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Tool Use in Capuchin Monkeys: Distinguishing Between Performing and Understanding

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ABSTRACT. A horizontal plexiglas tube containing a food-reward was presented to four naive tufted capuchins and suitable sticks were provided to push the reward out. Three monkeys out of four spontaneously used the tools and showed very different styles of solving the task. In more complex conditions, in which the sticks needed to be combined or actively modified in order to become effective, the monkeys were always successful; however, their performance was loaded with errors which did not disappear throughout the trials. Evidence of a difference between success in solving the problem and its understanding was found. This suggests that although capuchins can discover new means through active experimentation, they do not mentally represent the characteristics necessary for a tool to be effective, nor do they modify the tool appropriately beforehand. At this level, a major difference with chimpanzees emerges.

Key Words: Tool use; *Cebus apella*; Mental representation.

INTRODUCTION

The extent and nature of tool use among nonhuman primates is a subject of considerable importance in relation to the study of their cognitive capacities. Several detailed studies showed that both wild and captive apes use tools, in a variety of contexts and for different purposes (BECK, 1980). Tool use has been systematically observed in captive Plathyrrini monkeys belonging to the genus *Cebus* (ANTINUCCI & VISALBERGHI, 1986; COSTELLO, 1987; FRAGASZY & VISALBERGHI, 1989; KLUVER, 1933, 1937; VISALBERGHI, 1987; WESTERGAARD & FRAGASZY, 1985, 1987). Their great phylogenetic distance from Old World monkeys and apes (HOFFSTETTER, 1974, 1980), and the fact that among monkeys *Cebus* species seem to be "unique" in their strong propensity for spontaneous tool using, demand a more accurate study of the factors contributing to this phenomenon. VISALBERGHI and MASON (1983), in a comparative study on the determinants of problem solving success of two *Cebidae* species, found that the most important factor contributing to the better performance of squirrel than titi monkeys, was the *Saimiri* "style" (i.e., the latent period before approaching the problem, the tempo of activity, and the vigor and variety of responses emitted), whereas cognitive abilities were not. Capuchins are extremely explorative and manipulative monkeys, with long lasting interest toward objects (GLICKMAN & SROGES, 1966; KLUVER, 1933; VISALBERGHI, 1988). Similarly to chimpanzees (KOEHLER, 1925), *Cebus* use sticks as multipurpose tools. In fact, capuchins have been known to use sticks as weapons against other monkeys (COOPER & HARLOW, 1961), in killing a snake (BOINSKI, 1988), raking for food (KLUVER, 1933, 1937; POTI' & PARKER, in press), and probing for liquids (WESTSERGAARD & FRAGASZY, 1985).

The present study aimed at collecting detailed qualitative descriptions and quantitative

data of tool use acquisition in tufted capuchins (*Cebus apella*). We use a modification of the classical, box-and-pole test utilized by YERKES (1943) with a chimpanzee, and of the steel tube test (KLUVER, 1933). In particular, we aimed at assessing the extent to which success can simply derive from the monkey's manipulatory activity, or if it depends on the understanding of the instrumental relationship in which the stick becomes a functional extension of the hand. Another important goal was to better understand what kind of mental representation, if any, the monkey has of the characteristics a stick must possess in order to function effectively as a tool.

SUBJECTS AND METHODS

Subjects were four captive tufted capuchins: *Cammello* (*Cm*), a 9-year-old adult male; *Pippi* (*Pp*), a 6-year-old young adult female; *Brahms* (*Br*), a 5-year-old young adult female; and *Carlotta* (*Cr*), 3-year-old juvenile female. They all were captive born and hand-reared. The monkeys had lived together since 1984 in an indoor-outdoor cage ($1.7 \times 1.9 \times 2.6$ m and $1.7 \times 3.0 \times 2.6$ m, respectively). Their daily diet included monkey chow, fresh fruits, vegetables, cheese, and vitamins. Water was available ad lib.

The apparatus consisted of a 30 cm transparent tube with an internal diameter of 2.4 cm. A peanut was placed in the middle as reward, and sticks were provided to the monkeys to push it out of the tube. The tube was connected to a concrete base ($60 \times 48 \times 31$ cm) by means of inverted V-shaped metal frames (Fig. 1). Testing was carried out in an experimental cage ($1.7 \times 3.0 \times 2.6$ m) to which the monkey(s) had access through a guillotine door from the adjacent indoor cage. The trial started when the monkey entered the experimental cage, and in Phase II ended when solution occurred, i.e., the peanut was obtained (for Phase I, see Table 1). Behavior was scored on a time-ruled check list. Descriptive notes were also taken. The experiment was videotaped on a color VTR through a one-way glass window.

The experiment was made in two phases between April and June 1987:

PHASE I

This phase was aimed at assessing to what degree monkeys used tools spontaneously. It

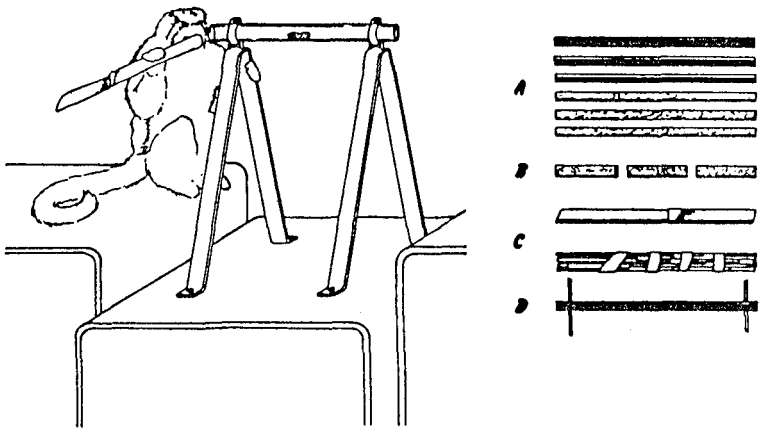

Fig. 1. The tube task. On the right are the tools provided in conditions A, B, C, and D.

Table 1. Experimental phases.

Sessions	Duration (min)	Subjects *Cm*	*Pp*	*Br*	*Cr*
Phase I					
I	11	6.5	11	11	11
II	30	30	30	30	30
III	2	2[1)]	2	2	2
IV	30	0	30	30	30[2)]
V	15	0	15	15	0
VI	15	0	15[3)]	15	0
Phase II					
Individual testing		+	+		+

1) *Cm*'s solution after 1 min and 43 sec (total time: 38 min and 13 sec); 2) *Cr*'s solution after 28 min and 30 sec (total time: 71 min and 30 sec); 3) *Pp*'s solution after 13 min (total time: 101 min). +: Subject present.

consisted of six sessions with no fixed duration, in which subjects had a variety of sticks at their disposal. They received wooden sticks in session I; twigs in session II; plastic sticks and reeds (*Arundo donax* = giant reed) in session III, IV, V, and VI. The capuchins were tested as a group. When a subject solved the problem for the first time, the session was interrupted, the solver removed from the group, and entered in phase II of the experiment. The remaining monkeys continued with phase I (Table 1).

Phase II

The subjects were tested individually and ten trials for each of the following conditions were given (see right part of Fig. 1): A: three reeds and three plastic sticks 32 cm long (diameter of about 2 cm). This can be considered as a baseline condition; B: three wooden sticks 10 cm long and 1.7 cm thick; C: one reed 32 cm long and 3 cm thick for *Cm*, and one sheaf (diameter of about 3 cm) of small reeds held together by rubber tape for *Pp*, *Br*, and *Cr*; (the single reed was too tough for the younger monkeys to crack, and therefore a sheaf of similar thickness was used); and D: one 32 cm plastic stick which had a transversal 10 cm stick inserted at 2 cm from both extremities (H-stick).

In order to obtain the peanut (solution), the monkey had to insert and push one stick in condition A; two short sticks one behind the other in condition B; in condition C it had to modify the tool making it thinner for the insertion in the tube; and in D it had to remove the transversal appendixe(s) from the stick. Each subject was allowed a total of 40 trials. *Cm* had only two trials in condition A because his times to solution were extremely short. Individual testing consisted of a mean of five trials a day, and the order in which conditions were presented was approximately balanced.

In both phases one-zero sampling (Altmann, 1974) at 30-sec intervals was made on the following behaviors: *Contact with the tube*: the monkey touched the plexiglas tube with its hands or mouth; *Manipulation of the stick*: the monkey contacted the stick or mouthed it; *Contact of the tube with the stick*: the monkey holding the stick contacted the tube with it. (The tube could be contacted with the stick far from, close to, and at the opening); *Direct reach*: the monkey reached directly toward the peanut despite the transparent tube; and *Hand in the tube*: the monkey tried to get the peanut inserting its hand inside the tube.

In all conditions the videotape screening provided the detailed description of the series of attempts until solution occurred. The following behaviors, which were considered inadequate and time consuming in respect to a straightforward solution, were scored: in condition B the

insertion of the second stick not behind the first one, but at the opposite side of the tube, or the removal from the tube of one of those sticks placed at the opposite side of the tube and its insertion back in the same side of the tube (Type I Errors); in condition C the use of the tool as provided by the experimenter without modification; the use of the tool slightly modified by the subject, but still markedly too thick to fit inside the tube (Type II Errors); the use of too short (<10 cm) splints (Type III Errors); the use of the rubber tape as a tool (Type IV Errors); and in condition D the use of the H-stick as provided by the experimenter; the removal of one block and the insertion of the opposite side of the plastic stick (Type II Errors); the insertion of a transversal block after its removal (Type III Errors).

Statistical Analysis

To compare the mean times to solution of a subject in each of the four conditions, and the mean times to solution in the same condition for different subjects, the nonparametric Wilcoxon test was used. To assess improvement over trials within each condition, the nonparametric Spearman correlation test was used for each subject. In all, comparison N was 10, and the level of significance accepted was 0.05 (two-tailed).

RESULTS

PHASE I

All the monkeys were interested in the problem. They approached the apparatus, noticed the peanut right away, and made several attempts to get it. In particular, especially at the beginning, they tried to reach it directly despite the transparent tube and inserted their hands in both the openings to get the peanut. Sticks were also actively manipulated. Table 2 shows the percentages of intervals scored before solution of the behaviors considered.

Three monkeys spontaneously used a tool to obtain the peanut. *Cm* solved in session III after a total of 38 min and 13 sec; *Cr* solved in session IV after a total of 71 min and 30 sec; *Pp* solved in session VI after a total of 101 min. *Br* was unsuccessful. Behaviors preceding solution, performance, and style of solution are described for each monkey.

Description of the First Solution

Cm: *Cm*'s first solution occurred in session III in which by chance he received, among other reeds, one which was too thick. He solved by using this one. At the beginning of the session he made several attemps to directly reach the peanut with his hand, roughly shook the tube, and then looked inside its opening. He then made his first stick-tube contact. After 30 sec, during which he moved around in the cage, *Cm* climbed on the platform and started to bite

Table 2. Percentages of intervals before the first solution in Phase I.

Subjects	Contact with tube	Manipulation of stick	Contact of the tube with the stick[1]			Direct reach	Hand in the tube
			Far	Close	At		
Cm	10.5	61.8	0	1.3	2.6	1.3	2.6
Pp	22.8	41.6	0	2.0	1.0	4.4	2.5
Br[2]	16.0	75.2	7.8	3.4	0	4.4	1.4
Cr	22.4	58.7	2.8	1.4	5.6	4.2	12.6

1) Contact of the tube by means of the stick when made far from, close to, and at the opening of the tube;
2) *Brahms*' sample was based on the same number of intervals considered for the last solver *Pp*.

the big reed until he took off a splinter from it. After having looked again inside the tube, he inserted the modified reed as far as it would go, and moved the peanut closer to the opposite opening. Then *Cm* withdrew the reed, hit it forcefully on the platform several times, bit it, and broke it. The diameter of the reed was reduced and immediately *Cm* inserted it into the tube and pushed out the peanut.

Pp: In session VI, *Pp* made her first bouts of stick-tube contact, which were directed close to the opening. After about 7 min from the beginning of the session, she shortened the reed by splitting it into two halves. She took one piece and placed an extremity in her mouth. Then, holding it in the mouth, she inserted it in the tube, pushed the peanut forward, moved to the opposite side of the tube, and recovered the reward.

Cr: In the three sessions prior to that of solution, *Cr* scored six bouts of stick-tube contact (four were directed far from the opening and two close to it). In session IV, right before solution, she had three bouts of the stick-tube contact and several times inserted her hand inside the tube in an attempt to grab the peanut. Since her arm is very thin, she almost succeeded. She then inserted a stick that was too short, and finally, she inserted a longer one and got the peanut.

PHASE II.

All the conditions were solved. For each subject, Table 3 shows the mean times to solution. Descriptions of the first solution in more complex conditions are given below.

Subject *Cm*

Condition B: He suddenly took one stick and inserted it in the tube, then he tried unsuccessfully to reach the peanut with his hand at the opposite opening. Afterwards, he put the second stick into this side of the tube and from that moment on, he removed and reinserted the stick several times. This behavior was shown at both openings. Suddenly, he looked around in the cage, found another stick and slipped it inside the tube right behind one of the two sticks already there. Then, he pushed it further inside and solved the task. Time to solution was 164 sec.

Condition C: Previously described as the first instance of solution.

Condition D: *Cm* looked inside the tube, then he moved around in the cage searching for something. Going back to the platform, he suddenly spotted the H-stick and tried to insert it in the tube. His attempt was unsuccessful, and he began to bite one of the transversal blocks. In this manner he removed both appendixes, he inserted one of them in the opening, then inserted the stick behind it, pushed and solved. Time to solution was 42 sec.

Table 3. Mean time to solution (sec) and S.D.*

Subjects	A: Sticks	B: 3 short sticks	C: Large stick	D: H-stick
Cm	9±7	40±46	130±78	49±33
Pp	172±109	77±186	81±47	56±34
Cr	45±63	74±64	78±51	107±82

*$N = 10$ for all the subjects in all conditions, with the only exception of $N = 2$ for *Cm* in A condition.

Subject *Pp*

Condition B: After about 16 sec during which she moved around in the cage, *Pp* climbed on the platform, placed one stick in her mouth, and inserted it in the tube. Then, she moved to the opposite side of the tube, and unsuccessfully tried to recover the peanut with her hand. Here, she inserted a second stick; this resulted in two sticks, one at each side of the peanut. Repeatedly, at both sides of the tube *Pp* recovered the sticks and inserted them back. After many of these attempts, she inserted the third stick behind one of the two already in the tube, and solved. Time to solution was 607 sec.

Condition C: She manipulated the sheaf and removed the rubber tape. Afterwards, she took off a small reed, placed it in her mouth, and inserted it pushing the peanut out of the tube. Time to solution was 33 sec.

Condition D: She directly removed the first block, placed the plastic stick in her mouth and then tried to insert the wrong side (the blocked one). Finally, she put the cleared side of the stick in the tube, and pushed it very carefully (in fact, the peanut did not fall outside the tube). Very cautiously she recovered the peanut. Time to solution was 43 sec.

Subject *Cr*

Condition B: She bit the tube and looked inside. Then she inserted a stick in one end of the tube, and inserted her hand in the opposite end to try to reach the peanut without success. After a while, she inserted another stick behind the first one and solved. Time to solution was 27 sec.

Condition C: With her hand, she reached inside the tube for the peanut, but without success. Then she tried to insert the stick. Afterwards, she bit and split the stick into three thin pieces and tried to insert one of these pieces, but it was still too thick. After having inserted a piece of rubber tape, she tried again to insert a stick. She split it again, inserted it in the tube, and finally recovered the peanut. Time to solution was 79 sec.

Condition D: She manipulated the plastic stick, then put her hand inside the tube. Soon after she tried to insert the plastic stick in the tube, then put her hand inside it again, and repeated these attempts over and over again. By chance a block was displaced, and *Cr* inserted the cleared side of the stick very slowly in the tube and recovered the peanut. Time to solution was 107 sec.

Performance and Style of Solution

The subjects used the tool with different "styles." *Cm*'s behaviour was extremely effective: when he was pushing the peanut out of the tube his style was rash and the strength of his movements often caused the reward to shoot out of the opening. On the contrary, *Cr* was very cautious in inserting the stick, and pushed it gradually; furthermore, instead of pushing the peanut out of the tube, she usually took it with her hand from the opposite opening of the tube. *Pp* showed a very particular technique: in all conditions and throughout the whole experiment, she first placed the stick in her mouth and then aimed the distal end of the stick at the opening of the tube. The action was undoubtedly difficult, especially in the first trials.

The difficulties posed by each condition and the different style adopted by each monkey, resulted in a non-unitary picture of their performances, i.e., across individuals conditions

did not rank the same as difficulty. Overall, times to solution were extremely varied as indicated by the high S.D. values (Table 3).

For *Cm*, mean time to solution was significantly higher in *C* condition, where the task of breaking apart the tough reed needed persistence and strength, than in *B* condition ($z = 2.39$, $p<0.02$), or in *D* condition ($z = 2.8$, $p<0.01$). For *Pp*, A condition was the easiest with time to solution significantly shorter than in the other conditions (conditions A–B, $z = 1.99$; A–C, $z = 2.09$; A–D, $z = 2.8$, all comparisons $p<0.05$). All the other comparisons between mean times to solution in the other conditions B–C, B–D, and C–D were not statistically significant. For *Cr* the mean time to solution of condition A was significantly shorter than in D condition ($z = 2.07$, $p<0.04$). All other comparisons between mean times to solution (A–B, A–C, B–C, B–D, and C–D) did not reach statistical significance. For all the subjects, in every condition, mean time to solution in trials 1–5 was higher than in trials 6–10; however, significance was reached only in the following cases: *Pp* improved in condition A (Spearman, $\rho = -0.76$, $p<0.006$, one-tailed), and *Cr* improved in conditions A and in D ($\rho = -0.87$, $p<0.001$; $\rho = -0.70$, $p<0.02$, respectively).

Within each condition significant interindividual differences in mean time to solution were found. In condition A the mean time to solution was higher for *Pp* than for *Cr* (Wilcoxon test, $z = 2.8$, $p<0.005$). This difference might depend on the difficulty of using the mouth to insert the stick. In condition A, *Cm*'s mean time to solution was 9 sec, but in his case statistical analysis was not appropriate since he was tested only twice in that condition. In condition *B* no significant differences were found. In condition *C* comparisons between *Cm* and the other two solvers were not made because whereas *Cm* was presented with a reed, *Pp* and *Cr* had a sheaf, and therefore the mean times to solution could have reflected dif-

Table 4. Instances of errors.

		Type I			
Condition B	Trials	2nd stick added in wrong side			
Cm	1–5	26			
	6–10	8			
Pp	1–5	13			
	6–10	4			
Cr	1–5	5			
	6–10	18			
		Type II		Type III	Type IV
Condition C		Whole stick	Thick splint	Short stick	Tape
Cm	1–5	29	11	2	0
	6–10	2	16	0	0
Pp	1–5	0	0	5	1
	6–10	0	0	7	1
Cr	1–5	1	3	1	2
	6–10	8	0	4	2
		Type II		Type III	
Condition D		H-stick	Wrong side	Short stick	
Cm	1–5	6	2	8	
	6–10	4	0	4	
Pp	1–5	2	3	8	
	6–10	1	4	0	
Cr	1–5	23	3	10	
	6–10	5	9	14	

ferences in the difficulty of breaking apart the tools. No difference was found between *Pp* and *Cr*. In condition D the difference was significant for *Cm* and *Cr* ($z = 2.1, p<0.04$) and for *Pp* and *Cr* ($z = 2.2, p<0.03$), but not for *Cm* and *Pp*.

The tapes recorded during the experiment allowed the scoring of trial-and-error patterns through time, and indicate how the tasks were mastered and understood. It can be assumed that whereas in the first trials of each condition the monkey needed to explore and try the tool in order to discover what was "wrong" with it and needed to be modified, (i.e., length in condition B and thickness in conditions C and D), in later trials, experience and understanding of the features of the problem must have allowed a more adequate use of the tools. Table 4 shows the number of instances of error made by each subject during trials 1–5 and trials 6–10. Errors are considered in relation to the particular aspect of the problem they suggest the animal did not master.

In condition B one stick is too short to be effective and a second one must be added behind it. An inadequate strategy consists in adding the second stick to the opposite side of the first one. Instances of this type of error (Type I Error) were scored throughout the experiment by all individuals; overall, 44 instances were scored in trials 1–5 and 30 in trials 6–10. In condition C the thickness of the tool must be reduced or in D the appendixes removed. Once this has been discovered during the first attempts, it would become obvious not to try to insert the intact tool (i.e., the reed, the sheaf, or the H-stick) or a part of the sheaf or reed that is still conspicuously too thick (e.g., the monkey subtracts a splinter and tries the sheaf again), or to insert the side of the H-stick which still has the block, after having freed the other. Overall, instances of these inadequate behaviors (Type II Error) were scored 83 times in trials 1–5 and 49 times in trials 6–10. In C and D, modification could be carried out on sticks, including the transversal blocks, which were conspicuously shorter than needed to solve the task (a stick shorter than 10 cm was considered inadequate unless the monkey used it in combination with another one, Type III Error). It must be stressed that the large majority of these instances of inadequate behaviors refers to cases in which the animal was inserting small sticks 1–2 cm long, and peanut shells; overall, Type III Errors occurred 34 times in trials 1–5 and 30 times in trials 6–10. *Cr* and *Pp* also showed a peculiar error consisting in the use as a tool of the very flexible rubber tape (Type IV Error). At the end of the experiment, *Cm* was also presented a few times with a sheaf of reeds held together by rubber tape, but he never attempted to use the tape as a tool. However, on another occasion in which the tools were in an adjacent room, he tried to push out the peanut using a hanging rope. The pattern of errors is not consistent across individuals, partly because it reflects different behavioral strategies used for solving the tasks. In condition C the primary goal of *Pp* was to quickly reduce the size of the sheaf in order to be able to insert it in her mouth, and afterwards in the tube. Therefore, she never used tools which were too thick mainly because she could not mouth them, and not because they would not fit into the tube. In fact, her attempts to insert the blocked end of the H-stick in the tube maneuvering the freed extremity of the stick with her mouth, show that she did not master this aspect of the task. The worsening of *Cr*'s performance in the second block of trials is difficult to explain; it could have resulted from the fact that during the experiment she dropped in hierarchy and became very stressed.

DISCUSSION

These results confirm other recent findings on the skilfullness of capuchin monkeys in using

tools in a variety of tasks (FRAGASZY & VISALBERGHI, 1989; VISALBERGHI, 1987; WESTERGAARD & FRAGASZY, 1987), and apparently suggest that the "great gulf between monkey and ape" is smaller than suggested by YERKES and YERKES (1929). A comparison with the performance obtained by KLUVER (1933, 1937) in the steel tube task is not appropriate since his subject was presented with a tube in which the experimenter have inserted a stick inside.

Three out of four capuchins spontaneously used tools. The first solution was preceded by sustained manipulation of both the apparatus and the sticks. Two solvers succeeded in the same session in which they started to contact the tube with the stick, the third subject began the tube-stick contact behavior in the session previous to that of solution. Despite the fact that *Br*'s scores of manipulative behavior were similar to those of her cagemates, she never tried to insert the stick inside the tube. These findings suggest that contact between stick and tube does not automatically lead to success, unless the monkey also tries to use it as a physical extension of its hand for reaching in. In the tube task, generic manipulation, persistence and vigor in the action, are not likely to determine success by chance, as it is the case for other less constrained tasks (VISALBERGHI & MASON, 1983).

Throughout the whole experiment, the monkeys showed marked interindividual differences. The style in using the tool was strikingly personal, and testify the independent acquisition of tool use skills. Despite the fact that *Pp* saw *Cm*'s and *Cr*'s first solutions, she solved with a completely different style. She used the mouth to insert the stick, and this original technique was developed and used only by her. The ontogeny, the significance and the adaptive value of using the mouth is not at all clear. What we know is that although at the beginning this technique was handicapping the monkey, later with thick, and H-sticks, it turned out to be advantageous.

The first success of the adult male has the characteristics of an insight solution: *Cm* not only discovered all at once the use of a stick as tool, but also modified the tool to insert it in the tube. However, the intentionality of this action cannot be proved; since, *Cm* was already biting the reed before making the first instance of reed-tube contact. It is important to stress that the monkey was very persistent in trying to fit the tool exactly into the opening of the tube, as if he clearly understood that in order to get the reward he had to reach for it using a tool. In fact, he tried both sides of tube and tool, and later alternated bites resulting in reduction of the diameter of the reed and attempts to insert it in the tube.

The more complex conditions in which the monkeys had to combine or modify the tool were always solved in a few minutes. However, the careful analysis of the tapes evidenced that capuchins made a variety of errors which seem not consistent with an understanding of the task. Monkeys inserted in the tube very short splinters when an appropriate stick was available; they inserted a short stick on one side and the second on the opposite side of the tube; they pull out a transversal block from one side of the stick, but attempted to insert the still blocked one; finally, the rubber tape was also used instead of the more appropriate reeds. Errors involving the use of too short tools were more frequent than errors involving too thick ones. Here again, we stress the fact that errors were those instances in which the monkey was not trying to solve the task with tools that might have worked, but with things completely out of scale, and wrong. These errors, as well as the use of the rubber tape, i.e., something long but not rigid enough to displace anything, have analogies with 12–18-month-old child behavior (BATES, 1979) in the fifth stage of Piagetian sensorimotor development, when they discover that a stick can be used to rake in an object out of reach, i.e., that a stick can be a substitute for their arm and hand. Later, between 18 and 24 months of age, in the sixth stage

of the sensorimotor development, the child is able to evision, prior to the first try, the requisites of the stick (elongated shape, maneuverability, and stiffness), and hence chooses an appropriate substitute the first time around. In the second year of life children show a gradual decrease in the amount of perceptual support given by the trial-and-error attempts. The capuchin's success in the more demanding conditions seems more related to generic manipulative activities than to a deliberate and foresightful modification of the characteristics of the tool to make it work. In fact, the monkeys made continuous attempts to insert the tools in the tube, and whenever the stick was not suitable for the opening they manipulated it roughly, bit it, and somehow changed its shape and size. The fact that often they discarded suitable tools and tried to use the unsuitable ones also confirm that their actions were not aimed towards a foreseen goal. In contrast with the claim made by PARKER and GIBSON (1977) that capuchins are capable of "invention of new means through mental combination," the results of this experiment show that in tool use the cognitive capacity of capuchins does not reach the sixth Piagetian stage of representational means. Capuchins did not show beforehand modification of the tool, but mainly modified it when their action was unsuccessful.

A mental representation of the characteristics necessary to a tool to be effective is present in chimpanzees. MCGREW (1974) reports that chimpanzees feeding upon driver ants select the adequate tools and modify the unadequate ones. In the Tai Forest, chimpanzees make and use sticks of different sizes to fish for honey, to dip ants, and to extract marrow from bones, or kernel from nuts. Recently, BOESCH and BOESCH (1988) showed that chimpanzees prepare the adequate tool for the specific use with all the necessary modifications beforehand, and modifications after first use occur in only 6.5% of the sticks used. There are also many other instances of foresight in chimpanzees, as for example when they carry stones from some distance towards an anvil, or carry sticks when they approach a mound (BOESCH & BOESCH, 1983; GOODALL, 1986).

In the wild, capuchins are specialized in "destructive foraging" (TERBORGH, 1983), which is based on their strong tendency to manipulate, break apart, or bang anything at hand. This vigorous approach allows them to exploit food resources not available to other sympatric monkey species. PARKER and GIBSON (1977) suggested that tool use in capuchins arose for feeding on embedded food. More recently, MCGREW (in press) showed that tool use in apes does not correlate with their terrestrial habits, social structure, or phylogenetic distance from humans, whereas there is a correlation between tool use and the amount of animal protein in the diet. In this respect, field observations show that capuchins' diet includes a large amount of animal proteins deriving from insects, lizards, birds, and small mammals (TERBORGH, 1983; FEDIGAN, in press). These findings suggest that the selective pressures that led and maintained these feeding habits may have favoured in capuchins, as in apes, the abilities involved in the use of tools.

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