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Training a New Trick Using No-Reward Markers: Effects on Dogs' Performance and Stress Behaviors

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Effects on Dogs' Performance and Stress Behaviors

by

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Abstract

The overall goal of modern dog training is to induce the greatest behavioral change with the least amount of undue stress to the canine learner. The possible advantages and potential pitfalls of using no-reward markers (NRMs) in dog training have been debated by scientists and trainers, but no empirical studies have been undertaken. In the current study, 27 dogs were trained during a single session to put their front two paws into a toy hoop immediately following the trainer's verbal cue "hoop". In the control (IG) group, dogs' errors executing the trick were ignored, and in the No-Reward Marker (NRM) group, the dogs' errors were followed by a tone, which signaled the lack of a forthcoming reward. All the dogs heard a click and were given a food reward after every correct execution of the target behavior. The dogs' performance and displays of stress behaviors were evaluated. The dogs in the IG group reached higher levels of performance on the novel training task, but there was no difference between the two groups in the overall frequency of stress behaviors. Consequently, when teaching a dog a simple new behavior, he will likely learn faster and with fewer errors if the errors he does make are ignored. No-reward markers do not appear to be a highly effective form of negative feedback in this context.

Dog training allows humans to communicate with their canine companions and helps build a repertoire of behaviors which allow the dog to exist in the human world (Greenebaum, 2010). While trainers strive to teach dogs these new skills efficiently, they also prefer to achieve their training goals with minimal stress to the dog. It is now understood that force-free, reward-based training generally yields better results with fewer welfare costs than punitive, aversive, punishment-based methods (Stilwell, 2014b). Following the "least intrusive, minimally aversive" approach, modern dog trainers aim to set up training sessions to minimize the possibility of errors and maximize the opportunities for reinforcement (APDT, 2015). However, even the most skilled trainers are unable to completely prevent a dog's errors during training. Little research has been done investigating the best ways to deal with the inevitable errors that occur during training. Empirically identifying a type of negative feedback that allows for better learning and avoids unneeded stress would be a great help to dog trainers and the animal care community at large.

Most dog training techniques aimed at teaching the dog a new skill are based upon the tenets of operant conditioning, a term coined by B.F. Skinner (1953). In operant conditioning, the animal is taught a contingency between his own actions and their effect on the environment (Domjan, 1993). Each behavior the animal offers is followed by feedback, a consequence that either reinforces or punishes the previous behavior (Hattie & Timperley, 2007). This concept is based on Thondike's Law of Effect (1927), which put forward the idea that a behavior which is followed up with an appetitive, or reinforcing stimulus, is more likely to be offered again in the future. Similarly, behaviors that are followed by aversive consequences will decrease in frequency. This pattern of contingencies allows for "feedback-based learning," where the animal bases its subsequent behavior upon the feedback it received after a previous performance (Van Duijvenvoorde, Zanolie, Rombouts, Raijmakers, & Crone, 2008).

This type of associative learning is dependent upon effectively pairing the animal's behavior with its respective consequence, and the temporal relationship between these factors is extremely important for effective learning (Yamamoto, Kikusui, & Ohta, 2009). However, it is often difficult for a human trainer to deliver a primary reinforcer (such as food) immediately following the behavior for which he wants to provide feedback. To effectively bridge the inevitable delay between the animals' response and the subsequent reward, Breland and Breland (1966) introduced the secondary reinforcer to the field of animal training. Also known as a "reward marker," "bridging stimulus," or "event marker," the secondary reinforcer allows for the trainer to mark the correct behavior and it informs the animal which behavior is earning the forthcoming reward (Pryor, 1999).

A secondary reinforcer begins as a neutral stimulus, which derives its reinforcing power from repeated pairings of the stimulus and a primary reinforcer, like food (Touretzky & Saksida, 1997). A clicker, a handheld noisemaker that produces a clear, metallic sound when pressed, serves as a commonly used secondary reinforcer (Pryor, 1999). In order to imbue the click with power as a secondary reinforcer, many trainers "charge the clicker" using Pavlovian classical conditioning: repeatedly sounding the clicker and immediately presenting the animal with a primary reinforcer (Kaplan, Oudeyer, Kubinyi, & Miklósi, 2002; Kelleher & Gollub, 1962). Because the stimulus is consistently paired with a reinforcer, it becomes a reliable predictor of the arrival of that reinforcer. This allows the trainer to use the secondary reinforcer during training to effectively bridge the temporal space between the animal's behavior and the delivery of the primary reinforcer.

Just as reward markers can be used as secondary reinforcers to let the animal know what behaviors the trainer wants to reinforce, no-reward markers (NRMs) can be used as secondary punishers to give the animal information about what they might be doing wrong. Repeatedly pairing a neutral stimulus with the absence of a primary reinforcer can cause that stimulus to become a conditioned negative punisher (Donaldson, 2013; Reid, 2009). After multiple exposures to the NRM, the stimulus becomes a signal that the learner has not earned a reward for the behavior they just executed. Many trainers and owners use verbal NRMs such as “no,” “try again,” or “uh-uh,” said in a neutral tone of voice. The NRM, being a previously neutral stimulus, is not inherently aversive, and is a tool that can be used to steer a dog away from errors during training without employing punitive techniques that are known to have negative welfare consequences.

The Stress Response and its Effect on Learning

Using NRMs in training might be a more humane alternative to more aversive punishment-based training methods. However, it is still possible that hearing an NRM could be an unnecessary stressor for the learner. Stressors are tangible or mentally generated events that precipitate a change in the animal’s internal state, the stress response (Joëls, Pu, Wiegert, Oitzl, & Krugers, 2006). This stress response is characterized by both physiological and behavioral changes in the animal (Bear, Connors, & Paradiso, 2007). The physiological aspect of the stress response is characterized by an activation of the sympathetic division of the autonomic nervous system and a release of cortisol from the adrenal glands (Bear et al., 2007). The hypothalamic-pituitary-adrenocortical (HPA) axis is activated during moments of stress and produces increased levels of glucocorticoids, including cortisol, in order to redirect energy towards behaviors that might help resolve the stressor (Creel, 2001) or protect the brain and the body from the effects of the stressor (Bear et al., 2007).

In addition to the physiological changes that occur in response to stressors, animals also exhibit behavioral manifestations of that stress. In general, there is an increase in avoidance behaviors and higher levels of vigilance and arousal (Bear et al., 2007). These stress behaviors are an outward representation of the animal's internal emotional state, and can be used as a proxy measure for the level of stress the animal is experiencing (Rooney, Gaines, & Bradshaw, 2007).

When stressed, dogs tend to exhibit behaviors that allow them to withdraw from the stressor and to attempt to redirect their stress onto something else in the environment. Extensive research has been done to identify stress behaviors common in domestic dogs, and in what contexts each behavior is more likely to be observed. In response to acute, unpredictable environmental stressors, a dog might suddenly crouch and tuck his head and tail, shake his body, and lick up over his snout (Beerda, Schilder, van Hooff, de Vries, & Mol, 1998; Schilder & van der Borg, 2004). When exposed to chronic stressors, a dog also might tend to groom himself more often (Beerda, Schilder, Van Hooff, De Vries, & Mol, 1999). When presented with a violation of expectations during training or a social challenge, many dogs express frustration by yawning, lying down, backing up or withdrawing from the situation, sniffing around, and vocalizing (Bentosela, Jakovcevic, Elgier, Mustaca, & Papini, 2009; Horváth, Igyártó, Magyar, & Miklósi, 2007; Jakovcevic, Elgier, Mustaca, & Bentosela, 2013; Sternberg). While all dogs draw from a similar repertoire of stress behaviors, individual dogs often behave differently in response to the same stressor (Hiby, Rooney, & Bradshaw, 2006), and the same dog might not exhibit the same behaviors in similar contexts over the course of its lifetime (Nagasawa et al., 2014).

High frequencies of these types of stress behaviors are often seen in response to punitive, aversive training methods. For example, when trained using shock collars or leash corrections, a dog might yawn and lick his lips, have tense and crouched body language, vocalize as if in pain, and withdraw from the training scenario (Cooper, Cracknell, Hardiman, Wright, & Mills, 2014; Deldalle & Gaunet, 2014; Schilder & van der Borg, 2004). Finding a form of negative feedback that doesn't elicit high levels of these stress behaviors might be helpful for modern dog trainers who aim to train dogs without pain and anxiety.

The NRM Debate in Dog Training

While in traditional training, trainers might use highly aversive methods to punish a dog's errors during training (Millan & Peltier, 2010; Skete, 1978), most force-free trainers today desire an effective way to respond to errors in training while maintaining a nurturing learning environment for the dog. No-reward markers (NRMs) are sometimes touted as a potential tool to accomplish these goals.

Many trainers that rely primarily on positive reinforcement assert that NRMs are unnecessary because a lack of positive feedback following an offered behavior implies to the learner that what they have done is not the desired behavior. Trainers such as Karen Pryor (the founder of modern clicker training) posit that ignoring errors makes it more likely that the dog will continue to offer other possible behaviors to be rewarded, rather than shutting down and refusing to act at all (VanArendonk, 2010). Famed trainer Ken Ramirez believes that even the most neutral NRMs, when overused, can lead to a lack of trust between the trainer and dog and will almost always lead to frustration (Boogie, 2013). Anecdotally, many trainers have seen that individual dogs respond to hearing NRMs differently: some take it as neutral information, while others see it as a more aversive experience and are reluctant to keep attempting new behaviors during a training session where NRMs are used (Alexander, 2003; Stilwell, 2014a).

Other trainers assert that because errors during learning are inevitable, ignoring those errors might also be frustrating for dogs that are attempting to learn a new behavior. Simon Gadbois, a canine researcher who trains dogs for scent work and studies their learning processes, claims that NRMs are useful tools to provide continuous feedback and help a dog update his understanding of the skill he is learning and allows him to better “understand the rules of the game.” He posits that the NRM, as an effective non-aversive punisher, gives the dog useful information that allows him to quickly abandon the wrong behavior and to attempt the task again. When errors are ignored, the dog might keep attempting the incorrect behavior, and as a result, Gadbois has seen many dogs become frustrated (Gadbois, 2015). Trainer Jean Donaldson also advocates the use of NRMs to help dogs abandon “dead-end strategies” and move on to other behaviors that might be rewarded (Donaldson, 2013).

This debate on the subject of the efficacy and potential stressful consequences of the use of NRMs in dog training was the impetus for the current study. Because of the lack of experimental work examining the benefits and consequences of using relatively non-aversive negative feedback with dogs, this study was an attempt to provide objective evidence to add to the NRM debate. The purpose of this study was to objectively evaluate the effects of hearing an NRM on dogs’ acquisition of a novel behavior and stress levels during training. Two groups of dogs were taught the same novel trick and their experience differed only in terms of how the trainer responded to the dogs’ errors: for one group, the trainer presented a tone (the NRM) when the dogs incorrectly performed the target behavior, while the other group’s errors were ignored.

The dogs' success in learning the trick and the frequency of displayed stress behaviors during the training process were measured and compared.

Method

Subjects

The subjects of this study were 27 domestic dogs (*Canis familiaris*) of various breeds (15 male, 12 females, all altered) that attended daycare at Ruby and Jack's Doggy Shack in New York City. Clients who utilized the daycare service on a regular basis were approached to participate in this study. Upon consenting to have their dogs participate, interested dog owners provided basic information about their dog's previous experience with clicker training and any food allergies or dietary restrictions which might affect the food treats given during training (see Appendix A).

Dogs were randomly assigned to either the No-reward Marker (NRM) condition or the Ignored (IG) condition with no regard to age, sex, or prior clicker training experience. There were fewer dogs with prior clicker training experience in the NRM condition (N=2) than in the IG condition (N=7). Eight dogs were excluded from the study due to an inability to follow the movement of the experimenter and eat all 20 treats during warm-up trials (see Procedure below). The age (*M* = 3.07 years, *SD* = 3.48), gender, and assigned condition of all 27 included subjects are presented in Table 1.

Table 1

Included Subjects' Demographic Characteristics

Ignored (IG) Condition			No-reward Marker (NRM) Condition		
Subject	Sex	Age (in years)	Subject	Sex	Age (in years)
Bull	M	1.00	Bruno	M	0.75

Penny	F	3.00	Wilbur	M	0.67
Mattie	F	12.00	Arema	F	0.42
Roy	M	2.00	George	M	13.00
Jackson	M	1.00	Murphy	M	7.00
Casey	F	10.00	Happy	M	1.00
Gideon	M	0.50	Nola	F	1.00
Dudley	M	2.00	Oscar	M	2.00
Dolly	F	2.00	Winnie	F	1.00
Charlie	M	1.00	Dooley	M	1.00
Barney	M	3.00	Tali	F	2.00
Bentley	F	5.00	Booboo	F	4.00
Teddy	M	0.67	Phoebe	F	2.00
Derby	F	4.00			

Materials

All training sessions were recorded using a SONY HDRCX330 video camera with 2.7in LCD display on a 57-inch tripod. The clicker used to mark each correct execution of the trick was a box clicker purchased from PetSmart®, produced by Top Paw. The tone used to mark errors for the dogs in the NRM group was a middle C produced by a Farleys Pocket Tones: Chromatic-C electronic pitch pipe. Food rewards during training were pieces of Merrick's Lamb Lung Fillets broken into approximately $0.5cm^2$ pieces. Dogs with food allergies were rewarded with treats provided by their owners, also broken into approximately $0.5cm^2$ pieces. The experimenter kept food rewards in a training pouch on her hip for quick access during training.

All training sessions took place in a bare room (measuring 12.5 ft x 14 ft) near the playrooms at Ruby and Jack's Doggy Shack. The toy hoop used as a target was 28 inches in diameter with a snap together design weighing 2.4 ounces, and was placed in the back right corner of the room. If a dog moved the toy hoop during training, the experimenter repositioned the hoop before the next trial. At the start of each trial, the experimenter stood at a blue tape mark in the back left corner of the room. Figure 1 depicts the arena, including the placement of the toy hoop, video recording equipment, and the experimenter's base position.

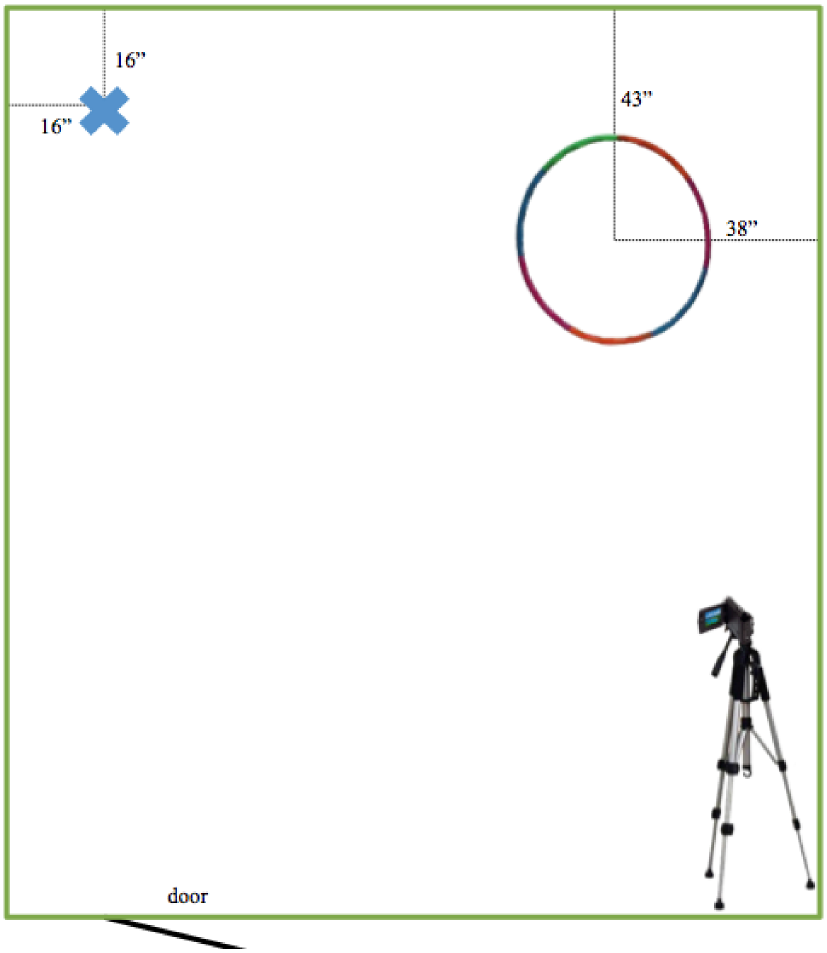

Figure 1. Schematic of arena

Procedure

At the start of each testing day, all dogs for whom the experimenter had previously acquired owner consent to participate and were present at daycare were randomly assigned to a feedback condition. Each dog participated in only one training session. The owners were not present during training sessions, and the stranger experimenter was the only human present during training.

After removal from daycare (playing off-leash with other dogs), the experimenter brought the subject dog into the testing room on leash. Upon entering the room, the experimenter unleashed the dog and gave it a few seconds to explore the new environment, and then turned on the video camera to begin recording. The experimenter said the dog's name to identify the recording for later coding, and then refrained from further verbal communication with the dog throughout the training session.

Warm-up trials: In order to classically condition the clicker as a reward marker, the experimenter paired the clicker (conditioned stimulus) with an immediately offered food treat (unconditioned stimulus) with no regard to the dog's behavior. She did this 20 times (Kaplan et al., 2002) while slowly walking back and forth from her base position in the left corner of the room towards where the target toy hoop would be during the training session. These 20 warm-up trials also acted as exclusion criteria: any dog that did not take all 20 treats from the experimenter was likely not being reinforced by the food, and dogs that were reluctant to follow the movement of the experimenter around the room were likely unwilling to follow her body movement while teaching the new trick. Dogs that did not pass the exclusion criteria were immediately taken back to daycare to prevent them from experiencing more stress than necessary from remaining in the training environment. Upon a dog's successful completion of the warm-up trials, the experimenter put the toy hoop into position in the right corner of the room and began training the target novel trick.

Trick Training: The dogs were trained to walk over to the toy hoop and put their two front paws inside it for any duration of time ("hoop"). This trick was chosen because of its novelty, since it was unlikely that any of the dogs would have learned a similar trick prior to participation in this study. Additionally, paw targeting is a useful behavior that can serve as the basis for many other more complicated tricks.

The target behavior was taught using lure/reward training (Dunbar, 2006), where the experimenter said the verbal cue "hoop" and then lured the dog to perform the trick with specific body movements. The goal of this type of training is to gradually fade out the lure so that the dog responds to the verbal cue in isolation. Commonly used lures are pointing, eye gaze and body position, which are effective because of dogs' excellent ability to decipher these human social cues (Hare & Tomasello, 2005; Soproni, Miklósi, Topál, & Csányi, 2002). Table 2 outlines the six lure levels used in this study, which progress in difficulty by systematically decreasing the amount of facilitation by the experimenter.

Table 2

Lure Levels and Description of Experimenter's Actions for Each

Lure level	Lure level description
1	Experimenter walks to the toy hoop with food in right hand and entices the dog to put front paws in toy hoop by holding right hand out in pointing gesture towards the toy hoop
2	Experimenter walks to the toy hoop with no food in right hand and extends empty right hand in pointing gesture towards the toy hoop
3	Experimenter lunges forward with left foot towards the toy hoop and extends empty right hand in pointing gesture towards the toy hoop
4	Experimenter takes one step forward with left foot towards the toy hoop and extends empty right hand in pointing gesture towards the toy hoop
5	Experimenter turns in the direction of the toy hoop and extends empty right hand in pointing gesture towards the toy hoop
6	Experimenter turns to look towards the toy hoop with no other body movement

A dog moved through the lure levels as he or she demonstrated an ability or inability to correctly perform the trick in response to each lure. In order to advance to the next lure level, the dog had to successfully perform the trick five trials in a row, similar to criteria in Blackwell, Bodnariu, Tyson, Bradshaw, and Casey (2010). If the dog made an error during five consecutive trials, he was demoted back to the previous lure level. Each dog could only attempt each lure level three times.

A trial began when the dog made eye contact with the experimenter, because greater attention to the handler significantly improves a dog's ability to respond correctly to obedience cues (Braem & Mills, 2010). The experimenter then said the cue “hoop” and performed the lure that corresponded to the current lure level the dog was attempting. The dog either then performed the trick successfully, for which he was reinforced with a click and a treat, or he made an error, which was marked either by a tone (the NRM group) or which was ignored (the IG group) and no treat was given. A success was defined as the dog walking to the toy hoop and placing his two front paws within it. A dog made an error by orienting his body away from the hoop, backing away from the hoop, jumping on the experimenter, sitting or lying down, or freezing for an excess of 30 seconds without approaching the toy hoop. Dogs were only reinforced for attempts to perform the trick immediately after the experimenter said “hoop” (Kelleher & Gollub, 1962). Once the dog was presented with feedback or was ignored, the experimenter reset her body in the left corner of the room to be ready for the next trial.

The training session ended if the dog successfully performed the trick five times in a row at lure level 6, made five errors in a row in lure level 1, had already attempted the current lure level three times, or when the dog completed the current lure level after training for more than 30 minutes[1]. The experimenter then verbally praised the dog for participation, turned off the camera, and took the dog back to daycare on leash.

Data Collection and Analysis

Each dog’s learning performance was measured by highest lure level attempted and the proportion of successes to total trials attempted. Training time was not taken into account due to the large individual differences in how quickly dogs completed each trial.

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[1] One dog (Derby) became unwilling to interact with the trainer for an extended period of time and was displaying acute stress behaviors during her first attempt at lure level 2. The training session was terminated as a result.

Each dog's stress levels were measured by coding each training video according to the behavioral ethogram in Table 3.

Table 3

Behavioral Ethogram Used to Code for Stress Behaviors During Training

Stress behavior	Definition	Origin of definition
Body shake	Dog vibrates body, starting from head, as if drying off.	Beerda et al. (1998)
Auto-groom	Dog executes a bout of behaviors directed towards the dog's own body, like scratching, licking, and biting itself.	Beerda et al. (1999)
Crouch	Dog exhibits at least two of these three behaviors: tail lowered below neutral position (for the individual dog), bent legs, or backward positioning of the ears OR dog ducks, with legs flexed and head towards ground.	Beerda et al. (1998); Schilder and van der Borg (2004)
Oral behavior	Dog licks snout (part of the tongue is shown and moved along the upper lip and/or nose); does not include licking objects or self or experimenter.	Beerda et al. (1998) – Because of the use of food in the current study, swallowing and lip smacking were not coded as stress behaviors, as they are more likely to be food-directed behaviors, rather than stress behaviors as in the original study.
Yawn	Dog opens the mouth and inhales and exhales air.	Jakovcevic et al. (2013)
Lie down	Dog puts whole body on the ground.	Jakovcevic et al. (2013)
Back up	Dog takes at least 2 steps (with front paws) to back away/retreat from experimenter or apparatus.	Horváth et al. (2007)
Withdrawal	Dog takes at least 2 steps (with front paws) while oriented away from experimenter/apparatus, where dog remains oriented away until movement stops or dog moves out of sight. When body and head are oriented differentially, the position of the head determines how orientation is categorized.	Jakovcevic et al. (2013); Bentosela et al. (2009)

Sniff	Dog puts muzzle on the ground, on the wall, a person, or objects, without chewing or eating anything. A sniff ends when dog's head returns to neutral position (even with shoulder height/not lowered). Sniffing bouts directed towards a treat should not be counted.	Jakovcevic et al. (2013); Sternberg
Vocalization	Dog barks, groans, snorts, or whines. Code vocalizations even if dog is out of sight.	Jakovcevic et al. (2013); Beerda et al. (1998)
Out of sight	At least 50% of dog's body leaves view of camera.	
Strike	30 seconds or more of inactivity: dog lying down while body oriented any direction or sitting with body and head facing away from experimenter. Change from sitting to lying down or vice versa signals a potential new strike.	

Two independent viewers coded for the presence or absence of each of the 12 stress behaviors within every 5-second interval of the training session. The codes for three videos (11.12% of 27 total videos) were used to calculate reliability between the two independent coders (Kappa = .706, $p < .001$, percentage agreement 96.6%). Because of the high level of reliability between the coders and the difficulty of the coding task, the scores of both coders were then averaged for all videos.

Results

Performance

Each dog's performance during the training sessions was evaluated both overall and on a trial-by-trial basis to measure how well the dog was able to learn the novel trick during the single training session. Performance was measured in two ways: the highest lure level the dog attempted during the training session and the proportion of successful trials to total trials attempted, see Table 4.

Dogs in the ignored condition performed better than the dogs in the NRM condition. A Mann-Whitney Test indicated that the dogs in the IG condition, *Mdn* = 4.00, attempted significantly higher lure levels than the dogs in the NRM condition, *Mdn* = 1.00, *U* = 39.5, *p* = 0.014. The proportion of successful trials for each dog was also significantly higher for the IG group (*M* = 0.600, *SD* = 0.069) than the NRM group (*M* = 0.268, *SD* = 0.298, *t*(25) = 3.91, *p* = 0.0006). Using a logistic regression model, condition was shown to be a significant predictor of individual trial outcome, *z* = 2.723, *p* = 0.006, where the odds of being successful on any given trial was 1.97 times higher for the dogs in the IG group than the dogs in the NRM group (see Appendix B, Analysis 1). Age (Spearman's rho, r_s = -.001, *p* = 0.87) and previous experience with clicker training (Mann-Whitney Test, *U* = 69.00, *p* = 0.528) did not have an effect on performance.

Table 4

Performance Statistics, Stress Ratings, and Previous Clicker Training Experience for All Dogs

Subject	Condition	Previous Clicker Experience	Highest Lure Level Attempted	Proportion of Successful Trials	Overall Stress Rating
Bull	IG	Some	6	0.714	0.143
Penny	IG	Some	6	0.606	0.097
Mattie	IG	No	5	0.563	0.085
Roy	IG	No	5	0.636	0.070
Jackson	IG	Some	5	0.564	0.089
Casey	IG	No	4	0.527	0.091
Gideon	IG	Some	4	0.592	0.118
Dudley	IG	No	4	0.554	0.143
Dolly	IG	No	3	0.667	0.151
Charlie	IG	Some	3	0.550	0.189
Barney	IG	Some	3	0.556	0.074
Bentley	IG	No	3	0.595	0.068
Teddy	IG	Some	2	0.526	0.123
Derby	IG	No	2	0.750	0.222
Bruno	NRM	No	6	0.759	0.095
Wilbur	NRM	No	4	0.567	0.148
Arema	NRM	No	4	0.533	0.067

George	NRM	No	4	0.607	0.121
Murphy	NRM	No	3	0.596	0.060
Happy	NRM	Some	1	0.250	0.201
Nola	NRM	Some	1	0.167	0.096
Oscar	NRM	No	1	0.000	0.240
Winnie	NRM	No	1	0.000	0.209
Dooley	NRM	No	1	0.000	0.195
Tali	NRM	No	1	0.000	0.167
Booboo	NRM	No	1	0.000	0.107
Phoebe	NRM	No	1	0.000	0.156

Due to the unequal distribution of dogs with previous clicker training experience across the two experimental conditions, it was important to check that the direction of the results was not affected when all previously clicker-trained dogs were removed. When only the dogs that were naïve to clicker training were included, the pattern of results remained the same, where the dogs in the IG group had significantly higher proportions of successful trials ($M = 0.613$, $SD = 0.077$) than the NRM group ($M = 0.278$, $SD = 0.325$, $t(16) = 2.654$, $p = 0.017$). The dogs in the IG group ($Mdn = 4.00$) also reached higher lure levels than the dogs in the NRM group ($Mdn = 1.00$), but this effect was not significant, $U = 21.00$, $p = 0.12$.

The outcome of the previous trial was also a very significant predictor of the current trial outcome, $z = 7.839$, $p < 0.001$. The odds of being successful on the current trial were more than 10 times greater if the previous trial had been a success (see Appendix B, analysis 2). While condition was a significant predictor of trial outcome on its own, when both condition and the outcome of the previous trial were included in the model, the outcome of the previous trial was significant but the effect of condition was not (see Appendix B, analysis 3).

The outcome of the current trial was not dependent on its lure level, but there was a significant interaction between lure level and condition, where dogs in the IG condition tended to reach higher lure levels than dogs in the NRM condition, but performed more errors at those higher lure levels (see Appendix B, analysis 4).

Not only were the dogs in the NRM group less likely to reach the highest lure levels, the dogs in the NRM group that began to fail early in the training session were not able to recover. In the NRM group, none of the eight dogs that had at least one error in the first lure level were able to progress to Level 2, while all three of the dogs in the IG group that made errors in Level 1 were able to progress to at least Level 2, see Figure 2. This difference was statistically significant by a Fisher exact test, p = .006. This pattern suggests that hearing an NRM early on in the learning process might play a role in a dog's inability to offer a variety of behaviors during training.

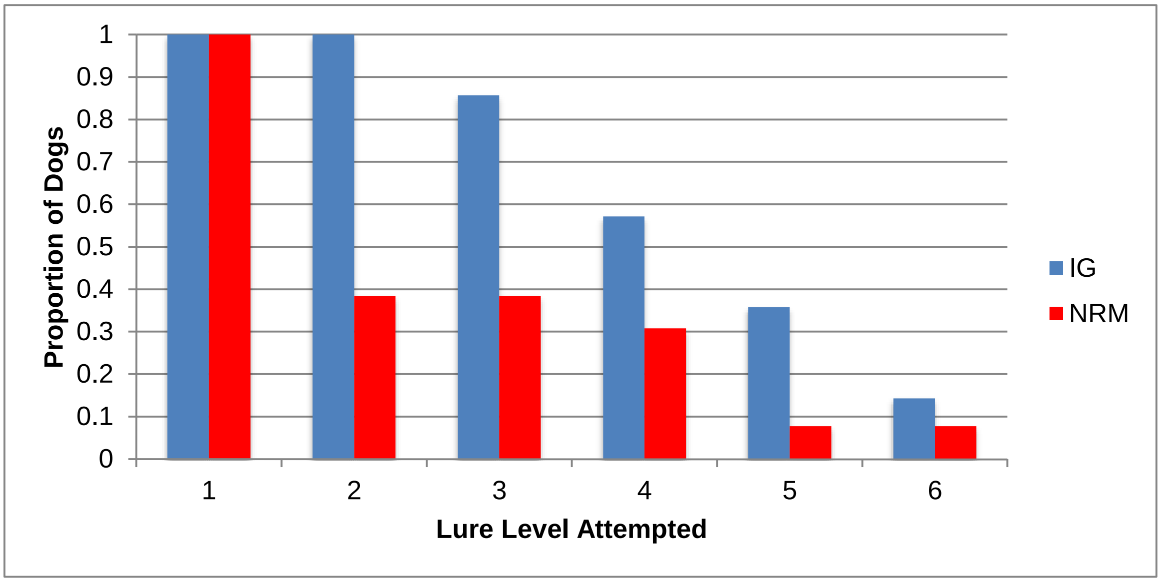

Figure 2. The proportion of dogs in the IG and NRM conditions that attempted each lure level.

Stress Behaviors

The amount of stress a dog experienced throughout the training session was measured using an overall and individual trial stress rating. A trial's stress rating was calculated by dividing the total number of occurrences of the 12 stress behaviors by the number of seconds in the trial. A dog's overall stress level during the entire training session was calculated by taking the mean of the stress ratings for all the trials the dog performed.

There was no significant difference in the overall stress ratings of the NRM dogs (M = 0.143, SD = 0.057) and the IG dogs (M = 0.119, SD = 0.046), $t(25) = 1.22$, $p = 0.234$, see Table 4. Neither the dog's age (Spearman's rho, $r_s = -.209$, $p = .861$) nor previous experience with clicker training (Mann-Whitney Test, $U = 79.00$, $p = .918$) had a significant effect on its stress level.

When analyzed on a trial-by-trial basis using a linear regression, the stress rating on any given trial was significantly predicted by the stress level on the previous trial, $p < 0.001$. This means that the more stress behaviors a dog exhibited during a trial, the more stress behaviors they are likely to exhibit in the next trial (see Appendix B, Analysis 5).

Across both conditions, sniffing, oral behaviors, walking out of sight of the camera, and withdrawing from the experimenter or apparatus were the most common stress behaviors observed. Taken together, these four stress behaviors made up more than 75% of all the stress behaviors coded. Figure 3 shows the breakdown for the frequency of all 12 of the stress behaviors observed.

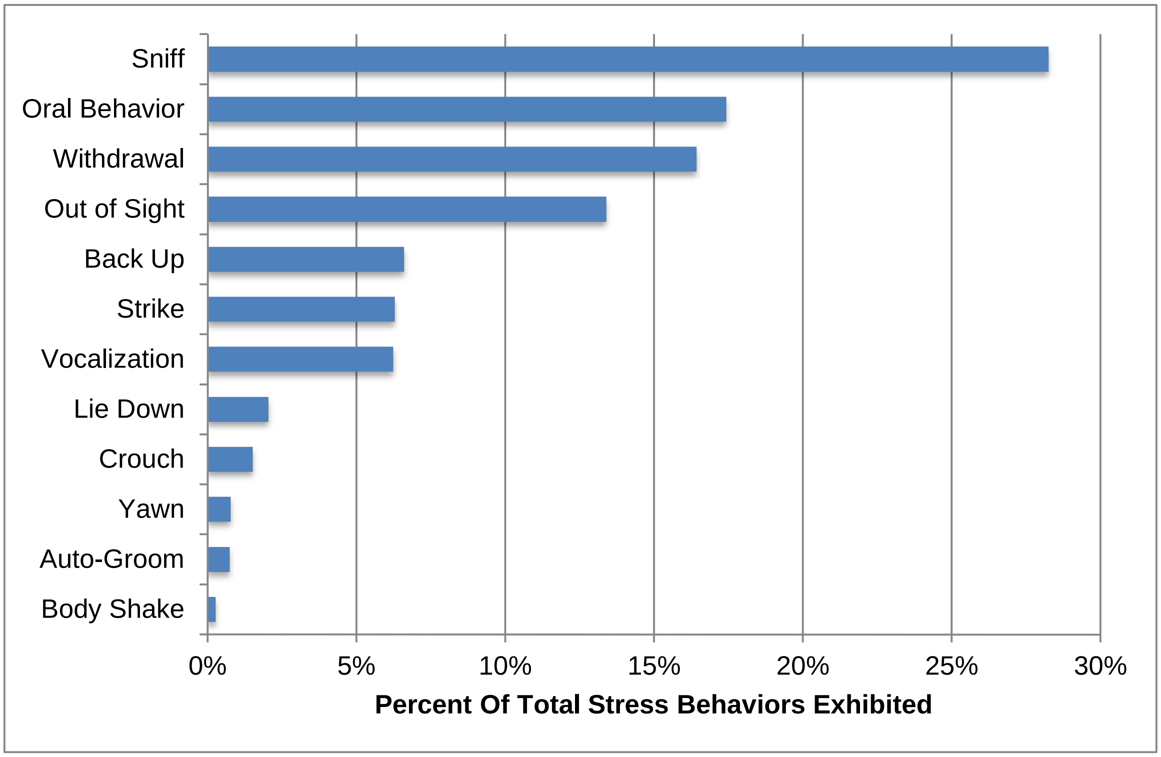

Figure 3. The percent of total stress behaviors contributed by each stress behavior, collapsed across experimental conditions.

Relationship Between Performance and Stress Behaviors

Taking into account that stress levels and learning are related (Yerkes & Dodson, 1908), it was important to examine the relationship between the stress levels in the dogs and how well they performed in the novel training task. Performance and stress were highly correlated ($r_s(27) = -.535$, $p = .004$), such that the dogs that reached higher lure levels tended to display fewer stress behaviors during training (see Figure 4).

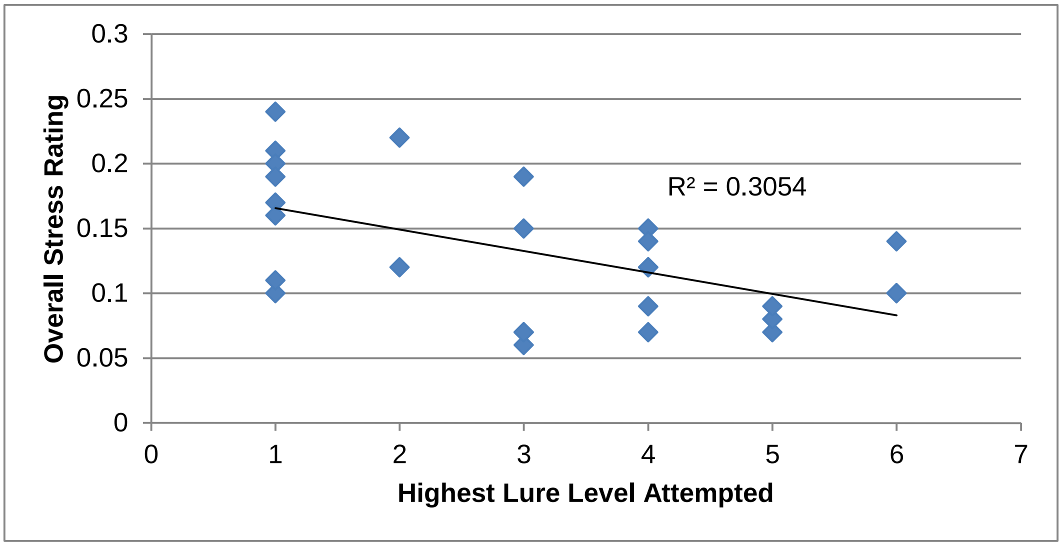

Figure 4. Correlation between overall stress behaviors and performance.

This pattern of results is also consistent with the training on a trial-by-trial basis. On a given trial, the dogs displayed significantly fewer stress behaviors during successful trials than during trials in which they made an error, $t = -4.125$, $p = 0.0001$ (see Appendix B, Analysis 6). Similarly, if a dog was successful on the previous trial, the stress rating of the current trial was likely to be lower than if they had made an error on the previous trial, $t = -2.56$, $p = 0.013$ (see Appendix B, Analysis 7). The stress rating of the previous trial also predicted the outcome of the current trial, where dogs that were less stressed on the previous trial are more likely to be successful on the current trial, $z = -3.035$, $p = 0.003$ (see Appendix B, Analysis 8).

Discussion

The results of this study indicate that when training a dog to perform a new behavior on cue, using an NRM can be detrimental to how efficiently the dog is able to acquire the new trick. In this study, ignoring the dogs' errors led more dogs to reach higher achievement levels over the course of the training session. Dogs whose errors were ignored (rather than marked with an NRM) also had significantly more successful trials over the course of the training session.

However, there was no overall difference in the number of stress behaviors exhibited by the dogs in either condition.

Not only did NRMs significantly affect dogs' performance overall, but they led many dogs to fail very early on in the training session. Dogs that heard an NRM following an early error continued to make errors, and none were able to progress to lure level 2. In contrast, dogs whose early errors were ignored were able to recover and eventually move on to at least lure level 2. This pattern of results lends credence to some trainers' assertions that hearing NRMs might cause certain dogs to abandon training, rather than attempting to work past their errors to perform the behavior correctly (Alexander, 2003; VanArendonk, 2010).

While overall, the dogs in the IG condition performed better than the dogs that heard NRMs, there were four dogs in the NRM condition that performed very well, reaching lure level 4 or higher[2]. It is possible that certain dogs are naturally more inclined to be receptive to negative feedback and are able to use it to inform the learning process, while other dogs cannot comprehend the negative feedback and continuously make errors during a learning task. These differences might be regulated by past learning experiences as well as genetic factors that affect an individual animal's ability to learn effectively from negative feedback (Klein et al., 2007). Further research is required to investigate what characteristics might allow us to predict an individual dog's proclivity to respond best to a certain type of feedback.

Despite the difference in how easily the dogs in both conditions acquired the new trick, there was no difference in how stressed the dogs were overall during the training sessions. It does not seem that using an NRM while training a new behavior is inherently more stressful for

[2] These dogs did not display significantly fewer stress behaviors than the other dogs in the NRM condition, $t(11) = -1.570$, $p = .145$.

dogs. All the dogs demonstrated some stress behaviors during the training, and this was to be expected, because low levels of arousal accompany and facilitate learning (de Kloet, Oitzl, & Joëls, 1999; Yerkes & Dodson, 1908). These results are in conflict with the welfare concerns some trainers have about using NRMs. While using NRMs during training might not help a dog perform well, it is unlikely that the dog's stress response to hearing an NRM would be destructively high.

The most common stress behaviors observed from dogs in both conditions were sniffing, withdrawing from the experimenter or toy hoop, walking out of sight of the video, and oral behaviors. These behaviors are consistent with the classic behavioral stress response, where a stressed animal attempts to withdraw from the source of stress and redirect their energy (Bear et al., 2007; Carere et al., 1999).

Although there was no difference in overall stress levels between the dogs whose errors were ignored and the dogs that heard an NRM following an error, there were fairly large individual differences in how many stress behaviors each dog exhibited during training. These differences in the stress response are consistent with studies showing that individual animals can display highly varied stress responses in reaction to the same stressors. There are high levels of disparity in how extensively the HPA axis and autonomic nervous system might activate in response to a given stressor (Joëls et al., 2006). Individual dogs also tend to display different stress behaviors as behavioral manifestations of their internal stress response. For instance, a dog might produce a certain stress behavior more often than another dog in the same context as a result of prior reinforcement, such as human attention (Rooney et al., 2007).

The current study did not differentiate between the types of stress behaviors being exhibited by the dogs. Behaviors that likely signaled acute stress (e.g. crouching, Beerda et al.

(1998)) were weighted the same as behaviors that could be attributed to frustration (e.g. yawning or sniffing, Jakovcevic et al. (2013)). Future studies could also examine stress behaviors directed at the source of frustration, like pawing or nosing at the toy hoop or jumping on the experimenter. Previous work has shown that animals sometimes take out their frustration on the operant device (McGowan, Rehn, Norling, & Keeling, 2014) or food dispenser (Lewis, 1999) when their expectations are violated. It is possible that differentiating between these types of behaviors could provide more insight into the type of stress response an individual dog might experience when presented with a similar training challenge, and allow for more understanding of the link between stress and performance in dog training.

It is also important to note that stress behaviors are not the only possible proxy measurement for dogs' stress response in response to a training challenge. While minimally invasive, coding for frequency of stress behaviors is a more subjective measurement than salivary cortisol levels, another commonly used indicator of animals' stress levels. However, measuring salivary cortisol levels would not allow for analyses on a trial-by-trial basis. A combination of both types of measurement might have allowed for a more complete picture of the changes in the dogs' stress response over time in response to the training and type of feedback they received.

This study suggests that ignoring dogs' errors while training a novel behavior leads to better performance than using an NRM. It is important to consider possible explanations for why this result might have emerged. It is possible that the dogs in the NRM condition performed poorly because of an inherent flaw in the nature of negative feedback. While there is only one way to perform the trick correctly, there are many more ways to produce an error. As a result, it is a considerably more difficult task for the trainer to produce the NRM at the correct time, which makes the NRM a relatively poor quality form of feedback. This same issue can be seen when using punishment in real-world training scenarios, where punishment is often unable to be initiated at the exact onset of undesired behaviors (Solomon, Turner, & Lessac, 1968). Poor timing increases the chances that the learner becomes confused, rather than informed by the feedback being offered by the trainer.

Another possible explanation for the poorer performance of the dogs in the NRM condition lies in the nature of the training task, where the dogs were given negative feedback while learning a novel trick. Some trainers advocate for the use of NRMs primarily as tools to train tricks that specifically aim to extinguish an undesired behavior. For example, trainer Victoria Stilwell advocates for the use of NRMs when training a dog the cue “leave it,” where the dog is required to inhibit his own desires and ignore an attractive piece of food or a toy. If the dog lunges for the treat or toy, Stilwell uses an NRM to let the dog know that its choice will not be rewarded (Stilwell, 2015). Trainer Jean Donaldson uses an NRM in a similar way when teaching dogs to walk on a loose leash: if the dog surges ahead and pulls the leash taut, she uses an NRM as negative feedback for that behavior (Donaldson, 2013). Simon Gadbois uses NRMs to train dogs to discriminate between clearly delineated scents, where the dog is rewarded for correctly alerting to the target scent but hears an NRM when he alerts in error (Gadbois, 2015). In these contexts, the role of the NRM is to extinguish an undesirable behavior. This is in contrast to the goal of the current study, where the dogs were being taught to offer a new behavior. Future work should examine the efficacy of NRMs while training these other types of tasks.

Another reason the NRM might not have helped the dogs in the current study is that the tone used as an NRM was not conditioned prior to being used as negative feedback. The first time the dogs in the NRM condition heard the tone was when they made their first error during training. It is possible, therefore, that the tone just wasn't meaningful to the dogs; it was merely an extraneous stimulus from the environment, rather than a helpful piece of information. Future studies could explore whether explicitly conditioning the NRM (Donaldson, 2013; Reid, 2009) would improve dogs' performance when being trained in novel behaviors.

The results of this study provide concrete support for avoiding the use of NRMs when teaching a new behavior and for tracking the stress behaviors a dog exhibits during training. Because the number of stress behaviors a dog displays during training is a good indicator of how well he or she will perform, trainers should reduce the difficulty or abort a training task if their dog begins displaying an above average rate of stress behaviors. Also, when teaching a new trick, it is more effective to avoid giving negative feedback in response to errors, and to focus on reinforcing the dog's offerings of the target behavior. It is natural to want to be encouraging and motivational during training, focusing more on positive rather than negative feedback (Thomaz, Hoffman, & Breazeal, 2006). Focusing on reinforcement only requires the trainer to produce one type of feedback, which should also make the training process simpler for novice trainers. Using only positive reinforcement and ignoring errors can help dogs achieve high levels of performance when learning new behaviors. In light of these results, trainers might examine their use of NRMs and consider whether they are truly helping to yield high levels of performance and causing less stress to the dogs they are training.

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Appendix A. Consent form signed by dog owners to allow their pets to participate.

RUBY & JACK'S DOGGY SHACK

Participate in a Dog Training Research Study!

Purpose: We are inviting your dog to participate in a research project comparing two different types of verbal feedback dog trainers and owners often use when training dogs. The purpose of this study is to better understand what helps dogs learn.

Procedure: During two days of daycare, your dog will be trained to place his or her front two paws in a hula-hoop on the floor and to touch a sticky note with their nose. Each training session will take no longer than an hour and will be videotaped. The videotapes will only be used for scientific purposes and you can request a copy to watch at home.

Risk, stress, and discomfort: There are no known risks to your dog for participating in this study. Dogs often really enjoy training sessions. If your dog seems to lose interest in the training session, the trainer will take a short break. If your dog seems overly stressed or continues to be uninterested in training, the training will stop immediately and your dog will be returned to daycare.

Other information: If you have questions regarding the procedure or participation in this study, please contact the primary researcher, Naomi Rotenberg, by email at naomi.h.rotenberg@gmail.com.

Owner's Statement: *The methods, inconveniences, risks, and benefits have been explained to me and my questions have been answered. I understand that access to this consent form will be restricted to Ruby and Jack's and the primary researcher.*

I (print name) ________________ allow my dog (print dog's name)

_________________ to participate in the above study.

Owner's signature: __________________________ Date: _____________

Researcher's signature: ______________________ Date: _____________

Has your dog had any experience with clicker training? YES NO

Does your dog have any food allergies? YES NO

If yes, please list here: ____

Appendix B. Results of individual mixed-effects model analyses.

* = p value less than .05, ** = p value less than .01, *** = p value less than .001

Analysis 1: Log-odds of success on an individual trial as a function of experimental condition.
Formula: Outcome ~ Condition + (1 | DogName)
Fixed Effects:

	Estimate	Standard Error	Z value	P value	Change in Odds
(Intercept)	-0.2840	0.1979	-1.435	0.15124	0.753
Condition	0.6761	0.2483	2.723	0.00648**	1.966

Analysis 2: Log-odds of success on an individual trial as a function of the previous trial's outcome.
Formula: Outcome ~ PreviousTrialOutcome + (PreviousTrialOutcome | DogName)
Fixed Effects:

	Estimate	Standard Error	Z value	P value	Change in Odds
(Intercept)	-1.0501	0.1848	-5.682	1.33e-08***	0.349
Previous Trial Outcome	2.3893	0.3048	7.839	4.54e-15***	10.906

Analysis 3: Log-odds of success on an individual trial as a function of condition and the previous trial's outcome
Formula: Outcome ~ Condition + PreviousTrialOutcome + (1 + PreviousTrialOutcome | DogName)
Fixed Effects:

	Estimate	Standard Error	Z value	P value	Change in Odds
(Intercept)	-1.1319	0.2087	-5.424	5.82e-08***	0.322
Condition	0.1460	0.1565	0.933	0.351	1.157
Previous Trial Outcome	2.3569	0.3016	7.814	5.54e-15***	10.558

Analysis 4: Log-odds of success on an individual trial as a function of the trial's lure level and condition
Formula: Outcome ~ LureLevel * Condition + (1 + LureLevel | DogName)
Fixed Effects:

	Estimate	Standard Error	Z value	P value	Change in Odds
(Intercept)	-0.9952	1.5785	-0.630	0.52838	0.369
Lure Level	0.7424	0.6108	1.215	0.22424	2.101
Condition	5.7496	2.1443	2.681	0.00733**	314.065

Lure Level x Condition	-2.3467	0.8150	-2.879	0.00398**	0.096

Analysis 5: Stress rating on an individual trial as a function of the stress rating of the previous trial
Formula: TrialStressRating ~ PreviousTrialStressRating + (1 + PreviousTrialStressRating | DogName)
Fixed Effects:

	Estimate	Standard Error	t value
(Intercept)	0.08349	0.00714	11.694
Previous Trial Stress Rating	0.26137	0.04426	5.906

Analysis 6: Stress rating on an individual trial as a function of the outcome of that trial
Formula: TrialStressRating ~ Outcome + (1 + Outcome | DogName)
Fixed Effects:

	Estimate	Standard Error	t value
(Intercept)	0.14302	0.01225	11.673
Trial Outcome	-0.04250	0.01030	-4.125

Analysis 7: Stress rating on an individual trial as a function of the outcome of the previous trial
Formula: TrialStressRating ~ PreviousTrialOutcome + (1 + PreviousTrialOutcome | DogName)
Fixed Effects:

	Estimate	Standard Error	t value
(Intercept)	0.131183	0.011385	11.52
Previous Trial Outcome	-0.021183	0.008274	-2.56

Analysis 8: Log-odds of success on an individual trial as a function of the previous trial's stress rating
Formula: Success ~ PreviousTrialStressRating + (1 + PreviousTrialStressRating | DogName)
Fixed effects:

	Estimate	Standard Error	Z value	P value	Change in Odds
(Intercept)	0.6645	0.1598	4.159	3.19e-05***	1.944
Previous Trial Stress Rating	-4.0096	1.3213	-3.035	0.00241**	0.018