Is the Click the Trick?

The Efficacy of Clickers and Other Reinforcement Methods

in Training Naïve Dogs to Perform New Tasks

by

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ABSTRACT

A handheld metal noisemaker known as a “clicker” is widely used to train new behaviors in dogs; however, evidence for the superior efficacy of clickers as opposed to providing solely primary reinforcement or other secondary reinforcers in the acquisition of novel behavior in dogs is almost entirely anecdotal. Three experiments were conducted to determine under what circumstances a clicker may result in acquisition of a novel behavior more rapidly or to a higher level compared to other readily available reinforcement methods. In Experiment 1, three groups of 30 dogs each were trained to emit a novel sit and stay behavior of increasing duration with either the delivery of food alone, a verbal stimulus paired with food, or a clicker with food. The group that received only a primary reinforcer reached a significantly higher criterion of training success than the group trained with a verbal secondary reinforcer. Performance of the group experiencing a clicker secondary reinforcer was intermediate between the other two groups, but not significantly different from either. In Experiment 2, three different groups of 25 dogs each were shaped to emit a nose targeting behavior and then perform that behavior at increasing distances from the experimenter using the same three methods of positive reinforcement as in Experiment 1. No statistically significant differences between the groups were found. In Experiment 3, three groups of 30 dogs each were shaped to emit a nose-targeting behavior upon an array of wooden blocks with task difficulty increasing throughout testing using the same three methods of positive reinforcement as previously. No statistically significant differences between the groups were found. Overall, the findings suggest that both clickers and other forms of positive

reinforcement can be used successfully in training a dog to perform a novel behavior, but that no positive reinforcement method has significantly greater efficacy than any other.

DEDICATION

For Shaggy, Scooby, and Remy, I hope to understand and do better by you a little more every day.

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CHAPTER 1

INTRODUCTION

Operant positive reinforcement is widely used by dog trainers (Hiby, Rooney, & Bradshaw, 2004). In operant conditioning, at a minimum, behavior is reinforced with a primary reinforcer (something which has reinforcing efficacy without need for any other behavioral manipulation), but primary reinforcers can also be paired with neutral stimuli which then become secondary reinforcers. A secondary reinforcer has no reinforcing effect until it is paired with a primary reinforcer (e.g., Domjan, 2005). A secondary reinforcer can be anything the animal can perceive – such as a light, a sound, a movement, or a smell. Common secondary reinforcers in dog training are a spoken word, a whistle, or the sound from a clicker device (Burch & Bailey, 1999; Schaefer, 1999; Skinner, 1951). The primary and secondary reinforcers here take the roles of the unconditioned and conditioned stimuli, respectively, in Pavlovian conditioning (e.g., Domjan, 2005).

Despite the prominence of positive reinforcement within the dog training community, there have been few studies that indicate whether any one positive reinforcement training method is more successful in forming new behaviors than any others.

Pryor (1999) proposed that clickers are the most effective secondary reinforcers for quickly establishing new behaviors in animals. Several studies in diverse species have shown that new behaviors can be established using appetitive primary reinforcement with clickers as secondary reinforcement (horses: Ferguson & Rosales-Ruiz, 2001; monkeys:

Gillis, Janes, & Kaufman, 2012; pigs: Croney, Adams, Washington, & Stricklin, 2003). Few studies, however, have attempted to compare positive reinforcement training with clickers to any other positive training methods in either dogs (exceptions include Thorn, Templeton, Van Winkle, & Castillo, 2006; Smith and Davis, 2008; Fugazza and Miklósi, 2015; Chiandetti, Avella, Fongaro, & Cerri, 2016) or other species (horses: Williams, Friend, Nevill, & Archer, 2004; goats: Langbein, Siebert, Nuernberg, & Manteuffel, 2007).

The aim of the present study was to clarify whether or not there was any difference in the rate of acquisition and (equivalently) terminal level reached in a fixed number of trials when establishing novel behaviors in dogs with a primary reinforcer alone when compared to the same primary reinforcer paired with two different secondary reinforcers. The primary reinforcer alone served as our control condition, while the spoken sound “chee” and a click from a standard clicker were the two secondary reinforcement conditions.

In the first experiment, each dog was taught to sit for increasing periods of time using one of the three reinforcement methods, and the differences in the greatest durations of sit achieved in a fixed number of trials were compared between conditions to determine whether one condition resulted in the dogs learning the behavior more rapidly and to a higher level than the others. In the second experiment, the hypothesis that clicker training is useful at a distance to the trainer was tested by shaping dogs first to touch a cone next to the trainer, and then increasing the distance between the trainer and the cone. Both how far the dog progressed through the shaping approximations and the greatest

distance from the cone that the dogs achieved in a fixed number of trials were compared between conditions to determine which condition resulted in the highest level of acquisition of the behavior. In the final experiment, dogs were shaped to touch an array of blocks, and then progressed through levels of increasing specificity wherein only targeting specific blocks was reinforced. How far the dogs progressed through the levels, the amount of time it took to complete each level, and the number of attempts made during each level were compared between conditions to determine which condition resulted in the highest level of acquisition of the behavior in a fixed number of trials.

CHAPTER 2

EXPERIMENT 1

In the first experiment, we tested whether there were any differences in the maximum duration a dog could be trained to sit for primary reinforcement, secondary reinforcement from a verbal stimulus (the trainer saying “chee”), and secondary reinforcement from a clicker in a fixed number of trials.

Design

Dogs were randomly assigned to one of three groups: the control group; the verbal group; or the clicker group. Dogs in the control group received a piece of hot dog, the primary reinforcer, as their only reinforcement when they sat for the required length of time. For dogs in the two experimental groups, a secondary reinforcer was established by pairing it with food 20 times before training commenced. Dogs in the verbal group received a piece of hot dog paired with the verbal sound “chee” as their reinforcement. The clicker group received a piece of hot dog paired with the click from a clicker as its reinforcement. If the dog met the current criterion for the duration of a sit three times in a row, the criterion duration of the sit was increased by 3 seconds. If the dog failed to meet criterion for the duration of a sit twice in a row, the duration criterion was decreased by 3 seconds. Dogs remained in the experiment until they completed 50 trials or failed to sit within 2 minutes of their last sit.

Setting and Subjects

A room at the Arizona Humane Society (AHS: Phoenix, AZ) was set up with a 157.5 cm by 259.1 cm area enclosed by two pieces of metal fencing. This testing area

was comprised of Zone 1 on the left, where the dog was reinforced for sitting, and Zone 2 on the right, where the dog was not reinforced for its behavior. The layout of the testing area is shown in Figure 1.

One hundred and ten puppies at AHS, 8 to 22 weeks old, free of illness, injury, and anesthetics participated in the first experiment (Appendix A). The age range was chosen to ensure that they were both old enough to be able to participate in training, but not so old as to have likely experienced any prior training. All procedures in this study were conducted with approval from the Arizona State University Institutional Animal Care and Use Committee.

Procedure

RG served as the trainer throughout the experiment, and all individuals handling the dogs were female. After an opportunity to urinate and defecate the dog was placed in the testing area, where it was given four minutes to explore. The trainer only interacted with the dog if it approached her. Next the trainer stood and placed a clicker on her left middle finger, and two treat bags along her shirt collar. One bag contained the primary reinforcer (pieces of hot dog), while the other contained the resetting treat (pieces of Pupperoni) that was used to return the dog to its starting position in Zone 2. The trainer approached the dog and said “sit” three times. If the dog sat each time, it was removed from the experiment. If it sat once or twice, after thirty seconds passed the dog was asked for three sits. If the dog sat two out of three times during this second set, it was removed, but if it only sat no more than once, it remained in the experiment.

Dogs in the two secondary reinforcement groups experienced 20 pairings of the primary reinforcer with the secondary reinforcer. This pairing was completed 20 times in succession, with each pairing beginning immediately after consumption of the last primary reinforcer. Each dog in the control group received 20 primary reinforcers with the trainer silently thinking "chee" before deliveries of the primary reinforcers to mimic the approximate duration it took to deliver the secondary reinforcers in the other conditions. Dogs that did not consume the primary reinforcer were removed from the experiment.

After the pairing was complete, the trainer stood at the far left end of Zone 1 on the Reinforcement Delivery Spot (RDS – see Figure 1). The dog was given 25 minutes to enter Zone 1 and sit for one second. If the dog did not perform this behavior within this time, it was removed from the experiment. If the dog did sit within Zone 1 for one second, it received its assigned reinforcement, and the resetting treat was thrown across the line into Zone 2 to encourage the dog to leave Zone 1 before being given the opportunity to return for another sit. If the dog did not follow the resetting treat out into Zone 2, the trainer walked to where the treat landed and verbally encouraged the dog to retrieve it, and then returned to the RDS once the dog left Zone 1 to get the treat.

All dogs were initially required to sit for one second to receive reinforcement, and the sitting criterion increased in three second intervals as each dog performed a complete sit for the required duration three times in a row. Dogs only received reinforcement at the end of their sitting criterion. If the dog did not sit for the complete required duration, it did not receive reinforcement, but still received the resetting treat. If the dog sat for less

than the current criterion duration twice in a row, the sit duration was reduced by three seconds. If the dog alternated performing criterion compliant and noncompliant sits, it remained at its current level until it successfully sat correctly three times in succession or failed to reach criterion twice in succession. Figure 2 diagrams this adaptive schedule of reinforcement. For every 15 seconds that the dog spent in Zone 2, the trainer would call to the dog by saying "puppy ba ba ba" and made a kissing sound to encourage it to return to Zone 1. Each sit constituted one trial, and each dog could perform a maximum of 50 trials. As long as a dog completed at least one trial, its data were retained and analyzed. The dog's training ended either when it did not perform another sit within Zone 1 within two minutes from its last reinforced sit, or once it reached 50 trials.

Results and Discussion

Thirty dogs in each condition, for a total of 90 dogs, sat at least once. After testing concluded, one dog was diagnosed with an illness likely present during testing, and thus was removed from analysis. This left 29 dogs in the control group and 30 each in both the verbal and clicker groups whose data were analyzed. Power calculations using G*Power (Faul et al., 2007) showed that the final sample size will result in 80% power to detect a medium effect size of $f = 0.31$, controlling for all covariates. After verifying the assumptions of normality and homogeneity of variances of residuals with a Shapiro-Wilk test ($W(89) = 0.97$, $p = 0.054$), a Levene's test ($F(2, 86) = 2.94$, $p = 0.06$), and confirming that no standard deviation of one group exceeded twice the standard deviation of any other group ($SD_{control} = 11.7$; $SD_{verbal} = 8.8$; $SD_{clicker} = 11.1$), we performed a one-factor ANCOVA in SPSS (Version 25) with age, sex, and weight as covariates to compare the

influence of condition on the maximum duration of the dogs' sitting behavior. Figure 3a gives the means and standard error of the means for each condition. The ANCOVA revealed a statistically significant difference in durations of sit between groups ($F(2, 83) = 3.95$, $p = 0.02$), with no covariate reaching statistical significance: $p = 0.57$ for age, $p = 0.85$ for sex, and $p = 0.28$ for weight. Furthermore, Tukey post-hoc tests indicated that the only significant difference between groups was between control and verbal ($p = 0.01$).

To test whether the superior performance of the control group was due to the lack of any intervening delay imposed by the delivery of the secondary reinforcer, we randomly selected 12 out of 30 dogs in each condition and analyzed the first, middle, and last two minute segments of their testing sessions to assess the delay to reinforcement they received using CowLog (Version 3.0.2; Pastell, 2016). Coders blind to the hypotheses and purpose of the experiment coded the delays to reinforcement of these dogs. The average delays to reinforcement for the clicker and verbal conditions were 2.6 s and 2.7 s respectively, and that of the control condition was 3.3 s. Thus, the greater efficacy of the control group cannot be attributed to a shorter delay to reinforcement than the secondary reinforcement groups.

CHAPTER 3

EXPERIMENT 2

One possible reason for the failure to find an advantage of clicker secondary reinforcement in Experiment 1 could be that the primary reinforcer could be delivered promptly. Pryor (2009), arguing for the effectiveness of clickers, gave an example where a click sound was used to signal reinforcement to the animal when it performed a behavior at a distance from the trainer. Under conditions where primary reinforcement cannot be provided instantaneously, secondary reinforcement can provide feedback to an animal that it has behaved correctly and will receive primary reinforcement upon returning to the trainer. In Experiment 2 we trained dogs under the same three conditions as in Experiment 1 to touch a cone at increasing distances from the trainer. This targeting behavior required a shaping period that preceded the distance component.

Design, Setting, and Subjects

The method for Experiment 2 was identical to Experiment 1, except in the following details.

A 625.0 cm by 157.5 cm area comprising Zone 1, which included the Touch Spot (TS) and the Primary Reinforcer Delivery Spot (PRDS), and Zone 2, which included the Upper Step Markers (USM), was enclosed by three pieces of metal fencing, as shown in Figure 4. All reinforced behavior and receipt of primary reinforcement occurred at the TS. The trainer stood on the PRDS when delivering the primary reinforcer over the TS, and both knelt and stood on the PRDS during Steps 1-7. A research assistant sat outside

the fencing at the far-right end of Zone 2 during training, and a video camera was set up to record all testing within the fenced area.

Eighty four dogs identified as eight to 22 weeks old participated (Supplemental Appendix B). Of the 84 dogs tested in this study, nine did not touch the trainer's hand within 25 minutes of beginning training, thus excluding them from the analysis.

Procedure

The trainer presented her empty palm to each dog and any dogs that spontaneously touched their nose to her palm were excluded. After the pairing of secondary reinforcers was complete, the trainer walked to the PRDS and knelt, holding her right palm out with a primary reinforcer in it over the TS. The dog had 25 minutes to come touch her palm. If the dog did not perform this behavior within this time, it was removed from the study. If the dog did touch her palm, it received its assigned reinforcement, and the resetting treat was thrown into Zone 2 to encourage the dog to leave the trainer's side and return for another touch. If the dog did not follow the treat out, the trainer would throw up to two more treats, after which point the research assistant would call the dog toward the far right side of Zone 2.

To measure the effectiveness of the three reinforcement methods, the dog was first shaped to perform a targeting behavior, and then asked to perform this behavior at an increasing distance from the trainer. Table 1 shows all successive approximations used in the shaping procedure. Dogs received their designated reinforcement when they made contact with the object as required by the step they were at. All dogs were required to meet criteria by completing Steps 1-7 before a distance component was introduced to the

testing. At Step 8, the experimenter pivoted on the PRDS and took a step back from the PRDS to the line. For Steps 8-17, the dog was tasked with touching the tip of the cone that was placed on the TS just as it had done in Steps 6 and 7.

Each touch or failure to touch the cone or experimenter's palm constituted one trial, and each dog was permitted to perform a maximum of fifty trials and a maximum of 17 training steps. As long as a dog completed at least one trial, its data were retained and analyzed. For every 15 seconds that the dog spent in Zone 2, the trainer would call to the dog by saying "puppy ba ba ba" and making a kissing sound to encourage it to return to Zone 1. If the dog did not enter Zone 1 within 2 minutes of its last touch, the dog's training ended at that trial. If the dog remained inside Zone 1 for 2 minutes without completing a touch, it was considered a fail and was reset. If this happened three times in a row, the dog's training ended at that trial. If the dog crossed the line with at least one forepaw, but did not make a touch, it was considered to be a failed trial. Once the dog reached Step 8, it was not permitted to return to the earlier shaping steps and its training was ended if it failed twice in a row at Step 8.

Results and Discussion

Twenty five dogs in each condition touched the trainer's hand at least once and their data were analyzed. Power calculations using G*Power (Faul et al., 2007) showed that the final sample size will result in 80% power to detect a small effect size of $f = 0.09$, controlling for all covariates. After verifying the assumptions of normality and homogeneity of variances of residuals with a Shapiro-Wilk test ($W(75) = 0.971$, $p = 0.08$) a Levene's test ($F(2, 72) = 1.14$, $p = 0.33$), and confirming that no standard deviation of

one group exceeded twice the standard deviation of any other group (SDcontrol = 3.4 ; SDverbal = 3.5 ; SDclicker = 4.4), we performed a one-factor ANCOVA in SPSS (Version 25) with age, sex, and weight as covariates to compare the influence of condition on the completed number of steps. Figure 3b gives the means and standard error of the means for each condition. The ANCOVA indicated that the difference in number of steps completed between groups was not statistically significant, $F(2, 69) = 1.10$, $p = 0.37$, with no covariate reaching statistical significance, $p = 0.57$ for age, $p = 0.71$ for sex, and $p = 0.07$ for weight.

Although we should be careful when making claims regarding non-significant results, it should be noted that, on average, dogs in the clicker condition completed a full additional step than those in the verbal condition, with control dogs performing to an intermediate level. It should also be noted that the greatest proportion of verbal-group dogs and the smallest proportion of clicker-group dogs dropped out at or before Step 7 – the final shaping step before distance was added to the task, with control dogs being intermediate. Future studies with a larger sample size may be able to separately analyze performance on the first seven shaping steps and the subsequent steps where the behavior had to be performed further from the experimenter.

To check the differences in delays to reinforcement, we randomly selected 12 out of 25 dogs in the control and clicker conditions and 10 out of 25 dogs in the verbal condition and analyzed the first, middle, and last two-minute segments of their testing videos for their delay to primary reinforcement. The same blind coders from the first experiment were assigned to each group, and it was found that on average the delays to

reinforcement for the control and verbal conditions were 3.4 s and 3.2 s respectively, and that of the clicker condition was 4.2 s. While it is possible that the clicker condition was negatively impacted by the greater delay to reinforcement compared to the other reinforcement conditions, it should be noted that, because, on average the clicker condition completed a greater number of steps than the control and verbal conditions in the distance phase of training, dogs in that condition necessarily required more time to walk the additional distance to deliver primary reinforcement.

CHAPTER 4

EXPERIMENT 3

As Experiment 2 found no reinforcement condition aided in more quickly establishing the shaping of the targeting behavior nor maintaining it over increasing distances from the trainer, in Experiment 3 we test whether the clicker secondary reinforcer will allow dogs to reach a higher criterion of behavioral acquisition in a fixed number of trials when the specificity of the behavior is the focus of training. Feng, Howell & Bennett (2018) reported that owners and trainers believe clickers to be more beneficial when teaching more specific behaviors, such as targeting, rather than less specific ones, such as coming when called. We tasked dogs with learning to emit a nose-targeting behavior upon an array of alternating yellow and blue wooden blocks. Initially nose-targeting any block in the array was reinforced, but in subsequent phases of training only contact with specific blocks was reinforced. Table 2 gives the criteria for progression through the testing levels.

Pryor (2009) theorized that employing a clicker secondary reinforcer is most beneficial to the dog's ability to learn to perform a targeting task of great specificity due to the speed and precision with which it could be employed, something that is often found to be lacking when using a verbal secondary reinforcer or just primary reinforcement. Pryor (2009) also proposed that clicker training is intrinsically reinforcing for dogs and aids in keeping dogs engaged with a task because it activates Panksepp's SEEKING circuit. Panksepp's (2010) theory of a SEEKING circuit states that "SEEKING coaxes animals to acquire resources needed for survival. It promotes learning by mediating

anticipatory eagerness, partly by coding predictive relationships between events" (p.538). Consequently, dogs in the clicker group may be predicted to make more contact with the blocks in this experiment because engagement of the SEEKING circuit increases the reinforcing qualities of the apparatus.

In line with Pryor's (2009) claims, we sought to determine whether dogs in the clicker condition attained different levels of acquisition of this new behavior than those in the primary or verbal secondary reinforcement conditions, and whether they attained different rates of responding at each level.

Design, Setting, and Subjects

The methods were identical to Experiments 1 and 2 except in the following details.

A 157.5 cm by 259.1 cm area comprising the Reinforcement Barrier (RB: two 61.0 cm by 91.4 cm tri-fold cardboard barriers supported by metal table easels), the Block Line (BL), and Zones 1 and 2 was enclosed by three pieces of metal fencing, as shown in Figure 5. The trainer knelt in the 35.6 cm space between the barriers during testing. The BL was comprised of a 94.0 cm by 2.4 cm by 1.3 cm metal bar secured to the floor with Velcro tape, and had five 3.8 cm by 6.4 cm by 9.8 cm magnetic painted wood blocks evenly spaced 18.7 cm apart along the length of the bar. All reinforced behavior and receipt of primary reinforcement occurred along the BL. A research assistant sat outside the fencing at the far-right end of Zone 2 during training, and a video camera was set up to record all testing within the fenced area.

One hundred and twelve dogs identified as eight to 22 weeks old by the shelter staff participated in the third experiment (Appendix C). Of the 112 dogs tested, one was excluded because it touched an empty outstretched palm, implying prior training, one was excluded for vomiting during testing, and one would not eat the primary reinforcer. Nineteen were excluded for not touching all five blocks within 25 minutes of starting training, thus excluding a total of 22 dogs from the analysis. Dogs came from the shelter's intake and adoption areas, and had to be free of illness, injury, and anesthetics to participate.

Procedure

After the four-minute acclimation period, the trainer stood and placed a clicker on her left middle finger, and a treat bag along her waistband on her lower back. After the pairing of secondary reinforcers was complete, the trainer led the dog to the research assistant, who restrained it facing away from the testing enclosure while the trainer assembled the testing apparatus. The primary reinforcer and the resetting treat were placed in bowls behind the right RB (from the trainer's perspective when facing the dog), and a cell phone running a timer was placed behind the left RB. The trainer placed each of the five blocks on the BL, then knelt between the RBs and placed a primary reinforcer on a predetermined randomly assigned block. The trainer indicated for the research assistant to return the dog to the testing enclosure, and the dog was given 25 minutes to enter Zone 1 and touch the block with the primary reinforcer on top of it. If the dog did not perform this behavior within this time, it was removed from the experiment. If the dog did touch the block with the primary reinforcer on top, it received its assigned

reinforcement, and the resetting treat was thrown into Zone 2 to encourage the dog to leave Zone 1 before returning for the next trial. While the dog retrieved the resetting treat, the trainer placed a primary reinforcer on a different predetermined randomly assigned block, and the process repeated until all five blocks had been exhausted thus completing the shaping phase.

Once the dog was shaped to perform the targeting behavior on each block individually, it was then required to perform this behavior on increasingly specific groupings of the blocks. The testing phase consisted of 11 levels, each comprising a different arrangement of blocks that were eligible for reinforcement if touched, and the dog was only allowed to advance to the next level when it touched a correct block four times in a row. Dogs were permitted an unlimited number of attempts to touch the blocks until they touched one eligible for reinforcement, and primary reinforcement was always delivered just above the eligible block that the dog touched.

Table 2 and Figure 6 show details of the progressively more stringent training and testing phases.

Each dog was allowed a maximum of 30 minutes to complete the shaping and testing phases. As long as a dog completed the shaping phase and was reinforced for a touch in Level 1 at least once, its data were retained and analyzed. If the dog remained inside Zone 1 for 30s without completing a touch, even one not eligible for reinforcement, it was reset by the trainer throwing the resetting treat across the line into Zone 2 to encourage the dog to continue the trial by leaving Zone 1 and returning for another touch. The dog's training ended if it 1) did not enter Zone 1 within two minutes

of its last touch, or 2) it completed the shaping phase and all 11 testing levels in less than 30 minutes, or 3) once 30 minutes had passed – whichever occurred first.

Results and Discussion

Thirty dogs in each condition, for a total of 90 dogs, touched a block in Level 1 at least once and their data were analyzed. The assumptions of normality and homogeneity of variances of residuals were verified with a Shapiro-Wilk test ($W(90) = 0.98$, $p = 0.12$), a Levene's test ($F(2, 87) = 0.09$, $p = 0.91$), and a confirmation that no standard deviation of one group exceeded twice the standard deviation of any other group ($SD_{control} = 2.7$; $SD_{verbal} = 2.4$; $SD_{clicker} = 3.0$). A MANCOVA was used instead of an ANCOVA to account for levels nearest each other like correlating more than levels further apart. For the focal between-group effect, power calculations using G*Power (Faul et al., 2007) showed that the final sample size will result in 80% power to detect a small effect size of $f = 0.17$ for the number of levels completed dependent variable. Missing data on the number of touches per level variable were handled using maximum likelihood estimation, which achieves maximum power compared to alternatives such as listwise deletion.

A one-factor MANCOVA was performed in SPSS (Version 25) controlling for age, sex, and weight to compare the influence of condition on the completed number of levels. Figure 3c gives the means and standard errors of the means for each condition. The MANCOVA indicated that the difference in number of levels completed between groups was not statistically significant, $F(2, 86) = 1.25$, $p = 0.29$, with the covariate sex indicating that males completed significantly more levels than females when controlling

for condition ($p = 0.04$). Neither covariate of age ($p = 0.14$) nor weight ($p = 0.06$) was statistically significant.

To test whether dogs in the clicker condition attained a different response rate at each level than those in the primary alone or verbal secondary reinforcer conditions, we performed a one-factor MANCOVA in SAS (Version 9.4) controlling for age, sex, and weight comparing the influence of condition on the average number of touches made per level. Blind coders recorded the number of touches made by each dog from their testing videos for all but one verbal group dog due to that video being lost. Mean count per interval inter-observer agreement (IOA) was tested on 8 out of 30 videos in control and clicker conditions, and on 8 out of 29 videos in the verbal condition, and all IOA were above 90%. The MANCOVA indicated that the difference in the average number of touches made per level between groups was not statistically significant, $F(2, 55.4) = 2.21$, $p = 0.12$, and that the level by condition interaction was also not significant, $F(20, 37.8) = 0.59$, $p = 0.89$, with no covariate reaching statistical significance, $p = 0.80$ for age, $p = 0.34$ for sex, and $p = 0.20$ for weight. Unweighted means were used so as not to give more weight to dogs that completed more levels. There was a linear trend to the data, $F(1, 26.1) = 39.64$, $p < 0.01$, indicating that the number of touches significantly increased as the testing level increased in a linear fashion, controlling for age, sex, and weight.

To check the differences in delays to reinforcement, we randomly selected 12 dogs from each condition and analyzed the first, middle, and last two-minute segments of their testing videos for their delay to primary reinforcement using BORIS (Version 5.1.0, 2017). Blind coders were assigned to each group, and it was found that on average the

delays to reinforcement for the control, verbal, and clicker conditions were 1.2 s, 1.5 s, and 1.3s respectively, so it is unlikely that the delay to reinforcement affected the number of touches made or highest level reached between groups.

Unlike in the first two experiments, sex was a significant covariate in the analysis of the highest number of levels completed, but it was not a significant factor in the analysis of the average number of touches made per level. This indicates that males completed more levels than females but without requiring a different average number of touches per level to do so.

CHAPTER 5

GENERAL DISCUSSION

Summary of Results

None of the three experiments here provides support for the widespread belief that using a clicker as a secondary reinforcer has a greater efficacy in teaching dogs a new behavior compared to using primary positive reinforcement alone, or other forms of secondary reinforcement (Pryor, 2009). The only significant difference between reinforcement conditions found here was between the control and verbal conditions in the first experiment, where dogs in the control condition attained a significantly longer mean duration of a sit than verbally-reinforced dogs. These results are somewhat consistent with Thorn et al. (2006), who found a significantly greater mean latency to sit for dogs being trained with a clicker secondary reinforcer on the second (but not first) day of training compared to a verbal secondary reinforcer. Additionally, Thorn et al. (2006) found that dogs in the clicker condition showed a greater latency to sit at the beginning of the second day of training compared to their last trial on the first training day, indicating a significantly lower retention of the behavior across days. Thorn et al. (2006) did not include a primary-reinforcer only group in their study.

The absence of any advantage to using a clicker as a secondary reinforcer in our Experiment 2 compared to primary reinforcement alone or a verbal secondary reinforcer is consistent with Smith and Davis (2008), who found no significant difference between primary reinforcement alone and a clicker condition when teaching Basenjis a targeting behavior with a similar procedure to that reported here.

The absence of any benefit to either form of secondary reinforcement in Experiment 3 matches Chiandetti et al.'s (2016) findings in training dogs to open a bread box.

Age of Dogs

In our experiments we tested dogs of two through five months of age in order to minimize any possible prior exposure to training. Marshall-Pescini et al. (2008) have shown that dogs with more training experience performed significantly better when learning a new task than dogs that had no prior training experience. With shelter dogs, it is not generally possible to know their training history, and thus the best way to control for training history was to test dogs least likely to have had any prior training. Of the three studies that compared the use of the clicker to other positive reinforcers in dogs, Smith and Davis (2008), and Chiandetti et al. (2016) used dogs six months to 12 years and eight months to 13 years in age respectively. These dogs had prior training experience but no prior exposure to a clicker. Thorn et al. (2006) used dogs over one year old of unknown ownership, and consequently unknown training histories.

It might be argued that the dogs in our studies were too young to attain the behaviors we trained, however the success of a majority of dogs in each experiment contradicts this contention. We also included age as a covariate in all our analyses and did not find any significant impact on the dogs' performance. Furthermore, at least one prior study found that dogs as young as 1.5 months can be successfully trained in operant tasks. Lozovskaia (1985) reported that pups of 1.5 months learned an escape task more rapidly than seven-month-old pups.

Number of Training Sessions

Studies on the effectiveness of different methods of training novel behaviors in dogs have differed in the number of training sessions each study employed. We chose to encapsulate all training and testing in a single session due to issues around the availability of dogs from day to day. Thorn et al. (2006) conducted testing on two separate days two days apart, while Smith and Davis (2008) used from two to six consecutive days. Chiandetti et al. (2016) conducted testing over "several" days. Demant, Ladewig, Balsby, & Dabelsteen (2011) found that, when using a six-trial training session, dogs trained once or twice per week reached a significantly higher acquisition in learning to sit and stay in a basket than those trained daily, as did those trained with only one session as opposed to three consecutive training sessions per day. They saw no difference between conditions in retention of the task. These results indicate that the frequency and duration of training sessions impacts the level to which a behavior is acquired, and while the number of overall trials was controlled in Demant, Ladewig, Balsby, & Dabelsteen (2011), Thorn et al. (2006), and our own studies, dogs in both Smith and Davis (2008) and Chiandetti et al. (2016) were offered unlimited numbers of trials to reach session criteria.

Although each of the prior three studies that investigated the efficacy of clicker training compared to other training methods varied along multiple procedural dimensions, none of them found that the clicker helped dogs reach a higher level of attainment for any behavior.

Studies in Other Species

In a study of relative efficacy of different reinforcers in horses, Williams et al. (2004) found no significant difference between primary reinforcement alone and a clicker condition when teaching a cone-targeting behavior with a procedure similar to both our second experiment and Smith and Davis (2008). Not only did Williams et al. compare primary reinforcement and additional clicker reinforcement, but they also looked at continuous versus variable reinforcement schedules and deployment or absence of the secondary reinforcer during extinction. The number of trials to reach criterion in the shaping and testing phases did not differ significantly between the types of reinforcer or reinforcement schedules, which is similar to what was seen in both our study and Smith and Davis (2008).

Extinction

The only published instance in which the use of a clicker showed an advantage over primary reinforcement alone occurred in a study investigating resistance to extinction in dogs (Smith and Davis, 2008). Both Smith and Davis (2008) and Williams et al. (2004) compared resistance to extinction of targeting behavior established with and without a clicker secondary reinforcer. Smith and Davis allowed a maximum of 60 extinction trials per day, and each touch made by a dog in the clicker condition was reinforced by the clicker but not the primary reinforcer. Dogs in the control group (trained with primary reinforcer alone) did not receive any reinforcement in extinction. Dogs in the clicker condition required significantly more time and trials to extinguish the trained behavior than dogs in the control condition. The continued presence of a

secondary reinforcer during extinction is expected to retard extinction of a behavior because the change in stimulus configuration is less pronounced (Pearce, 2008; Williams, 1994).

Williams et al. (2004) carried out an extinction test on horses similar to Smith and Davis' (2008) with dogs but failed to find any difference in number of trials to extinction between animals in their clicker and primary-reinforcer alone groups. Smith and Davis (2008) suggest that the difference between their results with dogs and Williams et al.'s with horses could be a true species difference in behavioral processes. However, other factors could also play a role in the increased resistance to extinction for clicker-trained dogs and not horses, such as heightened arousal to the clicker, frustration, or the inability to discriminate between testing and extinction conditions (Kelleher and Gollub, 1962; Williams, 1994).

Terminology

As Feng, Howell, & Bennett (2016) and Dorey and Cox (2018) have noted, that there is ambiguity in the practices and definitions that basic researchers and dog handlers use when referring to "clicker training." Martin and Friedman (2011) claimed that in clicker training the click sound is a secondary reinforcer, a bridging stimulus, and an event marker. A true marking stimulus does not provide information about a future opportunity to obtain primary reinforcement (as a secondary reinforcer does), but is a novel and unexpected auditory or visual cue that distinguishes the targeted response from the other behaviors the animal was offering around the same time (Lieberman, McIntosh, & Thomas, 1979). In our studies, the word "chee" and the clicker both distinguished the

targeted response, but they were not novel and unexpected stimuli and they did provide information about a future opportunity to obtain primary reinforcement, and therefore cannot be considered marking stimuli.

The word “chee” and the clicker could also be mistaken for bridging stimuli because they temporally connect the desired response with the delayed food reinforcement (Williams, 1994). A bridging stimulus can either occupy a small portion of the delay between response and primary reinforcement (known as trace conditioning) or the entire duration of the delay (delay conditioning). While it appears as though a trace conditioning bridging stimulus is similar to a secondary reinforcer in that it occurs after the desired behavior and predicts the arrival of the primary reinforcer, a bridging stimulus actually functions to connect stimulus-stimulus relationships, and not the response-stimulus relationships seen in applied animal training (Dorey and Cox, 2018).

Although they appear to share some properties of marking and bridging stimuli, both the word “chee” and the clicker seem to function most like secondary reinforcers because they are deployed immediately following the completion of the desired response and are paired to reliably predict the arrival of the US.

Though our findings here may be surprising in the context of guidance given to animal trainers, they are not inconsistent with theoretical analyses of secondary reinforcement and studies carried out in typical laboratory species. Training behavior with a secondary reinforcer invokes both Pavlovian and operant processes of conditioning. The establishment of the secondary reinforcer is a Pavlovian process, in which the presentation of the secondary reinforcer (Conditioned stimulus: CS) followed

by the primary reinforcer (Unconditioned stimulus: US) establishes an association between the two stimuli. However, the process is also operant in that the dog has to perform the correct behavior in order to elicit the CS and ultimately the US. In an operant response system, providing positive reinforcement after a desired response is performed will increase the likelihood of the response occurring again (Skinner, 1951). When a secondary reinforcer is introduced between the dog performing the desired response and the delivery of a primary reinforcer, the strength of the instrumental response becomes dependent on the Pavlovian properties of the context in which the response is performed (Pearce, 2008). Both the control group and the secondary reinforcement groups experienced unavoidable inherent secondary reinforcers, such as the trainer reaching for and delivering the treat, but as each group was equally exposed to the effects of these inherent secondary reinforcers, the only expected change in performance related to the strength of the Pavlovian relationship in the groups would be in those with the explicit secondary reinforcers. Thus, if the clicker functioned as a secondary reinforcer, we would expect to see any additional reinforcement value of the clicker reflected in an increased rate of performing the desired behavior compared to a control group that only receives primary reinforcement. This would be due to the operant relationship between the response and the clicker and the Pavlovian association between the clicker and the food (Williams, 1981). However, according to standard learning theory, in a situation in which the primary reinforcer is always available, the influence of an established secondary reinforcer on the rate of acquisition is relatively weak compared to that of the primary alone (Rescorla and Wagner, 1972).

Pairing

One explanation for our (and others) failure to find a positive impact of using a putative secondary reinforcer could be that the relationship between the primary and secondary reinforcers was not sufficiently established before testing began. In each of our three experiments, we paired the clicker with the primary reinforcer 20 times to establish the conditional relationship between the two. This is consistent with Smith and Davis's (2008) procedure in dogs and Williams et al.'s (2004) with horses; however Pryor (2006) claimed that only two or three pairings are needed to establish the clicker as a conditioned reinforcer before training an animal. Skinner recommended between 30 (1951) and 60 (1938) pairings of the CS and US for dogs and rats respectively under laboratory conditions, while Kelleher and Gollub (1962) stated that the limit at which further pairings no longer strengthened the conditioned reinforcement effect for rats in laboratory studies was 100 trials.

In additional dog training studies, Chiandetti et al. (2016) claimed that two or three pairings were sufficient, and Thorn et al. (2006) did not pair the auditory stimulus with the primary reinforcer at all before beginning testing. While more pairings would be expected to more strongly establish the secondary reinforcer (Wike, 1966), we were constrained by the risk of satiation in our young subjects. Dorey and Cox (2018) suggested that the effectiveness of the clicker as a secondary reinforcer could be tested by presenting the clicker contingent upon the occurrence of a new response, or by comparing resistance to extinction for groups in which the clicker is present and absent. While the latter recommendation has been shown to be unreliable in measuring the strength of the

secondary reinforcer in laboratory studies on rats (Kelleher and Gollub, 1962; Williams, 1994), implementing a final testing phase in which the clicker is used to train an unrelated behavior certainly could be used to show evidence of the status of the clicker as a secondary reinforcer (Wike, 1966). No study to date has attempted this however.

Power

Another possible explanation for our failure to find a positive impact of using a secondary reinforcer is that our studies did not have sufficient power to detect their effect. Our second and third studies had sufficient power to detect small effects, but we failed to see a significant for either secondary reinforcement group. There was not sufficient power to detect medium or large effects, thus it is possible that we failed to detect an effect of either secondary reinforcement group in the second and third studies due to insufficient power.

However, our first study did have sufficient power to detect medium-to-large effects, and found a significant difference between the control and verbal groups but no significant difference between the clicker and another group. This study did not have the power to detect small effects, and although this is a possible explanation for why we failed to see a significant impact of the clicker, the lack of significance found in our (and others) studies indicates that if the effect is there, it is not large enough to be noticed under thus far explored testing conditions.

Applied Training

While the focus of most studies in this field has been on the function of potential reinforcement methods, training a dog is more than just an exercise in conditioning it to

display desired behaviors. In a laboratory setting, not only are the environmental stimuli present during training and testing precisely controlled for and uniform across all subjects, but the timing and delivery of non-environmental stimuli can also be uniform across all subjects. In an applied setting, control of environmental stimuli is much less precise, and it is necessary to consider the variability in testing conditions introduced by the presence of a human in the environment, such as the relationship of the testing animal to the human and human inaccuracies in timing and delivery of stimuli. Dog training occurs in a setting that necessarily involves a relationship between a dog and its handler, and the characteristics of this relationship could interact with the outcome of the training method.

Our studies and those by Thorn et al. (2006), Smith and Davis (2008), and Chiandetti et al. (2016) attempted to maintain controlled training and testing environments similar to what is achieved in a laboratory setting, but the environments of these studies are closer in practice to the real world than an animal laboratory. Claims have been made that clicker training functions differently in applied settings compared to a laboratory setting, and it has been argued that the clicker could improve owner-dog relationships, and that owners perceive their dogs to be learning better with clicker training as compared to other positive reinforcement-based methods (Feng et al., 2018; Pryor, 1999). However, although there have been survey-based approaches at understanding how handlers perceive the effectiveness of clicker training (Feng et al., 2018), there is no empirical evidence that the handlers' perceptions align with the behavioral outcomes of their dogs.

Feng et al. (2018) attempted to evaluate the effectiveness of clickers as used by dog owners in their homes by assigning dogs and their owners to learn new behaviors either in a clicker or food only condition. Groups consisted of 15 dogs each, and owners were then asked to rate their dogs' and their own perceived difficulty and enjoyment in training the trick. Feng et al. (2018) found that owners in the clicker condition reported a less challenging training experience when teaching a nose-targeting behavior than was reported by owners in the food only condition, but observed no differences between training conditions for the other five tricks. Had the owners been given experience using both training methods and then asked to rate the perceived difficulty and enjoyment of the training, and had the dogs' performance on learning the new tasks with each method been objectively measured, this would have been a better foundation upon which to make a claim about differences in training method impacting the owner's perception of training and the dogs' performance. As it is, a significant effect was found in the measure of human perception, but no significant effects were found in objective measures, which does not allow a claim to be made that compares the applied use of the clicker to a food-only condition.

Conclusions

Clearly, in the present studies we have only explored a small subset of the ways in which clickers are used in dog training. Future avenues of investigation of the use of clickers in dog training should explore how clicker-trained dogs perform on different tasks, and how clicker training operates in an applied setting, bearing in mind the need for objective outcome measures independent of owners' and trainers' preconceptions.

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APPENDIX A

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE APPROVAL

Institutional Animal Care and Use Committee (IACUC)
Office of Research Integrity and Assurance
Arizona State University
660 South Mill Avenue, Suite 312
Tempe, Arizona 85287-6111
Phone: (480) 965-6788 FAX: (480) 965-7772

Animal Protocol Review

ASU Protocol Number: 16-1462R RFC 2
Protocol Title: Efficacy of Clicker Training in Dogs
Principal Investigator: Clive Wynne
Date of Action: 4/4/2017

The animal protocol review was considered by the Committee and the following decisions were made:

The request for changes was approved to add 66 dogs and additional procedures to the protocol.

If you have not already done so, documentation of Level III Training (i.e., procedure-specific training) will need to be provided to the IACUC office before participants can perform procedures independently. For more information on Level III requirements see https://researchintegrity.asu.edu/training/animals/levelthree

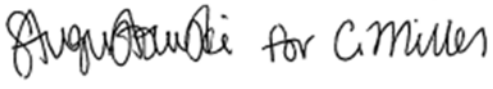
Total # of Animals: 198

Species: Dogs Pain Category: C

Protocol Approval Period: 9/24/2015 – 9/23/2018

Sponsor: N/A
ASU Proposal/Award #: N/A
Title: N/A

Signature:



Date: 4/7/2017

IACUC Chair or Designee
Cc: IACUC Office
IACUC Chair

Institutional Animal Care and Use Committee (IACUC)
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Arizona State University
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Animal Protocol Review

ASU Protocol Number: 16-1462R RFC 2
Protocol Title: Efficacy of Clicker Training in Dogs
Principal Investigator: Clive Wynne
Date of Action: 4/4/2017

The animal protocol review was considered by the Committee and the following decisions were made:

The protocol was approved.

If you have not already done so, documentation of Level III Training (i.e., procedure-specific training) will need to be provided to the IACUC office before participants can perform procedures independently. For more information on Level III requirements see https://researchintegrity.asu.edu/training/animals/levelthree

Total # of Animals: 96

Species: Dogs Pain Category: C

Protocol Approval Period: 8/23/2018 – 8/22/2021

Sponsor: N/A
ASU Proposal/Award #: N/A
Title: N/A

Signature: Date: 9/4/2018

IACUC Chair or Designee
Cc: IACUC Office
IACUC Chair

APPENDIX B
DOGS TESTED IN EXPERIMENT 1

Dog ID	Age (weeks)	Sex	Weight (kgs)	Condition	Longest Sit (s)
A#512945	10	f	2.04	Control	16
A#517844	9	f	3.76	Control	34
A#518272	13	f	1.59	Control	7
A#515400	11	m	9.07	Control	7
A#518461	17	m	3.76	Control	28
A#518833	12	f	5.31	Control	31
A#518830	12	m	4.72	Control	13
A#519080	21	m	13.29	Control	37
A#517692	23	f	3.08	Control	7
A#522622	17	f	4.26	Control	10
A#522562	11	f	4.44	Control	25
A#523272	11	f	4.54	Control	40
A#523471	9	f	3.31	Control	1
A#518704	11	m	2.00	Control	22
A#518705	11	m	1.81	Control	13
A#523473	9	f	3.22	Control	28
A#518703	11	m	2.27	Control	25
A#523855	21	f	5.26	Control	25
A#523657	8	f	1.81	Control	25
A#523854	21	f	5.26	Control	16
A#525318	20	m	9.98	Control	25
A#525436	11	f	2.04	Control	1
A#524641	11	m	2.18	Control	1
A#526451	21	m	5.62	Control	16
A#526850	14	m	18.42	Control	19
A#527128	22	m	11.25	Control	1
A#527246	9	f	2.81	Control	13

A#525159	8	f	3.67	Control	4
A#527361	10	m	0.95	Control	1
A#518213	11	m	3.18	Control	never sat
A#unknown	12	f	Unknown	Control	sat on command
A#518895	11	f	1.95	Control	never sat
A#524100	18	m	13.65	Control	ill during testing
A#517731	11	m	3.63	Verbal	never sat
A#517791	11	f	1.90	Verbal	13
A#512943	11	m	1.95	Verbal	13
A#517032	11	f	6.58	Verbal	sat on command
A#518949	10	f	2.09	Verbal	13
A#519408	22	m	19.05	Verbal	16
A#517323	10	f	3.90	Verbal	10
A#521748	10	m	1.77	Verbal	10
A#516153	9	m	6.71	Verbal	1
A#518960	20	m	30.50	Verbal	1
A#521492	11	f	2.90	Verbal	1
A#516533	10	m	3.22	Verbal	1
A#517732	10	m	3.67	Verbal	never sat
A#519369	8	m	1.54	Verbal	1
A#517324	10	m	4.17	Verbal	1
A#521997	13	m	3.81	Verbal	7
A#519029	22	m	15.65	Verbal	7
A#519719	9	f	1.22	Verbal	7
A#518225	17	m	12.02	Verbal	10
A#519756	9	m	2.27	Verbal	4
A#521621	11	f	9.03	Verbal	16
A#519733	20	m	7.70	Verbal	4

A#523585	16	m	4.90	Verbal	37
A#524035	13	m	3.63	Verbal	16
A#525907	11	m	9.43	Verbal	7
A#525320	20	m	9.52	Verbal	31
A#525249	10	m	4.35	Verbal	19
A#526852	9	m	3.67	Verbal	1
A#527133	13	f	4.04	Verbal	4
A#527247	9	f	2.81	Verbal	1
A#524619	12	f	1.86	Verbal	1
A#525199	11	f	5.26	Verbal	7
A#526907	8	m	2.09	Verbal	7
A#525158	11	f	4.13	Verbal	never sat
A#527363	10	f	1.09	Verbal	never sat
A#518831	12	m	5.40	Verbal	never sat
A#523932	18	m	2.81	Verbal	never sat
A#518035	22	f	3.13	Verbal	never sat
A#522165	11	f	6.12	Verbal	sat on command
A#518981	12	f	6.80	Verbal	sat on command
A#518059	9	f	3.58	Clicker	7
A#518463	22	m	3.54	Clicker	31
A#518834	12	m	7.85	Clicker	31
A#518950	10	f	2.54	Clicker	13
A#519720	9	m	1.32	Clicker	19
A#521027	11	m	6.94	Clicker	28
A#522013	16	f	5.12	Clicker	37
A#521749	10	m	1.45	Clicker	13
A#521689	9	m	1.86	Clicker	1
A#519188	18	m	7.89	Clicker	1

A#517834	13	m	4.94	Clicker	1
A#519368	8	f	1.50	Clicker	4
A#518273	9	f	3.26	Clicker	1
A#521751	9	m	1.41	Clicker	1
A#521492	10	f	2.90	Clicker	10
A#519718	9	f	1.59	Clicker	13
A#518212	12	f	16.01	Clicker	31
A#523415	13	m	2.81	Clicker	7
A#523853	21	f	5.99	Clicker	10
A#524101	22	f	11.34	Clicker	1
A#524036	13	m	4.40	Clicker	13
A#525794	13	m	10.43	Clicker	1
A#525434	11	m	3.04	Clicker	13
A#526779	12	f	3.45	Clicker	4
A#526775	12	f	2.00	Clicker	never sat
A#526851	9	f	2.72	Clicker	19
A#527132	13	m	3.00	Clicker	28
A#527248	9	m	3.22	Clicker	16
A#527428	11	f	4.22	Clicker	13
A#525201	11	f	4.99	Clicker	never sat
A#525197	11	f	4.35	Clicker	never sat
A#526906	8	m	2.18	Clicker	1
A#528039	9	m	3.90	Clicker	22
A#521750	9	m	1.27	Clicker	never sat
A#521244	10	m	8.07	Clicker	sat on command
A#520198	16	m	6.44	Clicker	sat on command
A#518621	22	f	6.89	Clicker	sat on command

"Longest sit" is the duration in seconds of the longest sit achieved during shaping, except for dogs noted as "sat on command," or "never sat." Seven dogs were excluded for sitting on first instruction; 13 for not sitting within 25 minutes of beginning training; and one due to identification of illness. Sex is male (m) or female (f). Age, sex, and weight were determined at the date the dogs were tested. IDs are those noted in shelter records. A dog for which the identification number was not recorded at the time of testing is missing its weight measurement and as such is marked "unknown."

APPENDIX C

DOGS TESTED IN EXPERIMENT 2

Dog ID	Age (weeks)	Sex	Weight (kg)	Condition	Highest Step
A#537279	10	m	1.5	control	8
A#537649	15	f	10.9	control	8
A#537712	17	m	10.9	control	16
A#537189	9	m	2.7	control	7
A#538221	18	m	2.6	control	11
A#538598	11	m	3.3	control	5
A#536320	11	m	5.3	control	17
A#535787	9	m	5.5	control	12
A#535759	10	f	5.6	control	8
A#539316	13	m	10.4	control	7
A#539885	10	m	4.5	control	2
A#538378	10	f	4.4	control	11
A#537506	10	m	4.6	control	8
A#539676	16	m	4.0	control	never touched
A#539190	11	f	1.6	control	5
A#540279	11	m	3.2	control	5
A#539987	11	f	2.2	control	5
A#541156	22	f	10.7	control	7
A#539182	8	m	3.4	control	9
A#540922	18	f	7.1	control	7
A#541049	9	m	2.0	control	4
A#540307	13	f	7.3	control	8
A#542066	9	f	2.0	control	6
A#542031	8	f	2.3	control	7
A#539026	9	m	2.3	control	9
A#541381	9	m	2.5	control	9
A#537673	9	f	2.6	control	never touched
A#538443	12	f	3.5	control	never touched

A#537412	10	m	1.7	verbal	8
A#537621	8	f	2.3	verbal	8
A#535399	9	m	6.2	verbal	6
A#535400	9	m	5.8	verbal	never touched
A#537405	22	f	1.9	verbal	5
A#535794	13	f	3.1	verbal	5
A#539172	14	m	8.9	verbal	7
A#535754	9	m	6.1	verbal	13
A#534018	22	f	6.1	verbal	13
A#539391	20	m	9.2	verbal	5
A#538383	13	m	4.5	verbal	8
A#538414	15	f	13.2	verbal	8
A#538382	14	m	5.4	verbal	8
A#537503	10	m	4.2	verbal	3
A#540550	8	f	5.2	verbal	8
A#539986	11	f	2.3	verbal	7
A#541157	22	f	10.2	verbal	7
A#539183	9	m	4.5	verbal	8
A#540923	18	m	6.9	verbal	15
A#541034	22	f	3.4	verbal	6
A#541047	9	f	1.6	verbal	7
A#541048	9	m	2.1	verbal	3
A#541733	18	f	1.5	verbal	1
A#542030	8	f	1.9	verbal	15
A#541147	22	f	7.5	verbal	6
A#541380	9	f	2.5	verbal	5
A#530751	19	m	2.8	verbal	never touched
A#539194	9	m	2.0	verbal	never touched

A#539886	11	f	5.2	verbal	never touched
A#531904	11	f	6.9	clicker	13
A#537963	10	m	6.8	clicker	9
A#536715	11	m	4.6	clicker	1
A#538483	11	f	1.5	clicker	7
A#538219	9	m	2.0	clicker	10
A#538597	10	m	4.4	clicker	8
A#535790	9	m	5.4	clicker	16
A#535753	9	m	6.8	clicker	1
A#535793	10	f	5.2	clicker	6
A#539545	9	m	5.7	clicker	14
A#539886	9	f	5.2	clicker	1
A#540061	16	f	9.9	clicker	14
A#539762	11	f	2.6	clicker	10
A#537502	10	m	4.6	clicker	4
A#540284	11	f	3.0	clicker	11
A#541070	22	m	16.4	clicker	8
A#539184	9	f	3.7	clicker	9
A#540921	18	m	7.3	clicker	8
A#537179	11	m	5.9	clicker	17
A#541046	9	f	1.8	clicker	4
A#541715	10	m	1.9	clicker	7
A#542029	8	f	1.9	clicker	8
A#541146	22	f	9.8	clicker	12
A#540981	11	f	2.6	clicker	7
A#540982	11	m	2.5	clicker	7
A#537857	10	m	1.8	clicker	never touched

"Highest Step" is the number of the highest completed training step achieved during the shaping and distance components, except for dogs noted as "never touched." Sex is male (m) or female (f). Age, sex, and weight were determined on the date the dogs were tested. IDs are those noted in shelter records.

APPENDIX D

DOGS TESTED IN EXPERIMENT 3

Dog ID	Age (weeks)	Sex	Weight (kgs)	Condition	Highest Level
A#550782	13	m	2.95	control	9
A#552544	9	f	1.63	control	4
A#552246	8	f	3.81	control	2
A#551316	11	f	2.68	control	10
A#548848	11	f	1.95	control	10
A#552967	10	f	4.58	control	11
A#553752	14	m	3.67	control	7
A#551396	11	m	1.95	control	11
A#554444	10	f	2.77	control	11
A#554855	10	m	3.67	control	3
A#554843	14	f	5.76	control	11
A#553355	19	f	8.84	control	9
A#551789	11	f	2.00	control	6
A#555534	9	m	1.91	control	7
A#552842	8	f	2.27	control	7
A#555477	9	f	2.99	control	8
A#555473	9	m	2.49	control	9
A#553347	11	m	5.22	control	8
A#555389	22	f	3.40	control	8
A#555978	9	m	3.58	control	6

A#552657	9	m	6.80	control	11
A#552659	9	m	7.26	control	9
A#566337	9	f	4.13	control	7
A#569018	9	m	1.32	control	7
A#564175	12	m	0.91	control	3
A#566396	10	f	1.32	control	5
A#569256	8	f	1.09	control	3
A#569567	22	m	6.98	control	11
A#568235	8	m	1.63	control	9
A#569189	10	f	4.81	control	7
A#554800	9	m	2.45	control	did not eat
A#553304	8	m	5.26	control	never touched
A#552239	10	f	5.44	control	no shaping
A#552959	9	m	4.81	control	no shaping
A#553627	11	f	3.99	control	no shaping
A#549469	12	f	1.90	control	no shaping
A#551780	10	m	2.09	verbal	6
A#552696	11	f	1.59	verbal	7
A#552244	8	f	4.31	verbal	2
A#549468	11	f	2.00	verbal	6
A#553167	12	m	1.77	verbal	9
A#552237	10	f	4.99	verbal	7

A#553753	8	f	4.67	verbal	5
A#554106	13	f	6.80	verbal	7
A#554856	10	f	2.86	verbal	4
A#554517	12	m	4.44	verbal	9
A#555011	22	f	13.42	verbal	7
A#553333	8	f	1.81	verbal	3
A#555698	10	f	5.35	verbal	8
A#554123	12	m	2.31	verbal	10
A#552840	8	m	2.81	verbal	11
A#555475	9	f	2.77	verbal	5
A#555472	10	m	2.99	verbal	2
A#550992	13	m	2.77	verbal	7
A#553332	11	m	1.68	verbal	4
A#552658	9	m	6.58	verbal	7
A#566342	9	m	3.63	verbal	6
A#566335	9	f	4.44	verbal	7
A#568217	8	m	1.68	verbal	10
A#564176	12	f	1.04	verbal	6
A#568639	22	m	2.77	verbal	3
A#568596	10	f	1.63	verbal	7
A#568957	10	m	2.63	verbal	8
A#568958	10	m	2.63	verbal	10

A#569979	18	m	2.40	verbal	9
A#569187	10	m	5.49	verbal	8
A#551478	13	f	3.36	verbal	never touched
A#550990	11	m	2.27	verbal	never touched
A#568832	14	m	10.43	verbal	vomited
A#569051	11	f	3.22	verbal	knew touch
A#552960	9	f	4.76	verbal	no shaping
A#552970	10	f	4.13	verbal	no shaping
A#552968	10	f	3.18	verbal	no shaping
A#553630	11	f	4.08	verbal	no shaping
A#555208	17	m	8.39	verbal	no shaping
A#552656	9	m	6.80	verbal	no shaping
A#565565	8	f	3.36	verbal	never touched
A#550228	11	m	2.40	clicker	11
A# 551477	13	f	3.76	clicker	5
A#548691	12	f	3.31	clicker	7
A#552242	8	f	4.54	clicker	8
A#548849	13	f	1.72	clicker	4
A#552958	9	f	3.08	clicker	7
A#553956	14	f	2.86	clicker	11
A#552966	10	f	3.04	clicker	3
A#553955	14	f	3.31	clicker	11

A#553741	10	m	9.25	clicker	11
A#554858	10	m	3.13	clicker	4
A#554857	10	m	3.13	clicker	10
A#555036	21	f	10.16	clicker	10
A#554668	18	m	13.24	clicker	9
A#554903	18	f	7.35	clicker	11
A#553328	8	f	2.22	clicker	2
A#555381	15	m	6.62	clicker	3
A#552841	8	m	1.81	clicker	10
A#555476	8	f	2.77	clicker	3
A#555474	10	f	2.99	clicker	7
A#555390	22	m	5.17	clicker	11
A#553329	11	f	2.68	clicker	5
A#552655	9	f	5.67	clicker	6
A#565562	8	m	3.45	clicker	7
A#568048	22	f	9.16	clicker	9
A#569010	18	f	16.33	clicker	11
A#569403	22	m	12.70	clicker	11
A#568239	8	f	1.54	clicker	6
A#569180	10	m	6.26	clicker	7
A#569195	10	m	6.35	clicker	7
A#555702	17	m	12.61	clicker	never touched

A#553751	8	m	4.08	clicker	no shaping
A#555212	17	f	8.66	clicker	no shaping
A#554762	11	m	4.76	clicker	no shaping
A#565567	8	f	2.90	clicker	no shaping

“Highest Level” is the number of the highest level of training the dog completed during testing. Sex is male (m) or female (f). Age, sex, and weight were determined on the date dogs were tested. IDs are those noted in shelter records.

Table 1

Testing Steps of Experiment 2

Step	Reinforced Behavior	Trainer Location, Stature
1	Touch trainer's palm containing food	PRDS (0 cm from cone), kneeling
2	Touch trainer's empty palm	PRDS (0 cm from cone), kneeling
3	Touch ball in trainer's hand	PRDS (0 cm from cone), kneeling
4	Touch ball affixed to cone held in trainer's hand	PRDS (0 cm from cone), kneeling
5	Touch ball affixed to the cone placed on TS	PRDS (0 cm from cone), kneeling
6	Touch cone placed on TS	PRDS (0 cm from cone), kneeling
7	Touch cone placed on TS	PRDS (0 cm from cone), standing
8	Touch cone placed on TS	Line (127cm from cone), pivot, standing
9	Touch cone placed on TS	USM 9 (177cm from cone), standing
10	Touch cone placed on TS	USM 10 (227cm from cone), standing
11	Touch cone placed on TS	USM 11 (277cm from cone), standing
12	Touch cone placed on TS	USM 12 (327cm from cone), standing
13	Touch cone placed on TS	USM 13 (377cm from cone), standing
14	Touch cone placed on TS	USM 14 (427cm from cone), standing
15	Touch cone placed on TS	USM 15 (477cm from cone), standing
16	Touch cone placed on TS	USM 16 (527cm from cone), standing
17	Touch cone placed on TS	USM 17 (577cm from cone), standing

List of each training step and corresponding reinforced behaviors, as well as the trainer's location and posture at each step.

Table 2

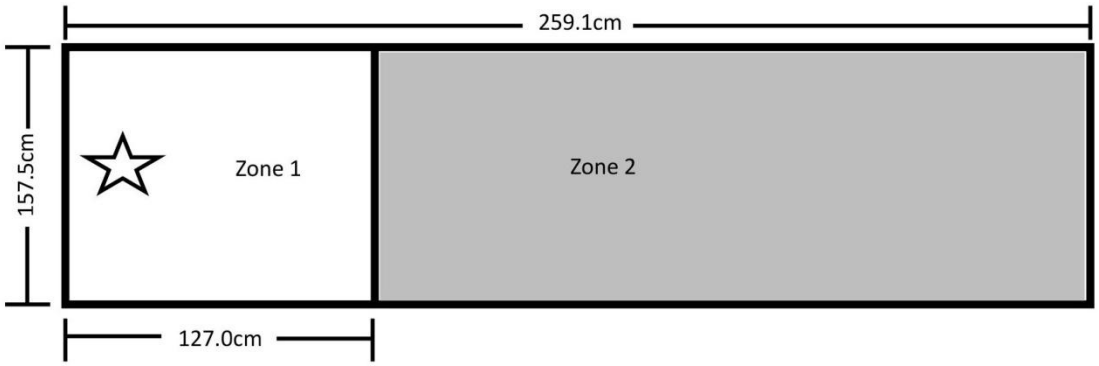
Shaping and Testing Levels of Experiment 3

Level	Blocks eligible for reinforcement
Training/Shaping	1 AND/OR 2 AND/OR 3 AND/OR 4 AND/OR 5
1	1 AND 2 AND 3 AND 4 AND 5
2	2 AND 3 AND 4
3	(1 AND 2) OR (3 AND 4)
4	(1 AND 2) OR (3 AND 4)
5	1 AND 3 AND 5
6	2 AND 4
7	1 OR 2 OR 3 OR 4 OR 5
8	1 OR 2 OR 3 OR 4 OR 5
9	1 OR 2 OR 3 OR 4 OR 5
10	1 OR 2 OR 3 OR 4 OR 5
11	1 OR 2 OR 3 OR 4 OR 5

Outline of the shaping and testing phases and all possible levels and their corresponding blocks eligible for reinforcement when touched. “AND” indicates that all listed blocks are eligible for reinforcement within that level at the same time as another block, while “OR” indicates that only a singular listed block is eligible for reinforcement within that level. Blocks listed within parentheses should be treated as a single unit in regards to these rules. AND/OR indicates that all listed blocks are eligible for reinforcement within that level, but not at the same time as another block.

Figure 1

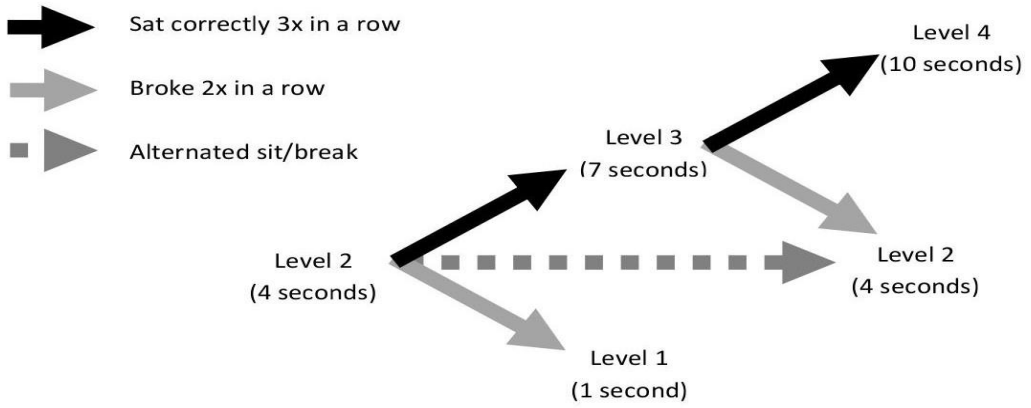
Testing Area for Experiment 1



The 157.5 cm by 259.1 cm enclosed space making up the testing area. A line of tape separating Zone 1 (where sitting was reinforced) from Zone 2 (no reinforced behavior) was placed 127.0 cm from the far end of Zone 2. The star marks where the trainer stood during testing and where reinforcement delivery occurred (the RDS). A research assistant was present on the far right end of Zone 2.

Figure 2

Adaptive Schedule of Reinforcement for Experiment 1



Adaptive schedule of reinforcement based on meeting the criteria of the sit duration. This illustration shows as an example a dog which is at Level 2, where it was required to sit for 4 seconds to obtain reinforcement. If the dog sat for four seconds three times in a row, it would advance to Level 3, where it was expected to sit for 7 seconds. If, however, at Level 2 the dog did not sit for a full 4 seconds twice in a row, it would drop down to Level 1, where it was expected to sit for one second. If the dog alternated sitting for 4 seconds and sitting for less than 4 seconds, it remained at Level 2.

Figure 3

Mean Duration of Sit in Experiment 1; Mean Highest Completed Step in Experiment 2; Mean Highest Completed Level in Experiment 3

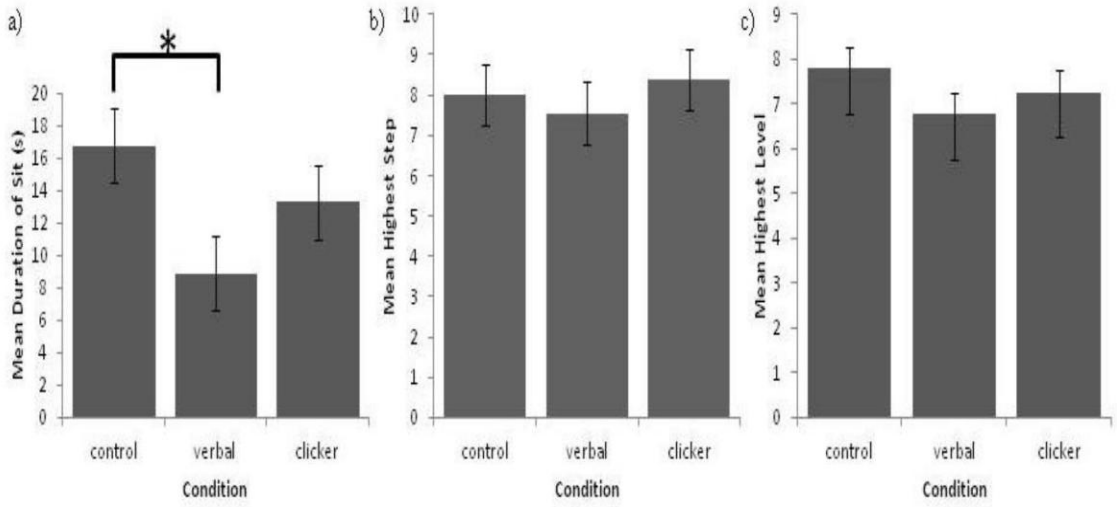


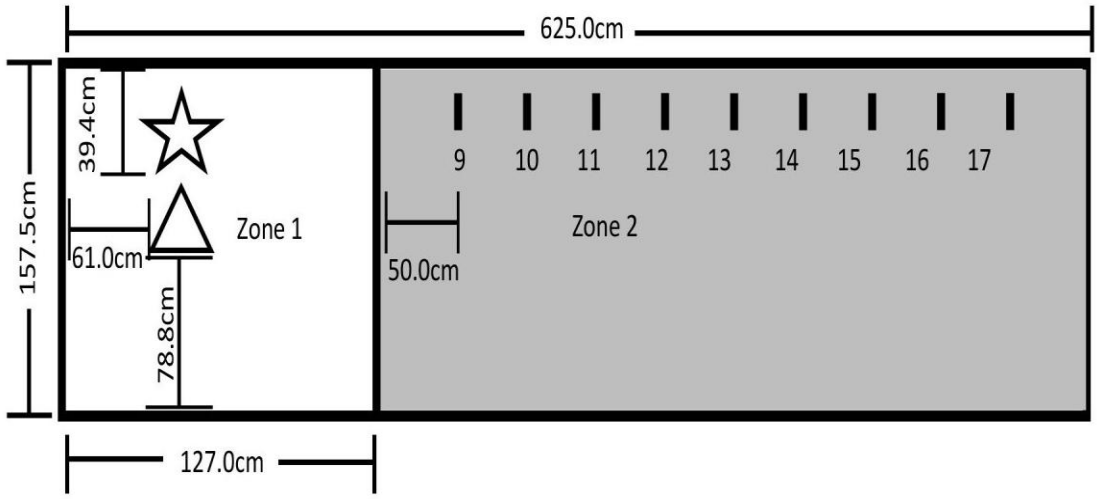
Figure 3a. Mean duration of a sit (with error bars depicting standard error of the mean) in seconds for each group of dogs in Experiment 1. Bracket with asterisk between groups indicates a significant difference in means on a post-hoc pairwise comparisons ($p < 0.05$).

Figure 3b. Mean highest completed step (with error bars depicting standard error of the mean) for each group of dogs in Experiment 2.

Figure 3c. Mean highest completed level (with error bars depicting standard errors of the mean) for each group of dogs in Experiment 3.

Figure 4

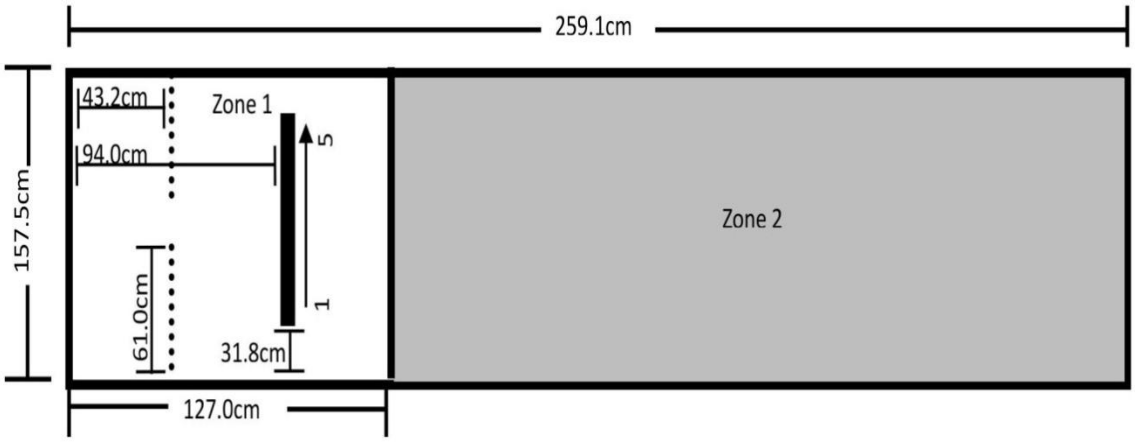
Testing Area for Experiment 2



The star represents where the trainer stood during testing and where primary reinforcement delivery by the trainer occurred (PRDS). The triangle represents the touch spot where all reinforced behavior occurred and where primary reinforcement was delivered (TS). The short lines represent the upper step markers (USM) 9-17 that marked where the trainer stood for steps 9-17. The USM were placed in line with the PRDS and were spaced 50 cm apart from one another, with USM 9 being 50 cm away from the line. A research assistant was present on the far end of Zone 2.

Figure 5

Testing Area for Experiment 3



The 157.5 cm by 259.1 cm enclosed testing area. The tape line dividing the zones sits 127.0 cm from the far left end of Zone 1. The thin dotted lines represent the Reinforcement Barrier (RB), between which the trainer knelt during testing and behind which sat the primary reinforcement and resetting treats. The black bar represents the Block Line (BL) where all reinforced behavior occurred and where primary reinforcement was delivered, and the arrow from 1 to 5 indicates the numbered direction of the blocks.

Figure 6

Array of Blocks in Experiment 3

Blocks are numbered from the trainer's left to right, beginning at Block 1. Consecutive blocks alternated colors, with a 3 blue/2 yellow and 3 yellow/2 blue arrangement assigned to equal numbers of dogs in each condition. Blocks were evenly spaced 18.7 cm apart.