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Short communication

Response to novel food in infant chimpanzees Do infants refer to mothers before ingesting food on their own?

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Abstract

We investigated infant response toward novel food in captive chimpanzees under the condition in which they can explore such items freely together with their mother. Infants first approached novel foods rather than familiar ones when presented simultaneously. However, they did not ingest novel food immediately, but always sniff-licked it first. Infants tended to pay attention to their mothers before mouthing or ingesting novel foods themselves, but never did so with familiar ones. In response to the infant's activity, mother chimpanzees were tolerant rather than actively interfering. Those results imply that chimpanzee infants respond to novel foods in a neophobic way and refer to their mother for some kind of cue before attempting to ingest them.
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Keywords: Food repertoire; Neophobia; Social reference; Mother–infant; Chimpanzee

1. Introduction

Many animal species hesitate to eat novel foods at their first encounter (Rozin, 1976). Such a behavioral propensity is known as neophobia and is presumed to be an essential feature of generalist feeders to acquire new foods gradually in small amounts into their repertoire to avoid the risk of ingesting noxious items (Glander, 1982; Milton, 1993; Visalberghi, 1994; Visalberghi et al., 2002, 2003). On the other side, they are also known to exhibit curiosity toward novel stimuli simultaneously (Greenberg and Mettke-Hofman, 2001; Hughes, 1997; Rozin, 1976). Such a co-existence of two kinds of responses toward novel stimuli seems relevant to maintaining the opportunity to utilize a variety of potential food resources safely.

To expand the food repertoire efficiently beyond neophobic propensity, social context may play an important role. In humans, young individuals accept and eat novel food more readily in the presence of adults or peers eating that food (Birch, 1980; Harper and Sanders, 1975). Such a socially enhanced acceptance of novel food appears to be advantageous to introduce new foods into the diet efficiently in a safe manner. In

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particular, this seems essential for young individuals' acquisition of their food repertoire. As for non-human primates, however, there have been few systematic studies investigating the response of young individuals toward novel food in the social context (Fragaszy and Visalberghi, 1996; Fragaszy et al., 1997). In those studies, young capuchins expressed more interest in another's food when food was novel. However, they expressed their interest equally often before and after they had ingested it themselves.

In the present study, we examined the response of infant chimpanzees (*Pan troglodytes*) toward novel foods in captivity under the condition in which they can explore food freely together with their mother. In particular, we will discuss the following two points. (1) Do infant chimpanzees exhibit neophobic responses toward novel food? (2) Do they refer to their mother for some kind of cue before ingesting novel food?

2. Materials and methods

The study subjects were two infants, Ayumu (male) and Pal (female), born in 2000 at the Primate Research Institute, Kyoto University, and their mothers, Ai and Pan, respectively. The infants were nursed by their biological mothers, and spend their daily life with their mothers and other community members in an indoor and vegetated outdoor facilities (Matsuzawa, 2003).

Subjects fed a variety of vegetables, fruits (e.g. cucumber, eggplant and apple) and monkey chow three times a day. Additional food items (e.g. grape, raisin and peanut) were given as reward for other experiments. They were never deprived of food for testing. The infants, Ayumu and Pal, were 33–38 and 29–34 months old during the survey period, respectively, and they still continued to suckle.

In total, we used four kinds of familiar foods as base (apple and cucumber) or test items (grape and eggplant) and six kinds of novel foods as test items (sweet confectionary, agar jelly, cream biscuits, salty confectionary, burdock and paste of arum root). Familiar items were what mothers and infants had often eaten before as their daily meals or experimental rewards. Novel items were what infants had never seen nor eaten before. Among those, three items were also novel for the mothers (Table 1).

Each mother–infant pair was observed separately twice a week on average only once a day: 1–2 h after feeding time. The session interval was more than 24 h. In every session, two kinds of food items were presented to a mother–infant pair. In the habituation phase, we presented two kinds of familiar foods (base items) for the first 10 consecutive sessions. Then, two consecutive test sessions and two baseline sessions were conducted by turns repeatedly. This series of two test sessions followed by two baseline sessions was repeated eight times in each mother–infant pair. It means that 32 sessions were conducted in each mother–infant

Table 1
Food items presented in test sessions and the subject's first approach toward alternatives of test or base (paired) items

Food items tested	Ai–Ayumu pair			Pan–Pal pair		
	Paired item (familiar)	First approach		Paired item	First approach	
		Mother	Infant		Mother	Infant
Familiar						
Grape	Cucumber	Test	Test	Cucumber	Test	Test
Egg plant	Apple	Test	Base	Apple	Base	Test
Novel						
Sweet confectionary*	Apple	Test	Test	Cucumber	Test	Test
Agar jelly	Apple	Test	Test	Cucumber	Test	Test
Cream biscuit*	Cucumber	Test	Test	–	–	–
Salt confectionary*	Cucumber	Test	Test	Apple	Test	Test
Burdock	Cucumber	Test	Test	Apple	Test	Test
Paste of arum root	Apple	Test	Test	Cucumber	Test	Test

Food items marked with asterisk were novel for both infant and mother. For Pan–Pal, the data on test for cream biscuit was not available because the mother did not enter into the experimental booth on that test session.

pair in total. Within the two consecutive test sessions, the same kind of test item and one base item were presented, and then in another two consecutive test session, different items were presented. In the baseline sessions, the same two base items were always presented. The testing order of items and the combination of test items and either of the base items were randomly assigned to differ between the two mother–infant pairs.

Each item was prepared in 1 cm cubes, 50 pieces each. We allocated each item into 5 patches with 10 pieces per patch, on the floor of an experimental booth (3 m width × 4 m depth × 2 m height). Each patch consisted of only one kind of item. Patches of different items were placed alternately, side by side with each other, and all patch–patch distances were approximately 60 cm.

Each mother infant pair was introduced to the booth from the outdoor compound and allowed to freely interact and explore the food items. A session was started when either the mother or infant entered into the booth, and terminated after the mother had finished picking up all the food pieces or stopped to approach remaining food for more than 1 min. All of the mother's and infant's behavior were recorded with two video cameras (SONY, TRV900) placed outside the booth.

We analyzed only the first session of every consecutive test/baseline session. In the Ai–Ayumu pair, eight test and baseline sessions were used for each analysis. In the Pan–Pal pair, the mother did not enter into the experimental booth in one test (for cream biscuit) and two baseline sessions, thus, seven test and six baseline sessions were analyzed in total.

From the video records, we coded the following behavioral measures for each mother and infant using the continuous sampling method: approach toward food, visual attention toward another individual and direct food transfer between the individuals (for details, see Ueno and Matsuzawa, 2004). Approach toward food was defined as manipulating food with hand or mouth, which occasionally led to ingesting the food. In particular, two categories of exploratory behavior were defined among approach behavior other than ingesting: (I) sniff-licking: moving a mouth close to food within 10 cm and sniffing, licking, touching food with mouth or holding food briefly inside the mouth; (II) mouthing: holding whole food inside the mouth for more than 2 s and masticating food but not swallowing it. When the subjects masticated and swallowed food, they were considered to have ingested it. Visual attention toward another individual was defined as looking at mother/infant for more than 2 s without moving. When visual attention was interrupted for more than 2 s, we considered the subsequent one to be another incident.

3. Results

The infants, Ayumu and Pal, entered into the experimental booth preceding their mothers in all of 16 and 12 of 13 sessions, respectively. Then, infant and mother approached food patches and ate foods, occasionally interacting with each other. If they ingested one piece of a particular food item, they ate up all the remaining pieces. The average session length was 195 s (S.D. = 117) for Ai–Ayumu and 143 s (S.D. = 99) for Pan–Pal.

When a novel item was presented with a base (familiar) item, both infants first approached the novel item in all sessions (Table 1). Both mothers also did the same regardless of where the infant was at that time. However, no subjects ingested novel food immediately, but first sniff-licked it (Table 2). Table 2 presents the subjects' responses to each food item and infants' visual attention paid toward their mothers approaching the item. The infants, Ayumu and Pal, exhibited exploratory sniff-licking toward novel items in all sessions, but did so only in one session toward a familiar item. When they approached food items, both infants sniff-licked the novel items significantly more often than familiar ones (Table 3). The significant difference was detected when we tested whether the same tendency was evident over individual differences (χ^2 test with Mantel–Haenszel procedure: χ^2 (1, $n_{\text{Ayumu}} = 28$, $n_{\text{Pal}} = 17$) = 33.4, $p < 0.01$). The average length of time from first touching to ingesting food was 5.8 s (S.D. = 7.9) and 59 (S.D. = 37) for familiar and novel food items respectively in Ayumu, and 2 s (S.D. = 2) and 32 (S.D. = 33) respectively in Pal. Both infants took significantly longer time till ingesting novel food items than familiar ones (Mann–Whitney *U*-test: $p < 0.05$ for each infant).

The infants, Ayumu and Pal, paid attention to their mothers at least once in 5 of 6 and 2 of 5 sessions, respectively, when their mother was approaching a novel item, but never when approaching familiar one (Table 2). They occasionally looked at the mother and

Table 2
Subject responses to food and emergence of an infant's visual attention toward the mother approaching the food items

Food item	Ai–Ayumu pair								Pan–Pal pair							
	Total	Responses toward food						Att.	Total	Responses toward food						Att.
		Mother			Infant					Mother			Infant			
		Appr.	Sniff.	Lev.	Appr.	Sniff.	Lev.			Appr.	Sniff.	Lev.	Appr.	Sniff.	Lev.	
Familiar (base)																
Apple	12	12	1	III	11	0	III	0	9	9	0	III	9	0	III	0
Cucumber	12	12	0	III	9	1	III	0	9	0	0	–	1	0	III	0
Familiar (test)																
Grape	1	1	0	III	1	0	III	0	1	1	0	III	1	0	III	0
Egg plant	1	1	0	III	1	0	III	0	1	0	0	–	1	0	III	0
Novel (test)																
Sweet confectionary*	1	1	1	III	1	1	III	1	1	1	1	III	1	1	III	1[b]
Agar jelly	1	1	1	III	1	1	III	1	1	1	1	II	1	1	III	0
Cream biscuit*	1	1	1	III	1	1	III	1[a]	1	//	//	//	//	//	//	//
Salt confectionary*	1	1	1	I	1	1	II	1	1	1	1	I	1	1	I	1
Burdock	1	1	1	II	1	1	II	1	1	1	1	I	1	1	II	0
Paste of arum root	1	1	1	I	1	1	I	0	1	1	1	I	1	1	I	0

Food items marked with asterisk were novel for both infant and mother. Tot.: total number of sessions in which each item was presented; Lev.: level of approach behavior finally reached (I: sniff-licking, but not mouthing or ingestion; II: mouthing not followed by ingestion; III: ingestion; –: no approach); Appr.: number of sessions with any kind of approach behavior; Sniff.: number of sessions with exploratory behavior of sniff-licking which was precedent to ingestion; Att.: number of sessions with an infant's visual attention toward the mother; //: the mother did not enter into the experimental booth.

[a] The infant, Ayumu, mouthed the novel item on his own preceding to paying attention to his mother, however, he first masticated and ingested it only after he looked at his mother ingesting the item.

[b] The infant, Pal, paid attention to her mother four times within a session.

food by turns. Both infants paid attention to their mothers significantly more often when the mothers were approaching novel items than familiar ones (Table 3). The same tendency was detected over individual differences (χ^2 test with Mantel–Haenszel procedure: $\chi^2(1, n_{\text{Ayumu}} = 32, n_{\text{Pal}} = 15) = 22.3$, $p < 0.01$).

Table 3
Summary of infants responses toward familiar and novel foods

	Food items	
	Familiar	Novel
Response to food		
Sniff-lick first	1	11
Ingest immediately	34	0
Visual attention toward the mother		
Pay attention	0	7
No attention	36	3

The number of sessions in which the infants sniff-licked the food items first (or not but immediately ingested them) and in which they paid attention toward the mother approaching the food items is presented for familiar and novel foods, respectively.

Pal paid attention to her mother approaching sweet confectionary four times within a session (Table 2). Except for this session, both infants paid attention to their mothers only once in each session. Among the 10 total incidents of infants' visual attention, seven occurred in advance of the infants' first mouthing and ingestion of the novel item (Fig. 1). Among the rest of three incidents, one occurred after Ayumu mouthed a tiny piece of cream biscuit. He paid attention to his mother while holding it inside his mouth, only after this did he first masticate and ingest it. The other two incidents occurred after Pal mouthed a scrap of sweet confectionary transferred by her mother. She discarded it, and then again paid attention to her mother who was ingesting the other pieces of this sweet confectionary.

Among the 10 total incidents of infants' visual attention, infants saw the mother finally ingesting food items in seven incidents, biting but not ingesting in one incident and sniff-licking in two incidents. Ai and Ayumu finally ingested the same three out of six novel items. Pan and Pal ingested one and two novel items, respec-

Fig. 1. Outcome of a trial in Ai–Ayumu pair. An infant (Ayumu) paid attention toward his mother (Ai) who was eating a novel item (sweet confectionary), even though he could obtain that item freely on his own from the floor.

tively. The infants ingested the novel foods without first paying attention to their mother only in one session. Pal did so with agar jelly.

Mothers never paid attention to their infants in any sessions, nor prohibited their infant from approaching a novel item which they did not ingest. They never rejected their infant's coming close to exhibit visual attention to them, even when the infants looked into their faces from a very close distance, with physical contact. Except for one incident, mothers just continued to explore and ingest food pieces. In a test session for sweet confectionary, Pan directly transferred a scrap of sweet confectionary when Pal paid attention and stretched her arm to Pan's mouth.

4. Discussion

Both infants first approached novel foods when these were presented with familiar ones. However, they did not ingest novel items immediately, but always sniff-licked them first. Infants are considered to discriminate novel from familiar items, and express curiosity and hesitance (neophobic propensity) together toward novel items at their first encounters with them. Such co-existence of these two kinds of behavioral responses toward novel stimuli has been noted in many other animal species (Greenberg and Mettke-Hofman, 2001; Hughes, 1997; Rozin, 1976). Exhibiting both curiosity and neophobic responses together seems beneficial for maintaining the opportunity to make use of a variety of potential food resources safely. Based on this set of two responses, infant chimpanzees may maintain the opportunity for exploiting potential food resources.

Only when encountering novel items, did the infants pay attention to their mothers. Similarly, Fragaszy et al. (1997) reported that young capuchins expressed more interest in another's food when that food was novel, but equally often before and after they had ingested it themselves. Differing from young capuchins, infant chimpanzees here tended to show interest in their mothers' behavior or food before they had mouthed or ingested it themselves. As the mouth is the final voluntary checkpoint to take potential food resources into the body (Rozin, 1976), it is relevant to be more cautious when further advancing exploratory behavior from sniff-licking to mouthing and ingestion. In wild chimpanzees (Goodall, 1986), it has been reported that mothers occasionally interfere with infants' activity upon novel food in active ways (e.g. discard an item which was not included in a mother's food repertoire from an infant's mouth). Such incidents have long attracted our attentions as a presumable form of teaching (Caro and Hauser, 1992). In this study, however, mother chimpanzees were tolerant rather than actively interfering in response to the infant's activity. Such a relationship between mother and infant has been generally reported in other problem-solving situations involving tool use, called "education by master-apprenticeship" (Matsuzawa et al., 2001). This might be a general process for infant chimpanzees to acquire new knowledge and skills.

Though the number of food items tested was rather small, the novel items finally ingested were almost identical between mother and infant. Since each subject could freely explore the food items on their own, it is possible that the sensory sensation elicited by each item was similar to mother and infant. Beside that, young chimpanzees (less than 41-months-old) are known to socially refer to their attaching caregivers or mothers when they encounter novel stimuli (Russel et al., 1997; Itakura, 1995). Although the small number of sample size does not allow us to reach into a firm conclusion, we can point out the possibility that the congruence of novel items eventually ingested by both mother and infant is largely the result of an infant's attention paid toward the mother. From the results of this study, it is implied that chimpanzee infants respond to novel

food in a neophobic way and refer to their mother for some kind of cue before attempting to ingest them. By socially referring to their mother, chimpanzee infants possibly cope with novel resources and expand their food repertoire efficiently beyond their neophobic propensity.

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