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Imitation in Free-Ranging Rehabilitant Orangutans (*Pongo pygmaeus*)

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We made an observational study of spontaneous imitation in orangutans (*Pongo pygmaeus*). Previous studies may have underestimated great apes' imitative capacities by studying subjects under inhibiting conditions. We used subjects living in enriched environments, namely, rehabilitation. We collected a sample of spontaneous imitations and analyzed the most complex incidents for the likelihood that true imitation, learning new actions by observing rather than by doing, was involved in their acquisition. From 395 hr of observation and other reports on 26 orangutans, we identified 354 incidents of imitation. Of these, 54 complex incidents were difficult to explain by forms of imitation based on associative processes grounded in experiential learning alone; they were, however, congruent with acquisition processes that include true imitation. These findings suggest that orangutans may be capable of true imitation and point to critical eliciting factors.

Imitation, in the general sense of replicating by whatever mechanism behavior inspired by a model, has been a focus of study for centuries. Imitation has wide significance in learning and cognition: It links social with ecological cognition (Byrne & Whiten, 1988), it offers a powerful mechanism for the social transmission of knowledge (Nishida, 1986), it can be produced by a variety of mental processes (Aronfreed, 1969; Galef, 1988), and it may be a critical feature of primate intelligence (Visalberghi & Fragaszy, 1990). Certain forms of imitation (e.g., deferred and true imitation) have been considered key phenomena for assessing the continuity of higher mental processes from animals to humans (Baldwin, 1902, 1984/1903; Bates, 1979; Piaget, 1945/1962; Yerkes & Yerkes, 1929; Zentall & Galef, 1988; but see Meltzoff, 1988). These issues focus attention on the great apes, those species most closely related to humans, and on their capacities for *true* imitation, learning new actions by seeing them done versus doing them. In true imitation an imitator attends to a model's actions then undertakes to replicate them in a purposeful, goal-directed way; observation of the modeled actions is sufficient instigation for the replication (Galef, 1988; Whiten & Ham, 1992).

Despite extensive research, findings on true imitation in great apes are inconsistent and inconclusive. Rich examples suggestive of true imitation have been offered (e.g., Boesch, 1991; Fouts, Hirsch, & Fouts, 1982; Hayes & Hayes, 1952; Mathieu & Bergeron, 1981; Mignault, 1985; Miles, 1990; Yerkes & Yerkes, 1929), but these commonly constitute isolated events observed in uncontrolled conditions, where analyses have been unable to exclude the possibility that the

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imitation derived from simpler mental processes (Tomasello, 1990; Tomasello, Davis-Dasilva, Camak, & Bard, 1987; Whiten, 1989; Zentall & Galef, 1988). Controlled experimental studies have been conducted with meticulously articulated procedural criteria for precluding interference from simpler processes; the imitation they have elicited has been of low mental complexity (Nagell & Tomasello, 1991; Tomasello et al., 1987). Therefore many workers consider there is no convincing evidence of true imitation in great apes. What is intriguing, however, is the inconsistency between the richness of imitation identified observationally and the impoverishment of imitation commonly elicited under experimental conditions. Such inconsistencies may reflect methodological factors. This study represents our attempt to grapple with one possible methodological factor, the use of subjects and conditions unlikely to elicit true imitation.

Methodological complexities in empirically studying true imitation include identifying it as well as eliciting it. Complexities in identifying true imitation stem from the conviction that true imitation represents only one of a number of mental processes that can generate imitative performances or *reproductions* (Aronfreed, 1969; Bandura, 1977; Galef, 1988; Mitchell, 1987; Tomasello, 1990; Whiten & Ham, 1992). The processes that can generate reproductions vary with respect to what the process generates—learning (acquisition of new behavior contours) or influence (evocation of preexisting behaviors), what learning processes generate any new contours (associative ones, grounded in trial-and-error experience, or more complex ones), what forces guide learning (the problem, social forces, forces within the imitator, or other external forces), and what components of modeled actions are reproduced (model-, action-, or problem-specific; see Galef, 1988; Mitchell, 1987; Whiten & Ham, 1992). In line with these distinctions, Galef's review identifies seven forms of imitation in nonhuman species. Only one of these, true imitation or observational learning, generates new behavioral contours through observation rather than through direct experience. The others all involve simpler mental processes, either influence (contagion or social facilitation) or associative learning processes based on individual or social experiential learning (local or stimulus enhancement, observational conditioning, matched dependent learning, or vocal copying). Empirically identifying true imitation is especially difficult because it represents the most complex of these forms of imitation, distinctions among these forms hinge on inaccessible internal processes, and no unique behavioral markers are known for true imitation. Moreover, true imitation can occur uncontaminated by other forms only in the first attempt at a reproduction, because subsequent attempts logically reflect some experience and thus derive from a mix of processes (Galef, 1988). Most commonly, it is such subsequent attempts that are witnessed. Many researchers therefore currently consider that the only way to identify true imitation is to exclude the processes underlying all other forms, procedurally, by experimentation (Galef, 1988; Tomasello, 1990; Visalberghi & Fragaszy, 1990).

Our interests concerned eliciting true imitation in great apes. Although researchers have devoted much effort to not eliciting interfering forms of imitation, they have devoted rather little to fostering the expression of true imitation. The literature suggests that the expression of true imitation may be, at best, fragile in great apes (Whiten & Ham, 1992); it may strain their capabilities, or its eliciting circumstances may be narrowly constrained. Also, earlier experimental studies may have used inhibiting conditions in which true imitation was unlikely to have developed or guided performance (Boesch, 1992; Cheney & Seyfarth, 1990; Hall, 1968; Huffman, 1984; Nishida, 1986). In establishing more appropriate conditions, considerations of ecology and development are likely important (Charlesworth, 1983; Cheney & Seyfarth, 1990; Davey, 1989; Dickinson, 1989; Dumas & Doré, 1986; Kummer & Goodall, 1985). Both constrain imitation in the benchmark species itself, humans (Yando, Seitz, & Zigler, 1978).

Environmental factors are critical to imitative performance. Both humans and nonhuman primates are highly and individualistically selective in the actions and models they deign to replicate. Action selection is known to be influenced by the demonstrated action's match with the imitator's competence levels (Kohler, 1925; Masur, 1988; Visalberghi & Fragaszy, 1990), by what the imitator is in the process of learning (Bloom, Hood, & Lightbown, 1974), and by the action's receptive familiarity, meaning, functional value, and contextual relevance for the imitator (Bandura, 1971; Meltzoff, 1988; Pepperberg, 1988). Model selectivity is likely equally critical, because it is increasingly recognized that imitation plays an important interpersonal function (Byrne & Whiten, 1988; Hayes & Hayes, 1952; Huffman, 1984; Miles, 1990; Nadel, 1986; Yando et al., 1978). Interpersonal factors have received little attention until recently, probably because research has concentrated on imitation's role in learning (Zentall & Galef, 1988). It is known that model selection is affected by age, sex, kinship, affective ties, and social status (Galdikas, 1982; Huffman, 1984; Nadel, 1986; Pepperberg, 1988; Russon & Waite, 1991).

From a developmental perspective the capacity for true imitation is seen as one achievement in an ongoing process of constructing increasingly complex mental capacities on the basis of less complex ones (Case, 1985; Miles, 1990; Mitchell, 1987; Parker, 1990). Developmental changes are found in capacities for imitation in humans (Masur, 1988; Mitchell, 1987; Nadel, 1986; Piaget, 1945/1962), but to date there are few direct data on this development in great apes. In humans the earliest clear signs of the capacities involved in true imitation appear near the end of Piaget's sensorimotor period, commonly between 12 and 18 months of age (Meltzoff, 1988; Piaget, 1945/1962). Great apes attain and surpass this threshold and so may be expected to develop the capacity for true imitation; however, they may not commonly reach this threshold before about 4 years of age (e.g., Chevalier-Skolnikoff, 1983; Gallup, 1977, 1979b; Mathieu & Bergeron, 1981; Mignault, 1985; Miles, 1983, 1990; Muncer, 1983; Woodruff, Premack, & Kennel, 1978; Yerkes & Yerkes, 1929). Furthermore, to the extent that processing capabilities are constructed through experience, developing the capacity for true imitation can be constrained by rearing environments (Case, 1985). Peculiarities in ape subjects' rearing experiences with tools, materials, situations, people, or conspecifics may generate problems for studies of true imitation (e.g., Hayes & Hayes, 1952). To our knowledge such developmental concerns have not been explicitly addressed in studies of imitation in great apes, with the exception of Mignault's (1985).

Perhaps it is because experimenters have not directly considered these factors that they have had difficulties in eliciting true imitation in great apes. Resulting findings may therefore underestimate and misrepresent the imitative capacities of the great apes.

We chose to study great apes living in environments likely to foster imitative capabilities and performances, namely, excaptive orangutans undergoing rehabilitation to forest life at the Orangutan Research and Conservation Project in central Indonesian Borneo. Research on intelligence in the great apes, including imitation, has concentrated on chimpanzees (Beck, 1982). Work relating to orangutan cognition, however, is now substantial (Chevalier-Skolnikoff, 1983; Chevalier-Skolnikoff, Galdikas, & Skolnikoff, 1982; Galdikas, 1980, 1982, 1985, 1988; Galdikas & Vasey, 1992; Gallup, 1977, 1979a, 1979b, 1982; Jantschke, 1972; Lefebvre & Palameta, 1988; Lethmate, 1977, 1982; Lethmate & Ducker, 1973; Miles, 1983, 1986, 1990; Milton, 1988; Mitchell, 1987; Rumbaugh & Pate, 1984; Suarez & Gallup, 1981; Visalberghi & Fragaszy, 1990; Wright, 1972). This work has shown that orangutans have intellectual abilities comparable to chimpanzees, that despite their reputation as solitary and asocial, they can be actively social, and that they are likely to be efficient imitators. Even early researchers were struck by their gift of observation, their insightful and reflective turn of mind, and their propensity for imitation (Buffon, 1785; Furness, 1916; Haggarty, 1909; Yerkes & Yerkes, 1929). These particular rehabilitant orangutans experience physical and social living environments that are stable, nurturing, and highly enriched, not just during the study but over the long term. They spend less time foraging than wild orangutans, who spend up to 60% of the day foraging, and so have more free time and indulge in extended dependency and gregarious periods (Galdikas, 1988). Finally, because of the cross-fostering involved, the rehabilitants acquire some humanlike behavior; this is more readily identified as imitative than behavior more typical of orangutans.

Using these rehabilitants meant designing a study sensitive to the community's opportunities and limitations. Goals for the rehabilitants include forest living and independence, which preclude extensive or restrictive manipulation. These orangutans enter and leave situations at will and imitation is in any case acknowledged to be more controlled by the imitator than by the model or the experimenter (Bloom et al., 1974; Essock-Vitale & Seyfarth, 1986). At the same time, some rehabilitants are well habituated to humans and are undisturbed by being followed, so they can be unusually accessible for close observation. These conditions favored observational over experimental designs (Dumas & Doré, 1986; Kummer & Goodall, 1985). We therefore designed an observational study of spontaneous imitation in the rehabilitant orangutans. Our goals were to collect a systematic, substantial, and detailed sample of imitative incidents and then to analyze those of greatest complexity with respect to the likelihood that true imitation was involved in their acquisition. Systematically collecting a substantial corpus of spontaneous imitation is an approach that has not yet been tried; in addition, work on imitation in great apes has not explicitly considered either ecological and developmental concerns or the abilities of orangutans. Although limited in the ways of all observational research, such a study can offer important descriptive, exploratory, and suggestive material to such underresearched issues. For example, an assessment of the scope and patterns of spontaneous orangutan imitation may provide important clues to critical eliciting factors.

Method

Subjects

The subjects were rehabilitant orangutans (*Pongo pygmaeus*) at the Orangutan Research and Conservation Project's Camp Leakey, Tanjung Puting National Park, central Kalimantan, Indonesia. This group was large ($N = 30$) with a broad mix of age and sex classes. All had experienced captive living, although its nature and duration varied greatly (zoos, family pets, or caged for trade; a few weeks to several years). Extensive life history information was available on many of them. Under rehabilitation they ranged freely through the camp (except in buildings) and surrounding forest; they engaged at will with objects, other orangutans, and human staff and visitors. At the time of this study, those who returned to camp were provisioned twice a day; however, they were not encouraged to stay in camp and frequently left. Subjects were selected on the basis of development (likely functioning beyond sensorimotor levels) and enriched experience (frequent presence in camp and forest). Systematic observations were made on 10 focal orangutans, 6 adult females and 4 juvenile orphans, with concentration on the adults. Because reproducing females travel in mother–offspring units, data were also obtained on their 8 dependent offspring. Two mother–offspring units were followed in both years during which data were collected. Ad lib observations or reports provided data on 11 other orangutans.

Setting

Subjects were observed in Camp Leakey and the surrounding forest. The camp consists of seven buildings (living quarters, dining hall, and herbarium) spread over about 2 acres (0.81 ha) of swampy lowland forest that borders the Sekonyer Kanan River in the park. The surrounding forest consists mostly of mixed dipterocarp forest and peat swamp forest (see Galdikas, 1988), transected over the 35-km^2 study area by a trail system. Camp was permanently staffed by 20 Indonesians who work with the rehabilitants, maintain the camp and trails, follow wild orangutans, assist visitors, and so forth; many were long-time employees. Students, researchers, Earthwatch volunteers, and visitors also periodically stay at the camp. Much camp work is conducted outside so that the orangutans have many opportunities to observe human activities, especially tool use. Their involvement in human activities is discouraged if it becomes problematic; otherwise it is mostly ignored or, very rarely, reinforced.

Procedures

Data were collected during two trips to Camp Leakey in the dry season, June to August 1989 and 1990. Most data were collected systematically through half- and full-day focal-individual follows by Anne E. Russon, students, and a few Earthwatch volunteers. Birute M. F. Galdikas provided additional incidents, life history data, and interpretations as part of her ongoing, long-term study. Half-day follows (in 1989) either began at morning feeding and ended when the orangutan left the camp or began when the orangutan returned to camp from the forest before the afternoon feeding and ended when the orangutan left camp or nested. Follows were extended to full days in 1990, from waking to nesting, to include the forest environment. Ad lib observations and reports from others knowledgeable about camp, primarily Galdikas, supplemented the systematic observations by providing additional incidents of reproductions and information on ages, length of stay in camp and in captivity, relationships and behavioral history, including living conditions before rehabilitation, typical behavior, opportunities to engage in relevant activities, and so forth. We did accept some data from inexperienced Earthwatch observers but only when their reports were independently substantiated by a second observer or photographs or were consistent with experienced observers' reports. As inexperienced observers tended to identify fewer reproductions and describe them in less detail than experienced observers, inclusion of their data did not inflate findings.

Data were collected by continuously recording the focal orangutan's behavior during the follow. This is possible because orangutans are slow-moving and frequently pause, watch, or rest (Galdikas, 1988). Reproductions were identified by their similarity to a known model along with contingency on the model, that is, little chance of spontaneously performing the actions without modeling (Hall, 1968; Nadel, 1986), such as when the behavior replicated was rare or involved an abrupt change of activity or when the imitator had not performed this behavior in the previous 10 min. When both model's and imitator's actions were observed, a reproduction was identified if (a) the imitator was likely to have perceived the model's actions (the model was salient and within the imitator's visual field), (b) the imitator's actions followed the model's in close temporal proximity (a maximum of 1–2 min), and (c) some modeled features were replicated. When only an imitator's actions were observed, a reproduction was identified by the precision with which it replicated a known model (Nadel, 1986).

This study used reproductions that involved the focal orangutan as model or imitator. For each, we described model and imitator (name, age, sex, and species), their relationship with one another, and the behavioral sequence of the reproduction. With continuous field notes, descriptions of the surrounding stream of behavior were also available.

Because we were unlikely to observe a first attempt at a reproduction and our background information on these orangutans was extensive but inevitably incomplete, we developed a procedure for isolating true imitation on the basis of the occurrence of qualities related to the reproduction that were incongruent with acquisition through the other forms of imitation known in nonhuman species.

First, we recorded any of four features considered incongruent with individual, trial-and-error, experiential learning—that is, learning derived from an orangutan's direct experience with stimulus conditions: (a) arbitrary actions, actions incongruent with stimulus conditions (Cheney & Seyfarth, 1990; Galef, 1988; Lefebvre & Palameta, 1988; Seligman & Hager, 1972; Visalberghi & Fragaszy, 1990; Zentall, 1988); (b) exceptional actions, actions incongruent with normal, spontaneous individual learning in this species (Beck, 1982; Boesch, 1991; Galdikas, 1982; Lethmate, 1982; Pepperberg, 1988; Visalberghi & Fragaszy, 1990; Walker, 1983; Wright, 1972; Zentall, 1988); (c) atypical actions, actions incongruent with spontaneous individual learning in this imitator (e.g., tool use in an orangutan for whom this was not characteristic or, in humans, routinized phrases that children copy from adult speech, such as delayed echolalia in autism; Ratner, 1989; Snow, 1981); and (d) rapid acquisition, actions productively but not necessarily receptively novel to the imitator that showed rapid, abrupt acquisition rather than the slow, gradual pattern characteristic of associative learning (Lefebvre & Palameta, 1988; Masur, 1988; Meltzoff, 1988; Thorpe, 1963; Visalberghi & Fragaszy, 1990; Zentall, 1988). These four features are distinct but not mutually exclusive; for example, exceptional actions are often also atypical. Actions were judged arbitrary when they included nonessential standardized techniques (*standardized* in the sense of replicating the exact technique modeled rather than more common, equally effective alternatives), model-appropriate problem-solving errors, or nonfunctional pretend performances. Actions were judged exceptional on the basis of published reports, when they were rare, nonexistent or inconsistent with known orangutan behavior, or when they appeared only after modeling despite prior opportunities for independent acquisition and when they do not occur in wild orangutans or commonly in captive or rehabilitant orangutans. Judgments of atypicality and rapid acquisition relied on judgments of behavioral novelty based on both the imitator's history and the nature of current behavior or evidence of rapid acquisition after demonstration. We judged actions novel when they were not observed during data collection and they were reported not to have occurred by several knowledgeable staff, including Galdikas. Each of these four features represents a misfit between the reproduction and what individual learning would have generated while remaining congruent with observational learning.

Second, for reproductions that showed any of these features, we also collected data on social experiential learning, both whether social reinforcement occurred and its nature (encouragement or discouragement). Absent, inappropriate, or insufficient social reinforcement suggests socially driven associative processes as insufficient for acquisition. Often, these adjunct qualitative data were collected subsequent to observing reproductions; they derived from various sources, including further observation, published reports, and reports from knowledgeable staff. In many cases we could not assess these qualities with confidence; in some, we could.

Analyses

Analyses were qualitative. We extracted a subset of complex reproductions (those with any of the qualities discussed) and then assessed what processes could account for the entire acquisition of each from all adjunct qualitative data. Given the possibility of a mix of processes, assessments focused on whether the other forms of imitation, those based on associative processes grounded in individual or social experience, had been sufficient to account for acquisition, even if they could have been. In line with the identification-by-exclusion procedure, we looked for qualities that tended to eliminate associative processes as sufficient yet remained consistent with acquisition by true imitation. The presence of such qualities logically suggested true imitation as one of the imitative processes involved in acquisition.

Results

We collected 395 hr of raw observational data on these orangutans—340 hr live (90 hr in 1989 and 250 hr in 1990) and 55 hr videotaped (10 hr in 1989 and 45 hr in 1990)—plus supplementary ad lib observations and reports. The amount of data per subject varied considerably due to visibility and, especially in 1989, the amount of time spent in camp. Raw data produced 354 reproductions by 26 different orangutans;

202 were observed directly by one of the authors (including 7 reported in Galdikas, 1980, 1982), and 152 by other students, researchers, or Earthwatch volunteers. In both form and probable acquisition processes, these ranged from simple (e.g., scratching, grooming an ear, adopting an unusual body posture or locomotory style, combing hair, or using an umbrella) to highly complex (multistep food processing, siphoning, or fire-related activities).

We identified 54 reproductions as complex (see summary, Table 1; incidents are grouped when they reflect similar action sequences). A majority involved tool use (41 of 54), in the general sense of using an object as an intermediate means to achieve a goal, and another 8 of 54 involved other complex object manipulations. Most were observed by the authors (21 by Russon, 14 by Galdikas, and 5 by several observers); 2 came from other students or researchers, and 12 from Earthwatchers (10 were corroborated directly by experienced observers, and the other 2, indirectly). In most, the essence of the reproduction and any associated novelty were in the organization or coordination of behavioral elements, not in the individual elements themselves. We judged the probability that the observed organization arose without demonstration to be very low.

The table summaries do no justice to the richness and individuality of the routines involved. We therefore selected several examples to present in detail. The first 5 observations show the most qualities incongruent with individual and social experiential learning, illustrating those most difficult to explain by associative processes alone; the 16th and 29th observations show fewer such qualities, illustrating the range included. The descriptions are taken from field notes. Each is prefaced by a sketch of the modeled actions and followed by a brief analysis of those qualities that reflected on acquisition. Comments are set off in square brackets. We emphasize that these reproductions were not encouraged and were definitely not trained circus tricks but were rather actions that these orangutans spontaneously chose to acquire and perform.

Observation 1: Siphoning

These observations were made by Russon. Two adult females were observed, separately, in a lean-to where fuel supplies were kept, manipulating a fuel drum, a hose, and once an empty jerry can. Staff siphon fuel from drums into jerry cans in standard fashion: They insert one end of a hose into the fuel in a drum through the drum hole, suck on the other end of the hose to start fuel flowing, and then quickly insert this other end into a jerry can. The insertion of the hose into the fuel, the amount of sucking, and the timing between sucking and inserting the hose into the can are critical to success.

In the first case, Russon arrived when the orangutan Supinah was already in the lean-to area and manipulating a fuel drum, a siphon hose, and a jerry can. The drum and can were empty, their caps were off (the assistant watching Supinah reported that she had independently unscrewed and removed both), and Supinah had inserted one end of the hose into the drum. Supinah put the second end of the hose into her mouth, closed her lips around it, and bellowed her cheeks out. She dropped the second end of the hose, pushed its first end further into the drum, withdrew it, and tasted it; she then picked up the empty jerry can, briefly lifted it to her mouth as though to drink, and put it back down. She returned to the first end of the hose, put it back into the drum hole, and held it in place with one foot; she picked up the second end of the hose, put it into her mouth, and bellowed her cheeks out briefly. She stood the jerry can up but dropped the the second end of the hose; she retrieved and inserted it into the can.

On another occasion Siswoyo, the second female, entered the lean-to, sat on top of a fuel drum holding a hose she found, pushing and twisting one end against the top of the drum at its hole, but the hole was still capped. She stopped pushing the hose at the capped drum hole after a few minutes, found a stick, wedged it under the edge of the cap, and pried. After several minutes of this, she pushed the drum over on its side, found a larger stick, and resumed prying at the cap. At this point Russon called camp staff, who shooed Siswoyo away.

Supinah's reproduction showed nonfunctionality (the drum was empty) and errors (the hose was not inserted into fuel, she did not clearly suck, and the timing between sucking and inserting the hose was flawed); nonethless, its visible forms and sequence are appropriate and replicate those used by humans who siphon effectively. Siswoyo's reproduction showed errors (e.g., she tried to insert the hose into a hole before one existed). Both had prior experience with these objects, but it was limited because extensive manipulation of fuel drums is tolerated only when drums are empty; to our knowledge, neither has effectively siphoned. Complete acquisition by individual experiential learning thus seems implausible. Acquisition through social reinforcement is implausible because humans do not encourage siphoning fuel for obvious reasons.

Observation 2: Fire

These observations were made by Russon and by other students and researchers. Supinah entered the outdoor cooking area near midmorning, one of the few times of day it was unguarded, when breakfast cooking fires were still smouldering. At this time the cooks used several techniques to make fires: They wet sticks with fuel kept in a metal container nearby, and they commonly scooped small amounts of fuel with a plastic cup also kept nearby; to start a new fire, they often touched a burning stick to a fuel-soaked one; to make fires burn faster, they blew on them or fanned them with a round metal lid (held vertically in one hand and waved briskly back and forth horizontally toward the fire).

On entering the cooking area, Supinah picked up a burning stick, blew on its burning end, and briefly bit gingerly at its hot tip. She next went to the metal container, removed the plastic cup and round metal lid sitting on top (Figure 1, top left panel), scooped fuel from the container with the cup, and plunged the burning end of her stick into the fuel. [Russon thought the container contained water, not fuel, and so let Supinah continue.] Plunging the stick into the fuel extinguished it. Supinah removed her stick and looked at it, dipped it back into the fuel, removed it and looked at it again, then got a second burning stick, and touched its burning tip to the

Table 1
Nature and Qualities of Complex Reproductions

Actions reproduced	No. incidents	No. imitators	Observers	Features: Level of novelty	Atypical	Exceptional	Standardized	Errors in performance	Nonfunctional
Siphon from fuel drums with plastic hoses into cans	2	2	R	2	no	yes	yes	yes	yes
Fire-related activities	2	1	R, S, E	2	no	yes	yes	yes	yes
Weed path edges with spade or hoe and remove chopped weeds	4	3	R, S, P	2	no	yes	yes	yes	yes
Make log bridges, then cross the river on them	1+	1+	P	1	yes	yes	yes	no	no
Paint buildings or shelves, paint or wash steps, and wipe spilled paint	4	2	G, R	2	yes	yes	yes	yes	yes
Put daughter into cage, lock door, and wipe cage with towel	1	1	E	1	no	yes	yes	yes	yes
Manipulate new grave (scrape or dig earth and wiggle or tap marker)	2	2	G, E	1	no	yes	yes	yes	yes
Brush teeth or tongue on both sides and spit foam over side of porch	1	1	R	2	yes	yes	yes	no	yes
Sharpen axe blade (dip stone in water and rub it on blade)	1	1	R, E	2	no	yes	yes	yes	yes
Pick up a toy Rambo gun and hold it in standard machine-gun style	1	1	G	1	yes	no	yes	no	yes
Bend sugarcane to squeeze out its juice	1	1	R	1	yes	yes	yes	yes	no
Place rice on bark plate and hand it to an observer	1	1	P	—	yes	yes	yes	yes	no
Splash water on head and rub wet hair (like shampooing)	1	1	S, R	1	yes	no	yes	no	yes
Manipulate motors on boats (like starting the motors)	1+	1+	G	—	yes	yes	no	yes	yes
Sweep with twig broom for path (and realign twigs) or common broom for porch	4	2	R, G, E	2	no	yes	yes	no	yes
Rehang a fallen hammock; if effective, ride in it	3	3	G, E, R	2	no	yes	yes	yes	no
Wipe perineal area with leaves	1	1+	P	1	yes	no	yes	no	yes
Manipulate a sick infant's body and limbs (as a nurse had done)	1	1	G, E	1	no	no	yes	no	yes
Unlock door's bar-lock with probe-key and make the key	1	1	R	4	yes	no	yes	no	no
Sand a blowgun dart (rub flared end of dart against hairy leaf)	2	1	R, S	3	no	yes	yes	no	yes
Apply insect repellent on head, arms, and legs	1	1	S	2	yes	yes	yes	no	no
Pour drink from cup into bottle, shake the bottle, and drink from it	1	1	E	2	no	yes	yes	no	yes
Put on a t-shirt correctly (except one arm through head hole)	1	1	R	2	no	no	yes	yes	yes
Harvest cassavalike plants after observing cassava planting	1+	1+	G	1	no	no	yes	yes	no
Chop at wood with an axe, with axe positioned correctly	1	1	R	3	no	yes	no	yes	yes

Table 1
Continued

Actions reproduced	No. incidents	No. imitators	Observers	Level of novelty	Features				
					Atypical	Exceptional	Standardized	Errors in performance	Nonfunctional
Shade eyes with hand when looking into the sun	2	2	R	3	no	yes	yes	no	no
Hold burning stick to cigarette held in lips, as for lighting	1	1	R, E	—	no	yes	no	yes	no
Hammer one stick with another (in one who is not a tool user)	2	1	G, R	2	yes	no	no	no	yes
Hammer nails into wood (with hammer, axe, or saw) and position nail	2	1	R, E	3	no	no	no	yes	yes
Use boats (untie, bale out, reorient, ride, and sometimes paddle)	2+	2+	R, P	2	no	yes	yes	no	no
Saw wood and position saw correctly into existing cut	4+	2+	R, G, S, E	3	no	no	no	no	yes
Ring camp dinner bell with standard stick	1+	1+	G	2	no	no	yes	no	no

Note. For observers who reported such incidents, R = Anne E. Russon, G = Birute M. F. Galdikas, S = student or other researcher, E = Earthwatcher, and P = Galdikas (1982). For level of novelty, 1 = completely novel act, 2 = occasional act, 3 = moderately common act, and 4 = very common act. For features that relate to acquisition processes, yes = presence and no = absence or unknown. + indicates that several incidents or imitators were mentioned nonspecifically.

extinguished tip of her first stick. Next, she poured the fuel from her cup back into the container (Figure 1, top right panel), placed the cup on the ground, picked up the container, poured new fuel from it into the cup (Figure 1, center left panel), stopped when the cup overflowed, and put the container down. She retrieved her first stick, put it back into the cup of fuel (Figure 1, center right panel), picked up the round metal lid, and fanned it repeatedly over the stick in the cup; in fanning she held the metal lid in one hand, in vertical position, and waved it back and forth horizontally in front of the cup and stick (Figure 1, bottom left panel). After this she removed the stick from the cup and blew at its [still extinguished] tip (Figure 1, bottom right panel). Her activities continued for another 10–15 min; she brought in six more sticks, some of them burning, set the plastic cup of fuel directly on the burning embers, dripped and poured fuel onto the embers (smoke or steam billowed), and stirred the embers with a long stick. She finally threw this last stick into the embers, dropped the cup abruptly [as if it were hot], poured most of the liquid out, and left.

Supinah's routine replicated much of the camp cooks' fire-making routine. We judged it exceptional because we found no reliable reports of apes' acquiring fire-making techniques in the normal course of individual learning, though there are anecdotes about their attempts to maintain fires (e.g., McGrew, 1992; Rousseau, 1754/1984). Supinah's routine showed standardized elements (use of the same tools and techniques as the cooks; e.g., scoop fuel from containers with cups, wet sticks with fuel before igniting them, and fan fire with the metal lid held vertically and waved side to side) and errors (plunging the burning stick into fuel extinguished it, and touching her first stick with a burning one did not ignite the former although it could have if handled more carefully). To our knowledge no one had ever seen her succeed in making a fire; nonetheless her procedure, in its techniques and their sequential organization, was basically appropriate for doing so. She had little opportunity to acquire this procedure by individual learning because the rehabilitants, especially Supinah, are prohibited entry to the cooking area; they tend to steal food and interfere with cooking, and Supinah frightens the cooks. She did periodically get into the cooking area and manipulate the sticks, pots, and containers currently available, but her only chances were when the area was unoccupied, normally a 1- to 2-hr period over midday when the cooks washed in the river. The specific tools and objects used in the cooking area have a short life because they are soon lost, broken, or stolen; nonetheless, Supinah used exactly those objects and associated techniques used by the cooks at that time. These considerations make it difficult to accept individual trial-and-error experiential learning as sufficient to generate this behavioral complex. Acquisition of her fire-related procedures through social reinforcement is unlikely because human efforts were to exclude her from this area; given the potential danger, it would have been foolhardy to encourage or tutor her to build fire. In contrast, Supinah did observe these activities extensively, frequently watching them from a distance or from beneath the adjoining dining hall.

Figure 1. Supinah's fire-related activities: (top left) She removed the round lid and cup from the top of the fuel container; (top right) she poured fuel from the cup back into the container; (center left) she poured fresh fuel from the container into the cup; (center right) she plunged the burnt stick into the cup of fuel; (bottom right) she fanned the burnt stick in the fuel with the round lid; and (bottom left) she blew at the extinguished, burnt tip of the fuel-soaked stick.

Observation 3: Weeding

Russon made the following observation. Mr. Mursiman, a long-time staff member who took care of young orphans, was cleaning weeds from the edges of paths in camp. A flurry of weeding had been undertaken around the camp over several days in preparation for important visitors. Weeding occurs in *sporadic bouts; when it* does occur, it occurs frequently, and several staff participate. Mursiman's technique involved chopping weeds off at the root with a hoe and then pushing the cut weeds into a neat row behind him along the center of the path for later removal.

When Russon arrived, Siswoyo was 3 m behind Mursiman on the same path, also removing weeds from the side of the path. Siswoyo mainly used a foot-long stick and chopped off the weeds but sometimes pulled them out with her hands. She put her chopped weeds into a neat row behind herself, in the center of the path. The incident ended when Russon interrupted to ask Mursiman about Siswoyo's weeding; he reported that she had followed him, watched his weeding, and then started weeding.

Siswoyo's method of disposing of weeds was standardized. It used the modeled technique of making a row in the center of the path over equally common and effective methods (e.g., throwing weeds into the bush). Her weeding, especially her weed row, seemed nonfunctional in that it was unlikely to have served any extrinsic goal for her. Camp staff usually discouraged weeding because orangutans' results were not appropriately neat. In other cases, workers hid tools to forestall orangutans' weeding, ignored their weeding, or removed tools when damage became excessive. It is thus unlikely that this routine was entirely shaped by individual or social experience.

Observation 4: Bridges (Galdikas, 1982)

Several years ago, the rehabilitant orangutans and their feeding station were moved across the river from the camp. On one occasion, a new assistant was sent across the river to feed them. After he arrived, 1 orangutan proceeded to sink his boat, and another charged him. The assistant could not swim, so he dragged a log over to the weeds at the river's edge, threw it across to the other side, scrambled over it back across the river, and pulled the log up behind him. Within minutes, 2 of the 8 rehabilitants watching began dragging everything they could find to the water's edge. A subadult succeeded in crossing on a thick vine, and soon others were crossing as well. Eventually, some rehabilitants crossed at will by making such bridges. When any logs were therefore removed, the rehabilitants resorted to using vines.

This incident shows abrupt acquisition of a routine that is productively novel: Before the assistant demonstrated this technique, no one ever observed orangutans do more than steal a boat or find and cross on a log that naturally spanned the river. It is likewise atypical and possibly exceptional: No orangutans were known to have performed such routines before this demonstration.

Observation 5: Painting

This observation was made by Galdikas. Several staff were on the porch of Galdikas's house around noon, painting a set of shelves they had brought outside. Supinah, Galdikas, and Fred (Galdikas's 8-year-old son) were also on the porch. Fred was helping to paint, and Supinah and Galdikas were watching. There had been considerable painting of camp buildings over the last month. This was unusual, and staff reported that Supinah had come and observed.

Supinah took one of the paintbrushes and put it in her mouth; this made her mouth white, and Galdikas pulled the brush out. Supinah next took the brush and painted the floor of the porch, holding the brush appropriately and painting effectively. Galdikas took the brush away after 10 s and had staff remove Supinah's paint, which they did by dipping a rag in a can of paint thinner and scrubbing the floor in wide, sweeping arcs. About 5 s later Supinah took the paintbrush and painted the floor again, for about 1 min, in similar wide sweeping arcs. At this point Fred and the staff were painting the side and back of the shelves, stroking up and down. Supinah then turned to the house wall behind her and started painting there, also stroking up and down, for about 20 brush strokes. The paint on the brush was then dry, and she handed the brush to Galdikas.

Five seconds later Supinah rushed into the open bathroom nearby. A staff member stopped her, but Galdikas gave her a sliver of soap and a pail of water [assuming this was what she wanted in the bathroom]. Supinah ignored the soap [which is unusual] and instead grabbed the paint-thinner–soaked rag earlier used to wipe her paint from the floor. She dipped this rag into the pail of water, wrung it out, and wiped the floor with it. She dipped, sloshed, and wrung the rag again, and then grabbed for a paint can. Staff immediately retrieved the paint can. Supinah then dipped her rag into the pail of water a third time and wiped it on the freshly painted set of shelves [this got paint on the rag]. She dipped the paint-covered rag in the pail of water again and wiped the floor with it [this got paint on the floor]. She repeated her maneuver with the rag and shelves twice, in between wiping the rag over spilled paint on the floor near the shelves. Five minutes later, as Galdikas went into the house, Supinah dropped the rag into the pail of water and abruptly moved away.

Supinah's painting and wiping replicated actions just demonstrated. We judged her painting exceptional; no orangutans had ever been seen painting before this flurry of painting around camp, and only 1 other had done anything remotely similar. The routine contained standardized features (e.g., painting with up and down strokes, wiping in wide sweeping arcs, and wiping spilled paint with a liquid-soaked rag), as well as errors (e.g., painting with a dry brush, wiping freshly painted shelves rather than spills, and soaking the rag in water rather than in paint thinner). It contained one atypical element, Supinah's ignoring an offer of soap: Soap was normally highly coveted by Supinah and by many other rehabilitants. The routine showed nonfunctional qualities: Supinah did not effect the goals demonstrated (she wiped paint off the shelves and onto the floor), and the routine was unlikely to serve any purpose for her beyond exploring the activities and effects she observed. Individual learning is implausible because paint and brushes were uncommon in camp and not available to her. Shaping through social reinforcement is unlikely. As seen here, her painting is at best tolerated but more commonly stopped.

Observation 16: Hanging Hammocks

These observations were made by Russon, Galdikas, and Earthwatch volunteers. Three adult females were observed, separately, rehanging fallen hammocks. Hammocks are uncommon in Indonesia but common in camp. Those used have a webbed sling attached at either end to a tie rope by a metal ring. They are hung by wrapping each tie rope twice or thrice around a vertical tree trunk, catching the rope's free end under the wrapped section of rope, and tying a loose hitchlike knot; weight in the hammock tightens the wrapped rope against the tree, and this pressure holds the knot. Many rehabilitants ride in already hanging hammocks given the chance, but their abilities to hang hammocks themselves are limited. Their success has been mostly due to luck, as, for example, when a tie rope fortuitously wedges into a crotch in a tree. Two incidents are offered.

Unyuk, an adult female, approached Russon and a female visitor who were in the forest, lying in their hammocks. Unyuk took the visitor's hammock and untied both ends. After playing with it, she took this hammock back to the trees where it had been tied. She first wrapped one of her tie ropes around the tie rope at the foot of Russon's hammock, near where Russon's hammock was tied to a first tree, but then undid it from there and rewrapped it around the trunk of the first tree. She next threaded the end of her rope through the metal ring at the foot of Russon's hammock and then wound her remaining rope around the webbing of Russon's hammock just below its ring. She left this end of her hammock in place, carried the other end to a second nearby tree, wrapped the second tie rope as well as some of the hammock webbing around its trunk, and wound the rest of the rope back around the webbing close to the tree. Her efforts did not rehang the hammock so that it could be used.

In the second case, Supinah was using a hammock when one end came untied and it fell to the ground. She picked up its tie rope and passed it through the fork of a tree where it had been tied. She pulled the rope tight, threaded its end through the metal ring and pulled it tight again. Then, still holding the rope with her left hand, she leaned on the hammock sling with her right hand. [Field notes state she seemed to be testing it.] Still holding the rope with her left hand, she climbed in and out of the hammock three times. [Field notes state she seemed to be testing the hammock's height from the ground.] After climbing out the third time, she let out some of the rope, which lowered the hammock. She threaded the rope again through its metal ring and pulled it tight. She climbed carefully back into the hammock and lay on her back with her head toward the newly tied end, still holding the tie rope, then carefully let go of the rope. The tie held. She sat up and then threw herself back in the hammock, hugging herself with both arms. She continued bouncing and swinging in the hammock for a couple of minutes, until the rope slipped and the hammock fell down. Supinah rehung it, without passing the rope through the ring, then tested it, climbed in, began to swing, and released the rope; her tie held again. Finally, the other end of the hammock released, and Supinah fell. She made five similar efforts to rehang this end; then she retrieved her daughter and left.

Both incidents involve the standard camp technique for hanging hammocks, that is, wrapping tie ropes around vertical trunks and knotting the ropes to secure them (orangutans simply wind them). Orangutans do practice hanging hammocks but have little independent success. In regard to social reinforcement, orangutans' hanging hammocks is discouraged—in fact, one of the few ways for humans to retrieve hammocks occupied by orangutans is to untie them so they fall because orangutans then commonly abandon them.

Observation 30: Boating

Russon and Galdikas made these observations. There have been numerous reports of rehabilitants taking camp boats for rides (Galdikas, 1982). They untied the knotted rope that moored a boat to the dock, shoved the boat, and got in, and then rode with the current. They have been observed making paddling motions with sticks, floor boards, or plastic dippers; they never used real paddles, but mostly threw these overboard. Because the orangutans jettison boats downriver after their rides, and staff must find and retrieve them, most boats left by the dock are now either sunk or moored at a raft that is inaccessible to the animals. Using a sunken boat requires retrieving it from the bottom of the river, righting it, and baling it out; using a moored boat requires untying it. Staff remove water from dugouts by rocking them side to side, sloshing water over the gunwales, or by baling with scoops or hands.

Supinah approached the end of the dock near a raft where the cooks were doing laundry. An assistant stood guard at the end of the dock, against orangutans' stealing soap or laundry or frightening the cooks. A dugout canoe was tied to a piling beneath the dock; it was visible, half-full of water and accessible in knee-deep water. Supinah climbed down from the dock into the dugout, untied its rope from the piling, then guided the dugout out from under the dock. After several moments she climbed out of the dugout, holding it by its rope; she stood in the water beside it and began to rock it from side to side. Her rocking sloshed water over the gunwales, and the dugout was three-quarters empty of water within minutes. At one point Supinah paused in rocking the dugout, looked at the water remaining in it, resumed rocking, and sloshed more water out. When most of the water was sloshed out, she climbed into the dugout and baled out more water with the slightly cupped palm of her hand. She next pulled against the dock pilings, and the dugout glided the rest of the way out from under the dock; she then reoriented the dugout toward the center of the river (parallel to the dock) and pushed off. As the dugout neared the raft with the cooks and laundry, she looked toward it and hopped on, bypassing the guard on the dock above. The cooks screamed and fled, leaving Supinah alone on the raft with their soap and laundry.

We identified one standardized element, removing the water by rocking the dugout from side to side; this replicates a special technique used by camp staff. Otherwise, the routine showed no errors, and it was clearly functional and neither exceptional nor atypical (other orangutans, including Supinah, have taken dugouts for rides). Other than the standardized element, her routine appeared original rather than copied and attributable to experiential learning. Social reinforcement was unlikely to have guided acquisition because humans discouraged orangutans' taking boats. Observation was a likely contributor; most rehabilitants came to camp in a boat, and they continued to observe boats often, partly because they were fed on the dock near where boats were moored and launched.

Discussion

These complex reproductions deserve serious consideration as more than mere anecdotes. Anecdotes suggest isolated incidents, commonly observed only because their unusual nature attracted attention, and then reported to researchers secondhand. Their interpretation and generalizability are problematic because of variability in observers' personal motives, observational expertise, knowledge of the species or the actors involved, and potential confounding of description with interpretation. Even with careful reporting, this unsystematic method of collection rarely provides the concurrent and historical contextual data needed for interpretation (Washburn, 1926). In contrast, our reproductions were mostly collected systematically, by experienced observers; our procedures generated multiple, not isolated, incidents; and extensive and expert background data were available on the species and individual orangutans involved. Description was distinguished from interpretation; suspected confounds were scrutinized, and scrutiny did lead to some rejections. We did accept some secondhand reports from inexperienced observers, but only those which could be corroborated. It is possible, even probable, that we erred in analyzing some of these incidents; however, given the size of this set of complex reproductions, its overall substance ought to be little compromised by individual errors.

The complex reproductions pose interesting questions about their acquisition because each manifests qualities difficult to explain by the associative imitative processes alone yet remains consistent with true imitation. All these complex reproductions almost certainly derived from a mix of acquisition processes; the rehabilitants almost certainly had experience with the basic actions and problems involved in most incidents, and some had had extensive contact with humans. However, these particular qualities logically point to true imitation as one process in that mix.

This sort of interpretation is consistent with other findings on cognition in great apes and humans. Great apes can develop language, self-recognition, pretend play, and insightful tool use to levels considered to reflect rudimentary symbolic processing in human children (Gallup, 1979a, 1979b; Langer, 1989, 1991; Mathieu & Bergeron, 1981; Mignault, 1985; Miles, 1983, 1990; A. J. Premack & Premack, 1972; D. Premack & Premack, 1983). *Symbolic processing* refers to the ability to use internal signs, like mental images, to stand for external referents rather than having to rely solely on direct sensation or motor performance (Case, 1985; Piaget, 1936/1954). Rudimentary symbolic processing in humans is characterized by the coordination, organization, or integration of several elements, rather than by new elements themselves (Case, 1985); our complex reproductions manifested this quality—their essence was such organization. Also in humans, developmental attainments across problem domains tend to be interrelated and synchronized; achievements in early language, self-recognition, pretend play, and insightful tool use emerge more or less concurrently with one another and just beyond deferred imitation, often considered a first form of true imitation. Recent findings have suggested that the great apes, like humans, but unlike monkeys, do show considerable synchrony across different problem domains (Langer, 1991; Russon, 1990). The possibility that orangutans may be capable of true imitation is thus consistent with these associated findings.

That orangutans may be capable of true imitation is also consistent with recent reports of social traditions for food processing and travel routes in wild orangutans (Galdikas, 1978, 1988; Galdikas & Vasey, 1992) and with the environmental and social constraints facing orangutans as large, arboreal, frugivorous primates inhabiting tropical forests (Clutton-Brock & Harvey, 1977a, 1977b; Milton, 1988). Particular constraints imposed by tropical forests include complexity, variability, and unpredictability of food resources, because of spatial and temporal patchiness, coupled with complex chemical and structural plant defenses (Fleming, Breitwisch, & Whitesides, 1987; Leighton & Leighton, 1983; MacKinnon, 1974; Sugardjito, teBoekhorst, & van Hooff, 1987; teBoekhorst, Schurmann, & Sugardjito, 1990; Whitmore, 1984, 1990), all of which may favor complex cognition (Galdikas & Vasey, 1992; Milton, 1988; Parker & Gibson, 1979). Social constraints, which may in part reflect the environmental ones (Galdikas, 1985, 1988; Sugardjito et al., 1987), constitute orangutans' limited sociality in the wild: They are semisolitary and encounter one another infrequently. Given that the primates evolved to rely on learning for forming many of their behavioral programs, it is plausible that such environmental constraints favored evolution of more sophisticated learning. It would not be surprising if social learning processes were included, in order to take maximum advantage of such limited social opportunities. True imitation constitutes one process that satisfies all of the constraints mentioned: It offers rapid, efficient acquisition of new knowledge, including the sorts of immediate correct responses needed to avoid toxic chemicals, to exploit ephemeral resources, and to maximally exploit limited social encounters. This analysis in no way constitutes proof that true imitation plays a major role in orangutan adaptation; it does suggest that the capacity for true imitation is consistent with other research findings on orangutan adaptation.

Four additional patterns are notable. First, many of the complex reproductions were singled out because they were empty routines, in that they served no clear extrinsic goal for the actor and replicated nonessential techniques. In replicating techniques versus goals, these orangutans appeared to go beyond the emulation found in other studies of great apes to impersonation (Nagell & Tomasello, 1991; Tomasello, 1990). Emulation involves reproducing observed goals with no effort to replicate the behavioral techniques demonstrated; impersonation involves replicating the techniques. We speculate that we found something resembling impersonation, whereas others have found only emulation because of models' identities; Boesch (1992) recently made a similar suggestion. Our imitators selected their own models, and those they chose were overwhelmingly individuals or groups with whom each imitator had well-established, stable, and positive affective relations (parent or friend); experimenters have tended to preselect models, with no apparent attention to models' relationships with subjects. Second, many reproductions did involve emulation, in that they appeared to serve a clear extrinsic goal for the imitator. Examples include unlocking doors (to access items inside), taking boats for rides (to attain a specific location), processing food (to eat it), making log bridges (to cross the river on them), and hanging up a hammock (to ride it). In several of these emulations, orangutans also showed impersonation, by also replicating actual techniques demonstrated (e.g., unlocking doors, hanging hammocks, baling out boats, and making log bridges). Third, in some emulations, orangutans appeared to go even a step beyond rote impersonation (see Mitchell, 1987; Whiten & Ham, 1992). They either replicated most components of demonstrated techniques but modified details, or they incorporated demonstrated techniques into their own routines. For example, Supinah (Observation 16) replicated the overall technique of hanging hammocks used by humans but replaced one component, the method of securing tie ropes, with her own technique. Fourth, the great majority of our complex reproductions involved tool use or other object manipulations. Galdikas (1982) had similar findings, that proficient tool-users among the rehabilitants had all had close contact with humans during infancy. Although our distribution probably includes a bias, that humanized, object-related actions were easily recognized as imitative, this link is nonetheless striking. Relations between tool use and imitation in apes are important because tools play a large role in scenarios about the evolution of hominid intelligence. It was earlier believed that ape tool use derived from true imitation but closer scrutiny of evidence suggested otherwise because much ape tool use can, and does, develop through individual experiential learning (Tomasello, 1990). Our findings suggest that true imitation may make an important added contribution. Ultimately, however, in terms of pongid and hominid evolution, tool use may not be the key process but rather an expression of more generalized cognitive capacities of the hominids (Galdikas & Vasey, 1992).

These rehabilitant orangutans produced reproductions that were rich and common, not simple or rare. This is consistent with our suggestion that enriched, stable environmental conditions, social and physical, may be critical to capabilities and propensities to imitate in great apes as in humans. The special qualities of the most complex reproductions suggest that most adequate explanation for these complex reproductions, and at the same time the simplest one, may involve true imitation.

If orangutans are capable of true imitation, then their capabilities resemble those reported in other great apes but not monkeys. These capabilities may then represent derived characteristics of hominoids, likely to have occurred in the common ancestor (Parker, 1990). Because orangutans are considered the great apes most distantly related to humans, these capabilities must have emerged before the orangutan lineage diverged from the ancestral hominoid line, some 10 million (± 3 million) years ago (Ciochon, 1983; Pilbeam, 1988). This is much earlier than the earliest date currently considered, at the common African hominoid–hominid ancestor some 4–8 million years ago (Campbell, 1988). This reinforces the notion that true imitation as a form of complex cognition may be a much older capability than is currently believed; thus, advanced social intelligence may have been in place well before the hominids diverged (Galdikas, 1978; Miles, 1983). It also points to a different set of selection pressures as critical to its evolution. Finding an important role for imitation in orangutan tool use suggests that early hominoid social intelligence was powerful enough to handle social transmission of tool use. This joins with other work (e.g., Galdikas & Vasey, 1992; Parker & Gibson, 1979) that has suggested that advanced social intelligence may have been an essential underpinning for hominid evolution, by allowing for the rapid spread of technological innovations. Such findings may influence debates over the interplay of social and ecological intelligence in the evolution of hominid intelligence (e.g., Byrne & Whiten, 1988).

If orangutans can learn by true imitation, then it ought to be possible to demonstrate this experimentally. Perhaps our study on the patterns in spontaneous orangutan imitation can dovetail with experimental work by suggesting factors important to eliciting true imitation. Our sense is that for orangutans, as for humans, the setting needed to elicit true imitation is complex, sensitive, and individualized. Particular consideration must be given to the model's affective relationship with individual imitators and to the modeled action's relevance for each imitator's current ability levels and interest. Attention to these factors may foster successful experimental elicitation, success that to date has proved so elusive.

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Ethical Standards for the Reporting and Publishing of Scientific Information

The following ethical standards are extracted from the "Ethical Principles of Psychologists and Code of Conduct," which appeared in the December 1992 issue of the *American Psychologist* (Vol. 47, No. 12, pp. 1597–1611). Standards 6.21–6.26 deal with the reporting and publishing of scientific information.

6.21 Reporting of Results

(a) Psychologists do not fabricate data or falsify results in their publications.

(b) If psychologists discover significant errors in their published data, they take reasonable steps to correct such errors in a correction, retraction, erratum, or other appropriate publication means.

6.22 Plagiarism

Psychologists do not present substantial portions or elements of another's work or data as their own, even if the other work or data source is cited occasionally.

6.23 Publication Credit

(a) Psychologists take responsibility and credit, including authorship credit, only for work they have actually performed or to which they have contributed.

(b) Principal authorship and other publication credits accurately reflect the relative scientific or professional contributions of the individuals involved, regardless of their relative status. Mere possession of an institutional position, such as Department Chair, does not justify authorship credit. Minor contributions to the research or to the writing for publications are appropriately acknowledged, such as in footnotes or in an introductory statement.

(c) A student is usually listed as principal author on any multiple-authored article that is substantially based on the student's dissertation or thesis.

6.24 Duplicate Publication of Data

Psychologists do not publish, as original data, data that have been previously published. This does not preclude republishing data when they are accompanied by proper acknowledgment.

6.25 Sharing Data

After research results are published, psychologists do not withhold the data on which their conclusions are based from other competent professionals who seek to verify the substantive claims through reanalysis and who intend to use such data only for that purpose, provided that the confidentiality of the participants can be protected and unless legal rights concerning proprietary data preclude their release.

6.26 Professional Reviewers

Psychologists who review material submitted for publication, grant, or other research proposal review respect the confidentiality of and the proprietary rights in such information of those who submitted it.