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## DO CHIMPANZEES HAVE EXPECTATIONS ABOUT REWARD PRESENTATION FOLLOWING CORRECT PERFORMANCE ON COMPUTERIZED COGNITIVE TESTING?

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To investigate whether 2 chimpanzees had expectations regarding the outcome of their responses on a computerized task, food reward that typically was given for correct responses was withheld on some correctly completed trials. There were two types of these probe trials: those which the chimpanzees performed correctly on their own, and those during which the chimpanzees needed the experimenter's assistance to complete the trial correctly. For both chimpanzees, reward procurement behaviors directed toward the experimenter occurred significantly more often on correctly completed probe trials than on incorrectly completed trials. This indicated increased expectation of food reward on correct trials as compared to incorrect trials. For 1 of the 2 chimpanzees, reward procurement behaviors were significantly more likely to occur on probe trials on which the chimpanzee received no assistance from the experimenter than on trials in which the experimenter assisted the chimpanzee. This behavioral difference was not predicated on reinforcement history, as all correctly completed nonprobe trials were rewarded whether or not assistance was provided by the experimenter. These data indicate that this chimpanzee may have a rudimentary sense of "equity" regarding what outcome should accompany the successful completion of trials that is dependent on the level of assistance provided by an experimenter during the trial.

De Waal (1991) described behaviors in chimpanzees that reflected the chimpanzees' sense of how others should or should not behave. He defined this sense for chimpanzees as "*a set of expectations about the*

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*way in which oneself (or others) should be treated and how resources should be divided, a deviation from which expectations to one's (or the other's) disadvantage evokes a negative reaction"* (de Waal, 1991, p. 336, italics in the original). De Waal (1991) stated that rules emerge when these animals learn the relationship between their behavior and the behavior of others. The circumspect manner in which these rules are violated provides some evidence of the animals' recognition of them. Familiarity with the rules is so great among chimpanzees that some individuals may act as informants about others' transgressions of those rules (de Waal, 1991).

In captivity, chimpanzees regularly engage in social interactions with their human caregivers in a variety of contexts. The humans develop expectations regarding the behavior of the chimpanzees in certain situations (such as moving for cleaning or partaking in basic husbandry procedures). A violation of those expectations can produce frustration in the human caregivers. The chimpanzees also learn contingencies between the behavior of themselves and that of their caregivers. For example, they may learn that preferred food is provided only after the chimpanzees move to holding areas so that humans can complete cleaning of the home cages. When these established contingencies are violated, the chimpanzees may show behaviors that are comparable to the frustration exhibited by humans who have had their expectations violated. To give a concrete example from our laboratory, an individual chimpanzee that sees the other animals in its colony receive fruit but that does not receive fruit itself during afternoon feedings may gesture toward a caretaker, pout its lips out toward the experimenter, or even smack the cage wire to get the caretaker's attention. The chimpanzee directs these gestures toward the experimenter and not toward other things such as the refrigerator or toward the other chimpanzees.

To examine the expectations of nonhuman animals experimentally, researchers remove rewards from a testing situation in which the rewards were typically provided. Amsel (1958, 1962) studied rats in runway mazes and found that speed of running increased after reward was omitted or diminished on an initial runway. Melges and Poppen (1976) found that when monkeys were trained on a differential rate of reinforcement for low rates of response, increases in the delay interval before reinforcement led to the monkeys becoming highly agitated, and they manifested frustrative behaviors such as biting their fingers, shaking the cage, and vocalizing. Tinklepaugh (1928, 1932) also found that monkeys and chimpanzees exhibited frustration upon failing to find a preferred type of food that was hidden earlier in a given location. These behaviors mirror those of humans, in whom anger and frustration become apparent when the humans do not receive an expected outcome after carrying out a plan of action that they believe will lead to that outcome (Melges & Poppen, 1976).

Itakura (1993) reported on a chimpanzee's emotional behavior during a match-to-sample procedure. After each trial, the chimpanzee was exposed to one of four types of feedback: (a) a buzzer for incorrect

responses, (b) a chime for correct responses, (c) a chime and food reward for correct responses, or (d) no feedback. The strongest negative emotional responses were to the buzzer after incorrect trials, but there was no behavioral difference between the chime and the chime + food feedback conditions. The frequencies of self-directed behaviors such as whimpering, scratching, pouting, and self-grooming in response to the chime alone were low despite the fact that some correctly completed trials were rewarded with food items as well. Itakura (1993) stated that this was because the chime was a secondary positive reinforcement. However, chimpanzees may be more likely to exhibit emotional behavior in such a situation when they can direct their behavior toward an individual with whom they associate the food reward, and thus also associate with the nonpresentation of food. In humans, violations in the presentation of expected outcomes promote a sense of inequity, and this sense of inequity often manifests itself through behaviors directed toward the individuals "held responsible" by those humans. Perhaps chimpanzees also show a sense of "equity" in their expectations for certain outcomes based on their behavior.

The chimpanzees at the Language Research Center interact with caretakers in the context of computerized cognitive testing. In the present experiment, the expectations of 2 chimpanzees were examined through recording the chimpanzees' reactions to the withholding of reinforcement typically given for correct performance during experimental testing of the chimpanzees' numerical skills using a computerized apparatus. If the chimpanzees have an expectation of receiving food reward from the experimenter only when a trial is completed correctly, then they should be more likely to exhibit reward procurement behaviors when food reward is not presented on correctly completed trials than when food reward is not presented on incorrectly completed trials. A second question of interest is whether these chimpanzees exhibit behaviors indicative of expectations that go beyond the simple association of food reward for correct performance on a trial. Such expectations will be evident if the chimpanzees respond differently to nonreinforcement on correctly completed trials based on the independence from or dependence on an experimenter's assistance during those trials. If the chimpanzees attempt to procure food reward only when a trial was completed correctly without experimenter assistance while not attempting to procure food reward on experimenter assisted trials, this may be evidence of some rudimentary sense of "equity" in the chimpanzee that was not intentionally instilled through the experimental procedure.

## Method

### *Participants*

Two chimpanzees were observed. Lana was a 27-year-old captive-born female who was taught a visuographic language system as an infant (Rumbaugh, 1977). Lana had been the focus of research on delay of

gratification (Beran, Savage-Rumbaugh, Pate, & Rumbaugh, 1999), long-term retention (Beran, Pate, Richardson, & Rumbaugh, 2000), counting (Rumbaugh, Hopkins, Washburn, & Savage-Rumbaugh, 1989; Rumbaugh & Washburn, 1993), and other cognitive neuropsychological studies (Hopkins, Morris, Savage-Rumbaugh, & Rumbaugh, 1992; Hopkins, Washburn, & Rumbaugh, 1990; Morris & Hopkins, 1993). Mercury was an 11-year-old captive-born male who was reared as a control subject (no language training) in language research with apes. Mercury has been the focus of research on delay of gratification (Beran et al., 1999), the acquisition of numerical skills, and other tests of cognitive neuropsychology.

Both chimpanzees were housed at the Language Research Center of Georgia State University. These chimpanzees had been involved in comparative cognition research for many years, and a large part of this work involved computerized testing. The chimpanzees had a long reinforcement history based on correct performance on these computer tasks. This reinforcement history also was associated with the interaction of chimpanzees and the human experimenters who provided the food rewards.

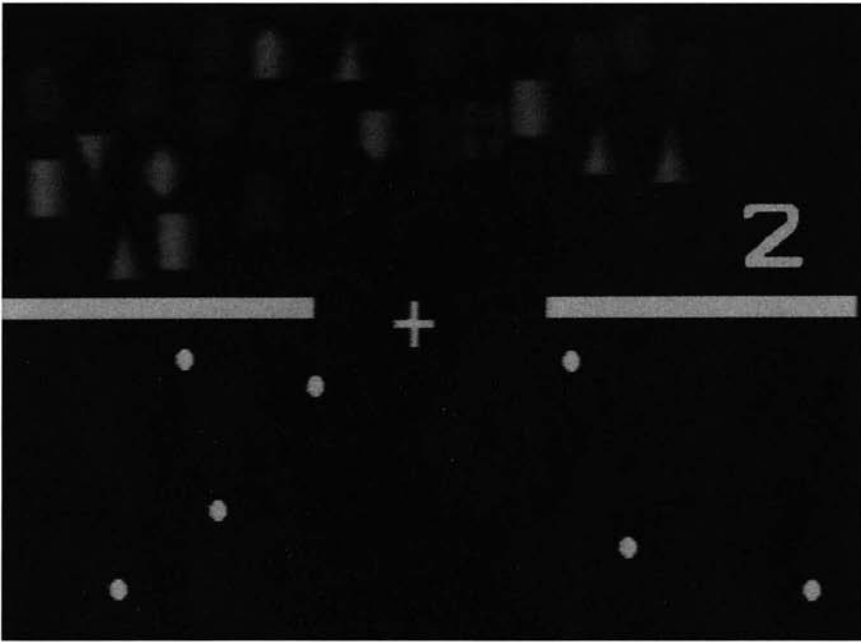
### *Apparatus*

Each chimpanzee was tested separately. At a work station in the home cage, the chimpanzee had access to a Kraft KC3 joystick mounted in a port attached to the cage. Manipulation of the joystick moved a cursor on a Commodore 1084S video monitor attached to a Commodore Amiga 2000 computer. The chimpanzee's behavior was videotaped with a Sony Video8 Pro camera for subsequent behavioral coding.

### *Design and Procedure*

To begin a trial of the numerical task, a chimpanzee moved a cursor, using the joystick, to a target numeral positioned on the right side of the screen above a white dividing line. When the cursor contacted the target numeral, an array of dots was presented in the bottom half of the screen (Figure 1). The chimpanzee contacted the dots at the bottom of the screen, one by one, with the cursor. Each dot contacted was moved to the top half of the screen as a visual reminder of the number of dots already selected. To complete a trial correctly, the chimpanzee had to move the cursor back into contact with the target numeral after contacting a number of dots equal to the target numeral. If the chimpanzee returned the cursor to the target numeral without selecting enough dots, or if the chimpanzee selected one dot more than was needed to match the target numeral, the trial was stopped, a buzz tone sounded, and the trial was recorded as an error. If a trial was completed correctly, a melodic tone sounded. Prior to this experiment, the chimpanzees always received preferred food rewards on correct trials in this task.

Throughout testing with this computerized apparatus, a correction procedure was used in which incorrect trials were presented to the chimpanzee again. If a chimpanzee was incorrect on the first correction trial, a second correction trial was provided. During this second correction



*Figure 1.* The computer monitor as seen by the chimpanzee. Here, the target numeral is 2, and there are seven dots available for selection with the cursor (the "+" in the middle of the screen). The chimpanzees had to select dots, one by one, until a quantity equal to the target numeral had been selected, and the chimpanzees had returned the cursor to the target numeral. The shapes in the top half of the screen (faint in figure) were holding positions for dots that were contacted and moved to the top of the screen as visual feedback of the number of dots selected.

trial, if the chimpanzee was about to make a mistake that would terminate the trial, the experimenter intervened. This intervention took the form of the statement "No" spoken plainly by the experimenter (i.e., with minimized emotional undertone). The chimpanzees always corrected their response by either selecting an additional dot, if necessary, or returning to the target numeral. Prior to the start of this experiment, the chimpanzees always received food reward on correction trials that were completed correctly.

At the time this experiment was conducted, the chimpanzees were still in the training phase of the enumeration task. Their performance was not of primary interest here. However, it is important to note that the animals already had performed a large number of trials correctly prior to the start of this experiment (Table 1), and all of these trials were rewarded. Additionally, the chimpanzees performed a large number of trials correctly during the course of this experiment, and nearly all of these trials were rewarded. The chimpanzees worked with the Arabic numerals 1, 2, and 3 prior to this experiment, and additional numerals were added during the course of the experiment (the numeral 4 for Lana and the numerals 4 and 5 for Mercury). The addition of larger numerals led to decreased performance



Table 1

Performance and Number of Trials Completed by Chimpanzees  
on Computerized Apparatus Before and During Experiment

Subject	Lana	Mercury
Trials Prior to Experiment	<i>N</i> = 1,946	<i>N</i> = 1,531
Trials Correct	1,275	1,077
% Correct	65.5%	70.3%
% Rewarded	100%	100%
Trials During Experiment	<i>N</i> = 3,080	<i>N</i> = 3,474
Number Correct	2,150	2,401
% Correct	69.8%	69.1%
% Rewarded	98.1%	98.3%

Note. Correction trials are included in this table.

for a period of time, and this explains the similarity in overall performance prior to and during the experiment (Table 1).

The only correctly completed trials that were not rewarded during this experiment were called *probe trials*, and their occurrence was extremely infrequent (less than 2% of the correctly completed trials during this experiment were unrewarded). Of primary interest were the reactions of the chimpanzees to these probe trials. There were two types of probe trials:

1. *Correct Outcome with Assistance Provided* (correct-assistance) - These probe trials occurred when a chimpanzee completed the trial correctly but received aid from the experimenter. This aid occurred when the experimenter observed that the chimpanzee was about to make an error that would end the trial. On these trials, the experimenter assisted the chimpanzee by saying the word "No" aloud. No other assistance was provided. As noted earlier, this assistance always led to the chimpanzee's correcting its current course of action by either returning to the target numeral and correctly ending a trial or by selecting additional dots to properly attain a quantity of dots equal to the target numeral. The chimpanzee did not receive food reward on these trials.

2. *Correct Outcome with No Assistance Provided* (correct-no-assistance) - These probe trials occurred when a chimpanzee completed a trial correctly without any assistance from the experimenter, but the chimpanzee did not receive food reward.

In addition to these two types of probe trials, incorrectly completed trials also were videotaped to examine the extent to which the chimpanzees produced food procurement behaviors when they were incorrect.

To diminish the possibility of cuing, the experimenter remained seated so that he could not view the monitor that the chimpanzees viewed. It was necessary for the experimenter to view a smaller monitor so that he could view the chimpanzees' performance and intervene before they made a mistake in two situations: (a) when a probe trial was given in the correct-assistance condition, and (b) when a chimpanzee was about to make an error on the second presentation of a correction trial. Food rewards were given on all trials that the chimpanzees correctly

completed except for probe trials. At the completion of the probe trials, the experimenter stared at his monitor and did not provide food reward to the chimpanzees. The experimenter remained in a still position, and he continued to stare at the monitor until the start of the next trial. The experimenter behaved in the same manner on incorrectly completed trials. The intertrial interval was 2 s regardless of the outcome of the previous trial.

In the correct-assistance condition, 20 probe trials were presented to each chimpanzee. In the correct-no-assistance condition, 40 probe trials were presented to each chimpanzee. Probe trials occurred approximately every 10 to 15 trials within a session, and probe trials were included in approximately one of every three sessions. The order of presentation of the two types of probe trials was randomized, but probe trials could not be specifically assigned to occur at a given time as both types of probe trials required some criterion to be met. For correct-no-assistance probe trials, the chimpanzee had to complete the trial correctly on its own, and for correct-assistance probe trials the chimpanzee had to be on the verge of making an error for the experimenter to intervene. However, probe trials typically occurred within a few trials of their predesignated position in a test session. The collection of data for the 60 probe trials presented to each chimpanzee occurred across approximately 50 test sessions spanning 3 months of testing. Lana and Mercury had been tested on this task for 4 months prior to the introduction of these probe trials. As noted earlier, prior to this experiment, the chimpanzees were rewarded on all trials that were completed correctly including those with experimenter assistance.

### *Scoring*

From the videotapes, the ends of all probe trials and the ends of 40 randomly selected incorrect trials were edited into single units for coding. The incorrect trials were of the type in which the chimpanzee returned the cursor to the target numeral without having selected a large enough quantity of dots to match that target numeral. These coding units began with the last 1 s of each trial during which the chimpanzee returned the cursor to the target numeral to complete the trial. The units continued until the chimpanzee moved the cursor into contact with a new target numeral to initiate the next trial.

For each probe trial unit, two observers independently examined the chimpanzees' behaviors when they did not receive the food reward. The observers were unaware of the trial condition as only the last portion of the trial was coded (which occurred after any possible assistance was given by the experimenter). The following behavioral categories were coded with a Yes or No score depending on whether or not they occurred during a given unit:

*Orient* - A score of Yes was given when the chimpanzee oriented toward the experimenter either through shifting the eye gaze, shifting the head, or shifting the entire body. This behavior was coded to score whether a chimpanzee looked at the experimenter, presumably to determine whether food reward was forthcoming.



*Reward procurement behavior* - This behavioral category consisted of two individual behaviors. Gesture/Touch occurred when a chimpanzee gestured towards the experimenter or contacted the cage with either the hand or the arm. This included pointing at the experimenter through the cage wire, tapping the cage wire, or slapping the cage. Lip Purse occurred when a chimpanzee pursed its lips in the direction of the experimenter. A score of Yes was given when either of these two behaviors were evident. Within this behavioral category, the observers also recorded which of the two individual behaviors occurred during each unit.

*No relevant behavior* - This code was given a Yes score when none of the reward procurement behaviors listed above were evident for a unit.

To check the reliability of the observers' scoring, all probe trials were compared. For the trials conducted with Lana, both observers noted that she oriented toward the experimenter for 56 of the 60 trials. For the remaining four trials, one of the two observers noted that Lana oriented toward the observer. For Mercury, both observers noted that he oriented toward the experimenter for 52 of the 60 trials given. For six of the remaining eight trials, one of the two observers noted that Mercury oriented toward the observer. This indicates that both chimpanzees looked toward the experimenter to determine whether food reward was forthcoming at the end of probe trials. Scores for the *reward procurement behavior* versus *no relevant behavior* categories were compared using Cohen's kappa (Cohen, 1960). Each kappa was computed for individual behaviors within the *reward procurement behavior* category to provide a more stringent test of reliability. For Lana, the kappa was .91 ( $SE = .10$ ), and for Mercury the kappa was .87 ( $SE = .11$ ). Based on these high levels of reliability, the author alone scored the 40 incorrectly completed trials using the same codes for the behavioral categories of *orient*, *reward procurement behavior*, and *no relevant behavior*.

## Results

The number of probe trials and incorrectly completed trials on which each category of behavior (*reward procurement* or *no relevant*) was produced by each chimpanzee is shown in Table 2. The frequency with which Lana exhibited reward procurement behaviors was significantly different depending on condition,  $\chi^2(2, 100) = 31.2, p < .01$ . Lana exhibited reward procurement behaviors on significantly fewer incorrectly completed trials than on correctly completed trials. Lana oriented toward the experimenter on only 35% of the incorrect trials, indicating a decreased tendency to determine whether food reward was forthcoming on incorrect trials as compared to correct trials (93% orientation on correct trials). Lana also exhibited reward procurement behaviors on a significantly greater percentage of probe trials in the correct-no-assistance condition than in the correct-assistance condition,  $\chi^2(1, 60) = 9.2, p < .01$ .

The frequency with which Mercury exhibited reward procurement

Table 2

Number of Probe Trials During Which *Reward Procurement* and  
*No Relevant* Behaviors Were Produced in Each Condition

LANA Behavior Condition	Behavior Observed	
	No Relevant	Reward Procurement
Correct - No Assistance	20	20
Correct - Assistance	18	2
Incorrect	40	0

MERCURY Behavior Condition	Behavior Observed	
	No Relevant	Reward Procurement
Correct - No Assistance	26	14
Correct - Assistance	12	8
Incorrect	38	2

behaviors also was significantly different depending on condition,  $\chi^2(2, 100) = 11.4$ ,  $p < .01$ . Mercury exhibited reward procurement behaviors on significantly fewer incorrectly completed trials than on correctly completed trials. Mercury oriented toward the experimenter on 50% of these incorrect trials, indicating that he had a decreased tendency to determine whether food reward was forthcoming on incorrect trials as compared to correct trials (87% orientation on correct trials). Mercury's frequency of reward procurement behaviors for probe trials was not significantly different depending on the type of probe trial,  $\chi^2(1, 60) < 1.0$ , *ns*.

### Discussion

This experiment was designed to examine the behavior of chimpanzees in a situation in which they failed to receive an expected reward that was typically provided for correctly performing a computerized task. The chimpanzees were provided with the auditory signal for correct completion of the trial, but food reward was withheld. The behavior of Lana and Mercury, who produced reward procurement behaviors to the presentation of the melodic tone alone without accompanying food reward on correctly completed trials, stands in contrast to the chimpanzee observed by Itakura (1993). Also in contrast to the Itakura (1993) findings were Lana's and Mercury's lack of emotional behaviors to the negative feedback associated with incorrect completion of trials. Possible explanations for these contrasts include age differences (Itakura's chimpanzee was 7 years of age whereas Lana and Mercury were 27 and 11 years of age, respectively) and testing histories (as noted earlier, Lana and Mercury had performed on computerized tests for many years). However, it is also possible that Lana and Mercury produced behaviors that were inter-individual (i.e., directed toward the experimenter) as a means of "protesting" the lack of food reinforcement from the experimenter. What is clear is that both Lana and Mercury had a clear expectation of receiving food reward when a trial was completed correctly that they did not have when a trial was incorrect.

The data from this experiment can be evaluated in two frames of reference: one based on the behaviors of the chimpanzees as would be described by reinforcement history alone and one based on describing the chimpanzees' behavior in terms of a "sense of equity." As already noted, both chimpanzees exhibited reward procurement behaviors more often when a trial was completed correctly than when it was completed incorrectly, and this is partly the result of the reinforcement history of these animals. However, within the category of correctly completed trials, Lana was significantly more likely to produce reward procurement behaviors when she was not aided than when assistance was provided by the experimenter. This finding is particularly interesting when one considers that, prior to this experiment, Lana always received food when a trial was correct, even when the experimenter had provided assistance. During those earlier trials in which she had received assistance, Lana heard the experimenter state the word "No" aloud as she was about to make an error. This indicates that the experimenter's statement "No" in the current experiment could not explain the difference in the behavior exhibited on the different types of probe trials, as food reinforcement in the past had accompanied trials with the experimenter correcting the chimpanzee using the word "No." Therefore, based on reinforcement history alone, Lana should have been equally likely to produce reward procurement behaviors whether she was aided on a trial or not, as the expectation could have been "correct performance leads to food reward from the experimenter." However, Lana was less likely to produce reward procurement behaviors when she was aided on trials than when she responded with no assistance, and this suggests a different expectation of "correct performance with no assistance merits food reward." This expectation was not instantiated by the humans working with her.

Because Lana directed her "protestations" toward the human working with her, Lana expected something from this individual, but only in situations in which she had performed the trial correctly with no assistance. This expectation indicates a rudimentary sense of "fairness" or "equity" in Lana. However, Mercury responded equally often with reward procurement behaviors independent of the role of the experimenter in the successful performance. Also, Lana did not universally "protest" the lack of food reward on the trials she completed correctly without the experimenter's assistance. In fact, she produced food procurement behaviors on only one half of those trials. If food procurement behaviors, at least in this situation, are driven by a sense of "equity," they always should be exhibited in the same conditions. However, one explanation for this inconsistency could be that the magnitude of the food reward was small enough that the chimpanzees did not always protest its absence but rather instead opted to begin the next trial immediately. Perhaps a shift to either a greater food reward or a longer intertrial interval would increase the frequency with which the chimpanzees produced food procurement behavior in this situation. Whether a sense of "equity" in other chimpanzees and other animals exists in similar situations also is presently unclear, but it suggests the need to investigate further the processes behind the expectation systems of nonhuman animals.

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