Tool Use in Wild Chimpanzees: New Light From Dark Forests

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In the early 1960s, direct observations of wild chimpanzees began in the wooded savanna of East Africa. This work revealed the surprising abilities of chimpanzees in using and making tools as well as in hunting for meat.[1] However, although the majority of chimpanzees live in a forest environment, it was not until 1979, when we started our project in the Ivory Coast, that chimpanzees living in the tropical rain forest were observed on a long-term basis. Habituation to human observers is a long process, for chimpanzees are very shy. Earlier studies relied on artificial provisioning to speed up this process. We did not because a feeding behavior was the main topic of our study. The Tai chimpanzees are today still the only community fully habituated without relying on artificial provisioning.

Tool use is rare in animals, and the chimpanzees stand out as the most proficient tool users besides humans. Toolmaking is even more rarely observed, and chimpanzees are the only animal species observed to make tools regularly in the wild. Knowledge of tool use in chimpanzees leads to better understanding of what is unique about humans' tool use. Here, we review some of the aspects of the nut-cracking behavior observed in our study community in the tropical rain forest.[2]

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NUT-CRACKING BEHAVIOR

Five species of nuts with different shapes and degrees of hardness are eaten by chimpanzees in Tai: Coula *edulis* nuts are very abundant and the softest of all; nuts of the *Panda oleosa* are the hardest; *Parinari* excelsa and *Detarium senegalense* are both very large trees with irregular fruit production; and Sacoglottis ga*bonensis* nuts are cracked only rarely at our site. This report deals with Coula *edulis* and *Panda oleosa.* These nuts are rich in protein, sugar, fat, and amino acids.

The anvils used by the chimpanzees to secure the nuts include emerging roots, the bases of large trees, suitable branches in trees, and rocks. Most hammers used to pound the nuts are fallen branches of various shapes, sizes, and degrees of hardness. Tool selection is related to the hardness of the nut, and chimpanzees select harder and heavier tools for the harder nuts. Stones are rare in the forest and highly sought after because a desirable nut species, *Panda oleosa,* is so hard that it is opened only with a stone. It is harder than any food processed by human hunter-gatherer societies. Physical experiments revealed that using a stone rather than wooden hammer has an energy advantage, reducing pounding energy by 30% for Coula nuts. This gain increases to 43% when cracking the harder Panda nuts,[2] so the chimpanzees' preference for stones is reasonable from the standpoint of energy use.

Nut cracking is restricted to some chimpanzee populations in some parts of the West African rain forests, although the same tree species and tools exist at other chimpanzee study sites in Central African forests. This fact has led several authors to propose that nut-cracking behavior is cultural in chimpanzees because ecological differences seem not to be responsible for its distribution.

In contrast to other well-documented types of tool use, such as termite fishing and ant dipping, which are acquired at about age 4, nut-cracking techniques are fully acquired only at adulthood (13 to 15 years in chimpanzees). Why is this behavior so demanding? Consider the difficulty of the task: First, it is the only tool use by chimpanzees requiring three different objects to be assembled before starting the task: an anvil, a hammer, and the nuts. As the three are never found together in the forest, transporting hammers and nuts to the anvil is the rule. Second, the chimpanzee does not see any result from hitting a nut until it opens. Third, this is the only known tool use in chimpanzees in which two types of tools are often used to gain access to the same food (i.e., a stone hammer and a stick; see Fig. 1).

Transport of Tools and Nuts

Some 12 nuts are collected at a time in the tree or on the ground and carried to an anvil for cracking. Per day, chimpanzees crack on average about 270 nuts in 2 hr; this activity involves more than 20 transports of nuts. Similarly, tools are transported between anvils during cracking sessions when chimpanzees move between different nut trees. They transport their hammers more frequently and over longer distances for harder nuts than for softer ones because of the relative rarity of the stones needed to open the harder nuts.

Fig. 1. Chimpanzees cracking nuts. An adult female is cracking nuts using a 7.6-kg stone hammer. Her 5-year-old youngster is watching the adult male getting kernel remains out of shells with the help of a small stick he prepared before use.

For nuts of *Coula edulis,* clubs are regularly transported for short distances on the ground, 20 m or less in 85% of the cases; stones are moved up to 50 m. In addition, hammers are always transported when nuts are cracked in the tree before they fall on the ground, which implies an anticipation process (i.e., thinking of the hammer before climbing the tree). Cracking in the tree requires particular dexterity. The chimpanzee must be able to transport the nuts and the tool and to handle them so that nothing falls to the ground. This feat is especially impressive when a mother, supporting her baby on her belly, holding spare nuts in one foot and in her mouth, supports the nut on the anvil with one hand while hitting it with the other. Given that most transports of Coula nuts are to a place visible from the original location, the decision to make a transport can be explained by a simple association process.

For Panda nuts, the situation is more complicated because stones, necessary to crack the hard nuts, are rare in the forest. As the trees of this species are not very common, chimpanzees have to transport the stones over long distances (average distance = 120 m), a special challenge for one can see 25 m at most in the forest. These facts lead to some obvious questions: How do chimpanzees select their hammers when they cannot see more than one at a time? And what cognitive capacities are required?

To arrive at some answers, we marked all the fruiting Panda trees in a given region of 30 ha, measured the distances between them, marked and weighed all the available stones, and kept a precise record of their locations. Analysis of 76 transports showed that chimpanzees cracking at a tree with no available hammer would choose, within a given class of weight, the nearest stone to that tree (average transport distance = 120 m, weight class = 1-12 kg). To make this selection, they have to compare the distances to the target tree for several possible stones (five on average within 300 m). In addition, to be able to mentally compare distances that are oriented in all directions in the forest, the chimpanzees must mentally reorient these distances before comparing them. The target tree and the positions of the stones change regularly, and these calculations have to be redone each time.[3]

Thus, in planning their hammer transports, Tai chimpanzees use a mental representation of space that allows them to conserve distances between objects (hammers and trees) at least over several days, to compare several of these distances, to permute objects (hammers) in this map, and to permute the point of reference (nut-bearing trees) to which distances will be estimated. In Piagetian terms, the simultaneous presence of these operations compares with the euclidean mental map observed for spatial representation abilities in 9-year-old children.[3] The selective pressure to survive in the tropical rain forest seems to favor the development of spatial abilities that are not required in more sedentary conditions (e.g., chimpanzees in captivity and even some human populations).[4,5]

Sex Differences in Frequency and Performance of Cracking Behaviors

We distinguish here three cracking techniques: Coula cracking on the ground, Coula cracking directly in the tree, and cracking the very hard Panda nuts. The latter two techniques are particularly demanding feats. They require transporting tools, and the physical peculiarities of the Panda nut demand special technical skill. The Panda nut has three seeds independently embedded in a hard wooden shell. Very powerful hits must be made at the beginning to open the nut and get at the first seed. Then the nut has to be precisely repositioned two or three times while hitting gently to extract the remaining seeds without smashing them.

Both techniques are used more frequently by females than males, and the females' performance (number of hits used to open the nut and number of nuts eaten per minute) is superior.[6] The reason for this sex difference is social in that males favor social contact whenever there is a conflict between cracking more nuts or remaining with other group members. These two particular techniques are relatively solitary activities, one taking place high up in the trees, usually out of sight of other chimpanzees, the other being restricted to one or two animals because of the lack of stones.[7] We may speculate that humans may already have had such a sex difference at a very early stage. The first tools, non-lithic ones, were possibly used for gathering and food-processing activities, such as cracking nuts. The first users and makers of these tools might well have been females. This hypothesis is in contrast with the common theory that tools were invented for hunting purposes.[8]

Ontogeny, Food Sharing, and Teaching

The nut-cracking behavior of the Tai chimpanzees may be the most sophisticated tool behavior observed so far in wild chimpanzees, says Jane Goodall. How do youngsters acquire this demanding behavior, and in what aspects do mothers influence their apprenticeship?

Sharing nuts is the dominant element in this apprenticeship, occurring for 6 years between a mother and her infant. (In contrast, Gombe chimpanzee mothers never share tool-acquired food with their offspring.) The sharing pattern is differentiated according to the age of the youngsters and seems directed to motivate them to crack. Up to 3 years, mothers let them take nuts directly from the anvil, from the mothers' hands, and even from their mouths. Mothers leave up to 40% of the nuts they crack to their offspring. During this time, the infants start handling the tools and the nuts and attempt to crack nuts, usually with an incomplete setting (e.g., by pounding a nut lying on the ground rather than on an anvil, hitting on an empty anvil with a hammer, or holding a nut in the hand and pounding it on the anvil or the ground).

Later, when the offspring are around 4 to 5 years of age (normally before a new baby is born), the mothers start to share less but while collecting nuts leave behind, on anvils, intact nuts and their own good tools. No chimpanzee without young offspring ever does so. Usually the youngsters use this opportunity and start using the tools, learn to recognize an optimal tool, and sooner or later succeed in opening a nut. This is the beginning of the true apprenticeship—when the offspring start assembling the three necessary objects for this activity and use them correctly.

It is during this period that we observed the very rare true cases of active teaching in a wild animal.[9] We saw two mothers correct errors in their infants' nut-cracking technique by demonstrating the right method. In both cases, only the infants were cracking nuts, and the mothers, who were resting nearby, saw the problem and intervened just for the time necessary to correct, in one case, the hammer grip and, in the other, the position of the nut. In the first case, the infant obviously learned from her mother's demonstration, and she then succeeded in opening nuts four times better without repeating the mistake corrected by her mother. We think it is not surprising that teaching happened in the nut-cracking context. Active teaching is rare, even in spontaneous interactions between mother-infant pairs in humans,[10] and occurs only when truly necessary. In the case of nut cracking, mothers have a direct interest in accelerating their youngsters' performance and helping them get access to a highly important food source, for this independence enables the mothers to invest fully in new offspring.

Recent critical reviews of animal learning processes have denied that animals have the ability to imitate, but the teaching instances we observed would have no functional role if the chimpanzees did not have an imitative capacity. Many people still consider pedagogy one of the uniquely human attributes; our observations of chimpanzees indicate otherwise.

CONCLUSION

Our observations of nut-cracking behavior in Tai chimpanzees have revealed surprisingly high cognitive capacities that were not suspected from previous studies. Studies of cognitive abilities done with captive chimpanzees who had received language training led some authors to state that the language training allowed the animals to acquire abilities that would be somehow dormant and never expressed in the wild.[5,11] Such a suggestion sounds strange to a biologist, for what mechanism could favor the evolution of unused abilities in an animal species? Contrary to this hypothesis, there is evidence that chimpanzees in the wild have more developed cognitive abilities than chimpanzees in captivity. First, considerable evidence from psychological studies shows that an individual who develops in socially or physically deprived conditions is impaired in its cognitive development (e.g., as shown in Mason's experiments with surrogate mothers[12]). Second, across human populations, degree of school education correlates positively with cognitive capacities.[13] Thus, it seems more reasonable to suggest that chimpanzees living in a deprived environment (i.e., captivity) do not have the opportunity to develop fully, but, through the supplementary enrichment provided by daily language training, some of their faculties are stimulated.[14] But life in the wild puts strong survival pressure on most learning processes and would constitute an even greater stimulant to cognitive development than language training in captivity.

Not surprisingly, therefore, evidence of the highest capacities in representational abilities ever observed in chimpanzees comes from the wild—the rich and highly demanding rain forest habitat of our study community. It is also from this forest-dwelling population that novel evidence has emerged on topics such as tool use, food sharing, teaching, cooperation in hunting, and adaptation to predation pressure by leopards. This evidence suggests, in contrast to prevailing theories, that the roots of human evolution might be found in a forest environment.

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Notes

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