Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Applied Animal Behaviour Science xxx (2007) xxx–xxx
APPLIED ANIMAL BEHAVIOUR SCIENCE
www.elsevier.com/locate/applanim

Clicker increases resistance to extinction but does not decrease training time of a simple operant task in domestic dogs (*Canis familiaris*)

Shawn M. Smith [a], Ellen S. Davis [b,*]

[a] *Department of Psychology, University of Wisconsin-Whitewater, 800 West Main St., Whitewater, WI 53190, USA*

[b] *Department of Biological Sciences, University of Wisconsin-Whitewater, 800 West Main St., Whitewater, WI 53190, USA*

Accepted 10 April 2007

Abstract

Despite its popularity among pet owners and professional trainers, we are not aware of any studies that have investigated the efficacy of clicker training in canines. To this end, we taught 35 basenjis to nose-touch an orange traffic cone. Upon meeting pre-determined criteria, dogs progressed through: (1) training trials, wherein correct responses were followed immediately with a click plus food (clicker group) or food alone (control group); (2) strengthening trials, wherein dogs received the same reinforcement protocol as in training trials, except nose-touching behaviour was variably reinforced; and (3) extinction trials, wherein food was withheld from both groups, but dogs in the clicker group received a click alone for nose-touches. We found that the clicker and control groups did not differ with regard to the number of trials or the time required to meet training or strengthening criteria ($P > 0.05$ for all). However, the clicker group required significantly more trials ($\log_{10}$ transformed means ± S.E. = 1.6 ± 0.03 trials versus 1.4 ± 0.03 trials, $P < 0.001$) and more time ($\log_{10}$ transformed means ± S.E. = 2.85 ± 0.03 s versus 2.73 ± 0.03 s, $P = 0.008$) to reach extinction criterion. Additionally, younger dogs required fewer training ($\eta_p^2 = 0.304$, $P = 0.001$) and strengthening ($\eta_p^2 = 0.140$, $P = 0.029$) trials and less training ($\eta_p^2 = 0.221$, $P = 0.005$) and strengthening ($\eta_p^2 = 0.180$, $P = 0.013$) time to meet criteria than did older dogs. However, no age effect was found on extinction for either the number or duration of trials ($P > 0.05$ for both), implying that persistence in previously reinforced behaviour did not influence the age sensitivity found in task acquisition. Overall, these results suggest that, whereas the clicker may prolong behaviour without primary reinforcement, it does not reduce the training time of a simple operant task in dogs when primary reinforcement is briefly delayed. We speculate that the clicker may be most useful in maintaining established behaviours when primary reinforcement is unavailable or when its delivery is impractical.

* Corresponding author. Tel.: +1 262 472 5141; fax: +1 262 472 5633.
E-mail address: davise@uww.edu (E.S. Davis).

doi:10.1016/j.applanim.2007.04.012

Additionally, we found that basenji dogs may become progressively impaired with age in the acquisition of stimulus-reward contingencies.

Keywords: Dog; Clicker training; Operant conditioning; Secondary reinforcers; Age influence

1. Introduction

Various forms of clicker training (Skinner, 1951; Pryor, 1999, 2005; Fjellanger, 2003) have been used to teach a variety of tasks to horses (Flannery, 1997; Ferguson and Rosales-Ruiz, 2001; Williams et al., 2004), as well as human cancer detection to dogs (Willis et al., 2004; McCulloch et al., 2006). Such training employs a clicker, a device that emits a distinct, double-click sound. This double-click sound is typically followed by delivery of a primary reinforcer (such as food) which by common definition has intrinsic value to the animal (Kelleher and Gollub, 1962). Pryor (1999, 2005) asserts that training time can be decreased by sounding a clicker at the instant the animal performs the desired behaviour and immediately following the click with food. She proposes that such a decrease can occur via three separate mechanisms. The first mechanism proposed by Pryor (1999, 2005) is that the clicker acts as a conditioned/secondary reinforcer whereby an initially neutral stimulus gains reinforcing value through its repeated, close temporal pairing with a primary reinforcer (Skinner, 1938; Hull, 1943). Secondly, Pryor (1999, 2005) suggests the clicker may act as a marking signal (Williams, 1994), which serves to distinguish for the animal a particular behaviour as the event that has earned the primary reinforcer. Finally, Pryor (1999) suggests that the clicker serves as a bridging stimulus (Williams, 1994), which fills the temporal gap between the behaviour and the primary reinforcer by signaling that the primary reinforcer is coming. Pryor (2005) asserts that dogs trained with food reinforcements alone are often eager, but that they learn slowly without the clear signal provided by the clicker.

Despite the popularity of clicker training among pet owners and professional animal trainers, we know of only two studies (McCall and Burgin, 2002; Williams et al., 2004) that have investigated clicker training techniques, neither of which involved dogs or showed much support for superior efficacy of this training method over the delivery of food alone. The use of conditioned reinforcers plus food did not decrease the amount of training required to teach novel behaviours to horses compared with using food alone (McCall and Burgin, 2002; Williams et al., 2004). Additionally, conditioned reinforcers had no effect on how long horses continued the newly-acquired behaviours in extinction trials in which primary reinforcement (food) was withheld (McCall and Burgin, 2002; Williams et al., 2004). However, learning a second new behaviour (flap pushing) was briefly facilitated by a conditioned reinforcer alone in horses that previously had received food paired with that conditioned reinforcer (McCall and Burgin, 2002). Regardless, as the clicker is commonly used in dog training, there is a clear need to study its utility in that species.

The purpose of this study was to determine if the use of a clicker to train a novel behaviour (nose-touching) to pet dogs in a typical training setting (their own homes) decreases training time or increases resistance to extinction, as would be expected if the clicker provides a detectable amount of precise feedback as a conditioned reinforcer, salient marker, or bridging stimulus as described above. Further, because there is conflicting evidence as to whether the acquisition of a simple operant task in canines is sensitive to age (see, Milgram et al., 1994; Cummings et al., 1996; Adams et al., 2000), we also explored the issue of age effects on learning.

Please cite this article in press as: Smith, S.M., Davis, E.S., Clicker increases resistance to extinction but does not decrease training time of a simple operant task in domestic dogs (*Canis familiaris*), Appl. Anim. Behav. Sci. (2007), doi:10.1016/j.applanim.2007.04.012

2. Materials and methods

2.1. Subjects

Thirty-five purebred basenji dogs were recruited through their owners who were members of a breed club in southern Wisconsin, USA. None of the recruited dogs had been previously exposed to a clicker. Subjects were raised in companion homes, and all but three 6-month-old puppies had had previous experience actively obtaining food through training with their owners. Owners were asked not to feed their dogs for at least 3 h in advance of their daily experimental session. All dogs remained in the custody of their owners during the entire study. All procedures met university Institutional Animal Care and Use Committee standards for conducting research with animal subjects (Protocol Case Number D045040006Q). Each dog was randomly assigned to the clicker ($n = 18$) and control ($n = 17$) groups with the caveat that the last two dogs (both 6 months of age) were assigned to balance sex between the groups (see Table 1 for detailed subject information).

2.2. Owner questionnaire

Owners completed a one-page questionnaire, which asked each dog's age, sex, number of pre-experimental well-trained behaviours (those the dog would perform always or most of the time on cue) and somewhat-trained behaviours (those the dog would perform sometimes or rarely on cue).

2.3. Equipment and training area

All experimental sessions occurred in the same quiet, but not completely distraction-free, room in each dog's home. Each subject was loosely restrained by a 1.8 m cotton leash attached to a flat nylon collar around its neck. During trials, the end of the leash was held to the ground by the trainer's foot, giving the subject opportunity for movement around, but not out of, the immediate training area (approximately 3.0 m in diameter). The trainer remained seated approximately 0.7 m from a stainless steel food bowl. An orange traffic cone was placed between the trainer and the food bowl. Small pieces, approximately 0.6 cm^3, of beef summer sausage were stored in a treat holder about the trainer's waist. A clicker was attached to a lanyard around the trainer's neck only in the presence of dogs in the clicker group. An assistant recorded the duration of each trial using a silent stopwatch. To ensure that the assistant did not give any incidental cues to the dogs, he remained seated approximately 2.0 m across from the trainer such that the dogs had their backs to the assistant when focusing on the trainer, food bowl and cone. Additionally, the assistant remained silent and did not give any reinforcements to the dogs. The same female trainer and male assistant worked with all dogs in this study.

Table 1
Comparison of age, sex, and previous training history between dogs in the clicker and control groups

Variable	Clicker group ($n = 18$)	Control group ($n = 17$)	$t_{(33)}$	P
Age (years) (mean ± S.E.)	5.5 ± 0.99	5.1 ± 0.98	−0.233	0.818
Sex				
No. of females (F); males (M)	13 F; 5 M	12 F; 5 M	−0.104	0.918
No. of neutered (N); intact (I) females	5 N; 8 I	4 N; 8 I		
No. of neutered (N); intact (I) males	5 N	2 N; 3 I		
Well-trained behaviours (mean ± S.E.)	4.3 ± 1.08	3.7 ± 0.59	−0.504	0.617
Somewhat-trained behaviours (mean ± S.E.)	2.3 ± 0.43	2.4 ± 0.45	0.122	0.904

Note: Data were obtained from dogs' owners. Well-trained behaviours = number of behaviours dog performs always or most of the time on cue. Somewhat-trained behaviours = number of behaviours dog performs sometimes or rarely on cue.

Please cite this article in press as: Smith, S.M., Davis, E.S., Clicker increases resistance to extinction but does not decrease training time of a simple operant task in domestic dogs (*Canis familiaris*), Appl. Anim. Behav. Sci. (2007), doi:10.1016/j.applanim.2007.04.012

2.4. Procedure

All dogs progressed through conditioning, training, strengthening, and extinction sessions, wherein each session consisted of multiple trials. Progression to the next stage occurred only after the dog met the performance criterion specific to the prior stage. All protocols and their respective criteria are explained immediately below. To accurately replicate a typical dog trainer's use of the clicker, timed intertrial intervals were not used. Instead, except for the first trial of each day, each new trial began when the dog looked at the trainer or the cone after receiving reinforcement from the previous trial.

2.4.1. Conditioning

The purpose of the conditioning trials was to teach dogs in the clicker group that a click predicted food delivery and to teach dogs that food would be delivered in the food bowl (not directly from the treat bag or the trainer's hand which was the initial, excited focus of all dogs). The conditioning session began after each dog accepted two individual pieces of food within 10 s of its placement in the bowl by the trainer. Once conditioning trials began, food was placed in the bowl approximately 1 s after a click for dogs in the clicker group. To ensure that dogs in the clicker group understood that the click predicted food delivery, they were required to meet the criterion of eating the food from the bowl within 5 s of the click for 10 consecutive trials or to receive a maximum of 20 click-food pairings, which meets or exceeds the minimum number of pairings thought to be necessary to establish the click as a predictor of food (Skinner, 1951; Pryor, 2005). Sixteen of the 18 clicker dogs reached conditioning criterion before this maximum. To avoid any difference in the amount of time spent with the trainer and the number of food reinforcements received in the conditioning session, dogs in the control group received 10–20 food deliveries directly to the bowl, the exact number of which was randomly determined for each dog.

2.4.2. Training

The purpose of training trials was to teach each dog to touch its nose to any part of the traffic cone upon a verbal cue, ''touch.'' Trials were limited to 40 per day beginning on the same day conditioning criterion was met, and continued on consecutive days thereafter. All correct responses by dogs in the clicker group received a click that was followed immediately by food placed in the bowl ($\sim$1 s after the click). All correct responses by dogs in the control group were reinforced with food alone.

Training occurred in four successive steps. Criterion was attained at each step before continuing onto the next step. *Step One* was an un-timed trial wherein the trainer introduced the cone, and the dog's behaviour was reinforced for looking at or touching the cone. *Step Two* consisted of timed trials in which the trainer lured the dog to look at the cone by holding food in front of the cone. Latency from the lure cue to the look behaviour was recorded, and the criterion for advancing to Step Three was $\leq$5 s latency for two consecutive trials. During *Step Three*, the trainer pointed to the cone and simultaneously said ''touch.'' Latency from the point cue to the touch behaviour was recorded, and the criterion for advancing to Step Four was $\leq$5 s latency for five consecutive trials. During *Step Four*, the trainer said ''touch'' (omitting the hand signal). Latency from the verbal cue ''touch'' to the touch behaviour was recorded, and the criterion was $\leq$5 s latency for 10 consecutive trials. To encourage dogs to point their noses towards the cone, all nose-touches that came within approximately 0.50 cm of the cone were reinforced even if actual nose contact with the cone was not made. If a subject did not nose-touch within 60 s of the cue during Steps Two, Three, or Four, that time (60 s) was recorded, and a new trial began with a step-back procedure. The step-back procedure consisted of reverting back to the previous cue one time. For example, the trainer pointed (Step Three cue) once to the cone for a dog failing to nose-touch within 60 s in Step Four. All subsequent training trials with that dog would be conducted using the Step Four cue.

2.4.3. Strengthening

The purpose of strengthening trials was to make the nose-touching behaviour more resistant to extinction (Pierce and Cheney, 2004). Trials were limited to 40 per day beginning on the same day that the Step Four training criterion was met and continued on consecutive days thereafter. All dogs received reinforcement

Please cite this article in press as: Smith, S.M., Davis, E.S., Clicker increases resistance to extinction but does not decrease training time of a simple operant task in domestic dogs (*Canis familiaris*), Appl. Anim. Behav. Sci. (2007), doi:10.1016/j.applanim.2007.04.012

after one to three nose-touches such that, on average, every two nose-touches were reinforced (VR 2 schedule), with the condition that each subject's first touch of the day was always reinforced. During trials that were pre-determined to be reinforced (as long as the dog performed correctly), dogs in the clicker group received a click followed immediately by food (~1 s after the click), and dogs in the control group received food alone. Dogs were required to give a definite, firm nose touch to receive reinforcement. Latency from the verbal cue ‘‘touch’’ until the dog performed the touch behaviour was recorded. If the dog did not nose-touch within 60 s of the cue, no reinforcement was given, but 60 s was recorded and a new trial began. Strengthening criterion was $\leq$5 s latency in nine out of 10 consecutive trials on two consecutive days.

2.4.4. Extinction

The purpose of the extinction trials was to determine if the clicker prolonged nose-touching behaviour when primary reinforcement (food) was completely withheld. Because satiation was not an issue during extinction trials, the trial limit was increased to 60 per day beginning on the same day strengthening criterion was met and continued on consecutive days thereafter. Dogs in the clicker group received a click alone for each touch response. Dogs in the control group received no reinforcement for touch responses. Latency from the verbal cue ‘‘touch’’ until the dog performed the touch behaviour was recorded. Because dogs entered extinction trials with a strong history of nose-touching within 5 s of the cue, reducing the single trial limit to 30 s (from 60 s in previous sessions) allowed the trainer to give more cues in less time during extinction. Upon meeting the extinction criterion of no response within 30 s of the cue for 10 consecutive trials, subjects completed the extinction session and the study.

2.5. Statistical analyses

All statistics were performed using SPSS Version 11.0 for Mac. Initial *t*-tests were performed to ensure the groups did not differ with regard to age, sex, previous training history, number of conditioning trials required, and total number of food reinforcements received. Data for the total number and duration (in seconds) of training, strengthening, and extinction trials were log transformed to satisfy normality requirements. Analyses of covariance (ANCOVA) were used to determine the effect of treatment with age as a covariate upon the total number and duration of training, strengthening, or extinction trials. Similar to r^2 in regression analyses, we report partial eta squared from these analyses as a measure of the strength of the correlation between age and the total number and duration of training, strengthening, or extinction trials. Regression analyses were used to determine if the number of click-food pairings received by the clicker dogs in conditioning trials had an effect on either the total number or duration of trials required to meet training criteria. Additionally, regression analyses were used to determine if the number of food reinforcements received by the clicker and control groups prior to extinction trials varied with the number or duration of trials required to meet extinction criterion. We report β coefficients (the standardized regression coefficient) for these regression analyses.

3. Results

3.1. Preliminary analyses

Dogs took two to six consecutive days to complete conditioning, training, strengthening and extinction sessions. Preliminary analyses found no significant difference between the clicker and control groups with regard to age, sex or training history (Table 1). Additionally, there were no differences between the clicker and control groups with regard to the number of conditioning trials required (mean ± S.E. = 13.4 ± 0.84 and 14.6 ± 0.69, respectively, $t_{(33)} = 1.047$, $P = 0.30$) or the total number of food reinforcements received (mean ± S.E. = 81.4 ± 5.28 and 94.4 ± 5.92, respectively, $t_{(33)} = 1.639$, $P = 0.111$) during all trials.

Please cite this article in press as: Smith, S.M., Davis, E.S., Clicker increases resistance to extinction but does not decrease training time of a simple operant task in domestic dogs (*Canis familiaris*), Appl. Anim. Behav. Sci. (2007), doi:10.1016/j.applanim.2007.04.012

Table 2
The mean number and duration (s) of trials required to train nose-touching behaviour in dogs

Training criteria	Log (10) transformed mean ± S.E.	Back-transformed mean + S.E.; −S.E.	$F_{(1,32)}$	P
Number of trials				
ANCOVA (overall model)			8.311	0.001
Treatment			3.145	0.086
Clicker	1.7 ± 0.04	51.9 + 5.05; −4.60		
Control	1.8 ± 0.04	61.9 + 5.66; −5.19		
Age covariate			13.985	0.001
Duration (s) of trials				
ANCOVA (overall model)			5.225	0.011
Treatment			1.651	0.208
Clicker	2.56 ± 0.07	362.65 + 66.25; −56.02		
Control	2.67 ± 0.07	463.39 + 82.67; −70.16		
Age covariate			9.095	0.005

Note: Dogs were trained on a continuous reinforcement schedule with either a clicker + food (clicker, $n = 18$) or food alone (control, $n = 17$).

3.2. Training

There was no difference between the clicker and control groups for either the total number or duration required to meet training criteria (Table 2). However, younger dogs reached training criteria in fewer trials ($\eta_p^2 = 0.304$, $P = 0.001$) and in less time ($\eta_p^2 = 0.221$, $P = 0.005$) than older dogs (Table 2; Fig. 1a and b). The number of click-food pairings received in conditioning trials by dogs in the clicker group had no effect on the total number ($\beta = 0.382$, $t_{(16)} = 1.651$, $P = 0.118$) or duration ($\beta = 0.331$, $t_{(16)} = 1.404$, $P = 0.179$) of trials required to meet training criteria.

3.3. Strengthening

There was no difference between the clicker and control groups for either the total number or duration of trials (Table 3) required to meet strengthening criterion. However, younger dogs reached strengthening criterion in fewer trials ($\eta_p^2 = 0.140$, $P = 0.029$) and in less time ($\eta_p^2 = 0.180$, $P = 0.013$) than did older dogs (Table 3; Fig. 1c and d).

3.4. Extinction

There was a significant difference between the clicker and control groups for both the total number and duration of trials required to meet extinction criterion (Table 4). The clicker group required more trials and more time to reach extinction criterion than did the control group. However, there was no signficant effect of age either for the number ($\eta_p^2 = 0.062$, $P = 0.154$) or for the duration ($\eta_p^2 = 0.086$, $P = 0.091$) of extinction trials (Table 4). Additionally, the number of food reinforcements received by the clicker and control groups prior to extinction trials did not vary with the number ($\beta = -0.317$, $t_{(33)} = -1.917$, $P = 0.064$) or duration ($\beta = -0.269$, $t_{(33)} = -1.602$, $P = 0.119$) of trials required to meet extinction criterion. Although the effect of the total number of reinforcements on the number of extinction trials did approach significance, the negative relationship suggests that, if anything, dogs receiving more reinforcements required

Please cite this article in press as: Smith, S.M., Davis, E.S., Clicker increases resistance to extinction but does not decrease training time of a simple operant task in domestic dogs (*Canis familiaris*), Appl. Anim. Behav. Sci. (2007), doi:10.1016/j.applanim.2007.04.012

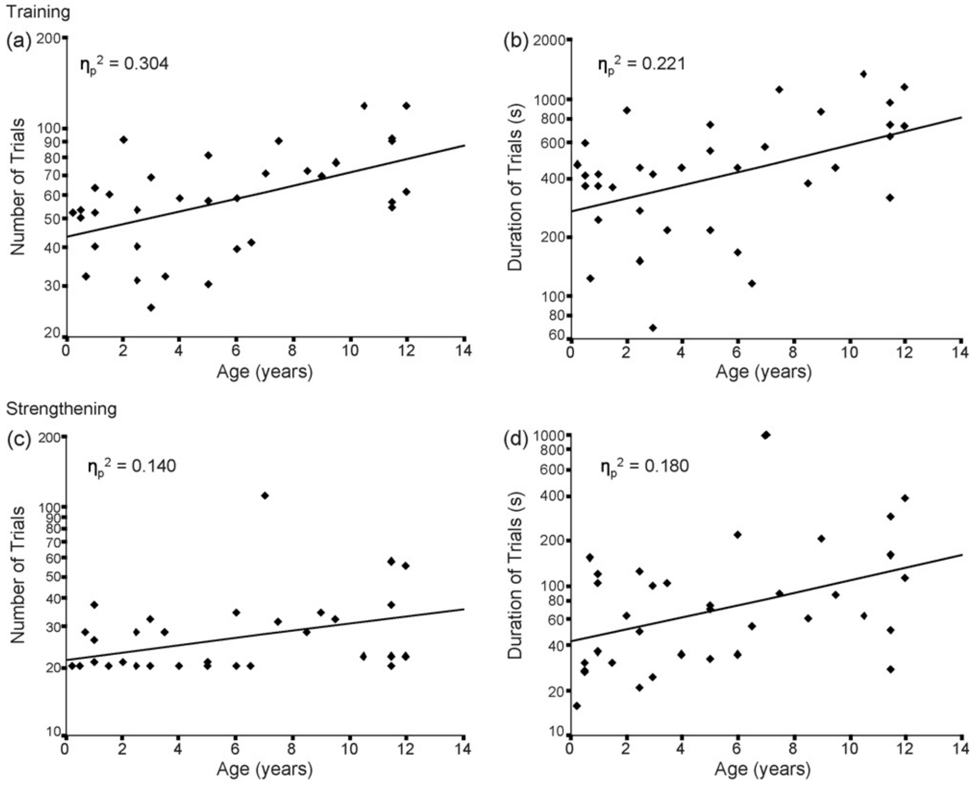

Fig. 1. The number and duration (s) of trials required for dogs to reach experimental criteria. Training (a and b) on a continuous reinforcement schedule and strengthening (c and d) on a variable ratio 2 schedule were positively correlated with age (least squares fit; log-scale *y*-axis).

Table 3
The mean number and duration (s) of trials required to strengthen nose-touching behaviour in dogs

Strengthening criterion	Log (10) transformed mean ± S.E.	Back-transformed mean + S.E.; −S.E.	$F_{(1,32)}$	*P*
Number of trials				
ANCOVA (overall model)			2.612	0.089
Treatment			<0.001	0.997
Clicker	1.4 ± 0.03	26.4 + 1.95; −1.82		
Control	1.4 ± 0.05	26.1 + 3.09; −2.76		
Age covariate			5.217	0.029
Duration (s) of trials				
ANCOVA (overall model)			3.514	0.042
Treatment			0.003	0.958
Clicker	1.86 ± 0.08	71.71 + 14.20; −11.85		
Control	1.84 ± 0.11	68.50 + 20.14; −15.56		
Age covariate			7.002	0.013

Note: Dogs' behaviour was strengthened on a VR 2 schedule with either a clicker + food (clicker, n = 18) or food alone (control, n = 17).

Table 4
The mean number and duration (s) of trials required to extinguish nose-touching behaviour in dogs

Extinction criterion	Log (10) transformed mean ± S.E.	Back-transformed mean + S.E.; −S.E.	$F_{(1,32)}$	P
Number of trials				
ANCOVA (overall model)			10.481	<0.001
Treatment			19.316	<0.001
Clicker	1.6 ± 0.03	41.2 + 3.13; −2.91		
Control	1.4 ± 0.03	26.3 + 2.05; −1.90		
Age covariate			2.131	0.154
Duration (s) of trials				
ANCOVA (overall model)			5.260	0.011
Treatment			7.869	0.008
Clicker	2.85 ± 0.03	701.61 + 53.89; −50.05		
Control	2.73 ± 0.03	538.76 + 36.61; −34.28		
Age covariate			3.029	0.091

Note: Dogs in the clicker group ($n = 18$) received a click for each correct response. Dogs in the control group ($n = 17$) received no reinforcement.

fewer extinction trials, but again, preliminary analyses above showed no difference in the number of reinforcements received between groups. Overall, neither age nor the number of reinforcements received contributed to the treatment effect on extinction.

4. Discussion

Neither the number of trials nor the time required to train and strengthen nose-touching differed between dogs whose behaviour was reinforced with a click plus food and those whose behaviour was reinforced with food alone. This finding suggests that the clicker did not provide feedback as a marking or bridging stimulus (Williams, 1994). However, the clicker group did require more trials and more time to reach extinction criterion than did the control group, suggesting that the clicker may have acted as a conditioned/secondary reinforcer (Skinner, 1938; Hull, 1943), but see further discussion in Section 4.2.

4.1. Response facilitation

We found no evidence that the clicker decreased the amount of training required, as might be expected had it acted as a bridge or marking stimulus. These results support those of McCall and Burgin (2002), who found no effect of an auditory stimulus when training horses. Both of these studies used a very short delay between the auditory stimulus and the presentation of the primary reinforcement, and it is not clear whether this magnitude of delay between a behaviour and primary reinforcement facilitates (e.g., Schachtman et al., 1987) or impedes (e.g., Pearce and Hall, 1978; Hall, 1982) response rates. However, longer delays (5–20 s) between the presentation of a stimulus and primary reinforcement have sometimes been shown to accelerate learning (Thomas et al., 1983, 1987; Lieberman et al., 1985). Lieberman et al. (1985) suggested that attention to a marking stimulus may interfere with the processing of other information in short-term memory such that a delay that is longer than 0.5 s between the behaviour and primary reinforcement may be necessary for the subject to remember what event caused the presentation of a stimulus, such as a click. However, Williams et al. (2004) found no bridging or marking

Please cite this article in press as: Smith, S.M., Davis, E.S., Clicker increases resistance to extinction but does not decrease training time of a simple operant task in domestic dogs (*Canis familiaris*), Appl. Anim. Behav. Sci. (2007), doi:10.1016/j.applanim.2007.04.012

effect by presenting a click 5 s prior to primary reinforcement in horses. To our knowledge, no studies have investigated whether the clicker has a bridging or marking effect on a behaviour trained with a delay of more than 5 s between the click and primary reinforcement. Such a delay in primary reinforcement is rarely used in the training of novel tasks in dogs.

It is possible that the clicker in this experiment did act to provide salient feedback to the clicker group during training, but that no difference in training time between groups was evident due to unintentional feedback to the control group. For example, during training trials, some dogs in both groups appeared to be watching hand movements involved in delivering food to the bowl, which may have facilitated learning. Dogs in the control group may have used such hand movements as a marking or bridging stimulus even if the sound of the clicker provided a more salient marking or bridging stimulus for dogs in the clicker group. As Williams et al. (2004) pointed out, if subtle stimuli do facilitate learning by providing feedback, such stimuli would be difficult to remove from typical pet training environments where food usually is delivered in ways that can be seen or heard by the animal. Therefore, secondary stimuli, such as buzzers or clickers, may add little to reduce training time if animals are attuned to other stimuli such as hand movements.

It is also possible that we did not find learning facilitation because these experimentally naïve dogs may not have had sufficient experience of training with the clicker. For example, McCall and Burgin (2002) found response facilitation when using an auditory buzz in teaching a novel behaviour to horses, but only after twice teaching and extinguishing a different behaviour with the buzz. However, by the end of the conditioning trials, all clicker dogs immediately went to the food bowl upon hearing the click but prior to any hand movements involved in food delivery (pers. obs.), suggesting that the number of pairings was sufficient for conditioning the dogs. Likewise, the number of pairings was consistent with that suggested for both dogs (Skinner, 1951; Pryor, 2005) and rats (Skinner, 1938). Moreover, despite the potential for additional pairings of conditioned and primary reinforcers to produce stronger reinforcing effects, the additive value of those reinforcing effects is likely small (see Kelleher and Gollub, 1962). Regardless, our results indicated that there was no relationship among clicker dogs between the number of pairings received during conditioning and either the number or duration of trials necessary to reach training criteria, further suggesting that the number of pairings during conditioning was sufficient for dogs to predict food delivery upon hearing the click in subsequent trials. Additionally, the response facilitation found by McCall and Burgin (2002) could be explained by factors other than the number of buzz-food pairings received, such as arousal to a conditioned stimulus (more fully discussed in Section 4.2).

4.2. Resistance to extinction

In contrast to studies involving horses (McCall and Burgin, 2002; Williams et al., 2004), we did find an effect of the clicker on extinction trials in dogs. These results are also in contrast to Melching (1954), who found no effect on the rate of extinction in rats. It is not clear why our results differed from these other studies, but we speculate that species differences rather than methodological differences may be a factor. Moreover, the clicker and control groups did not differ with regard to age, rate of performance during strengthening trials, or number of food reinforcements received prior to extinction trials, suggesting those factors could not account for our resistance finding.

Increased resistance to extinction does not necessarily suggest the clicker gained reinforcement value through its pairing with food, however. Studies using resistance to extinction as a measure of conditioned reinforcement have been criticized due to lack of experimental control (e.g., Kelleher and Gollub, 1962; Williams, 1994). Such criticisms suggest that clicker dogs may have performed longer during extinction trials because of heightened arousal to the sound of the click, increased frustration, or an inability to readily discriminate a change in conditions between acquisition and extinction trials (Kelleher and Gollub, 1962; Williams, 1994). Procedural controls were used to minimize these possibilities, as dogs in the control group never received a click throughout the study and were introduced to a level of uncertainty about when touches would be reinforced with food through the use of the VR 2 schedule prior to extinction trials (see Kelleher and Gollub, 1962; Williams, 1994). However, if clicker dogs were using the sound of the click to predict food delivery, presentation of the click during extinction may have made it harder for them to learn that nose-touching was no longer being reinforced. Indeed, clicker dogs did not receive a click during unreinforced strengthening trials, which may have reduced their ability to discriminate a change of conditions during extinction. Additionally, clicker dogs may have taken longer to complete extinction trials because they underwent a double extinction process requiring they learn that neither nose-touching nor the click sound resulted in reinforcement. In contrast, if control dogs were using hand movements associated with food delivery to predict reinforcement, the absence of such movements during extinction trials may have aided their learning that nose-touching was no longer being reinforced. Teasing apart the effects of conditioned reinforcement value from alternative explanations has proven to be rather elusive in laboratory settings (see Williams, 1994, for a discussion). Given the inability to control many variables in a setting typically employed by pet owners, we cannot make any definitive conclusion as to why the clicker increased resistance to extinction in the current study. Regardless, it is a finding that we believe may be of value to dog trainers, particularly when introducing distance between the dog and the trainer or when training dogs to perform a series of behaviours in quick succession, both of which are situations that render prompt presentation of a primary reinforcer difficult. However, it is not known how often the clicker would need to be paired with food to be used efficiently for this type of training.

4.3. Age effects

Contrary to Williams et al. (2004), we found positive correlations between age and the mean number and total duration of training and strengthening trials. Younger dogs reached training and strengthening criteria faster than older dogs. These correlations suggest that acquisition of a simple operant task by domestic dogs is sensitive to age, supporting Milgram et al. (1994), who found a similar effect for purebred beagles but not mixed-breed dogs. Other investigations suggest that simple tasks requiring procedural learning/memory or object discrimination are not sensitive to age in beagles or mixed-breed dogs with previous experience of obtaining food through training (see Cummings et al., 1996; Adams et al., 2000). Given the companionship status of the dogs in our study, it seems unlikely that we found a positive correlation between age and training time owing to a lack of previous training experience.

Our results together with previous canine research suggest a possible mechanism for the age sensitivity found in the current study. Tapp et al. (2003) identified two types of error in size discrimination reversal learning: old beagles (8.61–10.94 years) had difficulty learning new stimulus-reward contingencies, whereas senior beagles (11.10–13.81 years) exhibited an inability to inhibit responses to a stimulus that was no longer rewarded. In that extinction trials require learning that a previously rewarded response is no longer rewarded, resistance to extinction may be a measure of an inability to inhibit responses to previously reinforced behaviours (Elias and Elias, 1976; Arenberg and Robertson-Tchabo, 1977). Having found no effect of age on extinction, however, we conclude that the age sensitivities we found in the training and strengthening trials were not owing to such tendencies, but rather may be indicative of a progressive impairment of the dog's ability to learn stimulus-reward contingencies. Still, it is possible that the age effect that we found was due to other factors not addressed in this study, such as age-associated differences in exploratory behaviour (Siwak et al., 2001) or breed differences (Milgram et al., 1994).

5. Conclusion

We found that the clicker did not provide sufficient feedback to decrease the amount of time required to train dogs in a simple operant task using techniques typically promoted by professional dog trainers and often employed by pet owners. However, the clicker group did perform longer than did the control group when primary reinforcement was subsequently withheld, suggesting that the clicker may be most useful in maintaining established behaviours when primary reinforcement is unavailable or when its delivery is impractical. It is unclear, however, how effective such intermittent use of the clicker would be. Further study is also needed to determine if the clicker is a more powerful training tool after a dog has more experience with the clicker or when training requires a longer delay before delivery of primary reinforcement than we used in this study.

We also found that acquisition of a simple operant task is sensitive to age in canines. Further investigation is needed to determine if the training of a simple operant task is affected by a progressive impairment in the acquisition of stimulus-reward contingencies as dogs' age.

Acknowledgments

We would like to express our sincere gratitude to the members of the Basenji Club of Southeastern Wisconsin, who generously gave us access to their homes and to their wonderful dogs, to T. Thayer, our ever-dependable research assistant, and to M.A. Waraczynski for her input into our research design and her helpful comments on this manuscript. We also thank Dr. Petherick and two anonymous referees for their very helpful comments on this manuscript.

References

Adams, B., Chan, A., Callahan, H., Milgram, N.W., 2000. The canine as a model of human cognitive aging: recent developments. Prog. Neuro-psychopharmacol. Biol. Psychiatry 24, 675–692.

Arenberg, D., Robertson-Tchabo, E.A., 1977. Learning and aging. In: Birren, J.E., Schaie, K.W. (Eds.), Handbook of the Psychology of Aging. Van Nostrand Reinhold Company, New York, pp. 421–449.

Cummings, B.J., Head, E., Ruehl, W., Milgram, N.W., Cotman, C.W., 1996. The canine as an animal model of human aging and dementia. Neurobiol. Aging 17, 259–268.

Elias, P.K., Elias, M.F., 1976. Effects of age on learning ability: contributions from the animal literature. Exp. Aging Res. 2, 165–186.

Ferguson, D.L., Rosales-Ruiz, J., 2001. Loading the problem loader: the effects of target training and shaping on trailer-loading behavior of horses. J. Appl. Behav. Anal. 34, 409–424.

Fjellanger, R., 2003. General learning principles for training REST dogs. In: McLean, I.G., Glattbach, J. (Eds.), Mine Detection Dogs: Training, Operations and Odour Detection. GICHD, Geneva, Switzerland, pp. 11–22.

Flannery, B., 1997. Relational discrimination learning in horses. Appl. Anim. Behav. Sci. 54, 267–280.

Hall, G., 1982. Effects of a brief stimulus accompanying reinforcement on instrumental responding in pigeons. Learn. Motiv. 13, 26–43.

Hull, C.L., 1943. Principles of Behavior: An Introduction to Behavior Theory. D. Appleton-Century Company, Inc., New York, pp. 85–101.

Kelleher, R.T., Gollub, L.R., 1962. A review of positive conditioned reinforcement. J. Exp. Anal. Behav. 5, 543–597.

Lieberman, D.A., Davidson, F.H., Thomas, G.V., 1985. Marking in pigeons: the role of memory in delayed reinforcement. J. Exp. Psychol. Anim. Behav. Process. 11, 611–624.

McCall, C.A., Burgin, S.E., 2002. Equine utilization of secondary reinforcement during response extinction and acquisition. Appl. Anim. Behav. Sci. 78, 253–262.

McCulloch, M., Jezierski, T., Broffman, M., Hubbard, A., Turner, K., Janecki, T., 2006. Diagnostic accuracy of canine scent detection in early- and late-stage lung and breast cancers. Integr. Cancer Ther. 5, 30–39.

Melching, W.H., 1954. The acquired reward value of an intermittently presented neutral stimulus. J. Comp. Physiol. Psychol. 47, 370–373.

Milgram, N.W., Head, E., Weiner, E., Thomas, E., 1994. Cognitive functions and aging in the dog: acquisition of nonspatial visual tasks. Behav. Neurosci. 108, 57–68.

Pearce, J.M., Hall, G., 1978. Overshadowing the instrumental conditioning of a lever-press response by a more valid predictor of the reinforcer. J. Exp. Psychol. Anim. Behav. Process. 4, 356–367.

Pierce, W.D., Cheney, C.D., 2004. Behavior Analysis and Learning, 3rd. ed. Lawrence Erlbaum Associates, Inc., Mahwah, NJ, p. 108.

Pryor, K., 1999. Don't Shoot the Dog!: The New Art of Teaching and Training Rev. ed. Bantam Books, New York, pp. 13–16, 169–170.

Pryor, K., 2005. Getting Started: Clicker Training for Dogs, Rev. ed. Sunshine Books, Inc., Waltham, MA, pp. 3–7.

Schachtman, T.R., Reed, P., Hall, G., 1987. Attenuation and enhancement of instrumental responding by signals for reinforcement on a variable interval schedule. J. Exp. Psychol. Anim. Behav. Process. 13, 271–279.

Siwak, C.T., Tapp, P.D., Milgram, N.W., 2001. Effect of age and level of cognitive function on spontaneous and exploratory behaviors in the beagle dog. Learn. Mem. 8, 317–325.

Skinner, B.F., 1938. The Behavior of Organisms. An Experimental Analysis. D. Appleton-Century Company, Inc., New York, pp. 61–74.

Skinner, B.F., 1951. How to teach animals. Sci. Am. 185 (6), 26–29.

Tapp, P.D., Siwak, C.T., Estrada, J., Head, E., Muggenburg, B.A., Cotman, C.W., Milgram, N.W., 2003. Size and reversal learning in the beagle dog as a measure of executive function and inhibitory control in aging. Learn. Mem. 10, 64–73.

Thomas, G.V., Lieberman, D.A., McIntosh, D.C., Ronaldson, P., 1983. The role of marking when reward is delayed. J. Exp. Psychol. Anim. Behav. Process. 9, 401–411.

Thomas, G.V., Robertson, D., Lieberman, D.A., 1987. Marking effects in Pavlovian trace conditioning. J. Exp. Psychol. Anim. Behav. Process. 13, 126–135.

Williams, B.A., 1994. Conditioned reinforcement: experimental and theoretical issues. Beh. Analyst 17 (2), 261–285.

Williams, J.L., Friend, T.H., Nevill, C.H., Archer, G., 2004. The efficacy of a secondary reinforcer (clicker) during acquisition and extinction of an operant task in horses. Appl. Anim. Behav. Sci. 88, 331–341.

Willis, C.M., Church, S.M., Guest, C.M., Cook, W.A., McCarthy, N., Bransbury, A.J., Church, M.R.T., Church, J.C.T., 2004. Olfactory detection of human bladder cancer by dogs: proof of principle study. Br. Med. J. 329, 712–714.

Please cite this article in press as: Smith, S.M., Davis, E.S., Clicker increases resistance to extinction but does not decrease training time of a simple operant task in domestic dogs (*Canis familiaris*), Appl. Anim. Behav. Sci. (2007), doi:10.1016/j.applanim.2007.04.012