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Positive Reinforcement Training As a Technique to Alter Nonhuman Primate Behavior: Quantitative Assessments of Effectiveness

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Many suggest that operant conditioning techniques can be applied successfully to improve the behavioral management of nonhuman primates in research settings. However, relatively little empirical data exist to support this claim. This article is a review of several studies that discussed applied positive reinforcement training techniques (PRT) on breeding/research colonies of rhesus macaques (*Macaca mulatta*) and chimpanzees (*Pan troglodytes*) at The University of Texas M. D. Anderson Cancer Center and measured their effectiveness. Empirical analyses quantified the amount of time required to train rhesus monkeys to come up, station, target, and stay. Additionally, a study found that time spent affiliating by female rhesus was changed as a function of training low affiliators to affiliate more and high affiliators to affiliate less.

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Another study successfully trained chimpanzees to feed without fighting and to come inside on command. PRT is an important behavioral management tool that can improve the care and welfare of primates in captivity. Published empirical findings are essential for managers to assess objectively the utility of positive reinforcement training techniques in enhancing captive management and research procedures.

This article is intended as a review of several studies (Bloomsmith, Laule, Alford, & Thurston, 1994; Bloomsmith, Stone, & Laule, 1998; Schapiro, Perlman, & Boudreau, 2001) we have conducted examining the effects of positive reinforcement training (PRT) techniques on the behavioral management of large colonies of rhesus monkeys (*Macaca mulatta*) and chimpanzees (*Pan troglodytes*) in captivity. Although many primatologists and animal trainers claim that PRT techniques can be employed effectively to facilitate the behavioral management of nonhuman primates in captivity (Desmond & Laule, 1994; Laule & Desmond, 1995; Laule & Whittaker, 2001; Reinhardt, Liss, & Stevens, 1995; Whittaker, Laule, Perlman, Schapiro, & Keeling, 2001), relatively few quantitative reports are available in the literature. Indeed, one of the aims of this special issue of the *Journal of Applied Animal Welfare Science (JAAWS*) is to rectify this situation.

The primary goal of this article is to provide empirical data assessing the "effectiveness" and "value" of PRT techniques. Some of the most frequently asked questions concerning PRT include, "How long does it take to train behavior X?" and "What effects does training have on the behavior of the primates?" Therefore, for the purposes of this article, *effectiveness* will include measures of the time required to train desired behaviors and/or measures of the behavioral effects of training procedures.

PRT techniques are one type of behavioral management procedure that can be applied successfully and beneficially to many aspects of both the management of primates in captivity and their use in research (Bloomsmith et al., 1994; Desmond & Laule, 1994; Laule & Desmond, 1995; Laule, Thurston, Alford, & Bloomsmith, 1996; Laule & Whittaker, 2001; Reinhardt et al., 1995; Schapiro et al., 2001; Vertein & Reinhardt, 1989; Whittaker et al., 2001). PRT techniques are simply standard operant conditioning techniques in which animals, presented with a stimulus, perform a target behavior and subsequently receive a desired reward. These techniques allow the animals to cooperate voluntarily with husbandry and/or research procedures. See Laule and Whittaker (2001) and some of the contributions in this special edition for additional recent discussions of the methods of PRT.

Training primates in captive (including laboratory) settings to perform target behaviors that facilitate husbandry, veterinary procedures, and/or research protocols is possible and desirable (Laule & Desmond, 1995; Laule et al., 1996; Laule & Whittaker, 2001; Reinhardt, 1997; Reinhardt et al., 1995; Schapiro et al., 2001). The interaction of many factors, including facility design; housing conditions; research protocols; and animal characteristics (species, age, sex, rearing history) will help determine the specific target behaviors of the PRT program (Laule & Whittaker, 2001). There are relatively few captive situations in which PRT would be of no value to the primates or to those managing them.

This article reviews three previously published projects and one unpublished project. For the three previously published projects, the article presents only the basic elements of the procedures and results of the studies, referring the reader to the original reports (Bloomsmith et al., 1994; Bloomsmith et al., 1998; Schapiro et al., 2001) for additional details. For the unpublished study, the article presents more of the essential details of the procedures and results. All four studies demonstrate the potential contributions of PRT techniques to effective behavioral management and research programs.

METHODS AND RESULTS

Study 1: Training Rhesus Monkeys to Stay; Time Investment

Methods. The first study presented is unpublished and was designed to address issues related to quantifying the investment of personnel time required to train rhesus monkeys living in small groups (one male and five to seven females) to perform certain target/control behaviors. The target activities discussed are basic; yet, they provide a foundation of trained behaviors that facilitate the training of other, more complex and valuable behaviors.

Thirty adult rhesus monkeys of both sexes (3 males, 27 females) were trained while living in 5 unimale-multifemale groups in kennel-type runs (2.4 × 3.0 × 2.7 m); two of the males purposely were not trained; Schapiro et al. (1997) provide additional details concerning housing. Subjects were part of the specific pathogen-free (SPF) breeding colony at The University of Texas M. D. Anderson Cancer Center's Department of Veterinary Sciences and had participated in a number of other behavioral and/or immunological investigations (Buchl, Keeling, & Voss, 1997; Schapiro, 2002; Schapiro et al., 1994). Monkeys were clicker trained (Laule, Bloomsmith, & Schapiro, 2003/this issue) and then trained to perform four progressively more difficult behaviors (up, station, target, stay) using PRT techniques. Other articles in this issue provide additional details on conditioned reinforcers. Most training sessions were 15 min in duration, and groups participated in approximately 3 training sessions per week, each group being trained by a single trainer. No individuals were separated from their groups during training; therefore, training was conducted within the constraints imposed by the social hierarchy of rhesus groups. Typically, this meant that dominant individuals were reinforced not only for performing their target behaviors but also for allowing subordinate animals to receive their reinforcers. This issue will be addressed in more detail in the section devoted to cooperative feeding (Bloomsmith et al., 1994; Desmond, Laule, & McNary, 1987) presented below. A subject was considered reliably trained for one of the target behaviors when that monkey performed the behavior in three consecutive training sessions. Although the data are presented as the mean training time required per monkey to achieve reliable performance, it should be pointed out that this refers to the amount of time that the monkey's group was trained, not the amount of time that each monkey was trained.

The first trained behavior, "up," simply involved the monkeys' coming up to the front of the cage on command. Whereas monkeys would perform many of the target behaviors at times, one of the key issues in PRT is to put desired behaviors under some degree of stimulus control. This means that the animals reliably perform the behavior when requested to do so.

The second trained behavior, "station," required each monkey to approach an individual station (a uniquely shaped and positioned PVC target mounted on the cage front) on command. "Target" was the third behavior in the sequence, requiring the monkeys to touch their individual targets with a hand (again, on command). Finally, monkeys were trained to "stay," holding their target and/or not moving from their stations until verbally released by the trainer.

Results. Twenty-seven of the 30 monkeys were reliably trained (performed the behavior during 3 consecutive training sessions) to come up to the front of the cage on command after their group had received a mean of 2.5 hr of training. The fastest monkey took only 25 min to meet the criterion for this task, whereas the slowest took over 16 hr (see Table 1). Twenty-two of the monkeys took less than 2 hr to learn the behavior, whereas 3 animals never met criterion.

Monkeys were trained to station in a mean of just under 3 hr of total training time (see Table 1). This included the 2.5 hr (on average) spent learning the up command. The fastest monkey was stationing in just under 1 hr and 20 monkeys reliably stationed after less than 2 hr of training time. Only one of the 27 monkeys who were successfully trained to come up, could not be trained to station.

Twenty-four of the 26 monkeys who were successfully trained to station also were reliably trained to touch their targets on command. A mean of slightly more than 5 hr of total training time was required to meet criterion for this behavior (see Table 1). The fastest monkey required only 55 min to achieve reliability, and 14 monkeys were trained to criterion in less than 3.5 hr. Therefore, once monkeys had been trained to come up and to station, it took a mean of only an additional 2 hr to train them to target.

The next behavior in the progression, stay, presented an interesting challenge. Fourteen of the 24 targeting animals required absolutely no training to stay. Once at their targets, these typically lower ranking animals simply stayed. The other 10

TABLE 1
The Number of Hours Required to Train Rhesus Monkeys to Reliably Perform the Target Behaviors on Command

Target Behavior	*Up*	*Station*	*Target*	*Stay*
Number of hours of training required to meet criterion				
0 to 1	5	5	1	0
1 to 2	17	15	6	2
2 to 3	1	1	4	5
3 to 4	1	1	3	0
4 to 5	0	0	4	5
5 to 10	1	2	2	5
10+	2	2	4	7
M[a]	2.5	3.0	5.0	9.5[b]
Mode[a]	1.1	1.1	2.0	2[b]
Mdn[a]	1.2	2.0	3.2	6.8[b]
Subjects successfully trained	27/30	26/27	24/26	24/24

Note. Entries in the table indicate the number of subjects successfully trained during the time period.
[a]Given in hours. [b]14 subjects required no additional training to stay. Mean, mode, and median values refer only to those 10 subjects who required training to stay.

animals however, required considerable training (at least 4.5 additional hours, see Table 1) to achieve reliability for stay. These were the animals, typically higher ranking individuals, who would attempt to leave their targets and steal the reinforcers intended for other animals. Although stay is relatively difficult to train, it is an extremely valuable behavior for both management and research purposes, significantly increasing access to all animals in the group.

Study 2: Training Rhesus Monkeys; Affiliative Interactions

Methods. This study has been previously published (Schapiro et al., 2001) and was designed to use PRT techniques to manipulate prospectively the amount of time that adult female rhesus monkeys engaged in affiliative interactions. As increased levels of affiliative interactions have been correlated with enhanced immune responses (Capitanio, Mendoza, Lerche, & Mason, 1998; Kaplan et al., 1991), we felt this was an interesting relationship to explore. In brief, 28 group-housed subjects in the rhesus SPF breeding colony were identified as either high affiliators or low affiliators, based on a median split of the time they spent engaged in affiliative activities (social play, social grooming) during a baseline observation period (250 hr of focal animal data). Half of the 14 low affiliators were trained to affiliate, and half of the high affiliators then were trained not to affiliate (as a positive control condition), using PRT techniques. The rest of the animals, not trained, served as control subjects.

High affiliators were trained not to affiliate by training the monkeys to target and stay (as in Study 1) at targets that were gradually moved from within a social distance (< 8 cm) of another monkey to outside of a social distance (> 8 cm) of all other monkeys. Low affiliators, on the other hand, were trained to affiliate by training them to target and stay at targets that gradually were moved from outside a social distance of all other monkeys to within a social distance of a single partner monkey. Low affiliators then were trained, through the shaping of successive approximations, to place their hands on the back of the partner and simulate grooming-like hand movements. Schapiro et al. (2001) provide additional details on the training procedures and experimental design of this study. After the baseline period, subjects were observed both during (trained subjects only) and outside of training sessions (an additional 340 hr of focal animal data).

Results. PRT aimed at altering the affiliative interactions of socially housed, adult female rhesus macaques altered the affiliative behavior patterns of both high affiliators and low affiliators (see Table 2). In general, high affiliators were successfully trained not to affiliate, spending significantly less time affiliating during the training phase (a) than they did during the baseline phase, $t(5) = 5.5$, $p < .01$, and (b) than did untrained high affiliators during the training phase of the study, $F(1, 10) = 9.3$, $p < .05$. These data suggest that high affiliators were responding to the reinforcement contingencies of the training process yet were not altering their overall behavioral repertoire. Low affiliators were successfully trained to affiliate more (12.5% of observation time) during observations outside of training sessions, $t(6) = -2.14$, $p < .08$, than during the baseline phase (6.7%). This suggested that, unlike trained high affiliators, the overall behavioral repertoires of these subjects were altered as a function of PRT (the difference approached significance). For additional details concerning the results of this study, see Schapiro et al. (2001).

TABLE 2
Mean Percentage of Observation Time Spent Affiliating With Adult Rhesus Monkeys Across Study Phases (Baseline Versus Training), Experimental Conditions (Trained Versus Untrained), and Observation Times (During Training Versus Outside of Training)

		Training Phase	
Subgroup	*Baseline Phase*	*During Training*	*Outside Training*
Trained high affiliators	17.9	2.9	14.3
Untrained high affiliators	15.1	—	13.7
Trained low affiliators	6.7	4.5	12.5
Untrained low affiliators	8.2	—	11.2

Note. Complete data set can be found in Schapiro, Perlman, and Boudreau (2001).

Study 3: Training to Moderate Chimpanzee Feeding-Related Aggression

Methods. This study has been previously published (Bloomsmith et al., 1994) and was designed to measure the effect of a cooperative feeding paradigm (Desmond et al., 1987) on the amount of aggression during feeding in a relatively large group of chimpanzees. Our chimpanzee research colony contains approximately 160 animals housed in a variety of social settings including pairs, trios, small groups (4 to 6 animals), and large groups (7 to 16 animals). Facilities with both indoor and outdoor components house all animals. Most pairs and trios live in run-type enclosures, most small groups in Primadomes, and most large groups in corrals (Riddle, Keeling, Alford, & Beck, 1982).

In some groups of chimpanzees, certain dominant animals routinely chase more subordinate animals and steal their portion of food. This creates many problems; including dominant animals who may become overweight and subordinate animals who may not receive proper nutrition. The group we studied had such a dominant animal. Although it is difficult to use PRT techniques to train a chimpanzee not to do an undesirable behavior, it is considerably easier to train that animal to perform a behavior that is incompatible with the undesirable behavior (Laule & Whittaker, 2001). The process of training for cooperative feeding involves exactly this procedure. To train dominant animals not to chase and steal subordinates' food, the dominants are reinforced for sitting in one spot, a behavior incompatible with chasing and stealing. In essence, as alluded to briefly in Study 1, dominant animals are reinforced for allowing subordinate animals to receive their food ration.

Considerable details on cooperative feeding are available in Bloomsmith et al. (1994); in general, however, dominant animals initially are given the verbal stimulus, "sit," and are reinforced for doing so. As training progresses, these same animals are asked to sit while the other animals in the group are fed their rations and are reinforced for doing so. Eventually, the animals who remain sitting while allowing the other animals in the group to receive their food receive a high value reinforcer (an apple) in addition to their regular food items. The data included in the older report (Bloomsmith et al., 1994) included eight subjects. Currently, all 90 subjects living in our corrals generally feed without fighting, although not all groups required PRT to accomplish this.

Results. Training a group of chimpanzees using the cooperative feeding procedure resulted in significant changes in feeding-related agonistic behavior before and after training, $F(1,6) = 15.5$, $p < .05$. Aggressive, display, submissive, and reconciliatory behaviors all showed similar patterns of decline. These findings applied to incidents involving the target male as well as to the group as a whole (see Table 3). Levels of the behaviors included in Table 3 at times other than meal periods did not change as a function of training. These results indicate that the training

TABLE 3
Means and Standard Error Rates (Per Hour) of Agonistic Behaviors Among Chimpanzees During the Four Study Conditions

	Pretraining				*Posttraining*			
	No Meal		*Meal*		*No Meal*		*Meal*	
Study Condition	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Behavior								
Display								
Group[a]	0.9	1.5	6.6	5.1	2.4	2.2	1.4	1.4
Male	0.5		4.4		1.3		0.6	
Aggressive								
Group	0.6	1.1	7.7	5.7	0.9	0.9	1.7	1.7
Male	0.4		2.7		0.2		0.7	
Submissive								
Group	3.7	5.7	22.3	15.4	5.4	4.5	0.4	0.5
Male	0.1		0.0		0.0		0.0	
Reconciliation								
Group	1.0	1.2	2.7	3.0	0.4	0.5	0.3	0.5
Male	0.1		0.4		0.0		0.0	

Note. Complete data set can be found in Bloomsmith, Laule, Alford, and Thurston (1994).
[a]Group scores are for all eight group members combined, including the target male.

process decreased agonism to levels equivalent to nonfeeding times of the day, thereby eliminating the additional aggression that had been evident when meals were fed. For more details concerning the results of this study, see Bloomsmith et al. (1994).

Study 4: Training for Chimpanzee Voluntary Movement

Methods. This study has been previously published (Bloomsmith et al., 1998) and was designed to measure the effort required to train chimpanzees to reliably come into the indoor portion of their corral enclosure when asked to do so. A critical component of any behavioral management program is to be able to move animals from one section of their enclosure to another section on command (typically referred to as “shifting” or “gating”). This is accomplished best using standard operant conditioning procedures whereby the animals are asked to come inside and are reinforced with juice, fruit, and/or other treats when they come inside and the door is closed behind them (a training attempt). If 100% of the animals in the group complied, then the training attempt was equivalent to a training session. If less than 100% of the animals in the group complied during a training attempt, an additional attempt was made.

In this case, the training session was comprised of multiple-training attempts. Sixty-six chimpanzees were observed for this four-phase study, and we measured the percentage compliance of the subjects with the command, inside, during each phase. During the baseline phase, subjects received no reinforcement for coming inside when called by the trainer. During the initial training phase, subjects received positive reinforcement from the trainer for coming inside when called by the trainer. The initial training phase continued until 90% compliance was reached, at which point the maintenance phase of the study began. The maintenance phase also employed the trainers providing the stimulus and the reinforcement and continued until the transfer phase began. During the transfer phase, a member of the caregiving staff, rather than the trainer, called the animals in, reinforced them, and worked the doors. For additional details concerning the precise methodology of this study, see Bloomsmith et al. (1998).

Results. Means of 16.1 training sessions and 22 training attempts were required to reach the 90% criterion for successful training of the inside behavior (see Table 4). On average, a training attempt lasted less than 5 min; therefore, less than 110 min were typically required to train a group to criterion. There was considerable variability in the number of sessions required to reach reliability ($SE = 17.8$; range = 4 to 93). Females ($M = 11.6$) required significantly fewer, $F(1, 64) = 6.0, p < .02$, training sessions than did males ($M = 25$). Compliance differed significantly across phases of the study, and adult males were the poorest performers across all phases. There were no age effects or age by sex interactions. Compliance (89.8%) during the first 55 attempts at the beginning of the transfer phase was significantly lower, $F(1, 64) = 9.1, p < .004$, than compliance (94.2%) during the 20 final attempts of the maintenance phase. Although this difference is statistically significant, the compliance rate early in the transfer phase still is well above the baseline

TABLE 4
Percentage Compliance Scores for Chimpanzees Across Study Phases

Study Phase	*Baseline*[a]	*Initial Training*[a]	*Maintenance Training*[b]	*Transfer of Training*[b]
Subjects				
Adult females	77.9	88.7	95.8	94.2
Adult males	41.6	70.0	84.7	76.2
Immature females	65.4	81.9	87.7	87.2
Immature males	66.1	78.9	93.1	84.2
M all subjects	66.1	82.1	91.7	87.9
Total number of attempts for individuals	942	1,451	2,181	8,128

Note. Complete data set can be found in Bloomsmith, Stone, and Laule (1998).
[a]$n = 66$. [b]$n = 58$.

compliance level (see Table 4). For additional details concerning the results of this study, see Bloomsmith et al. (1998).

DISCUSSION

The primary goal of this brief review was to provide the reader with examples of studies of PRT that empirically measured the effectiveness of these techniques. For the purposes of this article, two specific measures of effectiveness were emphasized: (a) the amount of time required to train particular behaviors, and (b) the behavioral changes resulting from training. These specific measures of effectiveness should provide managers of primates in captivity with the information needed to assess the value of implementing positive reinforcement training techniques in their management and research programs.

The data included from the four studies discussed above emphasize the potential value of PRT to the captive management, well-being, and research utilization of nonhuman primates (Laule & Whittaker, 2001; Whittaker et al., 2001) and provide some of the empirical data necessary to evaluate the effectiveness of such procedures. The combined data from these four studies clearly indicate that PRT techniques can be used effectively to achieve both management and research goals. Although some behaviors are more difficult to train than others, it is clear that both desirable and undesirable behaviors can be manipulated using these techniques. Even affiliative and agonistic interaction patterns can be influenced, demonstrating the power of PRT techniques to alter even some of the most critical species-typical activities in the primates' behavioral repertoire. Although cooperative feeding is not a requirement for housing chimpanzees in large social groups, PRT aimed at minimizing aggression at meal times can only benefit the animals and those who manage them.

Two aspects of the present findings deserve special attention in this article. The first is the concept of training an incompatible behavior as a mechanism for facilitating the elimination of undesirable behaviors from primates' activity patterns. Although we addressed this primarily in the context of cooperative feeding (Bloomsmith et al., 1994; Desmond et al., 1987), there are many other circumstances in which the preferential reinforcement of desirable behaviors that cannot be performed at the same time as undesirable behaviors can be used to eliminate those undesirable behaviors from the animals' behavioral repertoire. One way to minimize primates' grabbing their caregivers (and thereby minimize risks to human safety) is to reinforce the animals for stationing and targeting with their hands on their perches inside their cages. Of course, this approach will not work for every animal or every undesirable behavior.

The second point worthy of emphasis from the cumulative findings of this article relates to the challenges inherent in attempting to train intelligent, socially oriented animals, like primates, without separating them from their social groups. Separating animals from their groups can be a time consuming process; more important, it can be stressful for both those removed and those remaining behind. Therefore, we prefer to work with intact social groups, even when the objective is to gain access to, and train, a single animal for a particular behavior (such as urine collection).

When working with groups of animals and the associated complex social dynamics, it often is easier to train certain group members than others. In some situations, "highly trainable" subsets of animals can be identified (e.g., female chimpanzees to come inside; lower ranking rhesus monkeys to stay as described previously), but this is not always the case. For commands such as station and inside, management goals have not been completely achieved unless all animals station or come inside. In other words, the amount of training time required per group may not be distributed evenly within the group; some animals may require only one or two sessions, whereas others may require many, many sessions or may never perform the behavior.

These animals may have learned the behavior but may be unwilling to perform it within the social context of the group. Similarly, the behavioral effects of training may not be equivalent across subjects. Some animals may benefit from increased proximity to group mates or from increased access to desirable food items, whereas others may find such new circumstances additionally stressful. For these, and other related reasons, often it is difficult to provide straightforward answers to the following questions: (a) How long does it take to train behavior X? and (b) What are the effects of training behavior X?

Well-designed studies should be published and should involve (a) appropriate experimental techniques, (b) sufficient numbers of subjects, and (c) suitable quantities of data to permit generalization across different species and settings. Although people always want to know how long it takes to train particular behaviors, and this article provides some empirical data to address this question, the answer rarely is as simple as it seems and typically requires considerable detail and explanation.

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