Journal of Comparative Psychology
2000, Vol. 114, No. 3, 291–296

0735-7036/00/$5.00 DOI: 10.1037//0735-7036.114.3.291

Naive Chimpanzees' (*Pan troglodytes*) Observation of Experienced Conspecifics in a Tool-Using Task

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The authors investigated the occurrence of naive chimpanzees' (*Pan troglodytes*) spontaneous observation of experienced conspecifics during a tool-use task entailing honey fishing. The chimpanzees were presented with 20 kinds of "tools" of which 12 kinds were usable. Six pairs of naive and experienced chimpanzees were brought to this honey-fishing situation. A total of 40 observation episodes occurred between the naive and experienced groups, 34 of which were from naive toward experienced individuals. Naive chimpanzees never observed their partners after their own success but did so after their own failure or before their first attempts. In addition, there were 10 cases in which naive individuals used the left-over tools of the experienced ones. Two factors for the transmission of tool use were clearly evident in this study: (a) spontaneous observation of an appropriate behavioral sequence and (b) enhanced environmental cues made by skilled individuals.

Tool use in chimpanzees and other animals has been a major focus of the study of their causal understanding of object relationships and also of social learning. Wild chimpanzees use a variety of tools (McGrew, 1992), including those for nonsubsistence purposes (Hirata, Myowa, & Matsuzawa, 1998). Longitudinal observation at several different study sites in Africa has shown the diversity in the wild chimpanzees' repertoire of tool use among different sites (Whiten et al., 1999). Experimental studies have also documented the propagation of tool use and object manipulation among group members of chimpanzees in the wild (Inoue-Nakamura &Matsuzawa, 1997; Matsuzawa, 1994; Matsuzawa & Yamakoshi, 1996) and in captivity (Paquette, 1992; Sumita, Kitahara-Frisch, & Norikoshi, 1985; Tonooka, Tomonaga, & Matsuzawa, 1997). Collectively, these studies suggest that social influences play an important role in the transmission of tool use within each population (e.g., Boesch, 1991; Matsuzawa, 1999). Researchers have attempted to sort out the mechanism of social learning by making a situation in which chimpanzees were exposed to human demonstrators (Nagell, Olguin, & Tomasello, 1993; Whiten, Custance, Gomez, Teixidor, & Bard, 1996). However, few researchers have examined tool use by using a conspecific as a demonstrator (Paquette, 1992; Sumita et al., 1985). By making a situation in which naive individuals stay with skillful conspecifics, we can simulate the phenomenon that occurs naturally in the wild. The first and most important thing for a naive individual to do in such a situation is to observe skillful conspecifics. Moreover, they ought to observe a model before their first attempt or after their own failure to learn efficiently how to use a new tool. The observation of a model ought not to occur randomly; rather, it should be contingent on the result of their preceding attempts. There has been no study in which these points were analyzed in detail.

An observation of the innovation and propagation of a tool-using feeding technique in wild vervet monkeys provides another view (Hauser, 1988). Hauser indicates that an animal might acquire the technique from obtaining the end product of an innovator without having observed its technique. He further suggests that learning from the use of abandoned materials can be another way for the social transmission of a new technique, in addition to learning from direct observation of a demonstration.

We designed our experimental study in such a way that we could examine the occurrence and the timing of naive chimpanzees' spontaneous observation of experienced conspecifics, as well as the use of abandoned tools. Adult and adolescent chimpanzees were brought to a "honey-fishing" task in which they had to use tools to obtain honey in a bottle. Chimpanzees could honey fish by inserting a short, slender, flexible tool into a hole of a honey bottle and dipping it into the honey. This technique is similar to that of ant fishing or termite fishing, which wild chimpanzees of some populations engage in (for a description of these activities in Mahale, see Nishida, 1973; for a description of these activities in Gombe, see van Lawic-Goodall, 1968;). We brought a skilled individual and a naive individual together to the honey-fishing situation, and we investigated whether the naive individual would observe the skilled partner. In the present article, we describe the

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The present research was financed by Grant 07102010 from the Ministry of Education, Science, Sports, and Culture, Japan. We gratefully acknowledge T. Matsuzawa for his idea of "honey fishing" and his generous guidance throughout the project. Thanks are also due to D. Fragaszy and M. Celli for their helpful comments on an earlier version of this article and to K. Kumazaki, N. Maeda, and the other staff members at the Primate Research Institute of Kyoto University for support in conducting the experiment and for taking care of the chimpanzees.

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sequence of the chimpanzees' observing their partners, along with the cases of use of left-over tools.

Method

Subjects and Housing Conditions

The subjects were 9 adult and adolescent chimpanzees (*Pan troglodytes*) at the Primate Research Institute of Kyoto University, Inuyama, Aichi, Japan. Two of them were males (Gon, 32 years; Akira, 21 years), and 7 were females (Puchi, 32 years; Ai, 21 years; Mari, 21 years; Pendesa, 21 years; Chloe, 17 years; Popo, 16 years; Pan, 14 years). Before this experiment, some of them had served in various types of experiments on perception and cognitive capacities (Biro & Matsuzawa, 1999; Fujita & Matsuzawa, 1990; Kawai & Matsuzawa, 2000; Kojima, 1990; Matsuzawa, 1985; Matsuzawa, Kojima, &, Shinohara, 1997; Myowa-Yamakoshi & Matsuzawa, 1999; Tanaka, 1995; Tomonaga, 1998). In addition, all of them had served in a tool-using experiment in which they used leaves for drinking juice (Tonooka et al., 1997). All of the chimpanzees lived together in a community of 11 chimpanzees in a seminatural, enriched environment, having a rich social life that included interactions with conspecifics and humans. The housing facility consisted of one large outdoor compound (about 700 m^2), two smaller outdoor compounds with wire mesh roofs, eight indoor rooms, and seven experimental rooms. The three outdoor compounds were enriched with streams and approximately 400 plants of 60 species, climbing structures up to 15 m high (Ochiai & Matsuzawa, 1997). The outdoor compounds and indoor rooms were connected to each other by passageways. The chimpanzees were fed various fruits and vegetables three times a day. Water was freely available, and they were not food deprived for testing. They were cared for according to guidelines produced by the Kyoto University Primate Research Institute.

Materials

Twenty kinds of objects were presented as "tools." The tools varied in material, shape, and size, with a range of 6.5 to 20.0 cm in length. Eight kinds of these objects were "unusable tools" (i.e., a stick, spoon, bolt, pouch, pin, chain, and two types of brushes) that could not be inserted into the honey hole because of the size of the object. The remaining 12 kinds of objects were "usable tools" (i.e., various types of short and slender objects made of metal, plastic, cotton, and hemp) that could be inserted into the hole. The chimpanzees may have seen or played with similar objects (e.g., strings, wires, spoons, brushes, bolts, or pouches), but they had never seen exactly the same objects before the present experiment. A transparent polyethylene bottle ("honey bottle," 4.0 cm long, 2.5 cm wide, and 6.0 cm high) was used as a container for honey. A hole 5 mm in diameter was made in one side of the honey bottle, approximately 4 cm from the bottom. Honey (about 35 g in volume) was put into the bottle, keeping it under the level of the hole.

Procedure

Single-subject condition. Three chimpanzees, Pan, Puchi, and Ai, were tested individually in a familiar playroom (5.0 m long, 7.2 m wide, and 3.0 m high; Figure 1). The walls of the room were partly constructed with transparent acrylic panels. In one of the panels was a hole 5 mm in diameter and 92 cm from the floor. A honey bottle was fixed from outside the room to the acrylic panel in such away that the holes of the bottle and panel fit each other. Two items of each of the 20 kinds of tools were scattered in a completely random manner on the floor within 2 m of the honey bottle. There were also some plants and a fish tank for environmental enrichment of the playroom, and these plants could be used as a tool in addition to the 20 kinds of tools provided. To help the chimpanzees recognize that the bottle contained honey, a human experimenter inserted a tool into the hole before the start of each test. Chimpanzees thus could get honey merely by pulling out the already inserted tool in the beginning of the test session. A session started as soon as a chimpanzee was brought to the room and lasted for 60 min maximum. The session was ended after 30 min if the chimpanzee had not obtained the honey and had stopped touching the tools. All test sessions were recorded on videotape using two video cameras. One video camera was fixed in front of the honey bottle and filmed the close-up view of the chimpanzees' honey-fishing activity. The other video camera followed all the chimpanzees' movements during the sessions.

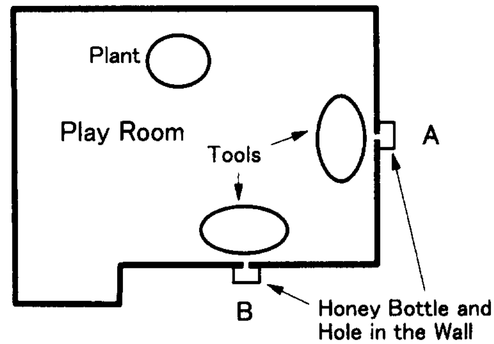

Figure 1. Experimental arrangements of the honey bottle, the hole, and tools in the playroom (top view). The single-subject condition was conducted using A. The pair condition was conducted using A and B.

Pair condition. When the chimpanzees that were tested in the single-subject condition had mastered the tool-using skill, they were paired with the naive individuals. A pair (consisting of an experienced and a naive individual) was brought in the playroom to the honey-fishing situation. When naive chimpanzees had acquired the tool-using skill in this pair condition, some of them were paired with other naive individuals and then served as the experienced chimpanzee in the next turn. A total of six pairs were formed in this manner. Two identical honey-fishing sites were prepared (Figure 1). Each site consisted of a honey hole, a honey bottle, and 2 of each of the 20 kinds of tools randomly scattered on the floor. One of the two sites was exactly the same as that used in the single-subject condition. The other site was positioned at an angle 90° from the first one. The distance between the two holes at these sites was 2.2 m. One session lasted for 60 min maximum. The session was ended when the two honey bottles became almost empty, and none of the chimpanzees had touched the tools for more than 5 min. Five sessions were conducted for each pair. All test sessions were recorded on videotape using four video cameras. Two of the video cameras were fixed in front of the two honey bottles and filmed the close-up view of the chimpanzees' honey-fishing activities. The other two video cameras recorded all the chimpanzees' movements during the session.

Data Analysis

The chimpanzees' behaviors were analyzed by reviewing the videotapes. First, chimpanzees' honey-fishing attempts were scored. An ***attempt*** was defined as a sequence of behaviors that began when a chimpanzee inserted a usable tool into the hole or when it touched the acrylic panel within approximately 20 cm of the hole with an unusable or usable tool; the attempt ended when the chimpanzee detached the tool from the acrylic panel. Thus, one attempt involved one tool.

The result of each attempt was divided into two categories: (a) success—the chimpanzees were able to dip honey with the tool, and (b) failure—the chimpanzees were unable to dip honey. The failure was further divided into two categories: *tool-choice error* and *technical error*. Failures with unusable tools were defined as tool-choice errors, whereas failures with usable tools (e.g., when the tool went upward or straight instead of bent towards the honey) were considered technical errors. The success rate was calculated by dividing the number of successes by the total number of attempts. The tool-choice error rate was calculated by dividing the number of tool-choice errors by the total number of failures.

In the pair condition, all occurrences of the chimpanzees' observation of the partner within the range of 1 m were analyzed (Figure 2). There were two directions of observations (naive toward experienced and experienced toward naive). It could be clearly distinguished whether a chimpanzee was observing its partner or not, because chimpanzees approached the partner very closely when observing its attempts in all cases. These observation episodes were coded independently by two individual coders to assess interobserver reliability. Although there were slight disagreements on the starting and ending time in several cases, each observation episode scored by a coder corresponded one-to-one to the other's score. The behaviors of both chimpanzees before, during, and after the observation were also analyzed from the videotape. The observers' sequence of behaviors were divided into three categories: (a) success—chimpanzees observed their partner after their own successful attempts, (b) failure—chimpanzees observed their partner after their own failures, and (c) immediate—naive chimpanzees observed their partner before having had the first experience of successful or unsuccessful attempts to use tools by themselves.

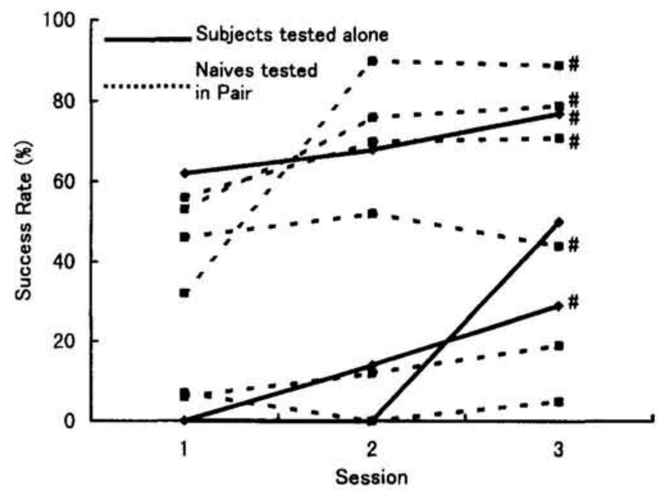

Figure 3. Success rate of the 3 chimpanzees tested in the single-subject condition and the 6 naive chimpanzees paired with the experienced partners in the pair condition over the first three sessions. A pound sign (#) represents a successful individual.

Results

Process of Acquisition of the Task

Of the 3 chimpanzees who were tested in the single-subject condition, 2 (Pan and Puchi) became skillful in using tools. The success rates of both Pan and Puchi constantly increased as sessions went on. Pan reached over 70% success in the 3rd session, and Puchi obtained the same rate in the 6th session. The other individual, Ai, did not become a proper tool user, and we stopped the test on the 10th session because she made no attempts at all in the 6th, 8th, 9th, and 10th sessions. In the case of chimpanzees tested in the pair condition, 4 of the 6 naive chimpanzees became skillful in using tools. The other 2, Popo and Akira, did not use tools properly. The success rates of these 2 unsuccessful chimpanzees did not reach over 20% throughout the sessions, and they attempted much less frequently after several failures. Figure 3 shows the change in success rates of the 3 chimpanzees tested alone and the 6 naive chimpanzees tested with experienced partners over the first 3 sessions.

The 6 chimpanzees who became able to use tools (i.e., the 2 chimpanzees tested alone and the 4 naive chimpanzees tested in pairs) showed the following in common: (a) many tool-choice errors and the use of a variety of tools in the first session, (b) then a gradual reduction of the tool-choice errors as sessions went on (Figure 4): repeated measures analysis of variance (ANOVA), $F(2, 5) = 14.29$, $p < .01$. There was also a decrease in the number of types of tools used (the mean numbers of tool types used by these 6 chimpanzees in the first, second, and third sessions were 7.8, 3.5, and 3.7, respectively; t tests revealed significant differences between the first and the second and the first and third sessions, $p < .01$ in both cases).

Figure 2. A naive chimpanzee (right) observing an experienced one (left).

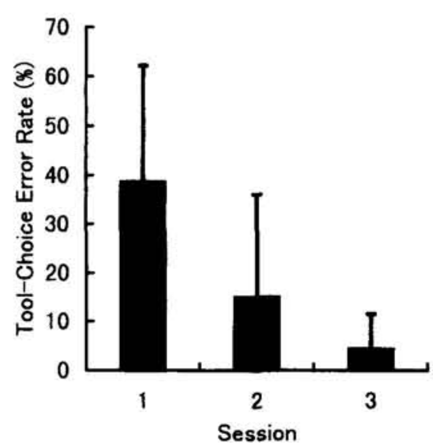

Figure 4. Mean tool-choice error rate (+*SD*) of the 6 successful chimpanzees over the first three sessions. Tool-choice error rate was calculated as the number of tool-choice errors divided by total number of failures (i.e., tool-choice errors plus technical errors).

Observation of the Partner

In the pair condition, the participants approached their partners to observe their activity of using tools. There were 40 observation episodes among six pairs in the first three sessions summarized in Table 1. Most of the observations took place in the first session (28 out of 40, or 70%). The number of observations during the first session tended to be larger than that during second and third sessions for each pair: $p < .05$, sign test, one-tailed.

With respect to the behavioral sequences of observation, naive chimpanzees never observed their experienced partners after their own successes, but they did so immediately after their failures, after abandonment, or before their first attempt (see Table 1). On the other hand, all of the six cases of experienced partners' observations took place after their successes. The distribution of these observation episodes was statistically tested by Fisher's exact test for each chimpanzee to see if this inclination had been caused by the fact that the naive chimpanzees had more occasions to observe the partner after their failures because they had a larger number of failures, and by the opposite fact in the case of experienced partners. The results showed that Pendesa and Mari, both naive chimpanzees, observed their experienced partners significantly more often after their failure attempts than after successful attempts ($p < .001$ both for Pendesa and Mari). The other 4 individuals observed their experienced partner just once. When the data were pooled into naive chimpanzee group and experienced chimpanzee group, a significant inclination to observe after failures was found in the naive chimpanzee group ($p < .001$, Fisher's exact test) but not in the experienced chimpanzee group ($p = .49$, Fisher's exact test).

The following are brief explanations of the events around the naive chimpanzees' first observation of tool use by experienced partners. Of the 2 naive chimpanzees that observed the experienced partner before their own first attempt, 1 used the same tool as the partner after her observation and immediately succeeded with it, while the other failed with a different tool. Of the 3 naive chimpanzees that observed their partner after their own failure attempts, 1 used the same tool as the partner's choice and succeeded, another failed with a different tool, and the other did not attempt to use a tool after observing the partner. The remaining naive chimpanzees did not observe their experienced partners at all.

Two naive chimpanzees observed their partners more than once. However, after their own first success, their choices of tools were not affected by these observations of the partners. They sometimes went to observe the partner after their own failures, but they tended to be persistent in their previous tool choices even after they had observed the partner succeeding with different kinds of tools.

Use of the Partner's Left-Over Tool

Four naive chimpanzees used their partners' left-over tool 10 times (2 to 4 times per individual). Seven out of the 10 cases occurred in the first session. Nine cases occurred after an experienced individual left the honey-fishing site with a tool inserted in the hole, and then a naive chimpanzee came to take it. The remaining case was "robbing"—an active taking of the partner's tool. A naive chimpanzee approached its experienced partner that was using a tool and took the tool out of the hole as the experienced partner was inserting it. This occurred after the naive chimpanzee's own failure. In another case, a naive chimpanzee succeeded for the first time by using a tool used previously by its partner. Out of a total of 38 attempts in the 10 cases where the naive chimpanzees used a "borrowed" tool, 25 were successes (66%), and the rest were technical errors. In the same sessions, the success rate of their own tool choices was 36% on average, and they showed an average tool-choice error rate of 28%.

Table 1
Observations of Partners

	Number of observations				Event before observation		
Subject pair (E & N)	Session 1	Session 2	Session 3	Total	Success	Failure	Immediate
N observed E							
Pan & Pendesa	4	3	0	7	0	6	1
Puchi & Chloe	1	0	0	1	0	1	0
Pan & Popo	0	0	0	0	0	0	0
Chloe & Mari	16	4	4	24	0	24	0
Puchi & Gon	1	0	0	1	0	0	1
Pendesa & Akira	1	0	0	1	0	1	0
Subtotal	23	7	4	34	0	32	2
E observed N							
Pan & Pendesa	1	0	0	1	1	0	—
Puchi & Chloe	3	1	0	4	4	0	—
Pan & Popo	1	0	0	1	1	0	—
Chloe & Mari	0	0	0	0	0	0	—
Puchi & Gon	0	0	0	0	0	0	—
Pendesa & Akira	0	0	0	0	0	0	—
Subtotal	5	1	0	6	6	0	—
Total	28	8	4	40	6	32	2

Note. Dashes indicate that the case is logically nonexistent. N = naive; E = experienced.

Comparison of Tool-Use Acquisition Between the Two Groups

The time of the first success of chimpanzees tested in the single-subject condition was (a) Pan: 10 min, 15 s in the first session; (b) Puchi: 1 min, 51 s in the second session; and (c) Ai: 12 min, 6 s in the third session. The first successes of all the naive chimpanzees tested with experienced partners occurred in the first session and those latencies were (a) Pendesa: 20 min, 0 s; (b) Chloe: 5 min, 59 s; (c) Popo: 22 min, 45 s; (d) Mari: 1 min, 8 s; (e) Gon: 4 min, 2 s; and (f) Akira: 1 min, 46 s. With respect to the comparison of tool-use acquisition between the single-subject condition and the pair condition, no clear difference was found between the chimpanzees tested alone and the naive chimpanzees tested with experienced partners in terms of the latency to the first success (Mann–Whitney U test, $p = .10$) and the change in success rate over sessions, even if the unsuccessful chimpanzees were excluded (see Figure 3). A two-way ANOVA revealed no significant effect of test condition, $F(1, 8) = 1.34$, $p = .31$, and no significant interaction between test condition and session, $F(2, 8) = 0.60$, $p = .57$.

Discussion

The present study provided a view on how chimpanzees respond to conspecifics in a tool-using situation when a naive chimpanzee was given the opportunity to observe an experienced model. The naive chimpanzees actually went to observe the experienced conspecifics at a very close distance. Most of these observations occurred in the initial stage of the naive chimpanzees' experience with the task. From a longitudinal study of the development of stone use for cracking nuts in wild chimpanzees, Matsuzawa (1999) pointed out the importance of infants' long-term, active observation of the other members of the community and the tolerance shown to the infants' spontaneous attempts, including "robbing." In addition, van Schaik, Deaner, and Merrill (1999) pointed out the importance of tolerance in facilitating social learning. If an animal cannot approach another because of the risk of attack caused by a dominance relationship, the animal cannot learn well by observation (Coussi-Korbel & Fragaszy, 1995). The chimpanzees in the present study were tolerant enough to allow their partners to come close to observe them, and the naive observers spontaneously approached to do so.

The timing of the naive chimpanzees' observations of their partners made it clear that the naive chimpanzees never went to observe their experienced partners after a successful attempt, with the proviso that most of the data came from 2 chimpanzees. They went to observe their partners after their failure or before their first attempt. The observation of the partner occurred in an efficient pattern to improve their own attempts to use the tool. This is the first step for chimpanzees to learn socially about actions. That they can do so has been confirmed by experimental studies in which a chimpanzee observed a human model (Nagell et al., 1993; Whiten et al., 1996). The present study of chimpanzees in captivity clearly demonstrated that they show the tendency to achieve this first step by themselves. On the other hand, the experienced partners also went to observe the naive chimpanzees' ineffective manipulation of tools. Close observation by these individuals may show their simple interest in the others' activities or altruistic concern for the unsuccessful partner. On the other hand, perhaps it can be more generally discussed in terms of stimulus enhancement, but further analysis on the nature of these cases could not be conducted because of the low frequency of these episodes.

No clear difference was found between the single-subject group and the pair group in the number of sessions needed to acquire the skill. This might indicate that the honey-fishing task could be learned just as efficiently through individual problem solving, as suggested by researchers who conducted a study on sponge-making by a captive chimpanzee (Kitahara-Frisch & Norikoshi, 1982). However, given that an individual in the single-subject group mastered this task quite quickly, it may be that the task was too simple for social learning to give a measurable advantage in acquiring the skill. Taking an example from wild chimpanzees, it takes 3.5 to 5.0 years for infants to master nut-cracking behavior, which is much longer than it takes for other kinds of tool use, such as ant-dipping or use of leaves for drinking water. These skills are acquired by 2-year-olds of the same population (Matsuzawa, 1999). Matsuzawa (1999) explained this difference according to the number of relations involved in these tool-use skills. Ant dipping or honey fishing involves only one relation (relating a twig to ants or relating a wire to honey), whereas nut cracking involves two relations (relating a nut to an anvil stone and then relating a hammer stone to this set). In a relatively difficult task that involves two relations, such as nut cracking, the infant's spontaneous observation of its mother or another group member in an appropriate behavioral pattern may play a more important role in acquisition of the skill. Future studies in which researchers use more difficult tasks may demonstrate the effect of the conspecific model in social learning.

We observed a physical condition that possibly facilitates the transmission of tool use. The unskillful naive chimpanzees used the tools left in the hole by their experienced partners. There was also a single case in which a naive chimpanzee robbed or actively took the partner's tool. These phenomena suggest other possible ways for naive animals to benefit from the activities of experienced partners as they acquire a new skill in tool use. In the present study, the activity of skilled animals set an appropriate environmental condition where tools were left in close distance from the food, which provided another means for naive animals to learn the relationship between the tool and the food. This finding is consistent with the result of another experimental study in a captive group in which several chimpanzees first acquired the skill of drinking juice by using leaf tools that were abandoned by a skilled individual (Tonooka et al., 1997).

The present study is the first to carefully examine tool-use acquisition using conspecifics as sources of information. The results clearly demonstrated two important factors for the transmission of tool use: close observation of a skilled individual in action and enhanced environmental cues provided by a skilled individual. The transmission of tool use in the wild that results in the great diversity in tool repertoire might have been accomplished through a mixture of individual learning aided by such a favorable physical condition and active observing of conspecifics using an appropriate behavioral sequence for observational learning.

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Received October 18, 1999
Revision received March 13, 2000
Accepted March 15, 2000 ■