

Hand Preferences of *Macaca radiata* monkeys in Shervaroy's Hills, Tamil Nadu, India.

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Abstract: *The present study examined hand preference in Macaca radiata based on the results of the tube task and reach task method. The Macaca radiata in the wild environment always used the same hand, whereas, in some conditions, the monkeys used both hands at less frequency. The statistical comparison between the Macaca radiata group of right - hand users versus left - hand users for the tube task and reach task revealed significant differences with variable HI scores. The real values of HI score in hand preference of male and female individuals showed significant differences. The number of male monkeys showing a left - handed preference did not significantly differ in all study sites. The female macaque individuals predominantly used their left hand to pick up food from tubes.*

Keywords: Monkey, Tube task, Handedness, Grasping and HI scores

1. Introduction

Preference for using one hand over the other is a typical way to quantify handedness, a behavioral asymmetry that has been extensively researched. Ecological factors such as postural demands and feeding strategies were thought to have driven hand use. In early primates who were arboreal and relied on ballistic movements to catch fast - moving insect prey, the left hand may have become specialized for reaching, while the right hand would have been used in a complementary role for postural support. (MacNeilage, 2007; Meguerditchian *et al.*, 2013). According to Papademetriou *et al.* (2005), the hand of preference is the one that individuals instinctively choose to use for a given task, regardless of whether it is the most efficient one. Handedness refers to a group - level bias in the functional dominance of one hand over (Zhao *et al.*, 2012). However, some researchers have claimed that reports of group - level handedness in nonhuman primates could be due to experiential, environmental, and situational factors (Papademetriou *et al.*, 2005). Most studies on hand preference in wild and captive primates have used relatively simple measures of hand use such as simple reaching (Hopkins, 2007). The tube task is an experimental task that assesses hand use. In the tube task, the monkey must grasp a baited tube in one hand and use the other hand's finger to remove the food from the tube (Rogers *et al.*, 2013).

The motions and behaviors of the bonnet macaque are quite varied and highly distinguishable. The male and female hierarchies are different and of non - overlapping or non - mixing types. Males are usually dominant over females. Males frequently switch between troops in order to advance in rank and reap the perks. However, males remaining in a single troop have been observed to rise to become the dominant male of that troop. Female philopatry, the tendency for individuals to stay with the troop they are born into, is the reason behind the stable dominance hierarchy in the case of females. As a result, matrilinear groups of females who are closely connected form. Even in confrontational situations, these matrilineal support one another. Rankings rarely alter since fresh female babies in a

flock maintain the matrilineal regularly. Due to their departure for new battalions, male infants would not aid in strengthening the matrilineal. . The main objective of this present study is to analyze the handedness practice of bonnet monkeys towards the food source in Shervaroy's Hills, Tamil Nadu, India.

2. Methodology

Study Site

This study was conducted on free - ranging bonnet macaques living at various sites in Shervaroy's Hills, Salem District, Tamilnadu. The hand and cheek - pouch usage patterns of macaques *viz*; adult males, juvenile males, adult females, and juvenile females were studied. These experiments were completely non - invasive; placed food on the ground within 3 meters of the macaque and observed their corresponding hand and cheek pouch usage from a distance. The methodology of the present research work adhered to the American Society of Primatologists (ASP).

Tube task

In this task, food mixtures were smeared inside both ends of a polyvinyl - chloride (PVC) tube measuring approximately 23 cm in length and 2.5 cm in diameter (Nelson *et al.*, 2015). Tubes were given directly to monkeys on the roadside and forest areas. Monkeys were required to hold the tube with one hand and insert one or more fingers of the opposite hand into the tube to retrieve the food substrate. Each entry into the tube where the hand was brought to the mouth to eat was scored as left or right. Entries that did not result in food being consumed were not scored. Any response that included the monkey holding the tube with a foot and removing food with one of the hands was not scored. The first 15 responses per monkey per session were recorded in real - time by verbal agreement. Monkeys were thereafter permitted to access the tubes until they lost interest, or until the tube dropped through the floor. More tubes were supplied so that the monkeys would not compete with one another.

Reach task

Hand preference was measured from an unimanual reaching task, which involved monkeys picking up food on separate trials. Additional feeding stations were provided to reduce competition among monkeys experiments done on nonconsecutive test days throughout the experiment (Nelson *et al.*, 2015). All monkeys were tested in their social group on this task and data were collected. Hand preferences in this unimanual task were assessed by following one individual at a time (focal sampling method). Then recorded which hand was used when it reached for food. A response was recorded each time the subject was in a quadric pedal or seated posture, grasped food in front of it in a sagittal median plane, and moved between reaches. The handedness index (number of right - hand responses minus the number of left - hand responses/total responses; HI) was calculated with 100 responses and a HI was calculated with the first 20 responses.

3. Data Analysis

The Handedness Index (HI) was computed by deducting the number of responses from the left hand from the number of responses from the right hand, and dividing the result by the total number of responses, $HI = (R - L) / (R + L)$. HI scores range from - 1.00 (only left - hand responses) to 1.00 (only right - hand responses). HI scores were calculated separately for each measure using the cutoff guidelines suggested by Hopkins (2013), HI scores greater than 0.20 were considered right bias, HI scores less than - 0.20 were considered left bias, and all other HI scores were considered to represent no bias.

4. Results

The study was carried out between June to August 2023 in different places at Shervaroy's hills (Table 1). The hand preference in *Macaca radiata* was determined based on the results of the tube task and reach task method. The *Macaca radiata* in the wild environment always used the same hand, whereas, in some conditions, the monkeys used both hands at less frequency. Figure 1A, 1B, 2A, 2B and 3A, 3B shows left hand and right hand tube task, left hand and right hand reach task and usage of left Cheek and right Cheek Pouch respectively.



Figure 1 (A): *Macaca radiata* left hand use on the tube task.



Figure 1 (B): *Macaca radiata* right hand use on the tube task



Figure 2 (A): *Macaca radiata* right hand use on the reach task



Figure 2 (B): *Macaca radiata* left hand use on the reach task



Figure 3 (A): Usage of left cheek pouch by *Macaca radiata*.



Figure 3 (B): Usage of right cheek pouch by *Macaca radiata*.

Table 1: Study sites at Shervaroy’s hills.

S. No	Site number	Name of the study site
1	S1	Yercaud foot hills
2	S2	60 Feet bridge
3	S3	12th Hair pin bend
4	S4	Yercaud Park
5	S5	Sengadu
6	S6	Keeraikadu
7	S7	Vzhavandhi
8	S8	Kottachedu
9	S9	Servarayan temple

The statistical comparison between the *Macaca radiata* group of right - hand users versus left - hand users for the tube task and reach task revealed significant differences with variable HI scores. The real values of HI score in hand preference of male and female individuals showed significant differences. The HI scores ranged from - 1.00 to +1.00. The wild *Macaca radiata* resided in S1, S2, S3, S4, S5, S6, S7, S8 & S9 study sites at Shervaroy’s hills are subjected to hand preference studies. From the results of the present work, it can be concluded that comparable numbers of left and right - handed occurrences appeared among monkeys, concerning hand preference. The male and female

monkeys' hand preference was studied separately during the study period. The ages of monkey was not considered in this study.

Individual hand - use data and HI scores by tube task are given in tables 2 and 3. On the tube task, among the nine study sites (S1 to S9). The male *Macaca* populations in a group were varied between 9 to 14 individuals in number. The highest number 7 monkeys were classified as having right - hand use bias in the S6 study area. The lowest number of 3 male monkeys out of 9 individuals are recorded as right - hand users in the S7 study site. In another study site, approximately 40% to 50% of male monkeys classified as right - hand bias, viz; 6.00, 4.00, 4.00, 5.00, 4.00, 5.00, 4.00 in S1, S2, S3, S4, S5, S8 and S9 study sites respectively (Table 2). The number of male monkeys showing left - hand preference differs from right - hand preference in all study sites. Among all study sites except S1 & S6, the left - hand usage is higher than the right - hand usage. The highest number (9.00) in the S8 study sites and the lowest number (5.00) were notified in the S1 and S6 study sites respectively. Generally, the left - hand usage ranged from 5 to 9 male monkey individuals in different study sites (S1 and S9) of Shervaroy’s Hill. The degrees of lateralization for the tube task were measured by taking the absolute value of HI scores. HI tube scores were ranged from - 0.33 to 0.17 (Table 2).

The table - 3 describes the hand usage for the female *Macaca radiata*. As suggested by tube task scores, a maximum 6 numbers of female monkeys preferentially used their right hand to pick up food from the tube lying on the ground. Followed by 5 monkeys individuals in a group used the right hand in S6, S8, and S9 study sites. The female macaque individuals predominantly used their left hand to pick up food from tubes. From these data, the results show that a maximum number of female macaque individuals preferred the left hand to pick up food in Shervaroy’s hills. The HI tube scores ranged from - 0.40 to 0.20.

Table 2: HI scores on the tube task of male *Macaca radiata*.

S. No.	Study site	Total numbers of monkeys/troop	Unimanual Tube task (Numbers)		HI index	Hand preference
			Right handed individuals	left handed individuals		
1	S1	11	6.00 ± 1.33	5.00 ± 1.33	0.09	R
2	S2	11	4.00 ± 0.66	7.00 ± 1.00	- 0.27	L
3	S3	10	4.00 ± 1.00	6.00 ± 1.66	- 0.20	L
4	S4	12	5.00 ± 2.33	7.00 ± 1.00	- 0.17	L
5	S5	10	4.00 ± 1.00	6.00 ± 1.00	- 0.20	L
6	S6	12	7.00 ± 1.33	5.00 ± 1.33	0.17	R
7	S7	09	3.00 ± 2.00	6.00 ± 2.00	- 0.33	L
8	S8	14	5.00 ± 1.00	9.00 ± 1.00	- 0.28	L
9	S9	11	4.00 ± 1.33	7.00 ± 1.66	- 0.27	L

R – Right hand usage; L – Left hand usage.

Table 3: HI scores on the tube task of female *Macaca radiata*.

S. No.	Study site	Total numbers of monkeys/troop	Unimanual Tube task (Numbers)		HI index	Hand preference
			Right handed individuals	left handed individuals		
1	S1	10	6.00 ± 1.00	4.00 ± 1.33	0.20	R
2	S2	09	3.00 ± 1.33	6.00 ± 2.00	- 0.20	L
3	S3	10	3.00 ± 1.33	7.00 ± 2.33	- 0.40	L
4	S4	07	3.00 ± 1.00	4.00 ± 1.66	- 0.14	L

5	S5	07	3.00 ± 1.00	4.00 ± 1.66	- 0.14	L
6	S6	09	5.00 ± 2.00	4.00 ± 1.00	0.11	R
7	S7	09	3.00 ± 1.66	6.00 ± 1.33	- 0.33	L
8	S8	10	5.00 ± 1.00	5.00 ± 1.00	0.00	N
9	S9	09	5.00 ± 1.00	4.00 ± 1.00	0.11	R

R – Right hand usage; L – Left hand usage; N – None.

The hand preference and handedness were also determined by the reach task method. In total 10 occurrences of unimanual food reaching tasks were recorded in 14 to 20 male monkeys in different study sites. The number of right - handed male monkeys reaches ranged from 5.00 to 9.00. The observed maximum number of right - handed individuals (9.00) was observed in the S6 and S7 study sites respectively and a minimum number of right - handed individuals (5.00) reaches was noticed in the S4 study site at Shervaroy's Hill. By comparison of handedness in *Macaca radiata* on the reach task, 10 to 12 numbers of male individuals were classified as having left - handed bias. The number of male monkeys showing a left - handed preference did not significantly differ in all study sites. Among the all study sites, the highest number of (12) male monkeys were classified in the S4 study site, followed by 11 and 10

numbers of left - hand users observed in S9 and S1 study sites respectively (Table 4).

The degree of lateralization for the reach task was measured by taking the absolute value of HI scores. HI reach scores ranged from - 0.50 to 0.12 in male monkeys (Table 4). Twelve to eighteen female *Macaca radiata* were tested for the unimanual reach task. Based on individual HI scores, 10 female macaques were classified as right - handed for the grain grasping reach task in the S8 study site. In other study sites, only a low number of female individuals (*viz*: 5.00 to 7.00 numbers) used their right hand for picking food from the tube (Table 5). In this study, a higher number of female monkeys (8.00 to 10.00) exhibited a significant preference to use left - hand reach over the other hand, whereas the others 5.00 to 7.00 monkeys showed right - hand reach preference. An overview of the HI score ranges between - 0.25 and 0.11.

Table 4: HI scores on the reach task of male *Macaca radiata*.

S. No.	Study site	Total numbers of monkeys/troop	Unimanual Tube task (Numbers)		HI index	Hand preference
			Right handed individuals	left handed individuals		
1	S1	18	8.00 ± 1.33	10.00 ± 1.33	- 0.11	L
2	S2	17	8.00 ± 1.66	9.00 ± 1.00	- 0.06	L
3	S3	17	8.00 ± 1.00	9.00 ± 1.00	- 0.06	L
4	S4	17	5.00 ± 2.33	12.00 ± 2.33	- 0.50	L
5	S5	14	6.00 ± 2.00	8.00 ± 1.33	- 0.14	L
6	S6	16	9.00 ± 2.33	7.00 ± 1.00	0.12	R
7	S7	17	9.00 ± 1.33	8.00 ± 1.33	0.05	R
8	S8	15	6.00 ± 0.00	9.00 ± 1.00	- 0.20	L
9	S9	19	8.00 ± 1.33	11.00 ± 1.66	- 0.16	L

R - Right hand usage; L – Left hand usage.

Table 5: HI scores on the reach task of female *Macaca radiata*.

S. No.	Study site	Total numbers of monkeys/troop	Unimanual Tube task (Numbers)		HI index	Hand preference
			Right handed individuals	left handed individuals		
1	S1	15	7.00 ± 1.00	8.00 ± 2.00	- 0.07	L
2	S2	16	6.00 ± 1.33	10.00 ± 1.33	- 0.25	L
3	S3	17	7.00 ± 1.66	10.00 ± 1.00	- 0.18	L
4	S4	17	9.00 ± 2.00	8.00 ± 1.00	0.06	R
5	S5	15	6.00 ± 2.00	9.00 ± 1.66	- 0.20	L
6	S6	12	5.00 ± 1.33	7.00 ± 1.00	- 0.17	L
7	S7	12	7.00 ± 1.00	5.00 ± 1.00	0.17	R
8	S8	18	10.00 ± 0.00	8.00 ± 1.66	0.11	R
9	S9	16	6.00 ± 1.00	10.00 ± 2.00	- 0.25	L

5. Discussion

The statistical comparison between the *Macaca radiata* group of right - hand users versus left - hand users for the tube task and reach task revealed significant differences with variable HI scores. The highest number 7 monkeys were classified as having right - hand use bias in the S6 study area. The lowest number of 3 male monkeys out of 9 individuals are recorded as right - hand users in the S7 study site. In another study site, approximately 40% to 50% of male monkeys are classified as right - hand bias, The Present

data provides convincing evidence that males and females differ in their handedness. Females tend to be more strongly left - handed than males. This finding is consistent with the findings of the study carried out by Tapley & Bryden (1985). The difference in handedness between males and females can be attributed to neurobiological differences found between the brains of the two sexes.

The number of male monkeys showing left - hand preference differs from right - hand preference in all study sites. Among all study sites except S1 & S6, the left - hand usage is higher than the right - hand usage. Knecht *et al.*

(2000), have found that males with gender identity disorder were significantly more likely to be left - handed. The degrees of lateralization for the tube task were measured by taking the absolute value of HI scores. HI tube scores ranged from - 0.33 to 0.17 (Table 2). Hopkins (2013), suggested that HI scores greater than 0.20 were considered right bias. HI scores less than - 0.20 were considered left bias, and all other HI scores were considered to represent No bias. HI scores range from 0 (not lateralized) to 1.00 (completely lateralized). From the results data, the values show that a maximum number of female macaque individuals preferred the left hand to pick up food in Shervaroy's hills. The HI tube scores ranged from - 0.40 to 0.20. Our results differed from that of Laska (1996), who reported a population - level left bias in spider monkeys on a series of unimanual tasks, including picking up raisins from the ground (comparable to our reach task) and taking raisins from an opaque tube.

The hand preference and handedness were also determined by the reach task method. The number of right - handed male monkeys reaches ranged from 5.00 to 9.00. Meguerditchian *et al.*, (2013) reported left trend for males on the tube task and right preference for females on a unimanual task in squirrel monkeys. The postural origins theory, presented by MacNeilage *et al.* in 1987, links the emergence of handedness to ecological variables such as feeding habits and posture. The left hand developed into a specialized tool for ballistic smash - and - grab reaching, whereas the right hand was employed for postural stability. The right hand was liberated from its function in posture as monkeys transitioned to a terrestrial lifestyle and developed into a specialized hand for dexterous hand movements. The postural origins theory continues to be a guiding framework for many researchers in the 48 field (MacNeilage, 2007). Recently, Meguerditchian *et al.* (2013), implicated the postural origins theory in an evaluation of nonhuman primate performance on the tube task. Studies support a general pattern of left - hand bias in arboreal species and right hand bias in terrestrial species.

Posture plays an important role in the evolution of cerebral and behavioral lateralization in primates (Hopkins, 2007; Boulinguez - Ambroise *et al.*, 2022). According to the postural origin hypothesis, more terrestrial monkeys prefer to use their right hand for manual work, whereas arboreal primates prefer to use their left hand for such chores and use their right hand to support their bodies in the trees (MacNeilage *et al.*, 1987; MacNeilage, 2007). Thus, Meguerditchian *et al.* (2013), outline the general pattern for left - hand preference in arboreal monkey species about the tube task. These results have ramifications not only for measurement but also for our understanding of the development of handedness in nonhuman primates. The postural origins theory (MacNeilage *et al.*, 1987; MacNeilage, 2007) continues to be used as a framework for many researchers and has overall increased interest in the topic of handedness in primates. Using data from the tube task across different study sites, Meguerditchian *et al.* (2013), laid out a general pattern for a leftward preference in arboreal species (i. e., orangutans, snub - nosed monkeys, De Brazza's monkeys, squirrel monkeys) and a rightward preference in terrestrial species (i. e., rhesus monkeys, baboons, bonobos, chimpanzees, gorillas). These results do

not fit entirely with the original conception of the postural origins theories, which is based on evolutionary continuity, given the split in the ape taxonomy. Nevertheless, Rhesus monkeys to the arboreal grouping of species that show a leftward trend on the tube task. Our results on the relationship between lateralities in hand usage in macaque monkeys substantiate the previous research findings.

Twelve to eighteen female *Macaca radiata* were tested for the unimanual reach task. Based on individual HI scores, 10 female macaques were classified as right - handed for the grain grasping reach task in the S8 study site. In other study sites, only a low number of female individuals (*viz*: 5.00 to 7.00 numbers) used their right hand for picking food from the tube. In this study, a higher number of female monkeys (8.00 to 10.00) exhibited a significant preference to use left - hand reach over the other hand, whereas the others 5.00 to 7.00 monkeys showed right - hand reach preference. An overview of the HI score ranges between - 0.25 and 0.11. The infant monkeys showed a "dominant" hand at the individual level. Their grasp movement pattern mirrored their mother's, suggesting mimicry, and their hand "dominance" was identical to that of their mother (Brinkman & Smithson 2007). In line with Hopkins & Cantalupo (2005), the present data in *M. fascicularis* show that, as far as hand preference is concerned, they considerably diverge from Boulinguez - Ambroise *et al.*, (2020). Our results reinforced several earlier findings (Vauclair *et al.*, 2005; Zhao *et al.*, 2012; Fagot and Vauclair, 1991), showing that the tube task was a more reliable method of measuring manual preferences in nonhuman primates than the unimanual grasping test. Our results correlate with those of several other studies with apes and baboons (Vauclair *et al.*, 2005; Hopkins *et al.*, 2011). Our study of macaque, an arboreal Old World monkey species, revealed several interesting findings. First, hand use for the tube task revealed group - level left handedness. Second, neither the direction nor the strength of hand preference differed significantly between the sexes. Third, adults exhibited much stronger hand laterality than juveniles did for the tube task. Finally, a higher degree of hand preference is elicited by the tube task.

6. Conclusion

It is concluded that, in terms of hand preference, there were roughly equal numbers of left - handed and right - handed instances among monkeys. In the tube task, adults showed significantly stronger hand laterality than juveniles.

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References

- [1] Boulinguez - Ambroise, G., Pouydebat, E., Disarbois, É. and Meguerditchian, A.2020. Human - like maternal left - cradling bias in monkeys is altered by social pressure. *Scientific Reports*, 10: 1–8.

- [2] Boulinguez - Ambroise, G., Aychet, J. and Pouydebat, E.2022. Limb preference in animals: new insights into the evolution of manual laterality in hominids. *Symmetry*, 14 (1): 96 - 128.
- [3] Brinkman, C. and Smithson, M.2007. Determinants of hand preference in monkeys (*M. fascicularis*): birth to weaning. The Abstracts of the 34th Australasian Experimental Psychology Conference, *Australian Journal of Psychology*, 59 (Sup1): 21.
- [4] Fagot, J. and Vauclair, J.1991. Manual laterality in nonhuman primates: a distinction between handedness and manual specialization. *Psychological Bulletin*, 109 (1): 76–89.
- [5] Hopkins, W. D., and Cantalupo, C.2005. Individual and setting differences in the hand preferences of chimpanzees (*Pan troglodytes*): A critical analysis and some alternative explanations. *Laterality: Asymmetries of Body, Brain and Cognition*, 10 (1), 65–80.
- [6] Hopkins, W. D.2007. Hemispheric specialization in chimpanzees: Evolution of hand and brain. In: S. M. Platek, J. P. Keenan & T. K. Shakelford (red.), *Evolutionary cognitive neuroscience*. Cambridge, MA: MIT. pp.95 - 120.
- [7] Hopkins, W. D., Phillips, K. A., Bania, A., Calcutt, S. E., Gardner, M., Russell, J. Schaeffer J., Lonsdorf, E. V., Ross, S. R. and Schapiro, S. J.2011. Hand preferences for coordinated bimanual actions in 777 great apes: Implications for the evolution of handedness in hominins. *Journal of Human Evolution*, 60 (5), 605–611.
- [8] Hopkins, W. D.2013. Neuroanatomical asymmetries and handedness in chimpanzees (*Pan troglodytes*): A case for continuity in the evolution of hemispheric specialization. *Annals of the New York Academy of Sciences*, 1288 (1): 17–35.
- [9] Knecht, S., Dräger, B., Deppe, M., Bobe, L., Lohmann, H., Flöel, A., Ringelstein, E. B. and Henningsen, H.2000. Handedness and hemispheric language dominance in healthy humans. *Brain*, 123 (12), 2512–2518.
- [10] Laska, M.1996. Manual laterality in spider monkeys (*Ateles geoffroyi*) solving visually and tactually guided food - reaching tasks. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior*, 32 (4), 717–726.
- [11] Nelson, E. L., Figueroa, A., Albright, S. N. and Gonzalez, M. F.2015. Evaluating handedness measures in spider monkeys. *Animal Cognition*, 18 (1): 345 - 353.
- [12] MacNeilage, P. F.2007. Present Status of the Postural Origins Theory. *Special Topics in Primatology* 5: 58 - 91.
- [13] MacNeilage, P. F., Studdert - Kennedy, M. G. and Lindblom, B.1987. Primate handedness reconsidered. *Behavioral and Brain Sciences*, 10 (2): 247 - 263
- [14] Meguerditchian, A., Vauclair, J. and Hopkins, W. D.2013. On the origins of human handedness and language: a comparative review of hand preferences for bimanual coordinated actions and gestural communication in nonhuman primates. *Developmental Psychobiology*, 55 (6), 637–650.
- [15] Papademetriou, E., Sheu, C. F. and Michel G. F.2005. A meta - analysis of primate hand preferences, particularly for reaching, *Journal of Comparative Psychology*; 119 (1): 33 - 48
- [16] Rogers, L., Vallortigara, G. and Andrew, R. J.2013. *Divided brains: The biology and behaviour of brain asymmetries*. New York: Cambridge University Press
- [17] Tapley, S. M. and Bryden, M. P.1985. A group test for the assessment of performance between the hands. *Neuropsychologia*, 23 (2), 215–221.
- [18] Vauclair, J., Meguerditchian, A. and Hopkins, W. D.2005. Hand preferences for unimanual and coordinated bimanual tasks in baboons (*Papio anubis*). *Cognitive Brain Research*, 25 (1): 210–216.
- [19] Zhao, D., Hopkins, W. D. and Li, B.2012. Handedness in nature: First evidence on manual laterality on bimanual coordinated tube task in wild primates. *American Journal of Biological Anthropology*, 148 (1), 36–44.