). The categories were introduced to label the varying stages of intensities of the aggression-related responses: (1) category I was defined by behaviors signaling very mild social interaction and pressure, for example, yawning or turning away (Shepherd, 2009); (2) category II behaviors were identified as responses displayed in situations of escalating stress and perceived threat (e.g., ears flattened and/or hovering over object); (3) category III behaviors included more intense threatening responses, for example, staring and/or growling; and (4) category IV was defined by overt aggressive behaviors, that is, snapping and biting. Although dogs may have shown category I behaviors, only category II and III responses were recorded. If dogs displaying category IV behaviors would have been suggested for participation, the initial telephone screening conducted with their owners would have flagged them, and they would have been excluded from participating because of safety risks and ethical concerns. However, no such dogs were brought forward for participation.

Data collection of baseline and intervention conditions took place in the respective living rooms of the owner-dog dyads. The participating owners were provided with an i-Click clicker (Karen Pryor Clicker Training, Waltham, MA, USA). The selection of treats as food reinforcers after the clicking sound was determined by the dietary habits and preferences of the dogs as stated by the owners. A GoPro Silver Hero 3+ camera (GoPro Cooeratief U.A., Amsterdam, Netherlands) mounted on a small tripod ($3.3 \times 3.3 \times 17.1$ cm) was used for video recording. The small size of the camera and tripod aided with unobtrusive observation and video recording.

The backward chaining procedure was initially implemented using a neutral item that the dog could easily carry, namely an ergonomically shaped Kong Safestix (KongCompany LTD, Salisbury, UK). This item was chosen because it is made of safe plastic and is gentle on the dogs' teeth. To ensure that the shaping process was safe for all participating dogs, suitable sizes of the sticks were used depending on the respective body sizes of the dog (e.g., medium or large).

Study design

The present study used a combination of single-case research methods (SCMs). These designs can involve only 1 subject but typically include multiple cases (e.g., 3-8), under the assumption that each subject is a replication attempt (Horner et al., 2005). SCMs involve repeated measures of 1 individual's behavior before, during, and typically after an experimental, educational, or therapeutic intervention (Iversen, 2013). Single-case designs are experimental rather than correlational or descriptive in nature (Horner et al., 2005). Internal validity, demonstrating that changes in behavior are a function of the independent variable and are not the result of uncontrolled variables, is achieved by each subject serving as their own control, whereas external validity, demonstrating the degree to which a functional relation is reliable and socially valid in a given experiment and holds across subjects, settings, and/or behaviors, is accomplished through replications of SCM methodologies, as in multiple-baseline (MBL) designs (Cooper et al., 2007; Dillenburger, 2015; Johnston and Pennypacker, 2009).

MBL designs use testing across subjects, behaviors, or settings (tiers) where several baseline and intervention data series are compared between and within data series. Introduction of the intervention is staggered across time (Kratochwill et al., 2010). Multiple tiers in which the intervention can be implemented are selected, and each tier is plotted in its own panel or leg (Figure 1; Byiers et al., 2012). In a concurrent MBL design, baseline data collection starts simultaneously across all panels, and the intervention is introduced systematically in one tier, whereas baseline measurement continues in the others (Byiers et al., 2012). A nonconcurrent MBL design across subjects where subjects are evaluated at different points in time (Carr, 2005), in combination with a multiple-probe design, was chosen for the present study because it allowed for brief reversals where baseline conditions were introduced for only one or few consecutive sessions (probes) without the risk of the dog displaying undesired and potentially dangerous behaviors (see Carr, 2005 for a review of MBL designs). Multiple-probe designs allow for extension of the MBL logic to situations in which concurrent measurement is impractical or potentially reactive (Cooper et al., 2007). The introduction of mini-reversals (i.e., probes) was intended to demonstrate the control of the independent variable (i.e., backward chaining procedure; Stolz, 1976). A multiple-probe design was chosen over a reversal design because the latter entailed exposing the learner to repeated and extended periods of baseline conditions, which can pose safety risks when self-injurious or aggressive behaviors are involved, and thus ethical concerns.

The dependent variables were (1) the percentage of successful trials (i.e., the dog released the object within approximately 3 seconds after the cue for letting go of the object was given) and (2) the percentage of trials where category II or III responses were displayed by the dogs whenever the owners prompted the dog to give up the preferred item. The behaviors were defined as ears flattened and/or hovering over object (category II), stiffening up and staring (category III).

The independent variable was a backward chaining training procedure, which aimed to teach the dog to deliver the preferred item to hand when requested by the owner with a vocal cue. Delivery-of-the-preferred-item response was defined as the dog taking the preferred item into his or her mouth and placing it into the presented hand of the owner (arm stretched out toward the dog with hand palm facing upward) when the vocal cue was delivered. This process included the combination of modeling the chaining procedure by the researcher and instruction and immediate feedback for the owners' performances.

Data collection

Baseline

A baseline level, that is, percentage of successful trials and percentage of category II and III behaviors, was established (e.g., dog D01 displayed in the fifth baseline session 0% success, 80% category II responses, and 20% category III responses). The interactions of each dyad were observed and scored while the dog was in possession of the preferred item. Event recording for behavioral measurement on discrete-trial behaviors, in which the count for each opportunity to respond is either 0 or 1, was used (Cooper et al., 2007).

A trial started when the owner gave the preferred item to the dog. After approximately 10 seconds, the owner approached the dog, touched, and gently held on to the object (i.e., a physical prompt), simultaneously saying a vocal prompt to release the preferred item while the dog was interacting with the object by carrying it in his or her mouth, chewing on it, or otherwise playing with it. The physical prompt was delivered for approximately 3 seconds. Simultaneously, the occurrences of category II or III behaviors were scored when the owner delivered the vocal prompt. The more intense category displayed by the dog was scored in the corresponding column on the data sheet.

A successful trial was recorded when the dog released the object within approximately 3 seconds after the cue was given. This marked the end of a successful trial. If the trial was successful, the dog got the preferred item back after approximately 1 second, and the next trial was recorded. Each session consisted of 10 trials, with a break of 10 seconds between the prompts if the trial was unsuccessful, that is, the dog held on to the preferred item. The end of an unsuccessful trial was marked by the owner retreating from the dog. During this 10-second break, the dog could continue interacting with the preferred item.

A maximum of 2 sessions per day were conducted, with a break of at least 15 minutes between sessions. The percentage of successful trials and the percentage of category II or III behaviors were recorded in the corresponding data sheet. All responses were scored by the first author. Successful and unsuccessful trials were recorded during real-time observations, whereas category II and III behaviors were scored off the video recordings.

Intervention

Intervention consisted of a backward-chaining procedure aimed at establishing the following target response in each dog: picking up a neutral object (Kong Safestix) from the floor and delivering and releasing it to the owner on cue. The task analysis (i.e., series of sequentially ordered steps/conditions; Cooper et al., 2007) of the backward chaining procedure is presented in Table 2. Each dog had to perform each step/condition to mastery level, as previously, before he or she was trained for the next step/condition of the chain.

A trial started when the owner delivered the vocal cue. Successful trials (delivery to hand and releasing object within approximately 3 seconds after a vocal cue) were immediately followed by positive reinforcement (i.e., click and treat). If the dog released the Safestix within the 3-second period, the sound of the clicker marked the end of a successful trial. If the dog took longer to release the object, an unsuccessful trial was recorded, irrespective of the reinforcement that may have followed for a target response that occurred after the 3-second period. The criterion for moving to the next condition consisted of a minimum of 2 consecutive sessions with success rate greater than 90%. Each session consisted of 10 trials. Successful and unsuccessful trials, as well as the display of category II or III behaviors, were recorded in the corresponding data sheet. Unsuccessful trials did not result in positive reinforcement (i.e., reinforcement was withheld without using a no-reward marker) and a 0 mark was recorded in the success column. Unsuccessful trials were defined as either (1) the dog keeping the Safestix in his or her mouth longer than approximately 3 seconds after the cue was given; (2) refusing to hold on to the object; or (3) refusing to pick up the stick. Points (2) and (3) were included as unsuccessful trials because dogs needed to hold the stick in their mouths before the owners could cue the release of it.

A new trial started when the owner presented the object again and gave the cue. The cue was given only once. If the owners delivered a second or third cue, the trial was also recorded as unsuccessful. If the dog refused to release the object after the cue was given, the owner approached the dog and took the item away. Depending on the responses of the dog, a remark in the column category II or III aggression was recorded. The more intense behavior was scored on the corresponding sheet.

Probes

Probe sessions were conducted in the same way as baseline sessions. Percentages of successful trials and undesired responses

Table 2
The backward chaining procedure comprises 5 sequentially ordered steps/conditions (i.e., task analysis), which are listed

Number of steps	Task	Description
1	Release	Opening mouth and releasing item while owner was sitting on a chair and delivering a verbal vocal cue
2	Place, sit	Taking item from the owner's hand, which was located approximately 10 cm above the floor, placing item into owner's hand, and releasing it on the height of the sitting owner's lap
3	Place, stand	Same as condition 2, only the owner was standing
4	Pick up, sit	Picking up the item from the floor, placing it into owner's hand at lap height, and releasing it while owner was sitting on a chair
5	Pick up, stand	Same as condition 4, only the owner was standing

The aim was to establish the target response, that is, releasing the Safestix on cue without displaying category II or III behaviors.

per trial were recorded using the dimensions of intensity (categories II and III) and frequency, both displayed as percentage of trials. Typically, probe sessions were conducted after the last condition of the intervention (i.e., *pick up, stand*) was shown at criterion level, and were conducted as the last condition before the 3-month break. Additional probe sessions were introduced in 3 dogs (e.g., sessions 10 and 15 in dog D01). These probes were intended to examine whether the target behavior, *releasing preferred item on cue*, deteriorated when the intervention/independent variable was briefly terminated, which allowed for testing the control of the treatment procedure (Stolz, 1976). The introduction of probe sessions was based on the performance of dogs meeting the criteria (i.e., a minimum of 2 consecutive sessions with success rates greater than 90%) and stability of data across the previous treatment condition (e.g., session 38 of dog D02). Dog D04 was exposed to only 2 probe conditions, namely, 1 probe session late in the intervention, after the condition *pick up, stand*—session 44, and the one before the break. This decision was reached because D04 displayed high rates of category III behaviors during the baseline condition, and conducting more probe sessions may have posed a safety and welfare risk. After conducting probe sessions, the next condition of the intervention started per the criteria described previously.

Generalization test

When the backward chaining process was completed and the dog reliably picked up and delivered the Safestix to hand on cue, with a success rate greater than 90% during 2 consecutive sessions during the last condition, the generalization process to the preferred item started. Before starting this process, a probe (1 session) was conducted. The generalization test included the same conditions as the backward chaining procedure (e.g., *release* or *place, sit*—see Table 2), with the only difference being that the preferred item was used for the chaining procedure. The same criteria for changing conditions as described previously were implemented.

Two additional generalization conditions were implemented in which the duration of the interaction (e.g., holding the item, carrying the item around or any other interaction) with the preferred item was prolonged before cueing the release, which was positively reinforced. During the first additional condition (i.e., *duration 5 seconds*, 10 trials per session), the dog was allowed to interact with the item for 5 seconds, whereas during the second additional condition (i.e., *duration 10 seconds*, 10 trials per session), the dog kept the preferred item for 10 seconds.

The study ended with a final probe phase consisting of 4 sessions (40 trials). Three months after the intervention ended, a follow-up probe phase consisting of 2 sessions (20 trials) was conducted. The probe sessions were performed consecutively with a break of at least 15 minutes in between the sessions.

Data analysis

In single-case research, intervention effects are typically evaluated through visual analysis of graphs, and certain characteristics of the data paths within and across phases are examined to evaluate the effectiveness of the intervention (Alberto and Troutman, 2013). In the present study, the percentage of the dependent variables (i.e., successful trials, category II and III behaviors) during baseline/probes and the backward chaining procedure (i.e., independent variable) were calculated and graphed using Microsoft Excel for Mac (version 15.20, Microsoft Corporation, Redmond, WA, USA).

Interobserver agreement

Interobserver agreement refers to the degree to which 2 or more observers report the same observed values after scoring the same events, and it is used to indicate measurement quality (Cooper et al., 2007). At least 20% of conducted sessions across all phases are typically assessed, and percentages of agreements between observers are checked against the minimal established threshold reported in the literature, generally > 80% (Cooper et al., 2007; Kratochwill and Levin, 2014). To assess interobserver agreement in the present study, a randomly chosen 25% of the sessions per dog were scored across all phases. Sessions were digitally recorded, and a second observer, a trained research assistant, scored them from video. The second observer had a general idea of the purpose of the study (i.e., categorization of responses and what constituted a successful or unsuccessful trial) but was unaware of the design and intervention of the study. Second-observer scoring entailed whether the dogs were successful during trials and whether they displayed category II or category III responses during baseline/probes and intervention sessions. Agreement was calculated by dividing number of trials (items) of agreements by the total number of trials (items) and multiplying by 100. Agreement was 83% (range, 67%-100%), 85% (range, 70%-93%), 86% (range, 73%-100%), and 97% (range, 93%-100%) for dyads D01, D02, D03, and D04, respectively.

Ethical approval

This research complied with the ethics and welfare provisions of the Austrian Federal Act on the Protection of Animals (Animal Protection Act—TSchG, 2013). Ethical approval was sought and gained for the present study from Queen's University Belfast School of Social Sciences, Education and Social Work's Ethics Committee dated March 7, 2016. The participants did not receive any type of compensation for their involvement in the study.

Results

The Figure 1 presents the total number of sessions per dog and the overall results.

Baseline

Dog D01 produced a mean success rate of 2% across all baseline trials (i.e., 50 trials, 5 sessions). He showed a mean rate of 84% for category II responses and a mean rate of 16% for category III behaviors across all baseline trials (i.e., 90 trials, 9 sessions). Dog D02 showed an average success rate of 32% when prompted to release the preferred item to the owner. During the last 4 baseline sessions, the success rate stabilized at 20%. Dog D02 showed an average rate of 61% for category II responses across all baseline trials, and a decrease to 40% was detected in the same behavioral category from sessions 6 to 9. The mean rate for category III behaviors for D02 was 16% across all 9 baseline sessions. Dog D03 had a mean success rate of 17% across all baseline trials (i.e., 130 trials, 13 sessions). She further displayed category II and III responses at a mean rate of 43% and 48%, respectively. Dog D04 produced a mean success rate of 14% across all baseline trials (i.e., 170 trials, 17 sessions), and further showed the lowest percentages of category II, and the highest percentages of category III behaviors across all 4 dogs. This resulted in a mean rate of 6% and 88%, for the respective categories. Overall, all dogs had very low success rates that did not exceed 32% and displayed mainly category II responses (6%-84%).

Comparing intervention to baseline for undesired responses

During intervention phases, rates <5% and 0% of category III behaviors were observed in dogs D01 and D04, respectively. Rates of category III aggression decreased during intervention in a range from 37% to 100% across all dogs (i.e., 82% for dog D01,

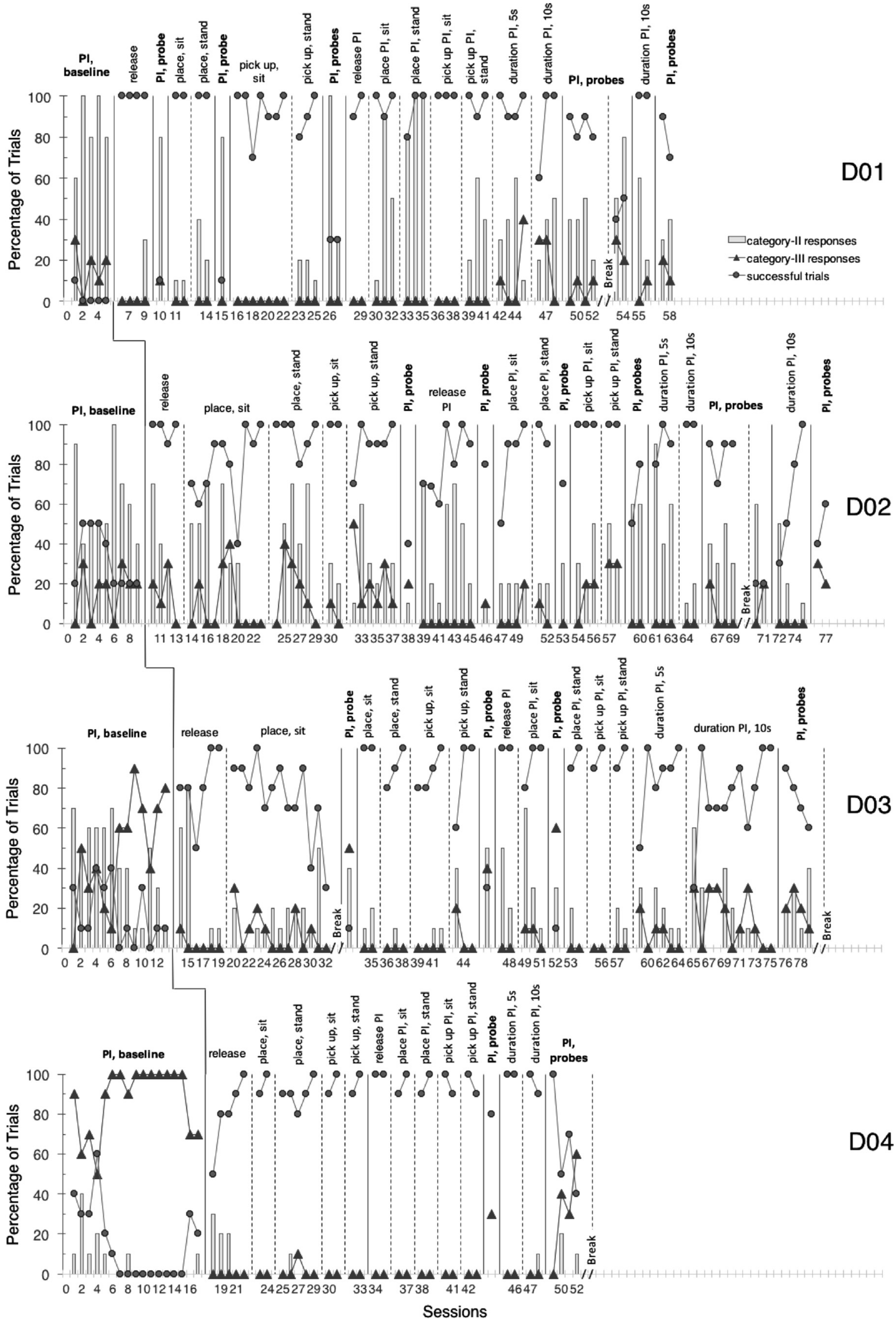

Figure 1. Each horizontally arranged graph shows the data for one of the dogs (D01, D02, D03, and D04) across sessions (x-axis). The percentages of trials per session (i.e., 10 per session) in which category II or III behaviors and target responses (i.e., successful trials) occurred during baseline, treatment and probe conditions are displayed for each dyad on the

y-axis. Each condition is represented in separate vertically arranged panels. Dashed vertical lines distinguish minor changes in conditions from each other (i.e., task analysis as displayed in Table 2). Probe sessions using the preferred items (in **bold** font, **PI, probe[s]**) were introduced between intervention conditions. The decision when to conduct a probe was based on the data collected up to that point in the intervention. For example, with D02, a probe (i.e., session 38) was conducted after the previous phase (i.e., *pick up, stand*) was shown to criterion level, and stability in performance was observed. These interspersed probes were meant to indicate if there already was an observable effect on the target behavior. Per the logic of MBL designs, the start of the intervention conditions was staggered across dyads (i.e., the intervention condition of D01 was initiated in session 6, D02 in session 10, D03 in session 14, and D04 in session 18). In total, dog D01 completed the study in 58 sessions, D02 in 77 sessions, D03 took 79 sessions until the break, and D04 needed 52 sessions until the break (indicated by double slashes on the x-axis).

37% for D02, 88% for D03, and 100% for D04), when compared with baseline rates. A comparison of baseline and intervention rates of category II responses showed a decrease ranging from 43% to 71% across all dogs (i.e., 71% for dog D01, 43% for D02, 62% for D03, and 54% for D04).

Probes

Probe sessions were introduced within intervention and generalization conditions. The last probes comprise 4 sessions (40 trials) for each dog. Mean rates for category III behaviors showed a reduction ranging from 58% to 69% across all dogs, when comparing baseline rates with rates for the last probes after intervention (i.e., 69% for D01, 68% for D02, 58% for D03, 63% for D04). Rates for category II behaviors within the same probe sessions showed a reduction of 55% for D01, 39% for D02, and 42% for D03 but resulted in an increase of 16% for D04.

As can be detected by visual analysis of baseline and probe sessions (Figure 1), success rates for *releasing preferred item on cue* more than doubled for each dog after the intervention (i.e., from 2% to 85% for D01, from 32% to 85% for D02, from 17% to 75% for D03, and from 14% to 65% for D04). Average success rates across all dogs improved from 16%, ranging from 2% to 32% during baseline, to 78%, with a range of 65%-85% during the final probe condition.

Comparing follow-up probe sessions to baseline

Follow-up probes, re-training of the *duration, 10-second* condition, and final probe sessions were only conducted with dogs D01 and D02. Because data collection of the follow-up and final probe sessions after the 3-month break for dogs D03 and D04 could not be confirmed by the time this article was in preparation, the decision to submit it for publication without including such results was made.

Average rates of category III responses during follow-up probes reverted to baseline levels in both dogs, and rates of category II responses decreased (23% for D01 and 35% for D02).

In the case of success rates, they increased from 2% to 45% for D01 and reverted to baseline levels for D02.

Comparing final probe sessions to baseline

Category III behaviors for both dogs stayed at baseline levels during final probe sessions (i.e., sessions 57 and 58 for D01 and sessions 76 and 77 for D02). In contrast, category II responses decreased by 58% and 100% for D01 and D02, respectively. Finally, success rates during final probe sessions increased in both dogs when compared with baseline levels (i.e., from 2% to 80% for D01 and from 32% to 50% for D02).

Discussion

Comparing baseline to intervention

The present study showed that backward chaining is an effective procedure to teach dogs to release a highly preferred item on cue. Overall, success rates and rates of category II and III behaviors considerably improved (i.e., increase or decrease, respectively) during intervention conditions. A comparison of performances during baselines and after the independent variable was introduced showed an increasing trend (e.g., sessions 39-45 of D02) or no tendency (e.g., sessions 40-44 of D04) of successful-trial data paths across all dogs and all intervention conditions. However, intervention phase labeled *place, sit* in D03 constituted an exception (Figure 1) as the respective data path showed a decreasing trend. Although the reason for this tendency is unclear (e.g., imprecise timing of the click, handling issues of the Safestix by the owner), the issue was resolved with implementation of a 7-day break. During this period, dog D03 was retrained on a pre-established response, holding an object, which was present in all dogs before intervention. The following probe session was conducted to provide evidence that the change in independent variables did not affect the dependent variables.

Although success rates increased, incidences of category II and III behaviors decreased during intervention conditions. These findings add to previous studies (Martin et al., 2011; O'Reilly, 1995), which reported that reinforcement-based interventions can be helpful with alleviating aggressive behavior displayed by various species. One explanation as to why rates of category II and III responses decreased right from the beginning of the backward chaining process relates to the design of the intervention. The procedure started by using a neutral, possibly less preferred object. In combination with preferred edibles as primary reinforcers, this may have functioned as a setting event for the change in the occurrence of the target behaviors. Setting events or motivating operations alter the value of a reinforcer and change the frequency of the behaviors maintained by those reinforcers (Kazdin, 2012; Pierce and Cheney, 2013). Such events or stimuli can include features of the situation, the task, or demands presented to the learner (Kazdin, 2012). This notion was further supported by the finding that rates of category II and III behaviors increased in 3 dogs after preferred items were re-introduced during the generalization-test conditions. Although this effect was not found in dog D04, these tentative findings suggest that an intervention as the current one should begin with a neutral object before generalizing the newly acquired skills across preferred items. The present study showed that this intervention is feasible and can be effective, as success rates for the target response, *releasing preferred item on cue* increased more than 2-fold for each dog when comparing final probe sessions to baseline sessions.

Comparing follow-up probe, re-training, and final probe sessions

As mentioned previously, follow-up probes, re-training of condition *duration, 10 seconds*, and the final probe sessions were only conducted in D01 and D02. Rates for follow-up category III responses in D01 showed an increase relative to the last probe sessions, before the break. Interestingly, the rates of category III responses of D02 during follow-up probe sessions remained unchanged. A possible reason for the increase or maintenance of these rates may be the fact that the dogs either had entirely no access to the respective preferred items during the 3-month break (D01) or had limited contact with it (i.e., access of D02 was scheduled for 7 consecutive days after 2 months into the break). This approach resulted from an effort to control for extraneous variables related to the target behavior (i.e., *releasing preferred item on cue*). Compared with baseline circumstances, where the dogs had arbitrary access in varying durations to their preferred items, the controlled context during the break constituted a state of deprivation from the preferred items (Pierce and Cheney, 2013). This may have altered the value of the preferred item, thus providing a motivating operation for the display of more intense responses when the owner later requested the dog to give up the preferred item. Furthermore, prevention or restriction from accessing the preferred item possibly resulted in forgetting, which means that the effect of conditioning is weakened or lost by the passage of time during which a response does not occur (Grant and Evans, 1994; Skinner, 1953/2014). In this case, both D01 and D02 had no or only few opportunities to emit the target behavior, which may have contributed to the decrease of success rates and increase of undesired behaviors in the follow-up probe, after the 3-month break, relative to the last probe phase, before the break. The findings related to the rates of category II and III behaviors further highlight the importance of conducting follow-up sessions after a behavior change program has been successfully completed, as these sessions examine the level of maintenance and generalization achieved (Kohler and Greenwood, 1986).

Another possible reason for the increase or maintenance of category II and III responses in D01 and D02 after the 3-month break results from the schedule of reinforcement implemented during the intervention conditions; namely, a continuous schedule of reinforcement (CRF). Although CRF is used to strengthen behavior primarily during the initial stages of learning new behaviors, intermittent schedules of reinforcement are typically used to maintain established behavior and are used for the progression to naturally occurring reinforcement (Cooper et al., 2007). Because the *releasing preferred item on cue* response ceased to be reinforced during probe sessions, extinction (EXT, where previously reinforced responses no longer produce reinforcement) may have occurred swiftly. Pierce and Cheney (2013) pointed out that EXT occurs more rapidly on CRF compared with intermittent reinforcement. One reason for this is that an organism discriminates between a high and steady rate of reinforcement, CRF, and EXT more easily than between a low and intermittent rate of reinforcement and no reinforcement at all (Pierce and Cheney, 2013). A variety of emotional responses (e.g., nonspecific frustration and/or aggression) occur across different human and nonhuman animals under conditions of EXT (Azrin et al., 1966; Delgado and Jacobs, 2016; Sullivan and Lewis, 2003). Different authors (Azrin et al., 1966, Dantzer et al., 1980, Duncan and Wood-Gush, 1971, Finch, 1942, Hutchinson et al., 1968, Skinner, 1953) have reported evidence of the association of EXT-induced frustration and aggressive behaviors in different species. More recently, Papini and Dudley (1997), and Starling et al. (2013) reviewed the emotional and arousing effects of EXT and operant learning approaches in nonhuman animals. To summarize, it is well established that arousal and frustration induced by EXT can lead to aggressive responses in different species (e.g., pigeons, pigs, and chimpanzees). In terms of influences of arousal on training outcomes, the report by Starling et al. (2013) on operant learning principles in dogs and horses suggests that arousal—in addition to contributing to aggressive behaviors (Papini and Dudley, 1997)—can have undesired effects on learning.

Limitations and future research

One major limitation of the present study was the categorization of the responses as it did not fully address the flexible properties of these behaviors. For instance, a dog may progress to overt aggression within seconds during a single episode if the perceived threat occurs quickly and at close proximity, or learn to dispense with less intense behaviors over time, if repeated efforts to appease are responded to inappropriately (Shepherd, 2009). Although the *Ladder of aggression* by Shepherd (2009) is considered a very good starting point, future research should address the fluidity and interconnectedness (Mugford, 2007) of canine aggressive responses by using a more fine-grained and expanded version of the categorization, that is, including less intense behaviors (e.g., category I) and establishing sequences of the intensifying responses.

The sample size of 4 subjects participating in the present study can be viewed as a limitation. From a single-case perspective, the number of subjects could be considered appropriate for the purpose (i.e., intervention efficacy) and the MBL design of this study (Echterling-Savage et al., 2014; Hagopian et al., 1996; Howard and DiGennaro-Reed, 2014). It is acknowledged that more replications involving larger numbers of subjects would be warranted to obtain stronger validity and increased generality.

The implemented design was a nonconcurrent MBL design across subjects, that is, subjects were evaluated at different points in time (Carr, 2005). Because this design does not provide a very strong support of high validity claims, further research attempting to replicate the findings and using a more rigorous design (e.g., reversal design) are called for.

Another limitation was that the attempt to control for extraneous variables during the break resulted in a possible deprivation of D01 and D02 to the preferred item. This may have inadvertently affected their responses during follow-up measurements. Other limitations involved the utilization of CRF during the intervention, in combination with its well-documented sensitivity to EXT (Pierce and Cheney, 2013). Because baseline probe conditions constituted EXT conditions, they possibly had disadvantageous effects on the rates of category II and III behaviors (they showed increasing or no trend). However, a benefit of the multiple-probe design is that baseline probe conditions are reduced to an amount necessary to show experimental control.

Furthermore, more research needs to be conducted to understand the undesired effects observed after the 3-month break, including testing if intermittent reinforcement improves maintenance of the target response (i.e., *releasing preferred item on cue*) and leads to decrements in aggression-related behaviors. Future studies should also systematically test the effects of planned access to or deprivation of the preferred item after the intervention was successfully completed and before scheduled follow-up sessions will be conducted.

Conclusion

The present study demonstrated that a backward-chaining procedure is suitable and effective to reduce dogs' category II and III behaviors in object-guarding situations and increase their release of the preferred item—success in this study—when prompted to do so, at least short-term. It is hoped that future research will subsequently address some of the highlighted issues (e.g., refining the categorization of aggression-related responses, effects of intermittent schedules of reinforcement on maintenance of the target behavior, and more replications with larger numbers of subjects) to further contribute to the applied animal-related behavior literature, considering the lack of research on the effectiveness of shaping and response chaining (i.e., forward, backward, and total task chaining) on treating aggression-related behavior problems in companion dogs.

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Conflict of interest

The authors declare no conflict of interest.

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