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The use of positive reinforcement training to reduce stereotypic behavior in rhesus macaques

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Abstract

Stereotypic behavior is a pervasive problem for captive monkeys and other animals. Once this behavior pattern has started, it can be difficult to alleviate. We tested whether or not using positive reinforcement training (PRT) can reduce this undesired behavior. Subjects for this study were 11 adult, female rhesus macaques (*Macaca mulatta*) with a history of locomotor stereotypy (e.g., pacing, bouncing, and somersaulting). We assessed baseline levels of stereotypic behavior and then utilized PRT to train six animals to touch a target and accept venipuncture. The other five monkeys served as controls. We assessed stereotypic behavior 1 week a month for 4 months, on days in which the monkey was not trained. Trained animals showed a significant reduction in stereotypic behavior after 1 month of training, compared to control monkeys (Mann Whitney U=28.00, P=0.02). These group differences did not persist after the first month (Month 2: Mann Whitney U=19.50, P=0.40, Month 3: Mann Whitney U=17.0, P=0.71, Month 4: Mann Whitney U=17.00, P=0.72). Still, the majority of the trained monkeys (n=4) engaged in less stereotypic behavior at the end of the study compared to baseline. Thus, training may be an effective way to reduce stereotypic behavior, at least for some individuals.

Keywords

Operant conditioning; stereotypy; nonhuman primate; welfare

1. Introduction

Stereotypic behaviors, defined as repetitive, habitual behavior patterns with no obvious function (Mason, 1991; Shepherdson, 1993), are commonly observed in captive animals in a wide range of taxa, including birds, ungulates, carnivores, rodents and primates. Stereotypies can manifest differently depending upon the species or individual (Würbel, 2006), but include whole-body locomotor behaviors such as pacing, bouncing, somersaulting, and rocking, as well as self-directed behaviors such as hair or feather pulling, eye poking and digit sucking. It is a widespread problem for captive animals, and is found in zoos, research laboratories, and breeding facilities (Laule, 1993; Mason and Latham, 2004). Recent reports have estimated that over 85 million animals living in captivity engage in some sort of stereotypic behavior (Mason

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and Latham, 2004). This estimate does not include nonhuman primates living in zoos or research facilities, but these animals are also prone to stereotypic behavior. Lutz and colleagues (Lutz, 2003) reported that close to 80% of individually housed research rhesus macaques in their study population engaged in pacing behavior. While stereotypic behavior is relatively common in captive environments, it often indicates compromised well-being (e.g., Mason, 1991), and as such is a concern.

Many factors have been implicated in the development of stereotypic behavior (see Mason, 1991 for review). There is evidence of a genetic component that may predispose individuals to develop the behavior (Schoenecker and Heller, 2000; Schwaibold and Pillay, 2001). Adverse experiences early in life, such as maternal separation or inadequate maternal care, can also play a role in the onset of stereotypies (Lutz, 2003; Novak, 2003; Novak et al., 2006; Latham and Mason, 2008). Still, the most commonly posited etiology is suboptimal housing conditions, such as a barren environment with insufficient external stimuli (e.g., Meehan et al., 2004; Swaisgood and Shepherdson, 2006) or lack of appropriate socialization (Bellanca and Crockett, 2002; Lutz, 2003; Novak, 2003). These factors can lead to frustration (e.g., animal cannot engage in a behavior it is motivated to do), boredom, fear and a lack of control over the environment (Rushen et al., 1993; Swaisgood et al., 2001; Swaisgood and Shepherdson, 2006), and, ultimately, the development of stereotypic behavior (Dantzer, 1986; Mason, 1991; Wemelsfelder, 1993).

Several approaches had been used to reduce the incidence of stereotypic behavior in primates and other animals. Treatments are typically aimed at improving the environmental conditions in which the animals live, by providing them with enrichment designed to allow them to engage in species-normative behaviors (e.g., Fontenot et al., 2006; Swaisgood and Shepherdson, 2006; Mason et al., 2007). For monkeys living in research facilities, enrichment aimed at reducing stereotypy often consists of items such as foraging or grooming boards (Bayne, 1991; Lam et al., 1991), foraging manipulanda (Lutz and Farrow, 1996; Boinski et al., 1999), novel toys (Line and Morgan, 1991), play cages (Bryant et al., 1988), and treats (Bayne et al., 1993). The results of such enrichment treatments on stereotypic behavior are varied, but have generally met with limited success. Even when enrichment does reduce stereotypic behavior, the results are typically short lived, and restricted to the time in which the animals are exposed to the enrichment (Lutz and Farrow, 1996). Pharmacological interventions such as fluoxetine or buspirone (Poulsen et al., 1996; Fontenot et al., 2005) have also been used to reduce stereotypic behavior in a variety of species with mixed results. While fluoxetine had some positive results in bears (Poulsen et al., 1996) and vervet monkeys (Hugo et al., 2003), it did not reduce stereotypic pacing in rhesus monkeys (Fontenot et al., 2005). Still, it is not always desirable to have subjects on psychotropic drugs that can affect many physiological parameters. Thus, novel treatments for stereotypic behaviors are warranted.

In the present study, we investigated whether training monkeys to perform various tasks such as touching a target and accepting venipuncture using positive reinforcement training (PRT) would reduce stereotypic behaviors in adult female rhesus macaques (*Macaca mulatta*). In positive reinforcement training, the trainer reinforces desired behaviors (e.g., presenting a body part) by rewarding the subject when it performs the behavior (e.g., Pryor, 1999). PRT desensitizes animals to various procedures, thus reducing the stress and fear associated with these procedures (Bassett et al., 2003; Schapiro et al., 2003; Lambeth et al., 2006). It also increases mental stimulation and, by providing choice and allowing individuals to cooperate with the procedures, can give animals a sense of control over their environment (Laule et al., 2003). We hypothesized that since PRT can decrease boredom and stress and increase perceived control over the environment, it might help reduce the incidence of stereotypic behaviors.

2. Methods

2.1 Subjects

The subjects for this study were 11 adult (6-19 years old), female rhesus macaques (*Macaca mulatta*) with a history of stereotypic behavior (based on behavioral assessments, see 2.2). All animals were singly housed in standard monkey cages (122 cm wide × 69 cm deep × 81 cm high) at the Oregon National Primate Research Center (ONPRC; Beaverton, Oregon, USA), in rooms that contained 16-90 monkeys. Six of the subjects were born at the ONPRC, and the other five were imported as adults from other facilities. While the monkeys had been singly housed for at least 2 months (mean= 497.91 ± 133.01 days) prior to the start of the study, all subjects had spent part of their lives socially housed, either in groups of 6-150 individuals or in pairs (i.e., two monkeys share a double-sized cage). During the study, the monkeys were housed in different animal rooms within the ONPRC, to ensure that no animal was in visual contact with another subject from the study. They were fed standard monkey chow twice a day, and were given fresh produce or other food enrichment daily. Water was provided freely through automatic lixit systems. The lights were on 12 h per day, from 7:00 h to 19:00 h and the temperature was maintained at 24 ± 2°C. Subjects participated in the ONPRC behavioral management program to ensure their psychological health and well being. The ONPRC animal care program is USDA compliant and accredited by AAALAC-International, and the ONPRC Institutional Animal Care and Use Committee approved this study.

2.2 Behavioral assessments

As part of the ONPRC Behavioral Management Plan, all caged monkeys are assessed at least annually. During these behavioral assessments, an observer stands approximately 1 m from the cage and monitors each animal for 5 min, taking care not to make direct eye contact with the animals, as this is considered a threatening posture to rhesus monkeys. The observer records any indication of behavioral problems including stereotypic behavior. For the purposes of this study, animals that engaged in whole-body locomotor stereotypies (e.g., pacing, repetitive somersaulting, circling, bouncing, Table 1) during at least three assessments were considered to have a history of the behavior.

2.3 Baseline stereotypic behavior

To assess baseline stereotypic behavior, we took continuous focal observations (Altmann, 1974). Focal observations were 10 min in duration (following a 5 min acclimation period) and were taken between 9:00-10:00 h by one of four technicians. This time period was chosen because it was after the animals had been fed their morning meal, but before other daily activities (e.g., cage cleaning) had begun. During the observation, the technician stood approximately 1 m from the cage, and recorded the amount of time the monkey spent in whole-body active stereotypic behavior (e.g., pacing, repetitive somersaulting, circling, Table 1), as well as the type of stereotypy. As with the behavioral assessments, observers avoided direct eye contact with the monkeys during the observations. Each animal was observed three times over a 4-5 week period (no more than one focal per week), for a total of 30 min of observations per individual. The animals did not show any signs of distress (e.g., freeze) towards the observer.

2.4 Training

Monkeys were randomly assigned to a “train” (n=6) or control (n=5) group. Three of the trained and three of the control monkeys were born at the ONPRC. The “train” animals were first trained to touch a target (a piece of PVC tubing hung on the outside of the cage) using positive reinforcement training (PRT) techniques (e.g., Laule et al., 2003). Each time the monkeys moved closer to the desired behavioral outcome (e.g., touching the target), the trainer reinforced

this behavior by rewarding the animal with a small food treat. After the monkeys reliably performed this task, they were trained to accept venipuncture. Five of the monkeys (T1-T5) were trained to come to the front of their cage and insert their arm in a “blood sleeve” (a plexiglass tube with a peg at the end that was hung on the outside of the cage at the door opening; see Coleman et al., 2008 for shaping plan) for venipuncture. The last monkey (T6) was trained to come to the front of the cage and extend her leg through the cage door for venipuncture, using a comparable shaping plan. The monkeys were first rewarded for moving towards the front of the cage and remaining stationary by the door. The monkeys were then trained to either put their arm in the blood sleeve and hold the peg located at the end of the sleeve (monkeys T1-T5) or extend their leg out of the slightly open (approximately 10 cm) door and hold the trainer's hand (T6). After the subjects were trained to perform these behaviors, they were desensitized to the sensation of being touched on either the arm (T1-T5) or leg (T6), first with the trainer's finger, and then with a capped syringe. Both shaping plans then called for the animals to be desensitized to the insertion of the needle. Training sessions were 10 min and were conducted three times per week for 4 months. Every animal was trained by one of two experienced trainers, both of whom used the same training techniques, including the same reinforcement schedule. The trainers ended each training session by asking for a behavior the monkey was able to perform. Animals were considered to be reliably trained for a task when they performed the task on command for three consecutive training sessions. The controls received no training of any type during the study, and were not located in rooms in which monkeys were being trained.

To assess the amount of stereotypic behavior during the training period, we took direct focal observations on all monkeys every other day for 1 week, at the end of each month of the study (n=3 per month). Focal observations were taken as detailed in 2.3 on days in which the animals were not trained. Individual monkeys were not observed and trained by the same human observer.

2.5 Statistics

We calculated the percent of time the subjects engaged in stereotypic behavior during each focal observation, and averaged across each time period (e.g., baseline, month 1, etc.). To determine if the amount of stereotypic behavior decreased with time, we calculated the percent change for each month, compared to baseline (i.e., (Month × – baseline)/baseline × 100%). The assumptions of normality and homoscedacity were tested for all variables. Because transformations did not normalize the data, we utilized nonparametric statistics (Mann Whitney U test and Spearman Rank Correlation). Data are presented as mean ± SEM. Alpha values were set at 0.05. SYSTAT 11 (Systat Software Inc, San Jose, CA, USA) was used for all analyses.

3.0 Results

3.1 Baseline

There was a great deal of variation in the amount of stereotypic behavior displayed by the 11 monkeys during the baseline period (Table 2; range= 12.39-87.72 % of time, mean= 29.67 ±7.80%). While most of the subjects engaged in stereotypy less than 30% of the time, two spent over 70% of their time in this behavior. Baseline stereotypy was not correlated with the length of time the subjects had been singly housed just prior to the start of the study ($r_s = -0.27$, P=1.00). The amount of stereotypic behavior during the baseline period was not significantly different between control (n=5) and trained (n=6) monkeys (Control Mean= 17.66 ± 3.08% of time, Train Mean= 39.69 ± 32.14; Mann Whitney U= 8.0, P=0.20). There was also no difference in stereotypical behavior between monkeys born at the ONPRC (n=6, mean= 21.16 ± 2.0% of time) and those imported (n=5, mean= 39.89 ± 16.76%; Mann Whitney U= 15.0, P= 1.0)

3.2 Training

The trained monkeys made significant progress during the first month of the study. All six easily learned to touch the target. In addition, four monkeys inserted their arms in the blood sleeve and one extended her leg out of the cage door reliably (i.e., performed the task on command for three consecutive training sessions) in the first month. By the end of the second month of training, they all remained stationary at the front of the cage and allowed the trainer to touch them with a finger. One monkey reliably accepted being touched with the capped syringe. However, there was little progress after the second month of training. None of the monkeys allowed venipuncture for three consecutive training sessions, and were therefore considered not to have completed the training.

3.3 Training and stereotypical behavior

At the end of the first month of the study, trained monkeys showed a significantly larger percent decrease in stereotypic behavior compared to control monkeys (Fig. 1, Mann Whitney U=28.00, P=0.02). Four of the six trained monkeys reduced stereotypic behavior by at least 85%, and three of these individuals showed no stereotypic behavior at all after 1 month of training (Table 2). In contrast, only two of the control monkeys decreased stereotypic behavior during the first month, and neither of these animals decreased stereotypy by more than 30% (Table 2).

These group differences did not persist after the first month of the study. There were no statistical differences between control and trained monkeys in the proportion of time spent in stereotypic behavior compared to baseline for months 2-4 (Month 2: Mann Whitney U=19.50, P=0.40, Month 3: Mann Whitney U=17.0, P=0.71, Month 4: Mann Whitney U=17.00, P=0.72; Fig. 1).

As a group, the trained monkeys continued to show a decrease in stereotypic behavior across the 4 months of the study, although there was considerable individual variation. While the overall decrease in stereotypy was less in month 4 (approximately 20% decrease compared to baseline) than in month 1 (71% decrease compared to baseline), the majority of the trained monkeys (n=4) engaged in the undesired behavior less at the end of the study compared to baseline (Table 2).

The control monkeys also decreased stereotypic behavior in months 2-4. At the end of the study, four of the five control monkeys showed less stereotypy than during baseline. As with the trained monkeys, there were individual differences in the pattern of stereotypical behavior across months for the control group (Table 2). Only one control had a sustained (e.g., at least two consecutive months) decrease in stereotypical behavior of more than 85%. In contrast, four of the trained monkeys decreased stereotypy by 85% or more for at least two consecutive months, and three maintained this reduction for 3 months. Interestingly, the two monkeys that did not exhibit this decrease (T4 and T5) had the highest levels of baseline stereotypical behavior. While low sample sizes preclude statistical analysis, these monkeys spent about the same amount of time in single housing prior to the start of the study (361.50 ± 98.50 days) as the other four trained monkeys (387.50 ± 154.91 days).

The monkeys were generally inactive when not engaging in stereotypy. They often remained stationary, occasionally self-grooming or foraging. They would sometimes also engage in normal, non-stereotyped movement. At no point did we notice a monkey freezing in response to the observations.

4.0 Discussion

Stereotypic behavior is a pervasive problem for captive monkeys in zoos and research facilities (Laule, 1993; Lutz, 2003). Further, it is almost always difficult to ameliorate once it has begun. We found that positive reinforcement training (PRT) helped to reduce stereotypic behavior in some adult female rhesus macaques housed in a research facility, at least in the short term. The majority of the trained monkeys in our study reduced stereotypic behavior by at least 85% after 1 month of training while there was no such reduction for the control monkeys. On the contrary, control monkeys had an overall increase in the amount of stereotypic behavior compared to baseline after 1 month. However, there were no differences between control and trained monkeys in percent reduction of stereotypy for months 2-4.

Even though the group differences did not persist, training had a pronounced impact on some of the subjects. Half of the trained monkeys (T2, T3, and T6) reduced stereotypical behavior by at least 85% for the first 3 months of the study. While the amount of time spent in stereotypy by these individuals increased in the fourth month, it was still less than baseline. It is possible that this increase was due to the type of training we selected. During the first 2 months, the training was novel and consisted largely of target training and inserting an arm in the blood sleeve or extending a leg out of the cage door. By the third month, the training focused on desensitization; i.e., the trainers were starting to touch the monkeys with an aversive stimulus (a capped syringe). The presence of the syringe may have increased stress for the monkeys, resulting in an increase in stereotypy. Further, there were few new tasks for the monkeys to learn, which may have lead to frustration or boredom with the training. Training animals for a variety of less aversive tasks, such as presenting body parts, may have resulted in a more sustained decrease in stereotypy.

Interestingly, the lack of continued statistical significance after the first month of the study was not due to an increase in stereotypic behavior in the trained animals, but rather from a decrease in stereotypy in the controls. It is possible that the control monkeys reduced stereotypical behavior as they got used to the presence of an observer. Other factors such as new caretakers, changes in environmental enrichment or the movement of conspecifics into or out of rooms could have affected the amount of stereotypy displayed by the control animals. Because confounds such as these are not always recorded in the animals' histories, we were not able to account for them in the present study. However, these types of confounds were equally as likely to have occurred with the trained monkeys as the control monkeys.

While there were no statistically significant differences, the trained monkeys exhibited over twice as much stereotypic behavior in the baseline period as the control monkeys. This was likely due to the fact that the two monkeys with the most stereotypy ended up in the trained group. These two animals (T4 and T5) spent over twice as much time engaged in stereotypical behavior compared to the other animals in the study. The reason for these high levels of baseline stereotypy in these individuals is not clear. They spent about the same amount of time in single housing prior to the start of the study as the other trained monkeys. However, neither of these monkeys were born at the ONPRC, and information regarding their rearing histories (e.g., whether they were raised with their mothers) was not in their records. It is possible that these monkeys had some sort of adverse early experiences, such as being reared in a nursery, which may have lead to the high levels of stereotypy (Novak, 2003). It is unlikely that the move to a new facility in itself caused the increased in stereotypy in this study, since there were no differences in baseline stereotypy between monkeys born at the ONPRC and those imported.

In the current study, our ultimate training goal was for the monkeys to remain stationary and accept venipuncture. Five of the animals were trained to put their arm in a blood sleeve and the sixth was trained to put her leg out of the cage door. We had started to train two additional

monkeys for this task as well, but those animals ended up being assigned to a different study before the end of the first month. While we utilized two different shaping plans, the steps were very similar between the two. In both, the monkeys were first trained to touch a target, and were then trained to present an appendage and allow the trainer touch them with their finger, and then with a capped syringe. Despite the difference in training plans, the monkeys progressed at roughly the same rate. All of the monkeys reliably presented an appendage, and only one monkey reliably accepted being touched with the capped syringe. Further, the one monkey trained to present her leg (T6) responded to the training very similarly to one of the monkeys trained for the blood sleeve (T3). Therefore, it is likely that we would have gotten similar results even if we had trained all monkeys with the same shaping plan.

While there are few published studies examining the effect of PRT on locomotor stereotypy, there is some evidence that it might be an effective treatment, at least for some individuals. Training was found to reduce the incidence of stereotypies in polar bears (D. Shepherdson, personal communication), and primate species (Morgan et al., 1993; Raper et al., 2002; Bourgeois and Brent, 2005; Pizzutto et al., 2007; Baker et al., 2009) but was not effective in others (Bloomsmith et al., 2005). The latter study was looking at the effects of PRT on abnormal behavior in general, and included self-injurious and self-directed behaviors. In contrast, we focused specifically on whole body locomotor stereotypies (e.g., pacing, circling, etc), and chose subjects with a history of this behavior. None of our subjects had a history of self-injurious or other self-directed behaviors. It is possible that the subjects in the two studies represented different subsets of individuals with stereotypic behavior, and as such responded differently to the training. Since a variety of factors have been implicated as producing stereotypy, including early experiences, boredom, stress, and lack of control over the environment, it seems reasonable to expect that therapies that help some individuals may not help others. Animals that engage in stereotypic behaviors due to lack of environmental control or boredom may respond relatively well to PRT. On the other hand, PRT may have less of an effect on an animal that engages in stereotypy due to adverse rearing experience, or other factors that cause the behavior to be ingrained in its behavioral repertoire. The small sample sizes in this study preclude this sort of analysis. However, in the present study, the two monkeys with the highest level of baseline stereotypical behavior (T4 and T5) did not respond as well as the others to the training, at least in the first month. Unfortunately, the records for these animals do not go back far enough to determine how long these animals had exhibited stereotypical behavior, nor do we have information regarding their early rearing histories. More studies with larger sample sizes are needed to examine the efficacy of PRT as a therapy for stereotypical behavior caused by disparate factors.

Because stereotypic behavior is often considered an indicator of compromised well-being for monkeys and other captive animals (Mason, 1991) much effort has been expended to try to reduce it. However, like other behavioral issues, stereotypy is challenging to treat. Positive reinforcement training can be a useful first step towards reducing stereotypic behavior. Further, unlike some other potential treatments such as pharmacological agents, training has few, if any, negative side effects. Done correctly, it provides subjects with a mental challenge (Laule et al., 2003), and allows them to cooperate with procedures (Bloomsmith, 1992; Reichard et al., 1992) which can reduce stress (Mineka et al., 1986) and improve psychological well being. PRT has been successfully used to lower aggression and increase affiliative behavior in group-housed primates (Bloomsmith et al., 1994; Schapiro, 2000; Schapiro et al., 2001). It can also reduce reactivity and threat behavior directed towards caretakers (Savastano et al., 2003). PRT can improve the relationship between caretakers and subjects (Bloomsmith, 1997). Further, PRT has been shown to reduce abnormal behaviors including self-directed behaviors (Laule, 1993; Bloomsmith et al., 2007), although this is not a universal finding (e.g., Bloomsmith et al., 2005, Baker et al., 2009). While PRT may not be a universal panacea for stereotypic behavior, it may be useful as a therapy, at least for some individuals.

5. Conclusions

The results of this study suggest that positive reinforcement training can help reduce whole-body active stereotypic behavior (e.g., pacing, repetitive somersaulting, circling) in some captive rhesus macaques, at least for the short term. Further, our results suggest that PRT may be more effective in alleviating stereotypy in some individuals than in others. Future studies should examine potential sources of this variation in response to PRT among subjects with stereotypy, including the type of training as well as the underlying cause of the stereotypical behavior.

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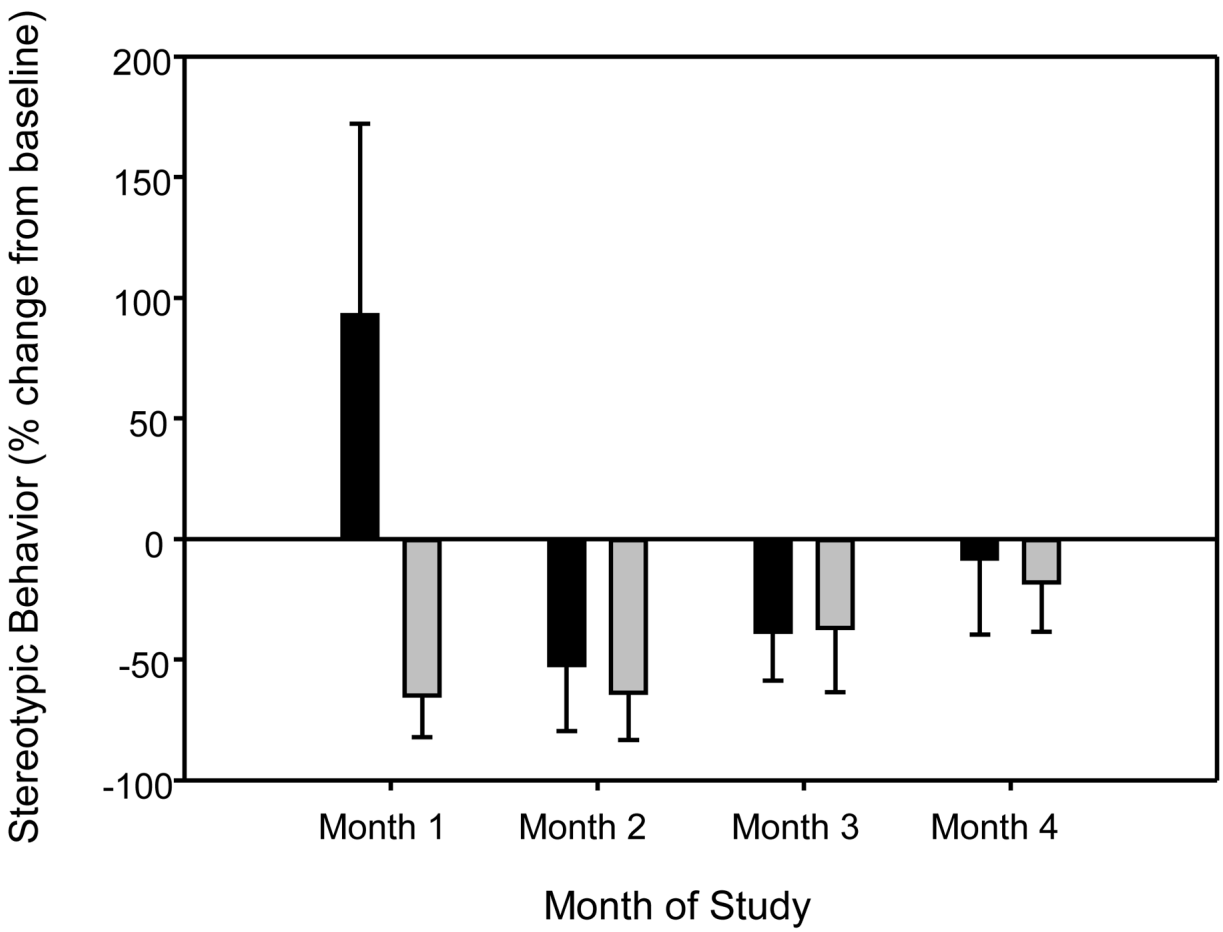

Fig. 1.
Percent change in stereotypic behavior from baseline to months 1-4 for control (black bars, *n*=5) and trained (grey bars, *n*=6) monkeys. Error bars represent SEM

Table 1

List of behaviors and definitions used in focal observations. Note: behaviors had to occur for at least 3 s before being scored as stereotypy

Behavior	Definition
Bounce	Repetitive hopping or bouncing in place
Circle	Repetitive twirling or walking in tight circle in place; subject typically holds top of cage during this behavior
Pace	Repetitive walking in same path in cage
Somersault	At least three back flips in cage

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Table 2

Percent of time control (*n*=5) and trained (*n*=6) monkeys spent in stereotypic behavior during observations in the baseline period and months 1-4. Numbers in parentheses represent percent change from baseline

ID	Treatment	Stereotypical Behavior				
		Baseline	**Month 1**	**Month 2**	**Month 3**	**Month 4**
C1	Control	24.72	36.72 (48.54)	0.00 (−100.00)	15.22 (−38.43)	21.94 (−11.25)
C2	Control	12.78	9.61 (−24.80)	18.72 (46.48)	16.67 (30.44)	8.28 (−35.21)
C3	Control	12.39	61.94 (399.92)	0.44 (−96.45)	1.11 (−91.04)	0.67 (−94.59)
C4	Control	25.67	18.89 (−26.41)	6.56 (−74.44)	17.17 (−33.11)	25.56 (−0.43)
C5	Control	12.72	21.44 (68.55)	7.78 (−38.84)	4.89 (−61.56)	25.22 (98.27)
T1	Train	21.11	0.00 (−100.00)	0.00 (−100.00)	32.28 (52.91)	35.11 (66.32)
T2	Train	23.72	3.00 (−87.35)	0.11 (−99.54)	0.00 (−100.00)	12.94 (−45.45)
T3	Train	19.33	0.00 (−100.00)	0.00 (−100.00)	0.00 (−100.00)	5.89 (−69.53)
T4	Train	73.39	74.56 (1.59)	69.11 (−5.83)	49.78 (−32.17)	38.17 (−47.99)
T5	Train	87.72	52.39 (−40.28)	73.44 (−16.28)	80.83 (−7.85)	91.83 (4.69)
T6	Train	12.83	0.00 (−100.00)	0.00 (−100.00)	0.00 (−100.00)	8.67 (−32.42)