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Differential Individual Access to and Use of Reaching Tools in Social Groups of Capuchin Monkeys (*Cebus apella*) and Human Infants (*Homo sapiens*)

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Abstract

The focus of much of comparative and developmental cognition has been on the individual as a solitary being whose behavior is isolated from the influence of social relationships. We report here results on access to and use of reaching tools by group-housed capuchin monkeys (*Cebus apella*) and a cohort of human infants in a daycare setting. In both cases, a given individual's—monkey or child—access to their respective tools differed as a function of his or her social rank, but the probability of successful use of a tool by an individual did not. These results demonstrate that membership in a group may not only facilitate an individual's opportunity to discover the functional affordances of its physical environment but also inhibit its opportunities to express that knowledge.

Key Words: tool use, capuchin monkeys, *Cebus apella*, human infants, *Homo sapiens*, social influences

Introduction

Primates are social creatures, but comparative psychologists, no less than our anthropocentric colleagues in human cognitive and developmental psychology, have tested/queried our experimental participants largely in isolation, essentializing the individual and ignoring the ways in which cognition has a social character (e.g., Oyserman & Packer, 1996). This approach leaves open questions as to the relationship between cognition and behavior as a solitary activity as opposed to one undertaken in a social milieu (Hutchins, 1995).

Much of the current interest in social cognition has focused on understanding the processes underlying social learning such as, for example, imitation and stimulus enhancement (e.g., Byrne & Whiten, 1988; Zentall & Galef, 1988). In contrast to this burgeoning literature, however, there are relatively few studies dealing with questions of if and how social relationships affect an individual's access to information and expression of knowledge about the functional affordances of the physical world (Russon & Waite, 1991; Drea, 1998; Drea & Wallen, 1999).

We report here results from two studies of tool-use in a captive group-housed colony of tufted Capuchin monkeys (*Cebus apella*) and human infants (*Homo sapiens*) in a daycare facility. In both cases, tool use was defined as "the external employment of an unattached environmental object to alter more efficiently the form, position, or condition or another object, another organism, or the user itself" (Beck, 1980).

The results from the monkeys were obtained in two conditions in which the animals were presented with an apparatus containing honey and wooden sticks (i.e., reaching tools) that afforded them the opportunity to retrieve the otherwise unreachable honey. The results for the human infants were obtained in a study of their ability to use hooked and straight reaching poles as tools to obtain an otherwise unobtainable small cookie container. Importantly, in both studies, no individual was presented with the reaching tools in isolation. In principle, during testing, all participants within their respective species' social group had equal access to the tools; however, as revealed by the results presented in this paper, such equality was not the case.

Social Effects on Access to Tools in Capuchin Monkeys

Materials and Methods

Animals—Two female and six male group-housed capuchin monkeys (*Cebus apella*), ranging from 1 to 24 y of age, served as participants (see Table 1). They were not food deprived during testing. Trials occurred prior to their afternoon feeding of monkey chow, fruit, and vegetables. Water was constantly available. The care and experimental treatment of the monkeys were handled in full accordance with federal, local and Franklin & Marshall College's guidelines and regulations concerning humane care and treatment of nonhuman primates.

Materials / Apparatus—A clear plastic container, measuring 17 cm x 9 cm x 28 cm, was connected with metal clips to the underside of one of the metal mesh platforms within the animal colony room. Openings in the wire platform measured approximately 3 cm x 3 cm. Pictures of the experimental setup and its use by monkeys (Figures 1-3) are available at http://edisk.fandm.edu/roger.thompson/publications/flemming/.

In one condition, six wooden dowel sticks of varying lengths (25 cm to 40 cm and 1.5 cm in diameter) were provided on the top of the platform at the beginning of each session. In a second condition, a long stick (30 cm) and a short stick (15 cm) were fitted with washers and allowed to rest on the platform level and hang down into the plastic container. The long stick rested in honey, while the short stick, regardless of how it was manipulated, could not reach the honey.

Procedure—Before each daily 30-min session began, a small amount of honey (4 cm) was placed in the container with the six wooden sticks placed on top of the platform in Condition 1 and with the short and long stick extending vertically downwards into the container in Condition 2.

Observations were made through a one-way mirror from a room adjacent to the colony. An "all occurrences" method was used in which each animal's frequency of "successes" was recorded. Contact with a stick was a success if it culminated in retrieval and consumption of honey. In Condition 2, the number of each animal's contacts with each stick and subsequent successes, possible only with the long stick, was recorded.

Results

Condition 1—The first contact and successful use of a stick that occurred within 30 s of the first of 10 sessions was made by Simon, the dominant adult male of the group. Simon continued to have priority of access to the sticks as reflected in measures of first and second use in each session and in his percent contribution to the overall group data as shown in Table 1.

Simon (dominant male) and Gracie (dominant female) made a significantly greater contribution to the overall tool-using bouts than all other group members in a social setting ($z = 13.18$, $p < 0.05$; $z = 2.05$, $p < 0.05$). Two males, Rusty (age 6) and Lucky (age 2), contributed as expected (12.5%), assuming equal access by all group members ($z = -.22$, $p > 0.05$; $z = -1.73$, $p > 0.05$). The remaining group members contributed significantly less than expected by an equal sharing of resources (Jaime, $z = -3.25$, $p < 0.01$; Jessie, $z = -4.27$, $p < 0.01$; Emmett, $z = -4.51$, $p < 0.01$; Miah, $z = -3.76$, $p < 0.01$).

Simon and Gracie also were significantly more often the first to contact the tools ($z = 5.49$, $p < 0.01$; $z = .72$, $p < 0.05$), and Gracie was significantly more likely to be the second animal to have access to the tools ($z = 3.59$, $p < 0.01$), whereas Simon was not ($z = 1.67$, $p > 0.05$). No other monkeys differed significantly from an expected 0.125 proportion as the first or second animal to have access to the tools (10%, $z = .239$, $p > 0.05$; 0%, $z = -1.19$, $p > 0.05$).

Table 1. Individual animal attempts/successes, percent contribution to overall group success, and probability of first and second use of tools in Condition 1

Individual	Sex	Age	Number of attempts (%)	Probability of first use	Probability of second use
Simon	Male	16	70** (48.95)	0.70**	0.30
Gracie	Female	24	26* (18.18)	0.20*	0.50**
Rusty	Male	6	17 (11.89)	0.10	0.00
Lucky	Male	2	11 (7.70)	0.00	0.10
Jaime	Female	5	7** (4.80)	0.00	0.00
Jessie	Male	1	9** (6.29)	0.00	0.00
Emmett	Male	24	0** (0.00)	0.00	0.00
Miah	Male	3	3** (2.10)	0.00	0.10

* $p < 0.05$, ** $p < 0.01$

Importantly, regardless of the number of contacts (mean = 17.9; range 0-70) an animal had with the sticks, they all resulted in successful retrieval and ingestion of honey from the container.

Condition 2—Across all five sessions, the overall percent of total contacts with the sticks that was directed to the longer of the two sticks was 90.28% (range 85.7% to 92.9%). On the very few occasions that an animal touched the short stick, it was dropped onto the floor and not touched again by any animal. As in Condition 1, Simon, the dominant male, contributed most to the overall group data (Table 2), but also as in Condition 1, all contacts (mean = 9; range 1 to 33) with the long stick by any of the animals resulted in successful retrieval of honey from the container.

Simon and Gracie dominated access to tools while the younger individuals and Emmett, a 24-y-old male, were afforded only restricted access. Simon and Gracie both made a significantly greater number of attempts than any other individuals ($z = 8.55$, $p < 0.01$; $z = 2.14$, $p < 0.05$). Rusty, Lucky, and Jaime performed within the expected proportion of 0.125 ($z = .36$, $p > 0.05$; $z = -1.78$, $p > 0.05$; $z = -1.78$, $p > 0.05$). Jessie, Emmett, and Miah were below the expected proportion of contributions ($z = -2.49$, $p < 0.01$; $z = -2.14$, $p < 0.05$; $z = -2.85$, $p < 0.01$).

The present results provide further evidence that the tufted capuchin monkey is one of the most facile natural tool users among nonhuman primates (Tomasello & Call, 1997). When any given animal had the opportunity to manipulate the sticks in either condition, it did so successfully on all occasions. The opportunity to use the sticks as tools in either condition was not equal among the eight animals, however (Table 3). This was true with respect to an animal's percent contribution to the overall success of the group per se in both conditions and whether it was either the first or second individual to contact any stick.

Simon and Gracie contributed significantly more to overall group success ($z = 15.7$, $p < 0.01$; $z = 2.91$, $p < 0.01$). Rusty contributed as expected, assuming equal access ($z = .03$, $p > 0.05$). All other group members contributed less than expected by an assumption of equal opportunity to access the

Table 2. Individual animal attempts/successes, percent contribution to overall group success, and probability of first and second use of tools in Condition 2

Individual	Sex	Age	Number of attempts (%)	Probability of first use	Probability of second use
Simon	Male	16	33** (45.83)	0.80**	0.20*
Gracie	Female	24	15* (20.83)	0.00	0.80**
Rusty	Male	6	10 (13.89)	0.00	0.00
Lucky	Male	2	4 (5.56)	0.00	0.00
Jaime	Female	5	4 (5.56)	0.00	0.00
Jessie	Male	1	2* (2.77)	0.00	0.00
Emmett	Male	24	3* (4.17)	0.20*	0.00
Miah	Male	3	1** (1.39)	0.00	0.00

* $p < 0.05$, ** $p < 0.01$

Table 3. Individual animal attempts/successes, percent contribution to overall group success, and probability of first and second use of tools across Condition 1 and 2 combined

Individual	Sex	Age	Percent contribution to overall success	Probability of first use	Probability of second use
Simon	Male	16	47.4**	73.3**	26.6
Gracie	Female	24	19.5**	13.3	60.6**
Rusty	Male	6	12.9	6.7	0.0
Lucky	Male	2	6.6*	0.0	6.7
Jaime	Female	5	5.2**	0.0	0.0
Jessie	Male	1	4.5**	0.0	0.0
Emmett	Male	24	2.1**	6.7	0.0
Miah	Male	3	1.8**	0.0	6.7

* $p < 0.05$, ** $p < 0.01$

tools (Lucky, z = -2.43, $p < 0.05$; Jaime, z = -3.27, $p < 0.01$; Jessie, z = -3.27, $p < 0.01$; Emmett, z = -4.92, $p < 0.01$; Miah, z = -4.72, $p < 0.01$).

Over both conditions, Simon emerged as a "first user" (z = 7.12, $p < 0.01$) rather than a "second user" (z = 1.65, $p > 0.05$) while Gracie took the role of the "second user" across all trials (z = 5.56, $p < 0.01$) rather than the first user (z = .10, $p > 0.05$).

Discussion

The results indicate that an animal's overall contribution to the overall successes of the group were not attributable to its ability to manipulate the sticks to retrieve honey. In both conditions, every contact with a stick by a given animal resulted in successful retrieval and ingestion of honey from the container. These results then are consistent with prior evidence that tufted capuchin monkeys are facile and spontaneous tool users (for summaries, see Fragaszy et al., 2004; Anderson, 2006).

Independent measures of priority of access/displacement (Franz, 2000) and allogrooming patterns (Sturm, 2000) indicate that the individual differences were associated with an animal's rank within the group's dominance hierarchy. Simon and Gracie are, respectively, the dominant male and female in the colony, and Rusty is the third ranking animal in the colony.

An animal's contribution to the group's overall successes is associated also with kinship relationships and possibly age. Gracie and Simon's offspring, regardless of age, contributed more to the group's success than Emmett. The same was true for Miah, offspring of Chye and Edie, a low-ranking male and female, both of whom had to be transferred because they were harassed by other group members and denied sufficient access to food.

These results are inconsistent with those reported by Westergaard et al. (1998), who found that younger monkeys in their colony were more likely to use tools than were older individuals. There was no reference to the social hierarchy of their group or whether this may have played a role in the tool-using behaviors. Westergaard et al. did speculate that their observed age effect might be the result of the older individuals lacking exposure to "an appropriate tool site during an important (but perhaps not critical) learning period" (p. 210). Even so, our finding that the older capuchins in the present study spontaneously used the sticks successfully as tools without prior experience does not support the Westergaard hypothesis.

Social Effects on Access to Tool Use in Human Infants

Introduction

Previous research on tool use in infants by Brown (1989) suggests that 20- to 30-mo-old infants can use a simple tool to reach a desired object. Brown presented infants with a set of tools, some of which could be used to reach a desired object and some that were unsuitable for reaching. She found that infants were able to choose the correct "reaching tool" in order to attain the object, and further, could transfer their knowledge to other "reaching tools."

At 20 to 30 mo of age, the infants in Brown's experiment were relatively advanced in their use of symbols. In our study, we examined reaching behavior in a younger population, 12- to 18-mo-old infants. The infants were tested for their ability to use either straight or hooked poles to retrieve an otherwise inaccessible small container of cookies along a flat ramp. They, like the capuchins, were tested as a group within their natural daily environment—a daycare center—thereby allowing us to examine the role of social factors on an individual's access to and use of the tools in addition to whether they understood the functional properties of straight and hooked tools.

Materials and Methods

Participants—Participants in Experiment 1 were eight 12- to 18-mo-old unrelated infants, four males and four females, all from the same pre-toddler group at a local daycare center in Lancaster, Pennsylvania. Six of the same infants, two females and four males, served in Experiment 2. Three individuals, one male and two females, served in Experiment 3. In Experiment 4, three female and three male infants served as participants. This group consisted of five original group members and one new female member. All procedures to which the infants were subjected were approved by Franklin & Marshall College's Institutional Review Board for the use of human subjects.

Materials and Methods—Two 150-cm and two 100-cm long poles made of white hollow PVC piping served as reaching tools. One pole of each length ended in a rectangular open-ended hook formed by attaching a 20-cm long piece of PVC piping at a right angle and a 10-cm long piece of PVC attached at a right angle to that piece. The other poles of each length were straight. The inside of each hooked pole was lined with Velcro tape as was the end of each of the two straight poles and the outside of a small clear plastic cup (9 cm wide by 10 cm tall). Contact between the Velcro on the poles and the cup locked them together.

The cup containing cookies was placed on a flat PVC ramp (105 cm wide and 260 cm long) within a rectangular cage of plastic orange mesh fencing. This apparatus hung on PVC piping that ran parallel to the dimensions of the ramp and extended 1.25 cm above the top of the ramp. Near the bottom of one end of the cage was a 15.2 cm (6 in) tall opening, where the tool could be inserted to reach the cookie cup filled with Keebler brand iced gingerbread cookies.

Pictures of the experimental setup (Figures 4 & 5) are available at http://edisk.fandm.edu/roger.thompson/publications/flemming/.

General Procedures—The infants were tested as a group with all children having simultaneous access to the reaching tools as described below.

On the first day of the study, but not on subsequent days, we placed one of the hooked poles into the apparatus and slid it back and forth five times, calling the children's attention to this activity. The apparatus was then baited with the cookie-containing cup, and the children were allowed to freely interact with the pole(s) and the apparatus as they so chose over four experiments as described below. On "short tool" (100 cm) trials, the baited cup was placed 90 cm from the front of the apparatus, and on "long tool" (150 cm) trials, it was placed 140 cm from the front of the apparatus.

The number of sessions and the number of trials within-sessions varied across experiments, determined by constraints imposed by staffing and the daily activity schedules of the infants at the daycare facility. A trial ended when an infant successfully retrieved the food container, if the container was pushed out of reach, or if neither event had occurred within 5 min. The infants were verbally encouraged to use the tools to reach the cookie cup throughout the experiments but were never visually shown how to complete the task. Cookies that were retrieved were shared equitably between the infants by their caregiver.

The behavioral criteria shown in Table 4 were used to measure the hierarchy of dominance relationships within the infant population prior to Experiment 1 and following Experiment 4.

Experimental Procedures—In Experiment 1, a single hooked pole was place on the floor outside the cage with the hook facing left or right in a balanced quasi-random order. Forty-eight trials occurred over nine sessions of 5 to 8 trials each.

In Experiment 2, a hooked pole was placed inside the cage with the food container within the hook that was oriented left or right in a balanced quasi-random order. Forty-two trials occurred over five sessions of 6 to 11 trials each.

In each trial of Experiment 3, the food container was placed in a balanced quasi-random order within the hook of one of two hooked poles. The poles were placed side by side in the cage. The orientation of each hook relative to the other was quasi-randomly balanced (i.e., same/different left/right) over five sessions of 12 trials each.

Table 4. Coding of dominance behaviors in human infants

Displacement: This takes place when Child 1 increases proximity to within one arm's length of Child 2, and Child 2 decreases proximity to greater than one arm's length.
Displaced Agonistic: Child 2 displays agonistic behavior to object or person other than Child 1.
Priority of access:
Priority of access 1: Child 1 increases proximity to within one arm's length of Child 2, who is consuming a resource (i.e., food, toys). Child 2 abandons the resource and decreases proximity.
Priority of access-taking: In a constrained situation (e.g., sitting at table playing or doing crafts), Child 1 acts to take resource from Child 2 by reaching or grabbing.
Priority of access-giving: In a constrained situation, Child 2 gives resource to Child 1.
Initiator of imitation: Idiosyncratic motor or vocal action display is repeated by peers.
Delayed imitation: Idiosyncratic behavioral display of Child 1 is repeated by one or more peers.
Caregiver prevents: Adult activity is followed by cessation of interaction between a dyadic pair.
Social reconciliation: Invitations to cooperate in play, apologies, offering a toy, sharing an object, or physical contact such as holding or stroking are given.
Agonistic behavior:
Push/pull: Applies force to an object or person by limb and trunk extension of flexion
Kick: Extends one leg suddenly, causing foot to make forceful contact with object or person
Throw: Moves object through air by releasing from hand at end of explosive over-arm extension
Hit: Moves an object suddenly and forcefully into contact with another object
Spit: To eject saliva towards an object or person
Bite: To place an open mouth on or around an object or person causing contact with teeth

There were two conditions in Experiment 4, which alternated in an ABBA-BAAB order over each of eight 12-trial sessions (96 trials). In one condition, a single hooked pole was placed outside the cage with the varied orientation of the hook balanced across trials. In the second condition, a single straight pole was placed on the floor outside the cage. Following Experiment 4, we again coded the dominance hierarchy rankings of the infants using the same criteria used prior to Experiment 1.

Results

Experiment 1—Six of the eight infants manipulated the hooked pole, attempting to reach the cookie cup on 80% of the trials, but they were in essence unsuccessful regardless of tool length. Only two of the children—Pet and Mad—succeeded in retrieving the container in 3% and 2%, respectively, of the trials in which they manipulated the hooked pole. Rare successes did not result from a systematic attempt to hook the container but resulted, for example, from the infants, instead, using the back edge of the hook to drag the container down the raised edge of the PVC platform.

The most common reason (74%) for a failed trial, despite consistent attempts by individual infants to retrieve the cookies, was failing to do so within the 5-min time limit. This was often because the infants moved the hook directly towards the cup, resulting in their pushing it further away.

Experiment 2—Four of the six infants manipulated the hooked tool, attempting to retrieve the container contained within the hook and did so 84% of the time. A 2-pole (100 cm or 150 cm) x 2 orientation (left or right) Chi Square analysis revealed no significant effect of either pole length or orientation.

Experiment 3—Overall, the infants performed well, choosing the correct hooked pole on 92% of their attempts to retrieve the cookie cup placed within the hook. A 2-pole by 2 orientation Chi-Square analysis of successful retrievals revealed no significant effect of either pole length or orientation of the hook.

Experiment 4—The infants successfully retrieved the cookie cup in 96% of their attempts to do so with the straight pole, but they were successful on only 11% of their attempts to do so with the hooked pole. Sixty-two percent of the hooked tool trials ended in failure when the infants failed to reach the cookie cup within the allotted 5 min. On 27% of these unsuccessful trials, the infants pushed the cookie cup beyond the reach of the pole.

Social Influences on Access to and Use of Tools by Infants

In both Experiments 1 and 4, priority of access to the tools (Table 5)—as defined by an individual's proportional contribution to the total number of tool manipulations made by the overall group—was significantly correlated with each infant's independently measured social rank within the group (Exp. 1, Spearman rank order: -.928, $p < 0.001$; Exp. 2, Spearman rank order: -.812, $p < 0.05$).

Discussion

Brown (1989) suggests that children as young as 2 to 3 y of age can use a simple rake-like tool to retrieve a toy that is otherwise out of reach. In contrast, Chen & Siegler (2000) found that toddlers between 18 and 35 mo of age failed to choose the appropriate tool to retrieve an otherwise out-of-reach toy unless the infants were given instructions in the use of the tool or active encouragement to choose the appropriate tool.

Our results are consistent with those of Chen & Siegler (2000). Here, in the absence of specific instructions or demonstrations of effective hooked tool use, the infants found it practically impossible to use a hooked tool to retrieve a cookie cup unless it was already placed within the hook of the tool. In contrast, however, the infants in our study were very successful at retrieving the cookie cup with the straight tool by locking onto it with the Velcro-covered end of the pole.

The infants did not differ among themselves in their use of the tools, but importantly, they did differ in their respective access to the tools during test sessions. Priority of access by individuals was significantly correlated with independent assessments of their social dominance rank within the group.

Overall, the infants' failures were not attributable to their ability to manipulate the hooked and

Table 5. Social ranks and priority of access (POA) to tools by 18-mo-old human infants

	Experiment 1		Experiment 4	
Child	Rank	POA	Rank	POA
Mad	3	0.57	1	1.00
Mad 2			3	0.57
Pet	1	0.54		
Lia	2	0.34	2	0.35
Mas	4	0.25		
Nic	5	0.14	5=	0.25
Ros	6	0.09	5=	0.16
Ben	7=	0.00	4	0.46
Jes	7=	0.00		

straight poles. In fact, the children consistently tried to reach the cookie cup with both tools. Despite this, no child learned (either conceptually or by trial and error) to first move the hook beyond the cookie cup before bringing the hook back into contact with the cup, allowing it to be retrieved. Rather, the predominant behavior of all the children was to move both the straight or hooked tool directly towards the cookie cup, resulting in success with the former, but in the case of the latter, resulting in the leading back edge of the hook moving the food cup further out of reach.

The rare successes with the hooked tool resulted in the serendipitous hooking of the cup with back and forth vacuuming motions or by dragging the cookie cup down along the raised wooden edge of the PVC ramp with the edge of the pole facing away from the orientation of the hook itself.

Comparing the Capuchin and Human Studies

The focus of much of comparative and developmental cognition has been on the individual as a solitary being whose behavior is isolated from the influence of social relationships. The results reported here demonstrate that although membership in a group may very well facilitate one's opportunity to discover the functional affordances of the physical environment, it can also effectively prevent an individual from having the opportunity to acquire or to express that knowledge within a social context. In our cases, this was true for two phylogenetically distinctive primate species, regardless of differences in the specific study procedures.

Access to reaching tools by individuals in group-housed capuchin monkeys and a cohort of human infants differed as a function of his or her social rank. If and when they did have access to their respective tool sets, both capuchins and infants, regardless of their social rank, effectively and spontaneously used straight sticks or poles, respectively, to retrieve a desirable food reward.

The capuchins, given a choice in Condition 2 between a pair of sticks protruding into the honey container, also spontaneously chose only the one with which they could retrieve the honey. None of the human infants learned to retrieve the food container with a hooked tool unless the container was placed within the hook portion of the tool prior to the infants having access to it. Given a choice between a previously baited hooked tool and a nonbaited hooked tool, they chose the former.

The current performance of the human infants with the hooked poles is similar to that reported for tamarin (*Saguinus Oedipus*) (Hauser, 1997) and capuchin monkeys. For example, Cummins-Sebree & Fragaszy (2005) found that their captive capuchin monkeys preferred to retrieve treats that were inside the hook of small canes as opposed to attempting to retrieve treats that were not. The infants were fully capable of manipulating the tools (e.g., "vacuuming" and flipping the hook back and forth), but no child learned to either go over the goal object or to go past it initially before then returning back towards it with the open portion of the hook. Successes could be accounted for by reinforcement of idiosyncratic behaviors such as using the straight back edge of the hook to slide the food cup down the side of the ramp.

Unlike the human infants in the present study, the capuchins in the Cummins-Sebree & Fragasy's (2005) study did learn by trial-and-error to reposition unbaited canes so as to retrieve a treat. Differences in the dimensions of the infants' poles and the monkeys' canes may have prevented the infants, but not the monkeys, from learning about the full range of functional affordances of the hooked tools via fine and gross motor/physical manipulations of the tools.

To summarize, the present results from both capuchins and infants point to the importance of spatial contiguity between tool and target if either primate is to perceive a tool as an effective extension of its arm in a target-directed reaching motion (see, also, Fujita et al., 2003). What then is to be made of previous reports of effective hooked tool use in young infants (Brown, 1989; van Leeuwen et al., 1994; Chen & Siegler, 2000)? It is likely that the crucial difference between those studies and those like the current one was the opportunity to observe and imitate an effective higher-ranking model. Russon & Waite (1991) reported that dominance was related to peer imitation by 11- to 16-mo human infants who preferred to model higher-ranking rather than lower-ranking individuals. In the present study, however, there were no effective models for the infants to imitate, regardless of rank.

In the capuchin study reported here, Simon, the dominant male, effectively limited the other monkeys' access to the sticks if not their unanimous success if and when they did gain access to them. We cannot say definitively that Simon did or did not serve as an imitative model for the other monkeys who had access to the tools. We can say that Simon himself did not have a model to imitate. Nevertheless, he spontaneously used the sticks effectively to retrieve honey within 30 s of the first session in Condition 1. Furthermore, other studies strongly suggest that to the extent the other monkeys' observations of Simon's tool-using behavior may have facilitated their success, it was likely by means of local stimulus enhancement and direct engagement with the tools and not by imitation (Fragaszy & Visalberghi, 1989; Visalberghi & Fragaszy, 1990; Whiten & Ham, 1992).

As in Drea & Wallen's (1999) study of discrimination problem-solving by group-tested rhesus monkeys (*Macaca mulatta*), there was no evidence of overt aggressive exclusion of subordinates from the tools by either the dominant capuchins or infants in the present experiments. Presumably then, subordinates voluntarily inhibited their behavior based on their past interactions with more dominant individuals in other contexts.

Informal observations of both the capuchins and children revealed some rare anecdotes in which subordinates used their dominant conspecifics as social tools. For example, Lucky, a juvenile male capuchin, licked honey from the end of a stick that Simon was holding, but only when Simon's head was turned away from Lucky. As Simon turned his head back towards the stick, Lucky shifted his attention elsewhere, decreasing his proximity to Simon, who again licked honey from the same stick.

In the case of the human infants, there were a couple of cases in which a subordinate child took a more dominant child by the hand and walked over to the apparatus. The subordinate infant would then stand or sit by the dominant child while the dominant child manipulated the available tool(s). Presumably, the subordinate infant's "social tool use" of another child was reinforced by the mandatory sharing of any retrieved cookies by the caregivers with all of the infants.

General Conclusions

For the most part, comparative studies of cognition in large-brained, presumably intelligent, primates (including humans), cetaceans, and birds have focused on understanding the underlying cognitive processes mediating performance of solitary individuals isolated from the influence of social relationships in experimental settings. As indicated by our results and elsewhere in this special issue, it is also logistically possible to experimentally explore cognition within the arguably more ecologically valid context of their respective everyday social milieu.

Membership in a social group may very well facilitate an individual's opportunity to discover the functional affordances of his or her environment. Nevertheless, as demonstrated by our results on access to—and use of—reaching tools by capuchin monkeys and human infants, an individual's social relationships with others can also inhibit his or her opportunity to express such knowledge. Informal observations of both monkeys and infants, however, revealed that subordinates are not beyond using dominant conspecifics as tools to offset the social constraints on an individual's expression of knowledge. Perhaps these social manipulative skills are the underlying requisite cognitive primitives from which cooperative social coalitions have emerged.

Clearly, group membership not only has its privileges, but also it has associated costs for both the monkey and child. Is the same true for cetaceans despite the differing environmental affordances and differing motoric degrees of freedom? The parallels of social and cognitive complexity between primates and cetaceans documented within this special issue and elsewhere certainly make it a question for which answers are well worth pursuing both in the field and laboratory.

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Literature Cited

Anderson, J. R. (2006). Tool use: A discussion of diversity. In K. Fujita & S. Itakura (Eds.), *Diversity of cognition* (pp. 367-400). Sakyo-ku, Kyoto, Japan: Kyoto University Press.

Beck, B. B. (1980). *Animal tool behavior: The use and manufacture of tools by animals.* New York: Garland STPM Publishers.

Brown, A. L. (1989). Analogical learning and transfer: What develops? In S. Vosnaidou & A. Ortony (Eds.), *Similarity and analogical reasoning* (pp. 369-412). New York: Cambridge University Press.

Byrne, R., & Whiten, A. (1988). *Machiavellian intelligence: Social expertise and the evolution of intellect in monkeys, apes, and humans.* Oxford, UK: Clarendon Press.

Chen, Z., & Siegler, R. (2000). Across the great divide: Bridging the gap between understanding of toddlers' and older children's thinking. *Monographs of the Society for Research in Child Development*, *65*(2) (Whole No. 261).

Cummins-Sebree, S. E., & Fragasy, D. M. (2005). Choosing and using tools: Capuchins (*Cebus apella*) use a different metric than tamarins (*Saguinus Oedipus*). *Journal of Comparative Psychology*, *119*, 210-219.

Drea, C. (1998). Status, age, and sex effects on performance of discrimination tasks in group-tested rhesus monkeys (*Macaca mulatta*). *Journal of Comparative Psychology*, *112*, 170-182.

Drea, C., & Wallen, K. (1999). Low-status monkeys "play dumb" when learning in mixed social groups. *Proceedings of the National Academy of Sciences*, *96*, 12965-12969.

Fragaszy, D. M., & Visalberghi, E. (1989). Social influences on the acquisition of tool-using behaviors in tufted

capuchin monkeys (*Cebus apella*). *Journal of Comparative Psychology*, *103*(2), 159-170.

Fragaszy, D. M., Visalberghi, E., & Fedigan, L. M. (2004). *The complete capuchin: The biology of the genus Cebus.* New York: Cambridge University Press.

Franz, T. (2000). *Tool use in human- and non-human primates: Comparative analysis.* Unpublished senior honors thesis, Franklin & Marshall College, Lancaster, PA.

Fujita, K., Kuroshima, H., & Asai, S. (2003). How do tufted capuchin monkeys (*Cebus apella*) understand causality in tool use? *Journal of Experimental Psychology: Animal Behavior Processes*, *29*, 233-242.

Hauser, M. D. (1997). Artifactual kinds and functional design features: What a primate understands without language. *Cognition*, *64*, 285-308.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge: The MIT Press.

Oyserman, D., & Packer, J. (1996). Social cognition and self-concept: A socially contextualized model of identity. In J. Nye & A. B. Brower (Eds.), *What's social about social cognition? Research on socially shared cognition in small groups* (pp. 175-201). Thousand Oaks, CA: Sage Publications.

Russon, A. E., & Waite, B. E. (1991). Patterns of dominance and imitation in an infant peer group. *Ethology and Sociobiology*, *13*, 55-73.

Sturm, P. (2000). *Allogrooming patterns in capuchin monkeys* (Cebus apella). Unpublished senior thesis, Franklin & Marshall College, Lancaster, PA.

Tomasello, M., & Call, J. (1997). *Primate cognition*. New York: Oxford University Press.

van Leeuwen, L., Smitsman, A., & van Leeuwen, C. (1994). Affordances, perceptual complexity, and the development of tool use. *Journal of Experimental Psychology: Human Perception and Performanc*e, *20*, 174-191.

Visalberghi, E., & Fragaszy, D. (1990). Do monkeys ape? In S. Parker & K. Gibson (Eds.), *"Language" and intelligence in primates: Comparative developmental perspectives* (pp. 247-273). New York: Cambridge University Press.

Westergaard, G. C., Lundquist, A., Haynie, M. K., Kuhn, H. E., & Suomi, S. J. (1998). Why some capuchin monkeys (*Cebus apella*) use probing tools (and others do not). *Journal of Comparative Psychology*, *112*, 207-211.

Whiten, A., & Ham, R. (1992). On the nature and evolution of imitation in the animal kingdom: Reappraisal of a century of research. In P. Slater, J. Rosenblatt, C. Beer, & M. Milinsky (Eds.), *The study of prosimian behavior* (pp. 207-246). New York: Academic Press.

Zentall, T., & Galef, B. G., Jr. (1988). *Social learning: Psychological and biological perspectives.* Hillsdale, NJ: Erlbaum.