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Use of Tools by Captive Western Lowland Gorillas to Acquire Food

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Honors Thesis
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Abstract

Tool using behaviors are viewed as more intelligent as they require a certain set of cognitive abilities. Many species, including great apes and, particularly, chimpanzees, have been shown to use tools both in the wild and in captivity. Gorillas have been observed to use tools in the wild twice and only recently have they been tested in captivity. The current study used two experiments to test the tool using capabilities of the group of Western Lowland gorillas under controlled conditions at Franklin Park Zoo in Boston, Massachusetts. The first study used a common test involving extraction of hidden food from a tube using a stick. The second study tested whether one male gorilla could use a different object (piece of cloth) as a tool to obtain out-of- reach food, and if he understood what features made a tool successful. Results showed some of these gorillas have the ability to select and use objects as tools to acquire food they cannot reach. One gorilla could use different objects as tools and demonstrated his ability to identify which features of those objects were functionally important. The results also suggest social learning variables, such as maternal support, may have an effect on the success rate of young gorillas in using tools.

Introduction

Tool Use

Prior to Jane Goodall's work with the chimpanzees of Gombe, tool using was considered a strictly human trait (Goodall 1986). Since then tool use has been observed across the animal kingdom. One of Darwin's finches, the Woodpecker Finch, used twigs and cactus spines to extract arthropods out of holes and crevices in trees and shrubs. The finches also modified their tools, by shortening twigs that were too long and removing side branches that would obstruct insertion into the trees (Tebbich et al. 2001). Other birds, such as corvids, also used sticks to probe cracks for bugs as well as adding stones to a tube to increase the water level, allowing access to a floating treat. One crow, Betty, even constructed a hook to pull a basket of food out of a tube (Bluff et al. 2007).

Several marine animals use tools as well. Bottlenose dolphins use marine sponges as nose protectors when sifting through the ocean floor for food (Krutzer et al. 2005). Octopodes living above soft sediment have been observed using and carrying coconuts to use defensively as shelter (Finn et al. 2005). Sea otters have long been reported to use two rocks, one as a table and another as hammer to crack open mussels and other mollusks (Hall and Schaller 1964).

Perhaps the best known non-human tool users are other primates. Chimpanzees have been the most studied, both in the wild and in captivity. They use blades of grass to pull out termites, heavy stones to crack hard shelled nuts, and a series of differently shaped sticks to scoop honey from a bee's nest (Boesch et al. 2009). They also perform very well on tool using tests in captivity, such as using a rake to pull in out of reach food (Herrmann et al. 2008), extractive fishing at an artificial mound (Lonsdorf et al. 2009),

and trap tube tasks (Martin-Ordas et al. 2008). Orangutans, bonobos, and gorillas were also successful with trap tube tasks (Martin-Ordas et al. 2008). Cottontop tamarins and marmosets do not use tools in the wild, but were able to select the appropriate tool out of an array of functional and nonfunctional tools. Tools included different materials to acquire food rewards such as a functional hook made out of clay and a non-functional rope shaped into a hook. They also pulled pieces of cloth with a reward placed on the end. If the subject pulls the intact cloth, they got a reward; if they pulled the cut cloth, they would not (Hauser et al. 1998). Hauser et al.'s study showed the monkeys understood what features were necessary to make the tool functional.

Gorillas do not use tools in the wild to the same extent as other great apes, such as chimpanzees. Only recently have they first been observed to use tools: a branch to test the depth of a river, and a tree trunk as a bridge (Breuer et al. 2005). Gorillas' tool using abilities have also not been tested as much as some of their close relatives. One of the few studies of this skill, and model for Experiment 1, was done by Pouydebat et al. in 2005 at the Beauval Zoo in France. In that study, researchers made the puzzle feeder out of three logs with cylindrical holes of different depths. The holes were filled with crushed figs and honey and the feeder was attached to the outside of the enclosure's wire mesh wall. Long branches between one and two meters with leaves were scattered around inside the enclosure to be used as tools. All the young adult subjects were able to successfully make and use a suitable tool to extract food from inside the feeder with no prior training (Pouydebat et al. 2005).

Why Should We Care?

Using tools is considered a sign of intelligent-like behavior that requires particular cognitive abilities (Gomez 1999). It is found all across the animal kingdom, granting researchers valuable opportunities to compare cognitive abilities across species. It also provides insights and hypotheses about the evolution of adaptive intelligent behaviors. As tool using behavior may be passed from generation to generation through social learning, it could give us a glimpse into the formation of our own beginnings and culture.

The more people understand the intelligence of gorillas, the better captive gorillas can be cared for. If gorillas do understand problems at a higher cognitive level, their habitats and enrichment opportunities need to reflect that. Increased understanding of gorilla behavior will allow people to more effectively promote gorilla survival and conservation.

Materials and Methods

These experiments were conducted over a 9 month period from July 2009 to March 2010.

Subjects

For the duration of the study there were seven Western Lowland gorillas housed in the Tropical Forest at the Franklin Park Zoo in Boston, Massachusetts. At the time of this study there was Kitombe, a 23 year old silverback male and father of the two young females: Kira a 10 year old adolescent and Kimani who was 5 years old. There were two adult females: Kiki, the 28 year old mother of Kira and Kimani, and Gigi a 37 year old, unrelated gorilla; and two young adult male gorillas who were 16 years old: Joe and Okpara. When a group was on exhibit either Kitombe, or the two younger males, Joe and

Okpara, would be on exhibit with the females, as all the adult males could not be out on exhibit together. While on exhibit, all gorillas had the opportunity to work with the feeder but only Joe, Kira, and Kimani consistently did so. Joe was also the focus of the second study conducted off exhibit in a separate holding facility.

Exhibit Habitat

The Western Lowland gorilla indoor habitat in the Tropical Forest building spans about one acre. When the public first enters the Tropical Forest they are faced with a large glass wall. Just to the left of this glass wall is a small glass enclosure with access to the training door. The training door is often used by keepers to show off husbandry routines with the gorillas. A video camera was set up inside the glass enclosure and the tube feeder was hung on the outside of the wire mesh training door. Another camera was often set up at the second public viewing window to capture a wider angle view of the habitat and gorillas. See Figure 1 for a diagram of the exhibit.

Experiment 1: Tube Feeder

General Methods

The tube feeder was a thick Plexi-glas sheet (2 x 3 ft) with four holes about 1.5 inches in diameter and two plastic tubes, 8 inches long, screwed into the two left most holes of the plate. The feeder was affixed to the exhibit training door at the beginning of a session and the far ends of the tubes were filled with peanut butter, a preferred treat. We recorded the frequency with which the gorilla attempted to or successfully retrieved some

peanut butter with their finger or a stick, as well as the time it took for all of the peanut butter to be consumed. Videotapes and recording sheets (see Table 1) were used to score specific behaviors, using behavioral units from an ethogram developed in a pilot study. These measures were also used to calculate inter-observer reliability tests between independent observers.

Procedure

In *Experiment 1.1*, stripped willow sticks of various lengths and widths, “standard sticks”, that could be used as tools to extract peanut butter from the tubes were placed into the exhibit under the training door by a keeper (see Figure 2). Data for this portion of the study were collected by the experimenter (HJ) using the recording sheets (Table 1) at the time of session and from videotaped recordings. Ten sessions were conducted on separate days from July 2009 to February 2010, totaling 6 hours 15 minutes. Kitombe, the silverback, was the male on exhibit for two of the test sessions but because he was blind in one eye he did not have the eye-hand coordination needed to use a stick effectively. Therefore, Kitombe’s data from these two sessions were not used in the final analyses.

In the four session of *Experiment 1.2* when Joe and Okpara were on exhibit, two different arrays of four sticks were presented on different days at the beginning of a session. In one array of four sticks one stick was forked midway down; another had many side branches; a third one was forked with side branches; and the fourth one was a sturdy, fat, straight stick. In this array, only the fourth stick would make an efficient tool without modification, while the other three had features that would limit their use. The first stick

picked up was recorded as the stick chosen by that gorilla. Data were collected on two sessions in February and March 2010 using the same recording methods as described in Experiment 1.1. Forty five minutes of data were collected over these two sessions.

For the last two tests, in March 2010, the gorillas were presented with an array of four poorly designed extractor sticks to see if the gorilla would modify any of these sticks to obtain peanut butter from the tubes. One stick was a two foot branch with several branching side twigs; another was a very small, skinny, flimsy twig; the third was a foot and a half long, forked and fat; the fourth stick had many side branches. The data for these sessions, a total of 1 hour 6 minutes were collected using the same methods as Experiment 1.1, with additional notes taken on the behaviors used to modify the sticks.

Table 2 is a list of the dates of all the tests conducted on exhibit, the male gorillas present, the length of each testing session, and the experimental conditions of that session.

Experiment 2: Cloth Test

General Methods & Procedures

The platform tray used in the tests with Joe off exhibit in the holding area evolved from several preliminary studies with Kitombe. It consisted of a wooden tray, 18 x 18 in, bordered on three sides with 1 in. high strips of wood. A wooden barricade divided the tray in half lengthwise, creating two rectangular compartments with one opening in each, by which the gorilla could access the compartment with his hand.

Joe was separated from his house mate, Okpara, in the holding area before each session. The session began when a cloth strip (3" x 12") was placed in each compartment

of the tray that was out of reach but in sight of the gorilla. While the gorilla observed, a piece of fruit was placed on one of the strips (see details below). A bell was rung as a discriminative cue and then the tray was rolled on a dolly against the wire mesh side of the holding area that had a gap of about 2 inches at its bottom. At this time the gorilla could grab hold of the end of either cloth on the tray and pull it in. The loading of the cloth strips, the fruit, and the movement of the tray were conducted by a keeper well-known to the gorilla.

Joe had 10 seconds to make a choice between the cloths. The first cloth he pulled was counted as his choice. The tray was removed after he made a choice and the trial terminated whether or not he had selected the correct cloth. If he did not respond within 10 seconds the tray was pulled back, ending the trial.

In each experiment Joe's choices and other behaviors were recorded by an experimenter using a check sheet, see Table 3. The gorilla's behaviors were also videotaped for later analyses.

In Experiment 2.1

One cloth strip had a piece of fruit placed on the far end from the gorilla's perspective and the other strip had no fruit, as illustrated in Figure 3. When the tray was set in place to abut the housing area, Joe had the option to pull the end of one of the cloths into his habitat. The first cloth he pulled was recorded as his choice, and then the tray was removed. The locations of the fruit (left or right side) were counterbalanced and presented in a semi-random order. There were 4 separate days of testing with 6-14 trials per sessions totaling 1 hour and 57 minutes (see Table 4).

In Experiment 2.2

Joe was presented with a two-choice test in which he had to attend closely to either (a) the design features of the cloth, as illustrated in Figure 4, conditions 2, 3 and 4, or to (b) the placement of the fruit on the cloth, as illustrated in condition 5, in order to pull the cloth strip that would get him a piece of fruit. These four conditions were designed to test if Joe knew what features made a cloth strip a good tool.

The condition and order of presentation during these sessions followed a semi-random and counterbalanced protocol. Each of the paired conditions in Experiment 2.2 was first tested on different days. Then, on the last day of testing, all four cloth pairings were presented during the same session using randomly mixed trials. See Table 4 for a list of all the testing dates and experimental conditions for Experiment 2.

Results

Inter-rater Reliability Tests

The behaviors recorded on the On Exhibit Recording Sheet (Table 1) were defined and explained to all observers who participated in the inter-observer reliability tests. Three observers independently scored each of the videotaped test sessions for Experiment 1.1 and 1.2 and these scores were subject to all possible pair-wise comparisons to generate a % agreement score for each session. The average inter-observer reliability score for these sessions was 82.3%.

Experiment 1.1 on Exhibit: Tube Feeder with Standard Sticks

Joe successfully used one of the provided sticks as a tool to obtain peanut butter from the tubes on the first encounter with the feeder. On successive days the frequency of his tool use increased. Joe's proficiency also increased over the sessions as indicated by his ability to acquire more peanut butter per poke into the tubes that resulted in his consuming all the peanut butter in less time as the sessions progressed (see Figure 5). As his proficiency increased the number of stick pokes decreased accordingly. While the time taken to consume the peanut butter and the number of stick pokes decreased substantially about mid-way through the Experimental sessions, there was a slight increase in these measures from sessions 13 onward when Experiment 1.2 began. These changes in the dependent variables could be explained by the fact these were the sessions where Joe was given poor extractor sticks that needed modifications to work as a tool and even after modifications the sticks were not as ideal as those in Experiment 1.1.

Kira was the only female gorilla on exhibit to have some success using a stick as a tool. She managed to retrieve some peanut butter with her finger, but she was only able to use a stick to extract peanut butter on the fifteenth and sixteenth session with 4 successful pokes and 3 successful pokes respectively, as indicated in Figure 6. Even in these sessions her skill level was far below Joe's success rate of 8 pokes on his first test day (Figure 5).

Kimani, the youngest female, although a frequent visitor to the feeder, sometimes picked up a stick, but did not show any competency in using the stick appropriately. Kiki, the mother, never showed any interest in the feeder at all. Gigi, the oldest female, did sometimes try to approach the feeder, but her very low social status made it difficult for

her to get significant experience with it. Okpara, the other male on exhibit with Joe and the females, showed very little interest in the feeder, sleeping through most of the sessions. When Kit, the father, was on exhibit with the females (without Joe and Okpara present), he only used a stick as a tool four times in all his sessions and his skill level as measured by attempt frequencies and success rate was low.

Importantly, Kit is blind in one eye and this may be the primary reason for his inability to use the sticks effectively to extract the peanut butter in this kind of tube test.

Experiment 1.2 on Exhibit: Array of Sticks to choose from for Tube Feeding

Joe was the only gorilla who came up to the door and made a deliberate selection. He was immediately able to select the most effective stick to extract peanut butter from an array consisting of one well-designed stick and three poorly designed sticks. Moreover, when presented on another session with a different array that consisted of only poor extractor sticks, Joe picked the stick with the largest diameter out of the bunch and modified it into a more efficient one. Specifically, he turned the stick around to use the end with fewer obstructing side branches and broke the stick down into a shorter, more manageable tool. The stick he chose to modify was most like the sticks he preferred to use in Experiment 1.1. It had the largest diameter, and after modification was long enough to reach the peanut butter, but not so long as to make orienting and guiding the stick into the tube difficult.

Experiment 2: Cloth Test

Joe's success rate in choosing the correct cloth was higher than chance (50%) each time he was presented with a new condition, whether it was in a separate, see Figure 7, or mixed trial session, see Table 5. Joe's first encounter with the cloth test was during experiment 2.1 with condition 1 (fruit vs. no-fruit choice). He correctly picked the cloth with the fruit on it 71.4% of the time. After the first few trials in a session for each condition, his choices in the remaining trials of the sessions were generally correct with his success rate staying above chance in most session. In the experiment 2.2 he had a 100% success rate the first time he worked condition 2, and an 80% success rate the first time for condition 3 and 72.7% success rate the first time with condition 4.

Discussion

General

This study was based around the question of whether captive Western Lowland gorillas could use tools. Joe's abilities to use objects effectively in obtaining food rewards in two different problem tests demonstrate that he can use tools. The use of a stick to extract food from a tube in the first experiment has been demonstrated in other captive gorilla groups (Pouydebat et al. 2005, Lonsdorf et al. 2007). However his ability to select the most efficient stick when given a choice, and, when needed, to modify a stick appropriately in Experiment 1.2 suggests that he also understands what features of an object make it a tool. These demonstrations in understanding have not been shown before and indicate the kind of underlying cognitive ability that a gorilla may be using in these

types of tasks. Joe's comparable success in using a very different object, a cloth strip, as a tool in Experiment 2 under a variety of conditions that rely on comparable cognitive abilities provide evidence that his tool-using skills can also be applied to solve a variety of problems in which a tool-using strategy is helpful.

Although Kira's success in using a stick as a tool by the end of Experiment 1 was limited, it does suggest that other gorillas in this group can use tools as well. However, the general lack of successful tool use by the females on exhibit is notable since another study using the 'termite fishing' set-up with captive gorillas groups at the Lester E. Fisher Center for the Study and Conservation of Apes at the Lincoln Park Zoo in Chicago found that young and adult females were very successful in using stick tools (S. R. Ross, personal communication to HJ, 2009). The social dynamics of the group at the Boston zoo may provide some possible reasons for the failure to find significant tool-using behaviors in the females.

Studies on the acquisition of tool using behaviors in wild chimpanzees show females usually pick up tool using earlier, and spend more time engaged in termite-fishing, than the males (Lonsdorf 2004). In addition, the chimpanzees were learning this technique from their mother. Interestingly, in a study with vervet monkeys, E. van de Waal et al. (2010) showed that juvenile monkeys learned significantly better from adult females than from males (van de Waal et al., 2010). Informal observations of the gorilla groups at the zoo in Chicago also suggested that the young gorillas were learning or developing their termite fishing behaviors by watching their mothers use the sticks (S. R. Ross, personal communication to HJ, 2009).

These studies with a variety of primate species indicate that adult females, and mothers in particular, play an important social role in the learning process of the young. In our captive gorilla group, Kiki, the mother, never once showed any interest in trying to use the feeder and the older female, Gigi, rarely and only briefly worked at the feeder. This could explain why over the 9-month period of this study Kira was substantially delayed and not very successful in learning how to use the stick as a tool, and why Kimani never did.

Another reason for the young females' lack of success could be due to Joe's dominance during the tests so they had little opportunity to work with the feeder when it was loaded with food at the beginning of the sessions. As a result, the feeder was cleared or substantially reduced of peanut butter, leaving little reward for any effort made by the young to use the stick. In addition, the feeder was positioned high up on the training door. This position had the tubes placed at Joe's eye level but was above the eye level of the smaller females. Thus, this position of the feeder might have impaired the younger females' ability to successfully insert the stick at the correct angle to access peanut at the peanut butter at the far end of the tube.

Finally, Kimani is at an age when she might not have reached the developmental stage needed to master the art of tool using. In the study of termite fishing in wild chimpanzees at the Gombe reserve (Lonsdorf 2004), it was not until the age of three and a half that all the chimpanzees had started interacting with both the termite mound and the extraction sticks and it was not until chimpanzees were five and a half years of age that they were observed successfully extracting the termites with sticks on a regular basis. Kimani at 5 years of age was often observed hitting the plastic feeder plate with sticks, or

pushing the sticks through the wire mesh door but around or under the feeder. This suggest that she may be in an early, perhaps the sensori-motor or cognitive, phase of development for using objects in this way. If our current study were to continue, and Kimani had better access to the feeder without Joe's interference, she might begin using the sticks as tools, as was observed with her older sister who was 10.

Joe

According to the zoo keepers at Franklin Park Zoo, Joe is a very inquisitive gorilla. Previous unpublished research from our research group on the personality characteristics of the gorillas in this group, along with our own experiences with the gorillas in the current study, support the assessment that Joe is a very curious gorilla. While we used food as an incentive, Joe may have worked just as much for the novelty of the experience with the tasks as for the snack. In addition, Joe also showed a strong interest in the primary experimenter in this study, who is female (HJ). On the other hand the other gorillas showed little if any interest in a particular experimenter. While we do not know the exact impact of Joe's particular interest in human females in this study, it may well have motivated him to work harder with us both on exhibit and in the holding area.

On exhibit Joe was the most dominant and displayed the most interest in the tube feeder. He was the first to use it during each session and would sometimes actively defend and hoard the feeder area. As a result, he got first choice of the sticks and freshly loaded peanut butter tubes. This behavior gave Joe more experience with the feeder than

the other gorillas and may have contributed to the increase in his skill level in extracting the peanut butter over the duration of the this experiment (Table 5).

Joe was able to use other objects as tools as well, shown in his success in experiment 2 with the cloth tests. He correctly picked the cloth with the fruit on it 71.4% of the time which is greater than the chance rate of 50%, during his first experience with the cloth test using condition 1 (fruit or no-fruit). Most of the subsequent sessions with this condition were also above chance (see Figure 7). However, in sessions 5 and 6 Joe's success rate was 50% and 60%, respectively. This was probably due to the fact that this was the 4th time he was being tested on this relatively easy condition and he was bored. Also, on the 5th session the keeper administering this test had not worked with us before and did not keep to the protocol as well as the other keepers.

In experiment 2.2 Joe had to understand that for the cloth to be a tool it had to be intact and not cut. To make sure Joe was not using the dark brown of the background in the space of the cut cloth as a cue to identify the incorrect cloth, we tried conditions 2.3 and 2.4. Both cloths in these choices had cutouts showing the dark brown background, but in only one of the cloths was there a connecting piece. He would not be successful in choosing the correct cloth more than chance if he was just using the dark brown of the cut-out space as the cue for his selecting the cloth. During the first session with these trials of 2.3 then 2.4, his success rate was 80% and 72.7% respectively, indicating he must have been paying attention to the features of each cloth, looking for the one that had the connecting piece. The ability to identify the key features and then select from among various possible objects the most appropriate object for a tool, suggests that he possesses a fairly high level of cognitive skills.

Conclusion

This study has shown that at least one captive gorilla, an adult male, can use objects as tools and, in some cases, modify an object to create an effective tool. Modifying a tool shows that the gorilla understands what the tool needs to be successful and how to change that tool to make it so. Since Joe performed well on all the tasks he was presented with, it would be interesting to try these same tasks with gorillas of Joe's lineage in other zoos. Would Joe's relatives be as inquisitive and as successful in these kinds of tests as he was? By examining Joe's close relatives, not only would there be a new group dynamic to investigate, but there might be a positive correlation between tool using success and genetic relatedness, opening up a new line of investigation of psychobiological contributions to tool using behaviors in gorillas and other great apes.

Continuing the tube feeder task with a few adjustments might give more insight into the abilities of the younger gorillas, as well as the effect of developmental and social variables on tool using. Additionally, if the feeder was lowered to eye level for the young females and they were given access to it without any males around, their performance on this feeder task might increase. In this way, the role of methodological and social variables in influencing the expression of tool-using capabilities could be systematically studied.

Beyond these research considerations, the present tool-using demonstration suggests a relatively simple and inexpensive method that could be incorporated into enrichment programs in zoos for the benefit of both the gorillas and the visitors.

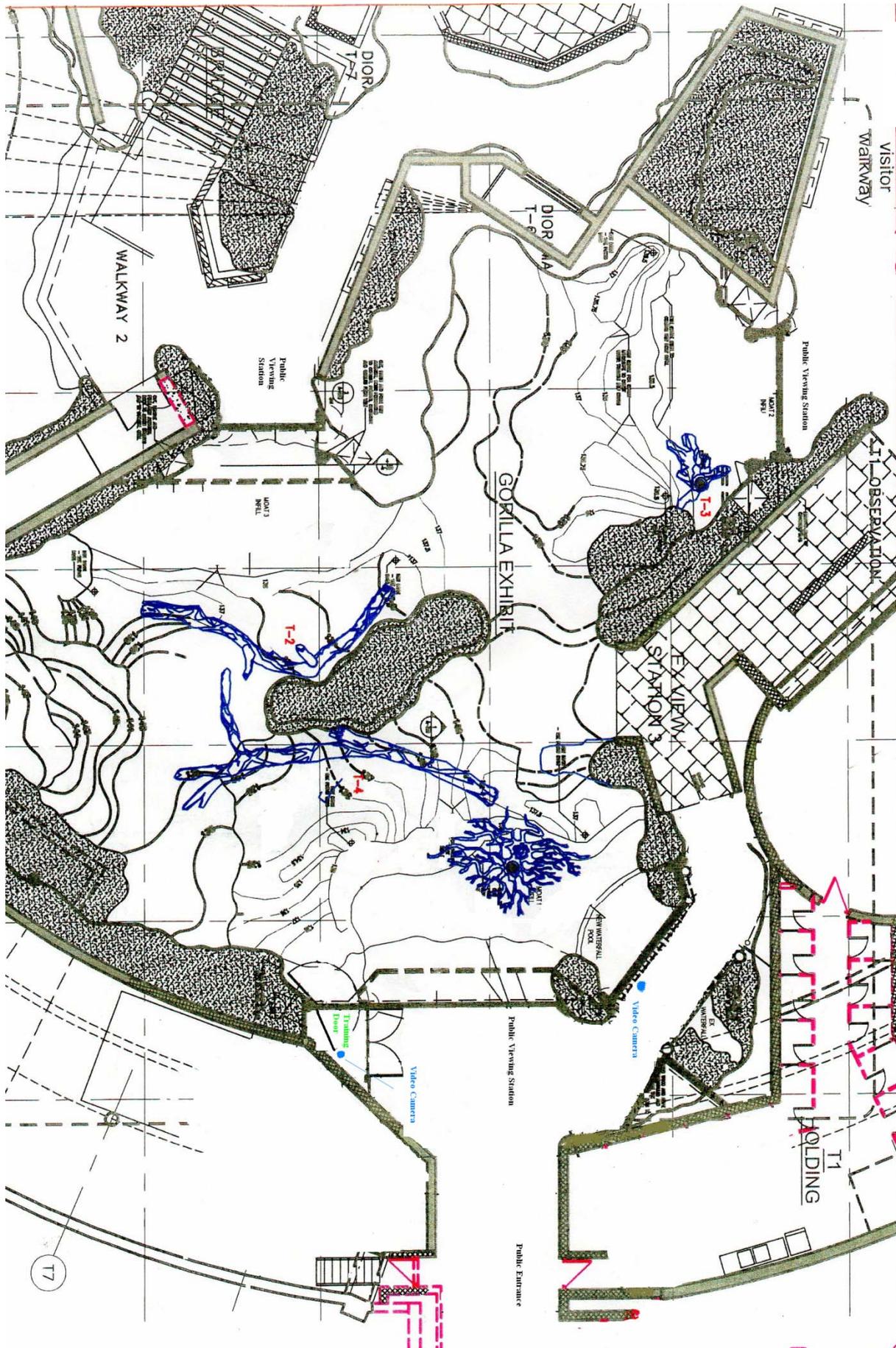
References

- Bluff, L.A., Weir, A.A.F., Rutz, C., Wimpenny, J.H., and Kacelnik, A. (2007). Tool-Related Cognition in New Caledonian Crows. *Comparative Cognition and Behaviour Reviews* 2, 1-25.
- Boesch, C., Head, J., and Robbins, M.M. (2009). Complex tool sets for honey extraction among chimpanzees in Loango National Park, Gabon. *Journal of Human Evolution* 56, 560-569.
- Breuer, T., Ndoundou-Hockemba, M., and Fishlock, V. (2005). First Observation of Tool Use in Wild Gorillas. *Public Library of Science* 3, e380.
- Finn, J.K., Tregenza, T., and Norman, M.D. Defensive tool use in coconut-carrying octopus. *Current Biology* 19, R1069-R1070.
- Gomez, J.C. (1999). Development of sensorimotor intelligence in infant gorillas: the manipulation of objects in problem-solving and exploration. Parker ST, Mitchell RW, Miles HL, editors. *Mentalities of Gorillas and Orangutans*. Cambridge: Cambridge University Press.
- Goodall, J. (1986). *The Chimpanzees of Gombe: Patterns of Behavior*. Cambridge, Massachusetts: Harvard University Press.
- Hall, K.R.L., and Schaller, G.B. Tool-Using Behavior of the California Sea Otter. *Journal of Mammalogy* 45, 287-298.
- Hauser, M., Kralik, J., and Botto-Mahan, C. (1998). Problem solving and functional design features: experiments on cotton-top tamarins, *Saguinus oedipus oedipus*. *Animal Behavior* 57, 565-582.
- Herrmann, E., Wobber, V., and Call, J. (2008). Great Apes' (*Pan troglodytes*, *Pan paniscus*, *Gorilla gorilla*, *Pongo pygmaeus*) Understanding of Tool Functional Properties After Limited Experience. *Journal of Comparative Psychology* 122, 220-230.
- Krutzen, M., Mann, J., Heithaus, M.R., Connor, R.C., Bejder, L., and Sherwin, W.B. Cultural Transmission of tool use in bottlenose dolphins. *Proceeding of the National Academy of Science* 102, 8939-8943.
- Lonsdorf, E.V. (2004). Sex differences in the development of termite-fishing skills in the wild chimpanzees, *Pan troglodytes schweinfurthii*, of Gombe National Park, Tanzania. *Animal Behavior* 70, 673-683.

- Lonsdorf, E.V., Ross, S.R., Linick, S.A., Milstein, M.S., and Melber, T.N. (2009). An experimental, comparative investigation of tool use in chimpanzees and gorillas. *Animal Behavior* 77, 1119-1126.
- Martin-Ordas, G., Call, J., and Colmenares, F. (2008). Tubes, tables and traps: great apes solve two functionally equivalent trap tasks but show no evidence of transfer across tasks. *Animal Cognition* 11, 423-430.
- Pouydebat, E., Berge, C., Gorce, P., and Coppens, Y. (2005). Use and Manufacture of Tools to Extract Food by Captive *Gorilla gorilla gorilla*: Experimental Approach. *Folia Primatologica* 76, 180-183.
- Tebbich, S., Taborsky, M., Fessler, B., and Blomqvist, D. (2001). Do Woodpecker Finches Acquire Tool-Use by Social Learning?. *Proceedings of the Royal Society: Biological Sciences* 268, 2189-2193.
- van de Waal, E., Renevey, N., Favre, C.M., and Bshary, R. (2010). Selective attention to philopatric models causes directed social learning in wild vervet monkeys. *Proceedings of the Royal Society: Biological Sciences*, 1-7.

Appendix:
Figures and Tables

Figure 1: Aerial View of Gorillas Exhibit at Franklin Park Zoo



Video Camera
Set up
Training Door

Figure 2: Joe at feeder, with Kimani looking on



Table 2: Dates, Dominant Male, and Lengths of On Exhibit Testing Sessions

Experiment 1.1: Feeder + standard sticks

1. 7/30/09 Joe 40mins
2. 8/6/09 Kit 28mins^Δ
3. 8/7/09 Joe 37mins
4. 9/14/09 Joe 37mins
5. 9/21/09 Joe 36mins
6. 10/5/09 Joe 26mins
7. 10/30/09 Kit 25mins*
8. 11/2/09 Joe 46mins
9. 11/16/09 Joe 35mins
10. 1/27/10 Kit 28mins^Δ

* *data not used*

^Δ *data for Kitombe not used*

Experiment 1.2: Feeder

+ *Array of sticks to select*

11. 2/1/10 Joe 20mins
12. 2/24/10 Kit 30mins *
13. 3/10/10 Joe 25mins
14. 3/14/10 Kit 32mins *

Experiment 1.2: Feeder

+ *Array of sticks to modify*

15. 3/22/10 Joe 36mins
16. 3/24/10 Joe 30mins

Table 4: Dates, Cloth Conditions (1-5), Number of Trials, and Durations for

Experiment 2 Tests

1. 11/19/09: 1 (14 trials) 17mins
2. 11/23/09: 1(6 trials) & 2 (11 trials) 17mins
3. 11/30/09: 2 (10 trials) 10mins
4. 2/14/10: 1 (10 trials) & 5 (11 trials) 15mins
5. 2/16/10: 1 (10 trials) & 2 (6 trials) 10mins
6. 3/9/10: 2 (10 trials), 3 (10 trials) & 4 (11 trials), 27mins
7. 3/17/10: 2 (5 trials), 3 (5 trials), 4 (5 trials), & 5 (5 trials) 21mins

Figure 3: Cloth Test Condition 1



Figure 4: Cloth Test Conditions 2-5

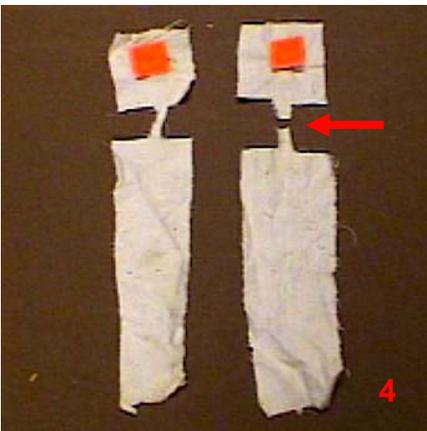
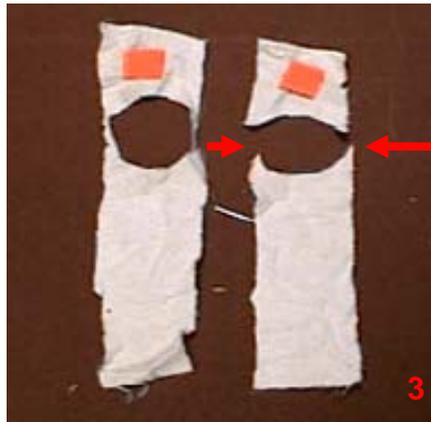
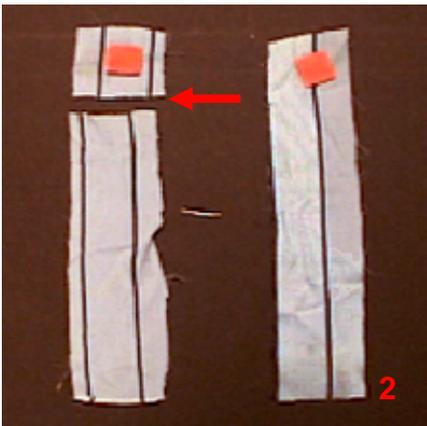


Fig. 5 Joe's Extractive Fishing Behavior in Experiment 1.1 & 1.2

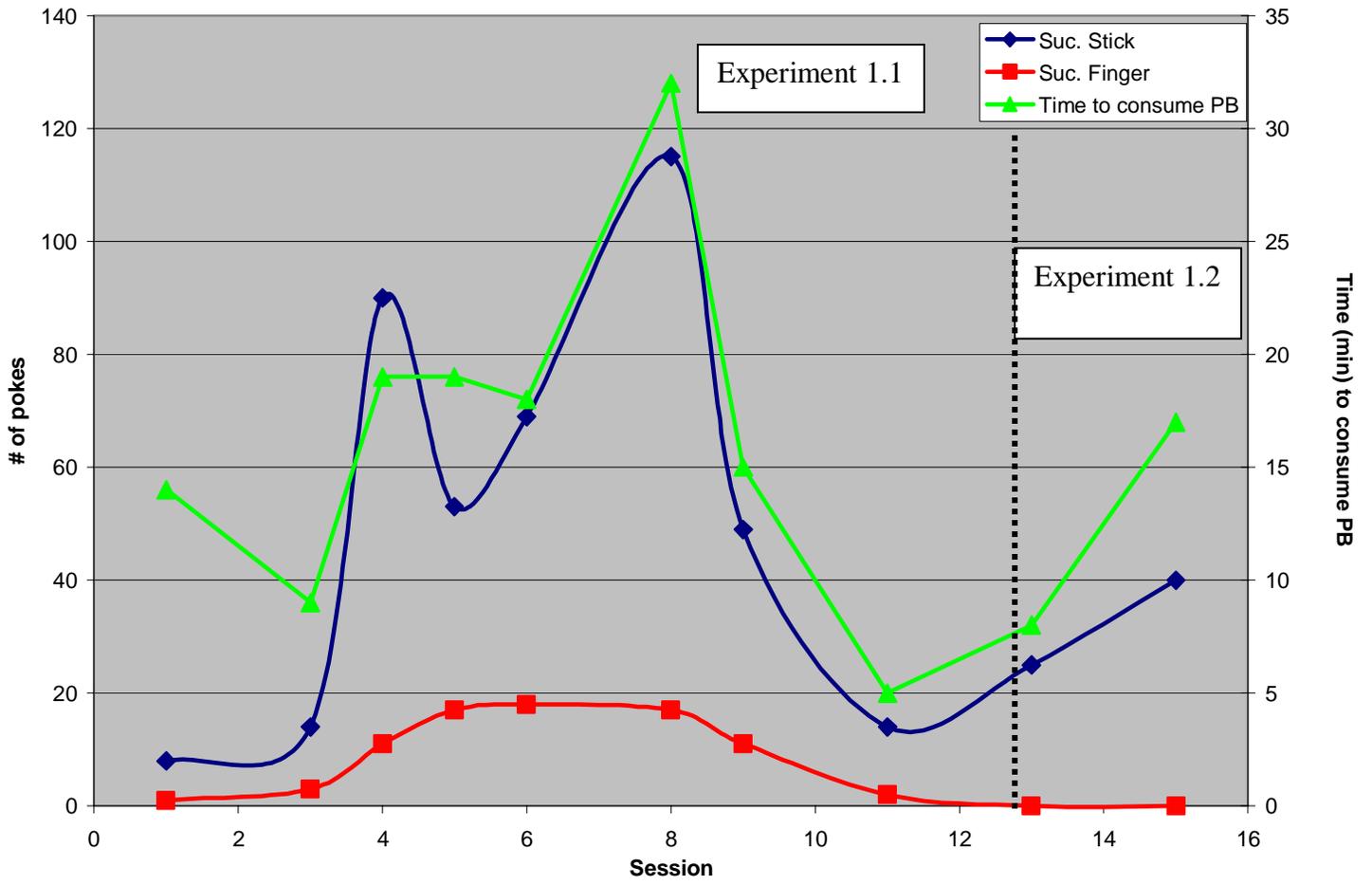


Fig. 6 Kira's Extractive Fishing Behavior in Experiments 1.1 and 1.2

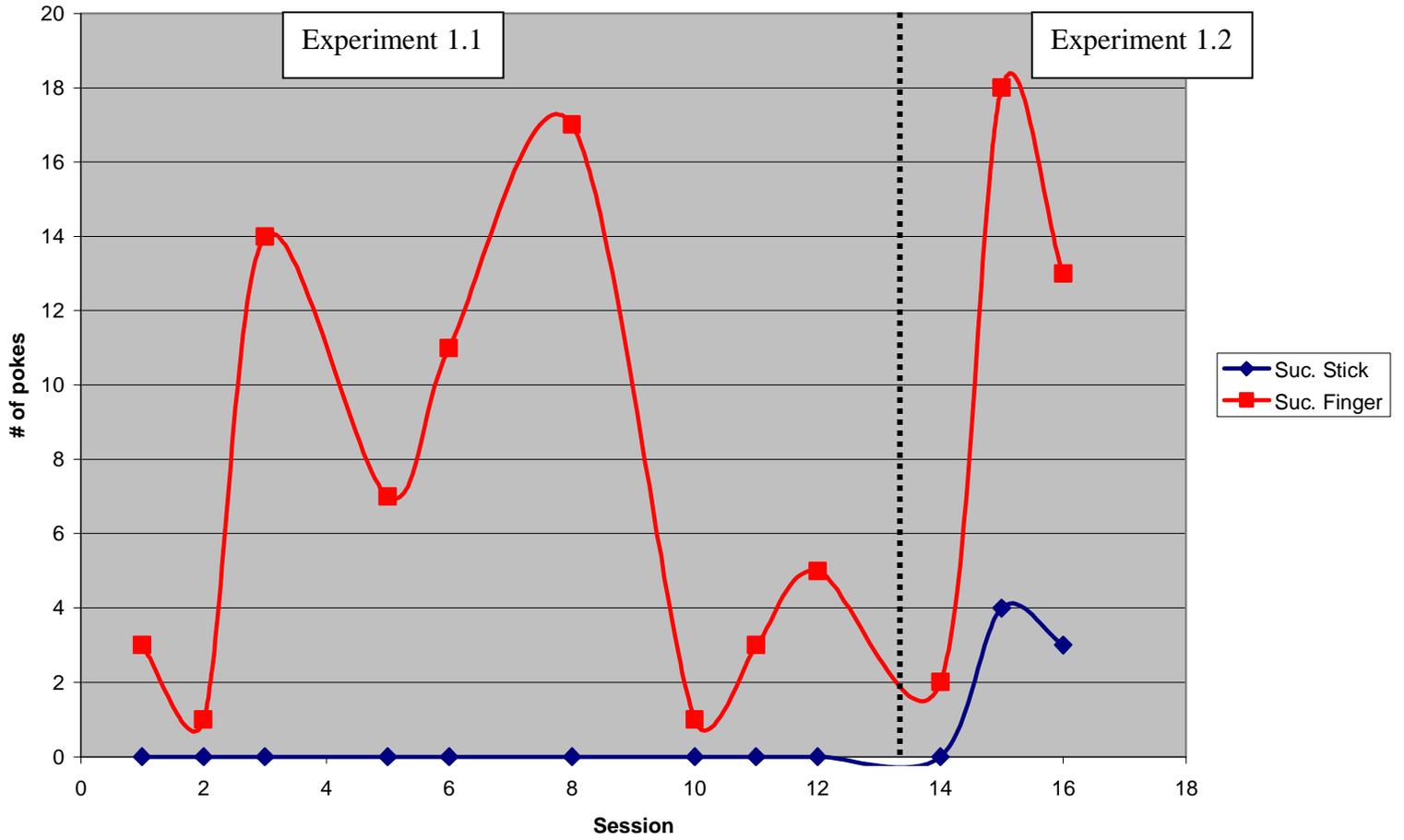


Fig. 7 Joe's Cloth Choices

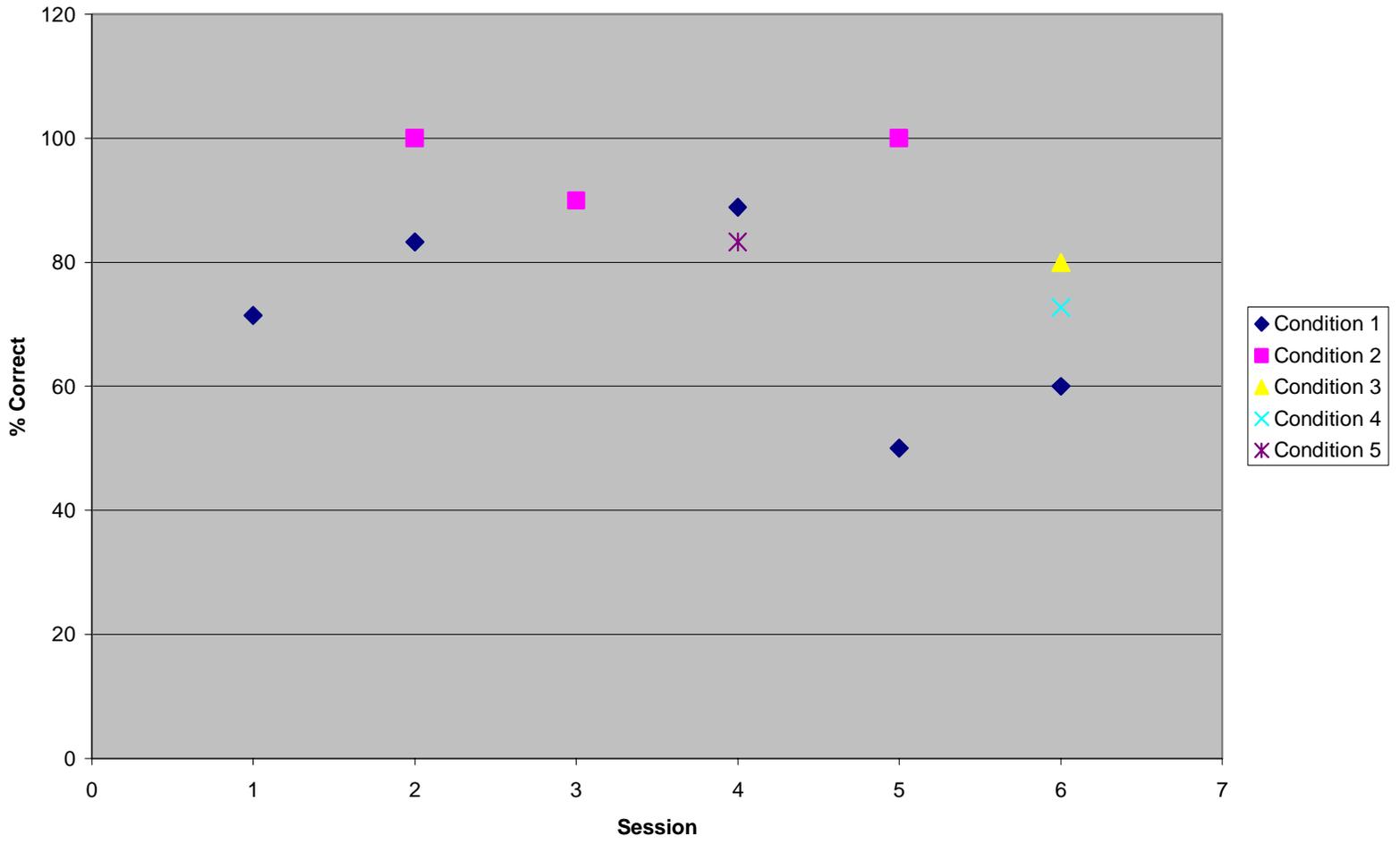


Table 5: Scores for Individual Conditions Presented in Separate or in a Mixed Trials Session.

Condition	% Correct	
	Separate	Mixed
1	70	NT
2	90.3	40
3	86.7	100
4	75	66.7
5	82.4	80