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Jamie Schrauth, author

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University of Wisconsin Oshkosh
Office of Grants and Faculty Development
800 Algoma Blvd.
Oshkosh, WI 54901
(920) 424-3215
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Hand-Use Lateralization in Ring-Tailed Lemurs *(Lemur catta)*

Jamie Schrauth, author
Kathleen Stetter, Psychology, faculty adviser

Abstract

As a part of a zoo enrichment program, this study examined hand preference for two captive adult (one male, one female) ring-tailed lemurs in order to determine whether bimanual hand preference was consistent with unimanual hand preference. Three different conditions (tube fixed high on cage, tube fixed low on cage and free rolling tube on cage bottom) determined unimanual hand preference. The bimanual condition used a tube hung vertically with a side hole for food extraction. This condition required the lemurs to hold the tube with one hand to prevent swinging while extracting with the other hand. Binomial *z* tests for each condition indicated significant ($p < .001$) left-hand preference for both lemurs across all conditions. Both lemurs exhibited 100% left-hand use for bimanual tasks, which supports research with other primates that has shown a greater degree of lateralization for bimanual tasks.

Introduction

The study of handedness in primates provides researchers with the opportunity to examine asymmetrical lateralization of brain function and how it evolved. It is important to establish where and when during evolution these tendencies toward asymmetrical lateralization first appeared, and to discover what purpose they serve (Papademetriou, Sheu, & Michel, 2005).

Macmeilage, Studdert-Kennedy, and Lindblom (1987) proposed that arboreal (tree-dwelling) prosimians used their right hands for grasping branches and their left hands for visually guided reaching and grasping of food because their brains' right hemispheres were better suited for visuospatial processing. Macneilage et al. (1987) also stated that as terrestriality (ground-dwelling) evolved, primates continued to reach using their left hands for grasping, and they began to manipulate objects with their right hands. They hypothesized that this right-hand bias for manipulation eventually led to an overall right-hand bias for both reaching and manipulating. This theory is called the postural origins theory (POT) for the evolution of right bias in human handedness.

Other researchers have proposed different hypotheses for the origin of hand biases. Fagot and Vauclair (1991) proposed that the presence of hand preferences was dependent on the tasks being performed. This theory stated that low-level manual tasks (familiar, well-practiced actions with low levels of cognitive processing like reaching) do not result in hand preference, whereas high-level manual tasks (novel, finely coordinated actions involving complex cognitive processing) would exhibit not only handedness, but also a population bias in handedness that reflected the underlying cerebral hemisphere specialization.

Previous research has determined that a majority of ring-tailed lemurs have a left-hand preference. These studies used unimanual (one-handed) free-feeding (Ward, Milliken, Dodson, Stafford & Wallace, 1990) and unimanual extraction from

a clear Plexiglas® box (Milliken, Forsythe & Ward, 1989), but did not employ a coordinated-bimanual (requiring the coordinated use of two hands) condition. The hand used for extraction of food from the apparatus is considered the dominant hand for a coordinated-bimanual task. Determining bimanual hand preference is important because coordinated-bimanual tasks require higher-order cognitive processing (Hopkins, Stoinski, Kukas, Ross & Wesley, 2003), and there are other factors, such as posture, that may influence a unimanual task (Westergaard, Kuhn, & Suomi, 1998).

This study used four measures of hand preference, each with a different posture as described in the method section. An addition is the first condition, which requires the subject to hang while retrieving the food. Previous studies have only used free reaching. This is important because the subject could use the dominant hand to grasp the cage or reach for food. Another addition is the fourth measure, a bimanual task, which has never been used in the study of lemur hand preference.

The purpose of this study was to provide additional evidence in support of the existing research that showed a left-hand preference in ring-tailed lemur handedness by adding a bimanual task as well as additional unimanual tasks. The first hypothesis for this experiment was that the hand preference exhibited by the subjects would match data from previous studies that showed left-hand bias (Papademetriou, et al., 2005). The second hypothesis stated that the bimanual task would show a greater degree of lateralization than unimanual free-feeding.

Method

Subjects

One adult female, one adult male, and one juvenile male ring-tailed lemur (*Lemur catta*) lived in a 10 m diameter and 7 m high corn-crib style cage at the Menomonee Park Zoo in Oshkosh, WI. The juvenile subject exhibited a preference for using its mouth when extracting food from the apparatus, and therefore did not produce usable data. This finding is consistent with Ward et al. (1990) who noted lack of hand use in juvenile lemurs. The Menomonee Park Zoo leased animals with unknown histories.

Apparatus

In Condition 1, a 25 cm PVC plastic tube was held in a fixed position by two, 10 cm square pieces of 6 mm thick Plexiglas®. The two Plexiglas® pieces had holes in the center matching the outside diameter of the PVC tube to hold the tubes in place. I placed one of the Plexiglas® pieces on the tube inside the cage and the other on the outside, and then secured them to each other using bolts and nuts. Condition 1 had the tube mounted 150 cm above the bottom of the cage. A plunger, made with a circular piece of Plexiglas® with a metal rod inserted through the center, pushed pieces of food into the PVC from outside the cage. Condition 2 used the same apparatus mounted 30 cm above the bottom of the cage.

Condition 3 used a 20 cm PVC tube on the cement floor of the subjects' cage. The tube, containing banana slices held in place with peanut butter, rolled freely on the cage bottom.

In Condition 4, a 60 cm PVC tube with covered ends hung vertically in the subjects' cage by a chain in a position that allowed the apparatus to swing freely.

A 4 cm round hole was cut in the side of the tube, 4 cm from the bottom, to allow for food extraction. Each condition is illustrated in Figure 1.

Figure 1

Photos of each condition taken during pretesting. (a) Upper left: Condition 1 (Tube mounted low on cage side). (b) Upper right: Condition 2 (Tube mounted high on cage side). (c) Lower left: Condition 3 (Rolling tube). Tube was placed on cage floor for testing. (d) Lower right: Condition 4 (Hanging tube used for bimanual condition).

Materials

The food used for this experiment was a portion of the lemurs' regular daily diet (with the exception of the peanut butter used in Condition 3 to adhere the bananas to the apparatus). This diet consisted of a variety of fruits and vegetables, as well as Purina® 64100X Monkey Chow®.

Procedure

Pretesting occurred prior to data collection by placing the apparatus in the cage for 5 to 30 min with all lemurs present. Pretesting provided familiarization of the subjects with the apparatus and how it worked. This pretesting also helped me to assess whether the lemurs would use the apparatus as intended. No data were collected during pretesting sessions.

At the beginning of each data collection session, the focal subject was isolated in the cage. The other lemurs moved to a lock-out cage through a tunnel connected to the primary cage in order to prevent them from competing for food with the focal lemur. Only the two adults were suitable for use in the study because the juvenile attempted to use its mouth to extract food from the apparatus. This lemur received its portion of the food separately after data collection was finished. The order of subject testing varied daily because when I shifted the subjects to the lock-out cage the last lemur remaining in the primary cage became the first focal subject.

Conditions 1 and 2 were tested simultaneously. These conditions required the lemurs to take food from a tube mounted in a fixed position on the side of their cage. Food placement required lemurs to go back and forth between the high and low tubes. This procedure forced the subjects to reposition themselves between each reach. The lower tube was more difficult to fill because the subjects could reach out of the cage and swat at me as I tried to place food in the tube. When this occurred, I went back to the high mounted tube. This resulted in an uneven number of reaches for each condition. Food preference also contributed to uneven reaches because subjects would not always reach for less desirable foods. Data collection continued until the focal subjects lost interest in the food or their portion of the food had been exhausted.

In Condition 3, the free-rolling tube containing pieces of banana held in place with peanut butter rolled freely on the cement floor of the cage. I initially thought the subjects would have to use two hands to extract the food, and planned to use this condition as a bimanual task; however, the weight of the tube allowed the subjects to extract food without holding the tube with the other hand. Although it could not be used as a bimanual condition, the condition was included because it required a crouched squat-like posture, which was different from the posture for the other conditions (sitting for Condition 1 and hanging for Condition 2). Each lemur received 20 min with the apparatus for five data collection sessions.

In Condition 4, the lemurs were shifted to the lock-out cage. I then filled the apparatus with food and hung it in the cage, and allowed the focal subject to return the primary cage. Data was collected until all of the food was extracted from the apparatus. At this time, I again shifted all of the lemurs to the lock-out cage to refill the apparatus, and then allowed the second subject to return to the primary cage for data collection. Repetition of the procedure resulted in two data collection sessions per lemur each day, for five consecutive days. Limited space for available food in the apparatus forced me to repeat the procedure each day. Satiation of animals and dietary limitations prevented additional daily replications.

Results

Separate binomial *z* tests, nonparametric statistics that evaluate frequency differences from chance, were done for each lemur in each condition. Significant ($p < .001$) left-hand preference emerged for both lemurs across all four conditions (see Table 1). This supports previous research with lemurs that showed left-hand lateralization (Papademetriou, et al., 2005). Both lemurs showed 100% left-hand use for the bimanual task.

Table 1
Frequency of Hand Use for Each Condition

Subject	Task	Total Observations[a]	Total Extractions[b]	Percent left	Binomial *z*
A. Male	High Tube	8	106	99.0	10.00*
A. Male	Low Tube	7	92	96.7	8.00*
A. Male	Rolling Tube	5	84	99.2	8.18*
A. Male	Hanging Tube	5	84	100.0	9.06*
A. Female	High Tube	8	157	96.9	11.00*
A. Female	Low Tube	7	111	97.3	9.87*
A. Female	Rolling Tube	5	138	97.1	10.98*
A. Female	Hanging Tube	5	69	100.0	8.00*

[a] Number of separate observation days
[b] Number of lemur reaches
* $p < .001$

Discussion

The lemurs in this study showed a significant left-hand preference in all reaching tasks, which supports previous research (Papademetriou, et al., 2005). The degree of hand lateralization was greater for bimanual conditions than unimanual conditions, which is consistent with research on other primates that has shown a greater degree of lateralization for bimanual tasks (Papademetriou, et al., 2005). These findings extend the knowledge of hand-use lateralization in the ring-tailed lemur. In addition, the apparatus and procedure provide a model for future hand-bias testing in lemurs and other primates.

Although the small sample size is typical of captive primate studies, testing of additional animals is needed before drawing firm conclusions about the species' hand bias. Also, I did not know the history of the subjects, so the subjects could be related with the same left-hand bias due to genetics. Another limitation was the setting in which the research took place. This study was part of a zoo enrichment program, and provided the animals with varied activities while providing visitors with information about the species. As such, I may have missed data points because of distractions from various sources. For this reason, videotaping data collection sessions would be advised for future research. Distractions from other animals and zoo patrons may have also affected the way the lemurs behaved.

More research is needed in order to determine a species-wide prevalence of hand lateralization. In order to do this, future researchers need a larger sample size consisting of subjects from different lineages. The cages at the zoo were small and not at all like the lemurs' natural habitat. The best subjects would be free-ranging lemurs in their natural habitat. However, in order to achieve this, the apparatus would have to be modified and the wild lemurs would have to cooperate by using the apparatus. The required field study would involve considerable expense and travel. In addition, wild populations of lemurs could become habituated to human presence. This could endanger these populations by decreasing their wariness for large predators.

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The Effects of Enriched and Typical Laboratory Environments on Object Investigation in Old Sprague Dawley Rats

Andrea June and **Jessica Linberts**, co-authors
Dr. Susan McFadden, Psychology, faculty adviser

Abstract

The purpose of this study was to observe the differences in object investigation between two groups of aged Sprague Dawley rats reared in an enriched and a typical laboratory environment. Research has shown that enrichment has a positive effect on behavior of young and mature rats. Our research question was: Will this positive effect on behavior be retained into old age? Object investigation was measured by recording exploratory activity and overall time spent with objects in an open field. Twelve rats were tested with six in each group. There was no significant difference found in bouts of behavior between the typical and enriched group on Day 1 or Day 2. However, there was a significant difference between the time engaged with objects on Day 1 but not on Day 2. Overall, the results of the study did not support the hypothesis that the enriched group would engage in significantly more object investigation, measured by bouts of behavior and time duration, than the typical laboratory group. Further research on the effects of environment on behavior of the old is important to understand how to maximize functioning through environmental stimulation in old age.

Introduction

Dating back to the time of Darwin, there has been a fascination with the general curiosity of animals and humans alike (Renner & Seltzer, 1991). Darwin studied this curiosity by “placing a live snake in a bag into the cages in the monkey house and the London Zoological Gardens” (as cited in Renner, 1987). Darwin’s description of the monkey’s reactions was that “they could not resist taking a momentary peak” (as cited in Renner, 1987). Over time, psychologists have further investigated curiosity and have called it animal exploration or investigation.

Thinus-Blanc et al. (1987) investigated exploratory behavior in hamsters placed in an open field by manipulating the distances between objects and topological relationships. The results indicated a renewal of exploration after the experimenters affected the spatial relations of the objects but not after they affected the distance. Similarly, a study done by Dubois et al. (1999) measured behavioral bouts of Wedge-capped Capuchin monkeys directed toward objects to address whether location affects activity. Overall, results showed a great deal of between- and within-subject variability. Renner and Seltzer (1991) defined several exploratory and investigative behaviors in rats in terms of their molar characteristics (e.g., large units of behavior) and studied how these change as a result of repeated opportunities to explore the same environment. The results indicated the activity levels remained the same over the period of observation, and the amount of time spent interacting with objects increased initially followed by a decrease. In an additional study, Renner and Seltzer (1994) suggested that behavioral grammars can be used to predict individual animals’