

Teaching among wild chimpanzees

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Teaching, along with imitation, are major processes that can accelerate the acquisition of novel behaviour in an individual and are considered instrumental in the development of human culture. Recent critical reviews of the known cases of imitation in primates challenge all such claims and offer more parsimonious explanations based on social facilitation and stimulus enhancement (Whiten 1989). Similarly, teaching has been restricted to humans, although in one case a sign-language-trained chimpanzee, *Pan troglodytes*, attempted to mould and influence the signing performance of a younger companion (Fouts et al. 1982).

Here I report how chimpanzee mothers influence their infants' attempts to crack nuts in the tropical rainforest of Taï National Park, Ivory Coast. The nut-cracking techniques have been described in detail previously (Boesch & Boesch 1984). Chimpanzee mothers may influence the development of nut cracking in three ways (excluding the very widespread nut sharing): (1) stimulating; and (2) facilitating nut cracking; and (3) active teaching.

Mothers can stimulate nut cracking by leaving hammers or nuts near the anvil. Commonly, adult chimpanzees carry their hammer, a dead branch or a stone gathered from the forest floor, with them when collecting nuts. However, when infants from the age of 3 years show increasing interest in nuts and the related tools, their mothers leave the hammer on the anvil more frequently during collecting trips with the risk of losing it to another chimpanzee, while the infant remains at the anvil (comparison of columns a and b plus c between age classes 2 and 3 in Table I: $\chi^2 = 17.29$, $df = 1$, $P < 0.001$; comparisons of the other adjacent age classes: $P > 0.05$). This provides the infants with their first opportunities to use the hammer in the right context and infants of all age classes tend to use the hammers in half of the cases except the more active 6-year-old infants ($\chi^2 = 5.05$, $df = 1$, $P < 0.01$).

Chimpanzees without infants were never observed leaving intact nuts near the anvil before

gathering more. However, four mothers were seen to do so (Héra eight times when her son was 3 and 4, Salomé six times when her son was 5 and 6, and Zoé and Aurore once with their youngsters). The infants need then only to place the readily accessible nut on the anvil to begin pounding it. In five of these cases, Héra, Salomé and Zoé were even seen to place a nut precisely on the anvil and leave the hammer next to it before collecting more nuts.

Mothers may directly improve their infants' efficiency by providing good hammers or nuts. Nut-cracking infants commonly have difficulties in getting access to good hammers (hammers of adequate weight and regular shape that will open a nut with fewer than 10 hits) in a group of chimpanzees, and their mothers' tools are usually better than their own. Mothers start to allow 3- to 4-year-old infants to use their own hammer (Table I). This involves certain costs; e.g. while nut cracking in a group, moving under different Coula trees, Ella let her son consecutively take four hammers from her and, as she had to look continually for another appropriate tool, was able to open only eight nuts in 40 min during which her son opened 36. Later, she opened 20 nuts in 9 min with her fifth hammer, while her son was working nearby with her handy fourth hammer.

When cracking by themselves, infants have to collect nuts and some mothers start to contribute to this from their own provision with 4-year-old infants (Table I). During one nut-cracking session, Ella's 5-year-old son took from her 43 of the 47 nuts he opened. Similarly, Aurore's daughter took 40 of the 59 nuts she cracked herself from her mother and, compared to when she was feeding only on her own collection with the same hammer at the same anvil, this resulted in an increase of 20% in the number of nuts eaten per min by the infant.

Infants, despite their willingness, may face technical difficulties that they cannot overcome. In such situations, they either try to find a better tool or quit and beg again for nuts from the mother. We observed two cases in which the mother, noticing

Table I. Ways in which chimpanzee mothers influence their offspring's nut cracking, according to the age of the infant (each mother has the same infant throughout the age classes)

Name of mother	Observation time (min)	Age of infant (years)	Stimulation			Facilitation		Active teaching
			a	b	c	Hammer	Nuts	
Malibu	24	<1	—	2	—	—	—	—
Poupée	20	<1	5	1	—	—	—	—
Gitane	19	1	1	—	—	—	—	—
Gauloise	144	1	17	6	4	—	—	—
Xères	39	1	4	—	—	—	—	—
Gauloise	31	2	3	1	—	—	—	—
Marlène	16	2	—	2	—	—	3	—
Ondine	61	2	3	2	—	—	—	—
Saphir	103	2	5	3	4	—	—	—
Tosca	57	2	5	—	1	—	—	—
Fanny	23	3	1	—	2	—	—	—
Héra	71	3	5	3	1	1	—	—
Kiri	329	3	5	26	33	—	1	—
Momo	42	3	—	1	—	—	—	—
Ondine	224	3	10	4	17	3	—	—
Saphir	112	3	—	5	10	2	—	—
Zoé	62	3	2	—	2	2	1	—
Fanny	66	4	—	2	3	—	—	—
Héra	273	4	8	13	14	9	9	—
Kiri	325	4	5	10	11	2	3	—
Marlène	76	4	—	2	3	6	42	—
Momo	69	4	—	4	4	2	—	—
Ricci	190	4	2	8	7	6	—	1
Aurore	114	5	—	—	—	6	57	—
Ella	296	5	—	5	2	19	144	—
Nova	30	5	—	—	—	2	—	—
Salomé	450	5	7	22	15	11	5	—
Héra	197	6	—	4	3	3	—	—
Fanny	66	6	—	3	3	4	4	—
Salomé	496	6	7	6	17	41	33	1
Salomé	112	8	—	—	1	153	14	—
Total	4137		95	135	157	272	316	2

For stimulations, the number of occasions where the mother either (a) took the hammer away from the anvil, (b) left the hammer near the anvil but the infant did not touch it, or (c) left the hammer and the infant used it, are listed. For facilitations, the number of objects provided by the mother, and for active teaching, the number of teaching attempts observed, are given.

the infants' difficulties, made a clear demonstration of how to solve them.

On 22 February 1987, Salomé was cracking nuts of the very hard *Panda* species. Sartre, 6, took 17 of the 18 nuts she opened. Then, his mother watching, he took her stone hammer and tried to crack the nuts by himself. These nuts are tricky to open as they consist of three kernels separately embedded in a hard wooden shell, and the partly opened nut has to be replaced pre-

cisely each time to gain access to the different kernels. After successfully opening a nut, Sartre replaced it haphazardly on the anvil in order to attempt access to the second kernel. But before he pounded it, Salomé took it in her hand, cleaned the anvil, and replaced the piece carefully in the correct position. Then, with Salomé observing him, Sartre successfully opened it and ate the second kernel. Here, the mother demonstrated the correct positioning of the nut,

although the infant may well have succeeded in opening it independently eventually.

On 18 February 1987, Ricci's daughter, 5-year-old Nina, tried to open nuts with the only available hammer, which was of an irregular shape. As she struggled unsuccessfully with this tool, alternately changing her posture, hammer grip and the position of the nut, Ricci was resting. Eventually, after 8 min of this struggle, Ricci joined her and Nina immediately gave her the hammer. Then, with Nina sitting in front of her, Ricci, in a very deliberate manner, slowly rotated the hammer into the best position with which to pound the nut effectively. As if to emphasize the meaning of this movement, it took her a full minute to perform this simple rotation. With Nina watching her, she then proceeded to use the hammer to crack 10 nuts (of which Nina received six entire kernels and a portion of the other four). Then Ricci left and Nina resumed cracking. Now, by adopting the same hammer grip as her mother, she succeeded in opening four nuts in 15 min. Although she still had difficulties and regularly changed her posture (18 times), she always maintained the hammer in the same position as did her mother. She whimpered whenever encountering difficulties, to attract her mother, but Ricci did not return to her even when she threw a temper-tantrum after unsuccessfully attempting to open a fifth nut for 3 min. In this example, the mother corrected an error in her daughter's behaviour and Nina seemingly understood this perfectly, since she continued to maintain the grip demonstrated to her.

Conclusively, Tai chimpanzee mothers show a concern about their infants' apprenticeship in tool use and, in various ways, facilitate their attempts even though at some cost to their own performance. They seem to have the ability to compare their offspring's behaviour to their own conception of how it should be performed and anticipate the possible effects of their actions on those of their offspring.

All functions attributed to human tutoring by Wood et al. (1976) seem to be performed by chimpanzee mothers here. Recruitment, direction maintenance and marking critical features are apparent in the stimulations, frustration control and scaffolding in the facilitations as well as in teaching alongside with demonstration.

These acts are adjusted to the level of skill attained by the infant: e.g. stimulation reaches its maximum at 3 when infants start to learn the basic skills of nut cracking, whereas facilitation starts at 3 with a maximum at 5 years (Spearman correlation coefficient: $r_s = -0.48$, $P < 0.05$). Such forms of teaching have not been observed in other wild chimpanzees and the fact that nut cracking, observed only in West African chimpanzees, requires 10 years to be fully acquired, may be important. Other behaviour patterns in chimpanzees probably require less practice and since the mother's fitness might suffer if the nut-cracking technique is not to some extent acquired by her infant before she invests in new offspring, she increases her involvement.

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