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Received 20 July 1981 and accepted 24 July 1981

Keywords: Chimpanzees, sex difference, tool-use.

Sex Differences in the Use of Natural Hammers by Wild Chimpanzees: A Preliminary Report

The chimpanzees of the Tai National Park, Ivory Coast, use clubs and stones to open different species of nuts. An intriguing sex difference has been observed in this behavior. It is almost exclusively females that open Coula nuts directly in the tree and crack the very hard Panda nuts. Both techniques are difficult and imply either anticipating the need of a hammer and its transport, or exact positioning of the nut and precise dosage of the hits. The efficiency of females is superior to that of males in the technique of cracking Coula nuts on the ground, which is performed by both sexes. Possible implications for the evolution of tool-use in humans are discussed.

1. Introduction

Among primates, sexual division of labour and active food sharing are features observed exclusively in hominids. Division of labour is always regarded in a complementary way, each sex being dependent on a part of the other's activity (Isaac, 1978). The only exception in subhuman primates are the chimpanzees, which show a partial division of labour (van Lawick-Goodall, 1968, 1975; McGrew, 1979; Teleki, 1973, 1975). Hunting, a typical male activity in humans, is also a predominantly male activity in chimpanzees, the females obtaining some meat through begging. So far, however, we knew of no specifically *female* technique of foraging which would have prepared the way for two-way food sharing among the sexes. McGrew (1979) recently noted a beginning of sex difference in the termite-fishing technique. The females have a tendency to fish more frequently than the males, but males do not beg or receive termites from females. We present in this paper a case of sexual difference in the use of "hammers and anvils" to crack nuts by wild chimpanzees (*Pan troglodytes verus*). There is, however, no evidence that males profit from the particular skills of females. These are the first results of a three-year project which started in July 1979.

2. Methods

Our study site is located in the western part of the Tai National Park, 20 km east of the nearest village, Tai, situated near the Liberian border. The park covers 350,000 hectares and is the biggest remain left of the tropical rain forest of West Africa. Our community of about 40 chimpanzees lives without significant human disturbance. The closest traditional plantations are situated 10 km from their home range limit, and the native tribes, the Oubi and Guéré, do not hunt chimpanzees for totemic reasons. We did not provision the chimps, but followed them by their vocalizations. The visibility in the forest is very low, i.e. 30 m or less. These distances are far too short to be tolerated by the chimpanzees. Therefore, habituation is very slow and, so far, we could only observe nut-cracking chimpanzees when they did not notice us. The fact that 4200 field-hours yielded only 62 hours of actual observation reflects the difficult observation conditions. We therefore had to recur to listening. When several animals crack nuts at the same time, we can easily distinguish one cracker from the other because the hammers are of different size, weight

0047-2484/81/070585+09 $02.00/0

and density, and therefore produce different sounds. The directions from which the sounds come are an important help. As soon as we can hear one cracker distinctly, usually the nearest one, we approach it and record its hammering by focal-animal sampling (Altmann, 1974). We determine its age and sex by sight as soon as possible, distinguishing infants, juveniles, adolescents, and adults (van Lawick-Goodall, 1968, 1975). The sample ends when the animal stops cracking nuts, either spontaneously or because it has noticed us.

The Coula nut opens with a distinct crack. The opening of a Panda nut starts with powerful strikes which then decrease in intensity. From our usual working distance of 30 m, the number of cracked nuts can thus be determined accurately even when the focal animal is not visible. To compare the performance of the different individuals, we use two measures based on these acoustic observations: (a) number of hits delivered to open one nut, and (b) number of nuts opened per minute. Since we cannot see the focal animal during most of the sample time the second measure includes the time spent eating and collecting new nuts. It is presumably influenced by factors other than pounding skill, such as hunger and proximity of nuts to the work site.

3. Description of the Nut-cracking Technique

The chimpanzees use tools to open five different species of nuts (Boesch & Boesch, in prep.) but we have sufficient observation data only for two species: *Coula edulis* and *Panda oleosa*. The chimpanzees use different techniques to open Coula and Panda, and we briefly describe them here. A more complete description will be presented elsewhere (Boesch & Boesch, in prep.). To feed upon both nut species, chimpanzees use a hard surface as an anvil, e.g. a rock or root emerging from the soil, and a stone or a wooden club as a hammer (for choice of material see Boesch & Boesch, in prep.). We never saw a chimpanzee open nuts without a hammer and an anvil.

Coula edulis (*Olaceae*)

This is a spherical nut of 2–3 cm in diameter, consisting of a 2 mm shell and one round kernel which is directly attainable when the shell is opened. They are cracked on anvils in two different locations: (a) On the ground and (b) in the tree.

(a) *On the ground*, the chimpanzee first collects about 12 to 15 nuts by picking them in the tree or, later in the season, by collecting them on the ground, and carries them to an anvil, i.e. a surface root close to the nut tree or a nearby flat rock. Most of the root-anvils show a depression or a hole produced by previous nut-cracking. In 75% of the 748 recorded Coula-cracking places on the ground, a hammer, most frequently a wooden club, lay on or beside the anvil. When no hammer was near, the chimpanzees were seen to look for an appropriate one and carry it to the anvil in one hand. They would then sit down and start to pound the nut, holding the hammer with one or both hands. Each nut is immediately eaten after opening and the hammer meanwhile rests on the ground. Before beginning to work on the next nut, the shells are brushed from the anvil with one hand. Nuts are usually collected several times during one feeding session.

(b) The animal may choose to open the nuts directly *in the tree*, using a horizontal branch as an anvil. In this case, it must always anticipate its action by looking for a hammer *before* climbing into the tree. While carrying the hammer in a hand or a foot, the chimpanzee picks the nuts and stores them in its mouth and a hand. It then chooses a branch as an anvil for pounding the nuts. To us, the subsequent behaviour in the tree resembles the performance of an equilibrist. The animal cracks a nut with one or both hands while holding the rest in the mouth and one foot. To eat the nut, the mouth has to be freed by transferring the nuts to one hand while the hammer is held with one foot or left to balance on the branch. To continue the cracking, the hand has to be freed again by putting the nuts back to the mouth, and so on. Often, to prevent the pounded nut from falling from the anvil, the animal retains it on the branch with the thumb and the forefinger of one hand between hits. To collect more nuts, the hammer is carried or left balanced on the anvil. Obviously, cracking nuts in the tree implies better co-ordination of more movements than doing so on the ground. On the other hand, nuts can be reached within arm's-length or collected at a few meters from the anvil. This is an obvious advantage compared to the chimpanzee who has to climb at least 15 m up a tree and down again for each load of nuts to open them on the ground.

Panda oleosa (*Pandaceae*)
This is an egg-shaped nut of 5–6 cm length, containing three or four boat-shaped almonds which are circularly arranged, each one separately hemmed in a thick hard shell covered by sticky husk. Chimpanzees open them only on the ground and on fairly big surface roots around the Panda tree or on nearby rock outcrops. A chimpanzee collects 4–6 nuts at a time on the ground and carries them in its hand to the anvil. Only once out of 25 sessions did we see an animal carrying Panda nuts in its mouth. As in the case of roots used for Coula, most roots show a depression made by previous Panda cracking. The chimpanzees were not seen to produce such holes except by simply placing the nut always on the same spot. Only stones are used as hammers, as the hardness of the nut almost completely excludes the use of a club. Stones have to be transported hundreds of meters if there are none at the anvil. As our own frequent attempts taught us, careful positioning and a precise dosage of hits are required to open the nut without smashing the almonds. Powerful hits are necessary to begin the opening procedure. Gentle, carefully placed ones must follow for freeing the almonds one after the other, demanding a precise control of the animal's strength.

4. Results

Table 1 presents the number of animals of each age–sex class in which we saw cracking Coula and Panda nuts, during the two nut seasons of November to May 1979–81. The danger of counting the same animal twice in one feeding session is low, because the chimpanzees leave immediately when they have noticed us. It is evident that two techniques were observed and used almost exclusively by females: cracking Panda and cracking Coula in the trees. Obviously, these results have to be compared to the age–sex composition of the community, which we could only estimate, since we did not know animals individually. Therefore, we recorded age and sex of all chimpanzees which we saw involved in other activities than nut-cracking (Table 2). We also differentiated between animals observed on the ground and in the trees, since unequal arboreality could be responsible for the male/female difference in Coula pounding in the tree. The total frequency of males and females encountered is not significantly different from an expectation based on a sex ratio of 1:1 for our community ($\chi^2 = 0{\cdot}86$, d.f. $= 1$, NS). The distribution of animals seen in the trees and on the ground when they did not open nuts is the same for both sexes (2×2 contingency table $\chi^2 = 1{\cdot}70$, d.f. $= 1$, NS). We can therefore reject a bias due to one sex being generally more arboreal than the other. Another possible bias could be that males and females are more likely to be found in unisexual groups. The data in Tables 1 and 2, collected on 142 and 162 groups, respectively, suggest the contrary: When we were able to identify two individuals of the same group, they were of a different sex in about 50% of the cases ($\chi^2 = 0{\cdot}66$, d.f. $= 1$, NS).

Table 1 **Number of animals of each age–sex class cracking nuts, observed in a total of 142 encounters**

	Coula			
Sex and age	On the ground	In the tree	Total	Panda
Male				
Adult	34	2	36	2
Adolescent	1	1	2	—
Juvenile	1	2	3	—
Female				
Adult	57	41	98	35
Adolescent	5	4	9	2
Juvenile	3	9	12	3
Infant	1	1	2	—
Total	102	60	162	42

Table 2 **Number of adult animals of both sexes seen when *not* nut-cracking, observed in a total of 162 encounters**

Sex	On the ground	In the trees	Total
Male	69	72	141
Female	65	92	157
Total	134	164	298

In comparing the results of Tables 1 and 2, the sex difference for Panda is highly significant in favour of the adult females (2×2 contingency table $\chi^2 = 23{\cdot}63$, d.f. $= 1$, $P < 0{\cdot}001$). For the Coula technique on the ground, the statistical test is not significant (2×2 contingency table $\chi^2 = 2{\cdot}79$, d.f. $= 1$, NS). That is, both sexes use it with equal frequency. The difference between the Coula technique in the tree and on the ground is significant (2×2 contingency table $\chi^2 = 15{\cdot}9$, d.f. $= 1$, $P < 0{\cdot}001$) in favour of the adult females cracking Coula in the trees.

There are several biases which could lead to the observed sex difference in favour of females, and we discuss here why they can probably be ruled out.

(a) When not cracking nuts (Table 2): In order to find and to follow the chimpanzees, we oriented ourselves by the vocalization and drumming of males. Thus, we could have found males more often than females. As mentioned above, however, the sex ratio of two-member samples was close to 1:1. The artifact would therefore require an incredibly high proportion of females in the community.

(b) In the Panda-cracking situations (Table 1): If males spotted us earlier than females and departed silently without being noticed by us, this might cause a bias favouring females. The visibility in the forest, however, is about the same for observing Coula-cracking on the ground and for Panda-cracking. Table 1 shows that in Coula-cracking on the ground, males and females were equally often observed. We therefore reject this bias; it is highly improbable that males would react differently to us only when cracking Panda.

(c) In the situation of cracking Coula in the tree, the argument that the males spotted us earlier than the females could again be forwarded. The observations on Coula crackers on the ground suggested no such difference. Why would males react differently towards us when in the trees? The visibility on the ground is higher than from the tree, due to the dense foliage between 5–30 m in height. The chimpanzees which collect nuts see us much quicker when cracking on the ground than in the tree. During the first ten minutes of recording, we were seen by four out of 32 crackers in trees and by 21 out of 47 crackers on the ground. Visual contacts with tree crackers are only possible when we are close to the tree (15 m) or, if by chance, there is an opening in the vegetation. If males were more inclined than females to spot a human from afar, the difference should therefore take effect on the ground and not in the trees, as this criticism requires.

These sex differences are striking because they have a common aspect. Cracking Coula in the tree and cracking Panda are both more complex and different techniques than cracking Coula on the ground. They are also almost exclusively female activities. The difference between subadults is not significant, but shows a similar tendency, suggesting a learning or maturation process. The only two males we observed cracking Coula in a tree did it at the same time and in the same tree as an oestrous female; this may be significant in that they presumably followed her.

Differences in efficiency were noted during the two nut seasons. Mean values of efficiency measures were first calculated for each observed individual and were used for the statistical tests. Table 3 presents the overall means by each age–sex class. The following conclusions can be drawn:

(a) Cracking Panda nuts is more time- and energy-consuming than cracking Coula. This may be seen by comparing the efficiency between adult females cracking Panda and Coula on the ground (Mann–Whitney U-/test:hits/nut, $P < 0{\cdot}001$; nuts/min $P < 0{\cdot}001$, Siegel, 1956).

(b) Comparing the results for adult females and males, it appears that the females seem to be more efficient in both measures in cracking Coula on the ground (Mann–Whitney U-/test:hits/nut $P < 0{\cdot}01$; nut/min $P < 0{\cdot}01$).

(c) Comparing the efficiency of the adult females cracking Coula on the ground and in the tree does not reveal any difference (Mann–Whitney U-/test:hits/nut NS; nut/min NS). About half of these measures (29 and five respectively) were taken on animals who were observed cracking for less than 10 minutes (usually subsequently disturbed by us) and did not collect nuts a second time during their feeding session. In order to test our hypothesis that cracking Coula nuts directly in the tree presents the advantage of saving time for collecting the nuts, we compared the efficiency of females cracking for 10 or more minutes on the ground versus in trees. In this comparison, the first efficiency measure, hits/nut, is again the same (Mann–

Table 3 **Mean efficiency measures (a) number of hits/nut and (b) number of opened nuts/minute for each age–sex class**

	Coula								Panda			
	Numbers of		On the ground		Numbers of		In the tree		Numbers of			
Sex and age	individuals	nuts	Hits/nut	Nuts/min	individuals	nuts	Hits/nut	Nuts/min	individuals	nuts	Hits/nut	Nuts/min
Male												
Adult	22	289	8·75	1·41	1	7	4·00	1·16	2	8	14·58	0·55
Adolescent	1	15	5·6	1·66	1	16	4·37	1·77	—	—	—	—
Juvenile	—	—	—	—	1	12	10·08	0·88	—	—	—	—
Female												
Adult	47	760	6·35	1·78	31	1155	6·46	1·91	35	258	16·96	0·45
Adolescent	3	48	8·42	1·77	4	152	6·23	1·48	—	—	—	—
Juvenile	2	24	10·87	0·72	8	129	16·93	0·96	3	?	∞*	?*

*We never found evidence that female juveniles succeeded in opening a Panda nut.

Whitney U-test, NS). This indicates that females master the additional difficulties of cracking in the tree without additional hits per nut. The second measure, nuts/minute, however, is significantly greater in trees than on the ground (Mann–Whitney U-test, $P < 0{\cdot}02$), and thus supports our hypothesis.

(d) The learning process of the technique is a long one and extends into adolescence. From our data we can only compare the females' performance of cracking Coula in the tree. The difference between juveniles and adolescents is significant for both measures (Mann–Whitney U-test:hits/nut $P < 0{\cdot}02$; nuts/min $P < 0{\cdot}01$). The differences of both measures between adults and adolescents is not significant.

Termite-fishing and ant-dipping are techniques which are normally acquired by old juveniles (McGrew, 1977). We conclude, therefore, that the learning of nut-pounding is more difficult and requests a longer apprenticeship.

5. Discussion

The results presented in this paper are apparently among the first to show a distinct sex difference in technique and efficiency of tool behaviour by any animal (Beck, 1980). As mentioned earlier, McGrew (1979) reported that female chimpanzees at Gombe fish for termites more frequently than males, but he did not mention a sex difference in efficiency.

In our opinion, the tool techniques of chimpanzees show a gradient in difficulty ranging from termite-fishing to Coula-cracking on the ground, to Coula-cracking in the tree and Panda-cracking. Termite-fishing might be easier than the Coula nut-cracking on the ground for the following reasons:

(a) For termite-fishing, the tools are picked up at a shorter distance from the working site than in Coula-cracking. 85–94% of the fishing tools are collected within arm's reach (McGrew *et al.*, 1979), whereas only 75% of the hammers for cracking Coula are found on the anvil or at arm's length.

(b) The hits in cracking must presumably be aimed more precisely and their strength be controlled within narrower limits than the probes in termiting.

(c) In termite-fishing, the success of each probe can be directly perceived by retrieving the tool. In cracking a nut each hit reduces its resistancy, but this cannot be perceived; it has to be learned. A stroke which is too powerful can smash the nut, leaving hardly anything edible.

Even greater difficulties are met in cracking Coula nuts in the tree, because in this case the use of a hammer must be anticipated already before climbing the tree. For cracking on the ground the animal must think of the tool only after it has perceived the nuts; for cracking on the tree, it must do so before. When deciding to crack on the ground, it usually sees both the anvil and the hammer; when deciding to crack in the tree, it sees none of the three requisites simultaneously. It also requires faultless transfers of hammer and nuts between the mouth, hands and feet between phases of work.

Panda-cracking also appears more difficult than Coula-cracking on the ground, as it requires exact positioning of the nut at least three times during the opening process and a precise dosage of strength. Furthermore, some of the stone transports for Panda-cracking imply high cognitive capacities (Boesch & Boesch, in prep.).

The gradient from termite-fishing to Coula-cracking in trees and Panda-cracking is accompanied by the apparition of a sex difference in tool-use. The two most difficult techniques are almost exclusively used by females. Why is there such a sex difference and how does it appear during ontogenesis? In order to find a key to the problem, we forward the following six hypotheses. They are not mutually exclusive and should explain all or part of the difference.

(1) Females are more dependent on the proteins contained in nuts, whereas males obtain more proteins through hunting.
(2) Males are more attentive to the social stimuli of the group and therefore use the only technique performed in groups and where the visual conditions permit a good control of the group members: that is Coula-cracking on the ground (preliminary results suggest that Panda-cracking is done only by single animals or in pairs).
(3) Males lack concentration while cracking nuts and this makes them so inefficient at Coula-cracking in the trees and Panda-cracking that these techniques are of no interest to them.
(4) Males have more difficulty in controlling their emotions when using a tool to open nuts. Stones and clubs are sometimes part of their displays and therefore are emotionally loaded. This could negatively affect their motor control of a task that demands great precision.
(5) Female subadults are more motivated than subadult males to observe and learn the nut-cracking behaviour and, therefore, master the techniques more quickly and efficiently.
(6) Chimpanzee mothers take an active part in the apprenticeship of their female offspring by either rewarding their attention with nuts or affection or by supplying them with tools (such incidents have been observed). We shall attempt to test these hypotheses with the data that will be available at the end of the three-year project.

The observations we made on the Tai chimpanzees might shed new light on the evolution of human tool-use. When analysing human stone technology, anthropologists rely mainly on lithic materials, of which the most characteristic ones are the flaked stones. Our first suggestion is that flaked stones could have been produced by chance. We noted that female chimpanzees produced flaked stones by pounding the hard Panda nut, three times when using a granite stone and once with a quartzite stone. These chimpanzee-made artifacts suggest that such tools could have been produced by early hominids when they used stones as hammers in a gathering activity. Secondly, one tends to imagine that the makers of early human stone implements were men. Isaac (1978) refers to a "male bias". The skill of female chimpanzees at Tai suggests the possibility that the first human toolmakers were women.

The chimpanzees represent a stage in tool evolution which may give us some insight into motivational differences of the sexes when working with tools. Their investigation might help to clarify the puzzle of how sexual division of labour emerged in human ancestors.

This study was supported by grant No. 3.391.78 from the Swiss National Foundation to Prof. Hans Kummer. We are greatly indebted to the Ministère de la Recherche Scientifique de la Côte d'Ivoire for allowing us to work in the Tai National Park. This project is integrated in the UNESCO Project TAI-MAB and we wish to thank the general supervisor of the project, Dr Henri Dosso, for his support.

We are very grateful to the following people: Prof. A. Aeschlimann for his constant support and encouragement; Prof. H. Preuschoft for his advice in the planning stage; J. F. Graf, M. Knecht and M. Gremaud, directors of the Centre Suisse de la Recherche Scientifique in Abidjan, for their kind and efficient logistic help; Prof. E. Boesch, V. Dasser and E. Stammbach for critical reading of the manuscript; M. Gore for correcting the English text, and J. Stocker for typing the manuscript. Finally, we wish to express particular thanks to Prof. H. Kummer for his valuable guidance, critical discussion and moral support throughout the study.

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