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A Comparison of Positive Reinforcement Training Techniques in Owl and Squirrel Monkeys: Time Required to Train to Reliability

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Abstract

Positive reinforcement training (PRT) techniques enhance the psychological well being of nonhuman primates by increasing the animal's control over his or her environment and desensitizing the animal to stressful stimuli. However, the literature on PRT in neotropical primates is limited. Here PRT data from owl monkeys and squirrel monkeys are presented, including the length of time to train subjects to target, present hand, and present foot, important responses that can be used to aid in health inspection and treatment. A high percentage of the squirrel and owl monkeys were successfully trained on target and present hand. Present foot, a less natural response, was harder to train and maintain. Although squirrel monkeys did learn to target significantly faster than owl monkeys, the 2 genera did not differ on time to train on subsequent behavior. These data demonstrate that although owl monkeys may require slightly more time to acclimate to a PRT program, it is still possible to establish a PRT program with neotropical primates, and once animals have been introduced to the program, they can learn new responses in a relatively few short sessions.

Keywords

positive reinforcement training; squirrel monkeys; owl monkeys; welfare

Positive reinforcement training (PRT) techniques are used as part of behavioral management programs in many biomedical facilities, sanctuaries, and zoological parks in order to enhance the psychological well being of nonhuman primates (NHPs) and gain voluntary cooperation for routine husbandry and clinical procedures. PRT employs standard operant conditioning techniques in which an animal is presented with a stimulus or a cue, performs a desired behavior, and receives a reward (Laule, Bloomsith, & Schapiro, 2003; Pryor, 1999; Schapiro & Lambeth, 2007). These techniques allow the animal (rather than the trainer) to have control over the event, and, more important, cooperate voluntarily.

PRT techniques have been successfully used to train NHPs to cooperate with collecting blood, urine, and saliva samples (Coleman et al., 2008; Lutz, Tiefen-bacher, Jorgensen,

Meyer, & Novak, 2000; Smith, McCallister, Gordon, & Whit-takar, 2004); shifting between locations and/or enclosures (Bloomsmith, Stone, & Laule, 1998; Veeder, Bloomsmith, McMillan, Perlman, & Martin, 2009); husbandry and clinical exam procedures (Baker, Bloomsmith, Neu, Griffis, & Maloney, 2010; McKinley, Buchanan-Smith, Bassett, & Morris, 2003); and moderating both aggressive and affiliative behavior (Bloomsmith, Laule, Al-ford, & Thurston, 1994; Minier et al., 2011; Schapiro, Perlman, & Boudreau, 2001).

Moreover, cooperation from the animal in these procedures decreases both physiological and behavioral signs of stress (Koban, Miyamoto, Donmoyer, & Hammar, 2005; Lambeth, Hau, Perlman, Martino, & Schapiro, 2006; O'Brien, Heffernan, Thomas, & McGreevy, 2008; Reinhardt, 2003), suggesting that PRT not only enhances psychological well being but also improves the quality of the data acquired from those animals (Dettmer et al., 1996). Indeed, PRT data from callitrichids and capuchins indicates that New World primates can also be trained in relatively few sessions for voluntary collection of blood and urine samples (Dettmer et al., 1996; Smith et al., 2004), shifting (McKinley et al., 2003), and clinical examination (McKinley et al., 2003; Savastano, Hanson, & McCann, 2003).

Owl monkeys (*Aotus spp.*) and squirrel monkeys (*Saimiri spp.*) are two of the most common New World monkeys in primate research. Although both genera are small, arboreal primates native to Central and South America, owl monkeys are generally nocturnal whereas squirrel monkeys have a more typical diurnal activity pattern (Tardif et al., 2006). PRT and operant conditioning have been used with both primate genera to train them in jumping, shifting, and voluntary restraint (Hupfer & Maurus, 1975; Mendoza, 1999; Moseley & Davis, 1989). However, negative reinforcement is used in some cases, and the time investment required is ambiguous, ranging from a few sessions (Mendoza, 1999) to over 200 (Hupfer & Maurus, 1975).

The three main goals of this study were to assess (a) the time investment necessary to establish a solely PRT program for two genera of neotropical primates in a research facility, (b) training progress when learning new responses, and (c) retention of trained behavior.

MATERIALS AND METHODS

Subjects and Housing

The subjects of this study were 28 (12 females, 16 males, age range 0–25 years) owl monkeys (*Aotus spp.*) and 30 (30 males, age range 2–16 years) squirrel monkeys (*Saimiri spp.*) housed at The University of Texas MD Anderson Cancer Center, Michale E. Keeling Center for Comparative Medicine and Research. All the animals were born in captivity and have been raised by their dam. The subjects were not involved in any other study during data collection.

The owl monkeys were socially housed in either family groups or pairs. Family groups contained an adult male/female pair and any offspring they may have had in the previous 2 years. Pair-housed animals could be in same- or mixed-sex groups. All animals in each group were trained. Animal home cages measured approximately $0.9 \times 1.2 \times 1.7$ m. The owl monkeys were maintained on a 12-hr light/dark schedule. Indoor lights were illuminated

from 00:00 hr to 12:00 hr. Partially shuttered skylights provided a dim dusk period until 15:30 hr, at which point the shutters were closed completely to provide full darkness. The shuttered skylights were reopened at 07:00 hr each morning. We trained 12 groups of owl monkeys consisting of 28 animals (see Table 1).

The squirrel monkeys lived in a variety of housing situations, but all animals were socially housed in either groups or pairs. Twelve males were housed in indoor pens measuring approximately $1.2 \times 2.0 \times 4.0$ m that could be connected by porthole doors. These pens each housed 1 male, for breeding, and a variable number of adult females and their offspring. Including the male, groups ranged in size from 6 to 31 animals. Eighteen additional males were housed in rack-mounted cages measuring approximately $0.8 \times 0.8 \times 1.8$ m. These racks housed six all-male groups ranging in size from 2 to 5 animals. For groups larger than 3, two of the rack cages were connected via a wire-mesh tunnel. Squirrel monkey indoor lighting was illuminated from 07:00 hr until 19:00 hr. Overhead skylights were never closed and provided additional, natural lighting when sunrise and sunset fell outside the indoor light schedule. Although only the breeding males in the indoor pens were trained, all group members housed in the racks were trained (see Table 1).

Training and Behavior

All training sessions were conducted between 10:00 hr and 17:00 hr from April 22, 2010, to July 20, 2011. Animals were trained during their active period; therefore, squirrel monkeys were trained during the daylight, whereas owl monkeys were trained during the dusk and dark periods. Individuals were involved in the training program from 10 to 452 days. All training sessions with all subjects were conducted in the animals' home cages with all cage mates present and free access to food and water. In the owl monkeys, both the male and female of the pair were trained. Squirrel monkey females, who were not receiving training, would attempt to steal the reward; however, the trainer continued to hand out a reinforcer until the training subject received it. No attempts were made to preclude interference by the squirrel monkeys.

All training sessions were conducted two to three times per week per subject and lasted until the subjects lost interest, after approximately 10 min. No subject was forced to participate in a training session. All sessions ended after a reinforcement with the subjects given a larger than normal reward, a jackpot, at the end of the session. Four trainers trained all subjects, two for each genera, and each trainer had a specific list of individuals/groups whom they trained.

Training Methodology

Subjects were trained using positive reinforcement and standard operant conditioning techniques. During a voluntary training session, the task was presented to the subject through a verbal and visual gesture (e.g., the word "target" and the fingers of one hand pointing to the target). The desired behavior was followed by a primary reinforcer (i.e., food, primarily raisins, grapes, and marshmallows); a secondary reinforcer (a clicker) and verbal cue (e.g., "good job") were used as a bridge between the behavioral response and the reward. We designed detailed shaping plans prior to training. Shaping plans generally

consisted of desensitizing the animal to the new stimulus (i.e., a target or touch), reinforcing successive approximations of the animal's movement toward the desired behavior, and introducing the visual and verbal cues (Laule et al., 2003; Pryor, 1999). For the purpose of this study the subjects were first trained to approach and touch a target (stationary PVC elbow); second, to extend a hand from the cage and allow the trainer to grasp it; and third, to extend a foot from the cage and allow the trainer to grasp it.

Data Collection

In order to keep track of an animal's progress, each training session received two scores: (a) a performance level score and (b) a training level score (see Table 2). An animal was considered trained on a given behavior on the first training session he or she received a score of 3/P (excellent/progress), and an animal was switched to "maintained status" after five consecutive training sessions were scored as 3/P.

Although we did establish the successive order of behavior to be trained, training of the responses did overlap to some extent. The training sequence was always initiated by "target," followed by "present hand," and finally "present foot." The responses the animals were trained for and their descriptions are listed in Table 3. These three responses are considered fundamental for establishing a more comprehensive training program that would expand into behavior that facilitates husbandry and clinical procedures (i.e., shifting, medical examination, and voluntarily presenting for treatments or injections; Laule et al., 2003).

Statistical Analyses

All analyses were conducted using SPSS, Version 17.0.2. In order to describe the differences in training investment between the two genera, we used Mann-Whitney *U* tests to compare the session duration (in minutes). We also compared the number of sessions that owl and squirrel monkeys required to become trained and reach maintained status for all three responses. In order to account for multiple tests, we used the Bonferroni correction and only considered values significant if $p < .05/6 = .008$. We also tested, within genera, for any effect of age class (adult ≥ 3 years vs. not adult < 3 years) or group type (pair vs. group) on the number of sessions until trained for all three responses using Mann-Whitney *U* tests. Again, we used the Bonferroni correction and only considered values significant if $p < .05/6 = .008$. Preliminary analysis indicated there were no differences between the male and female owl monkeys, so the data were collapsed across sex.

RESULTS

Table 4 lists the proportion of animals of each genus that became trained and reached maintained status for each of the three responses. Fisher's exact tests indicate that neither genus had more or less success than the other in any case. The number of sessions required for individuals to reach trained status, regardless of behavior, for the two genera ranged from 1 to 22 sessions. All the squirrel monkeys and all but three of the owl monkeys reached training criteria for both targeting and present hand. However, only 18 of the 30 squirrel monkeys and 6 of the 28 owl monkeys reached training criteria for present foot. For subjects

to achieve “maintained status,” five consecutive training sessions needed to be scored as 3/P. Under these training conditions, this higher criterion was reached by 19 of the 28 owl monkeys and 26 of the 30 squirrel monkeys for the targeting response. Equal numbers of owl monkeys and squirrel monkeys (18) reached maintained status for present hand, whereas very few of the animals, 3 squirrel monkeys and 7 owl monkeys, reached maintained status for present foot.

Training Frequency and Duration

Owl monkey subjects received 30.83 hr of training within 235 training sessions for an average of 21.43 ± 3.43 training sessions per animal (range: 2–60). Squirrel monkey subjects received 34.32 hr of training within 266 training sessions for an average of 14.00 ± 2.26 training sessions per animal (range 2–40). Training session duration did not significantly differ between the two genera, with owl monkey training sessions lasting an average of 7.08 ± 0.33 min/group and squirrel monkey training sessions lasting 7.98 ± 0.39 min/group (Mann Whitney $U = 337.0$, $N_{OWL} = 28$, $N_{SQM} = 30$, $p = .195$).

Training Investment

We compared the number of training sessions required to become trained and reach maintained status for all three responses between the two genera. Squirrel monkeys took significantly fewer sessions to both train and maintain target (Mann-Whitney U : Trained: $U = 154.0$, $N_{OWL} = 28$, $N_{SQM} = 30$, $p < .001$; Maintained: $U = 117.0$, $N_{OWL} = 19$, $N_{SQM} = 26$, $p < .001$). However, when exploring subsequent behavior, owl and squirrel monkeys did not significantly differ (Mann-Whitney U : Hand Trained: $U = 250.0$, $N_{OWL} = 26$, $N_{SQM} = 23$, $p = .297$; Hand Maintained: $U = 70.0$, $N_{OWL} = 16$, $N_{SQM} = 14$, $p = .085$; Foot Trained: $U = 14.0$, $N_{OWL} = 4$, $N_{SQM} = 9$, $p = .604$; see Figure 1). Age class and group type did not significantly affect the number of sessions required to become trained or reach maintained status for any behavior for either squirrel or owl monkeys.

All squirrel monkeys who reached maintained status did so in a minimum of five sessions for all three responses. The owl monkeys showed significantly more variation in the number of trials to reach maintain status with some animals regressing after initial training (Fisher’s Exact Test: Target Maintained: $df = 1$, $p < .001$; Hand Maintained: $df = 1$, $p = .013$).

DISCUSSION

Time Investment

Both owl and squirrel monkeys learned two basic responses, to “target” and to “present a hand,” in just a few very short sessions. Also, despite the fact that training occurred in the animals’ home cages and with access to all group members, training was still very successful and minimal intragroup aggression was observed. Moreover, because the animals were trained in their social groups and often all group members could be trained simultaneously, the actual time investment per animal would be even lower than the time presented.

Training Progress and Retention of Behavior

Although squirrel monkeys were quicker to learn the initial target behavior than owl monkeys, subsequent behavior showed no significant differences. It is important to mention that owl monkeys are especially susceptible to environmental disturbance and can be very neophobic to new people and routines (Ehrlich, 1970; Tardif et al., 2006). For this reason, it is quite possible that the additional two sessions required for owl monkeys to become target trained were a result of the owl monkeys acclimating to the new trainer and the addition of PRT to their daily routines. Indeed, once the novelty of the PRT sessions wore off, and both genera had training experience, training time was not significantly different between squirrel and owl monkeys.

When looking specifically at the present foot data in this preliminary study, despite the small sample size and low power, the animals could learn the task and the number of sessions required to learn the task were within the range of the other two responses. Of the animals who reached maintained status some owl monkeys did regress, whereas no squirrel monkey did. This suggests that owl monkeys may need more training than squirrel monkeys to learn and maintain new responses. However, owl monkeys did reach maintained status within 5 to 22 sessions. The training time to criteria reported in this study compare favorably with those reported previously: Savastano et al. (2003) reported between 1 and 8 sessions were needed to train other neotropical primates, and Gillis, Janes, and Kaufman (2012) reported an average of 10.9 days to targeting criteria.

We chose to train the animals on “target,” “present hand,” and “present foot” because these three responses are fundamental and extremely versatile. These responses are essential for the establishment of a more comprehensive training program that will be expanded into responses that facilitate husbandry and clinical procedures, including shift training, stationing for weights, present for injection, and voluntary blood draws. We conclude that PRT can be used successfully with squirrel and owl monkeys as a practical behavioral management tool, thus allowing animals to have control over their environment and cooperate voluntarily, thereby increasing their psychological well being.

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FIGURE 1.

Owl monkey (shaded) and squirrel monkey (open) training progression. Panels show the average number of sessions until (a) trained or (b) maintained for both genera on all three responses; data are mean *SEM* (* $p < .001$).

TABLE 1

Group Demographics for Owl Monkeys and Squirrel Monkeys

Species	Group Type	Number of Animals/Group	Number of Groups Trained	Number of Animals Trained
Owl monkey	Pair	2	8	16
	Group	3–6	4	12
Squirrel monkey	Pair	2	4	8
	Group	4–31	17	22

TABLE 2

Scores for Each Training Session With Definitions

Score	Definition
1—Poor	Ranges from animal does not respond to the animal is moving toward the correct behavior, but the behavior is not shaped.
2—Good	The animal is giving the correct behavior the majority of the time but misses a descriptive stimulus or two.
3—Excellent	The animal consistently gives the correct behavior when both the verbal and the visual cues are given.
P—Progress	The animal is in the process of learning the behavior.
M—Maintained	The animal is trained on the behavior and is now on a maintenance schedule.

TABLE 3

Descriptions of Visual and Verbal Cues and Definitions for Fundamental Responses

Behavior	Verbal Cue	Visual Cue	Description
Target	Target	Point to target or extend target to animal	Animal comes up and touches the target.
Present hand	Hand	Upturned open palm	Animal presents whole hand through the mesh and touches the trainer's hand.
Present foot	Foot	ASL "F" sign	Animal presents whole foot through the mesh and allows the trainer to touch his or her foot.

ASL = American Sign Language.

TABLE 4
Percentage of Subjects in Each Genus Who Reached Training and Maintained Statuses for Each Response

	Trained			Maintained		
	Target	Present Hand	Present Foot	Target	Present Hand	Present Foot
Owl monkey	100%	92%	24%	68%	67%	25%
Squirrel monkey	100%	100%	60%	87%	61%	11%