other mineral oils alone. They involved the oil granuloma and were associated with ascites that contained the characteristic large plasmacytoma cells.

Twenty-three of the 26 primary plasmacytomas produced a myeloma protein. The heavy chain class of immunoglobulins (IgC_H) was immunoglobulin A (IgA) in 18 (69 percent) cases and immunoglobulin G (IgG, γ2a or γ2b) in 5 (11.8 percent). The myeloma proteins differed from each other in electrophoretic mobility (see Fig. 2). The restriction of immunoglobulin production to a single class, and the individuality of the electrophoretic mobility suggest, but do not prove, that these tumors are monoclonal.

Seven of the plasmacytomas have at this time been transplanted to new recipients. The transplants were made into pristane-treated mice in order to rapidly establish the tumors in transplant (*10*). In the five cases tested so far the myeloma proteins produced in the transplanted tumors were identical in class and electrophoretic mobility to the proteins produced in the respective primary host.

The ascites and serum from pristane-treated mice that developed lymphosarcomas have also been studied in both agar gel electrophoresis and immunoelectrophoresis, and no myeloma proteins have been observed.

The oil-primed peritoneum is clearly necessary for development of plasmacytomas in this system, since no plasmacytomas have been reported by others or observed by us in unprimed mice given MLV-A. Since mineral oil alone will eventually induce plasmacytomas, the question arises of the principal role of the virus: that is, is it a direct transforming agent, or merely a helper or accelerator of a process that would occur in any case? A plausible interpretation of our results is that MLV-A infection induces transformation of plasma cells or their precursors, while the role of pristane might be either to increase the number or susceptibility of the target cell population, or to induce microenvironmental changes in the peritoneum that are essential for the growth of transformed cells into detectable plasmacytomas (*10*).

As mentioned previously, our MLV-A preparations contain at least three different viral components. Any one or any combination of these might be the plasmacytomagen.

Several applications of this system are readily apparent. The marked reduction in the induction time for plasmacytomas will facilitate determining factors involved in the pathogenesis of plasmacytomas. Of major importance is the possibility of inducing plasmacytomas that produce antibodies to a given specific antigen. Because of the rapidity of the process, it should be possible to use the virus to investigate the genetic basis of the vastly different susceptibilities of different mouse strains for oil-induced plasmacytoma formation. Finally, the discovery that a virus can induce plasmacytomas in the oil-primed mouse provides a system for looking for other viruses, especially endogenous ones, that can do the same.

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7. LDV virus determination was made by Dr. J. Parker, Microbiological Associates, Inc., Bethesda, Maryland.
8. Pristane was purchased from Aldrich Chemical Company, Milwaukee, Wisconsin.
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Cooperative Tool Use by Captive Hamadryas Baboons

Abstract. *A bonded pair of hamadryas baboons developed cooperative tool use without training. The male could get food with the tool but first had to get the tool from an adjoining cage which he could not enter. The female learned to give him the tool. Cooperation was temporarily disrupted by the terminal phase of the female's estrous inflation.*

Cooperation is common in many insects, birds, and mammals (*1*). However, it usually occurs in highly evolved protective, reproductive, and subsistence patterns and is not indicative of a capacity to cooperate in the face of novel environmental demands. Laboratory studies of cooperative problem-solving can expose such plasticity and reveal the dynamics of learned cooperative behavior. Rhesus monkeys can be trained to use the anticipatory affective or orienting responses of another rhesus as conditioned stimuli for operant discriminations (*2*), but other attempts to produce cooperative problem-solving by monkeys, even with patient training, have been generally unsuccessful (*3*). Chimpanzees are capable of cooperative problem-solving (*4, 5*), and Menzel (*6*) has reported spontaneous cooperative tool use by captive chimpanzees. I describe here cooperative problem-solving, involving tool use, by untrained monkeys.

In a previous experiment (*7*), a subadult male of a captive harem of hamadryas baboons (*Papio hamadryas*) learned, without training, to use an L-shaped tool to procure a pan of food which was out of reach. The tool use was learned by instrumental trial-and-error, resulting fortuitously from exploratory manipulation of the tool. The same harem, containing the tool-using male, was used in the present experiment. During this experiment, the harem consisted of eight animals: male-1, the harem leader, adult male estimated to be over 40 years old; female-1, adult female, estimated to be 10 years old; male-2, the tool user, young adult male born 20 April 1967; female-2, young adult female born 11 August 1968; female-3, young adult female born 21 August 1969; male-3, juvenile male born 9 May 1970; female-4, juvenile female born 30 January 1971; male-4, infant male born 14 February 1972. Male-1 and female-1 were the parents of all the other animals. Female-2 had formed a sexual bond with

male-2, as evidenced by her bearing an infant by him (the infant was removed from the group), and female-3 was forming a sexual bond with male-2, as evidenced by her becoming pregnant by him during the experiment. The harem was housed in two adjoining cages, each 356 by 183 by 239 cm (Fig. 1). A door, 12.7 cm wide, joined the two cages. Male-2 was confined to one cage and male-1 and female-1 were confined to the other, since they were too large to pass through the door. The other animals were small enough to pass through the door and thus had access to both the male-2 cage and the male-1/female-1 cage. During testing, a black wooden platform extended out from the male-2 cage at the level of the cage floor, and an aluminum pan filled with highly preferred fruits and vegetables was placed on the board 53.5 cm from the barred cage front, 5 cm beyond male-2's reach. The L-shaped tool was made of ⅜-inch (0.95-cm) threaded steel rod with a shaft 84 cm long and a hook 11.5 cm long. The tool was placed on the floor of the male-1/female-1 cage, as far from the door as possible.

I conducted the experiment on 75 mornings between 11 July and 26 October 1972. Sessions began at about 0815 and were terminated when visitors or keepers disturbed the group (usually about 1015) or when the animals had gotten the pan four times. At the end of each session the group was fed its usual daily ration of 2.5 kg of monkey chow and one orange cut into eighths.

With a stopwatch I recorded the duration in seconds of each trial. A trial began when I placed the tool in the male-1/female-1 cage and ended when male-2 got the food pan. Trials discontinued by the end of a daily session were resumed in the next session, and duration time was accumulated. I recorded the time from male-2's getting the tool to his getting the food pan and estimated the percentage of the food eaten by each group member. I took 5-second time samples every 5 minutes, noting which animal(s) was touching the tool, and made written descriptions of all behavior involving the tool and of other behavior which I felt to be relevant to problem solution. I also monitored estrous cycling and sexual behavior of the mature females.

Male-2 got the tool and used it to get the food pan 200 times. Figure 2 presents average trial duration for successive blocks of eight consecutive trials each. Although 7 months had elapsed since male-2 had last used the tool, he showed total recall. The overall mean time for him to get the pan after getting the tool in the present experiment was only 43 seconds, a small fraction of total trial duration.

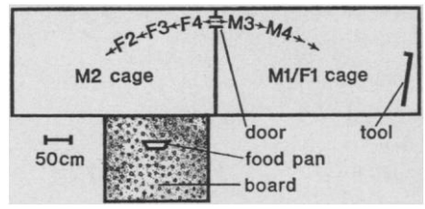

Fig. 1. Schematic ground plan of experimental setting. Male-1 (*M1*) and female-1 (*F1*) are confined to the cage on the (reader's) right and male-2 (*M2*) to the cage on the left, since they are too large to pass through the door. Female-2 (*F2*), female-3 (*F-3*), male-3 (*M3*), female-4 (*F4*), and male-4 (*M4*) are small enough to have access to both cages. To get food, male-2 must first get the tool from the male-1/female-1 cage and then use it to get the pan.

There were two modes by which male-2 got the tool from the male-1/female-1 cage. In one, called "independent acquisition" by Nissen and Crawford (*5*), male-2 simply grabbed the tool if another animal brought or dropped it within his reach. This mode was distinctly characterized by squealing by the animals from whom male-2 grabbed the tool and by their attempts to pull it back from him. Clearly, on independent acquisition trials, there was no attempt by the other animals to give the tool to male-2; rather, he simply took it from them. Of the 200 trials, 27 involved independent acquisition. Male-2 grabbed the tool from male-3 or female-3 on 22 of the 27 independent acquisition trials. The average duration of independent acquisition trials was 3399 seconds, and only one (36 seconds) was under 120 seconds.

The second mode by which male-2 got the tool was by another animal's passing it to him by bringing it through or to the door and giving it to him without squealing or attempting to prevent his getting it. Only one animal, female-2, provided male-2 with the tool in this passing mode.

Female-2 first passed the tool to male-2 on the fifth trial. During the first four trials, female-2 had not even touched the tool. She had eaten some of the food procured by male-2 after he had grabbed the tool but otherwise she had shown no behavioral evidence of involvement in the problem situation. On the fifth trial, she twice tried to reach for the food pan with her hand, an incorrect (unrewarding) response which other group members had also tried frequently. At 12,030 seconds of the fifth trial, female-2 and male-2 were engaged in mutual grooming in male-2's cage when she saw the tool lying loose in the male-1/female-1 cage. Female-2 abruptly left the grooming bout, entered the male-1/female-1 cage at 12,060 seconds, and picked up the tool at once. She carried the tool into the male-2 cage at 12,090 seconds where she sat holding the tool and watching male-2. Male-2 sat close to her, watching her and the tool attentively, but he did not try to take it. At 12,450 seconds, female-2 put the tool down, whereupon male-2 picked it up and began at once to use it to get the pan. He got the pan at 12,471 seconds and he and female-2 ate 99 percent of the food in about equal proportions.

Trials 6 through 13 were independent acquisition trials. Female-2 touched or held the tool only 13 times during these trials. Although female-2 ate some food secured by male-2, there was no evidence that she recalled her behavior in the solution of trial 5.

After 1320 seconds of trial 14, female-2 picked up the tool in the male-1/female-1 cage and brought it into male-2's cage at 1950 seconds. Again male-2 watched her and the tool attentively but made no attempt to take it. At 1995 seconds female-2 dropped the tool and male-2 picked it up at once and got the pan at 2003 seconds.

Female-2's cooperative behavior then became firmly established: on 171 of the succeeding 186 trials female-2 passed the tool to male-2 by taking it through or to the door and giving it to him. The average duration of the 173 passing trials was 964 seconds, only 28 percent of that of independent acquisition trials. The shortest passing trial duration was 9 seconds, and duration was less than 120 seconds on 40 passing trials. The abrupt decrease in average trial duration seen in the third trial block in Fig. 2 marks female-2's mastery of passing the tool.

Female-2's emitting the complete correct response sequence (retrieving the tool and bringing it to male-2's cage) suddenly after a period of non-problem-directed behavior (grooming and so forth) which in turn followed incor-

rect attempts at problem solution (reaching by hand for the food pan) fits the operational definition of insight, a unique learning process (*8*). Trial-and-error learning in initial solution is counterindicated by the fact that female-2 had never even touched the tool during the experiment before she first brought it to male-2. Further, I have never seen female-2 or any other group member bring other available objects or food through the door to male-2. Female-2's lack of immediate recall of the response is also consistent with previous observations on insightful problem-solving by primates (*8*).

Although female-2 actively provided the tool to male-2, other group members actively tried to keep it from him. Of those time samples in which at least one animal had the tool, female-2 had it in 15.1 percent, while other group members had it in 84.9 percent. Yet male-2 got the tool from female-2 in 87.5 percent of the trials (173 passing and 2 independent acquisition trials), while he got it from others in only 12.5 percent (25 independent acquisition trials). Male-2 communicated differently with female-2 than with other group members when they had the tool in the male-1/female-1 cage. He lipsmacked (an appeasement gesture) to female-2 18 times but threatened her only 17 times; respective totals for other group members were 8 and 243. When female-2 got the tool, male-2 commonly walked away from the door looking back at her over his shoulder, a behavior used by hamadryas males to elicit following by females. I suggest that female-2's established sexual bond with male-2, characteristic for this species (*9*), uniquely predisposed her to cooperate with him. Other group members showed no evidence of learning to provide the tool to male-2 despite their eating food secured by him and despite their repeated observation of female-2. The lack of observation learning of tool-using behavior by baboons is consistent with previous findings (*10*).

Male-2 ate an average of 73.9 percent of the food. Female-2 got 15.7 percent and other group members (mainly male-3 and female-3) got 10.4 percent. Proportions were essentially the same for independent acquisition and passing trials.

The chief source of variation in trial duration resulted from female-2's estrous cycling. She had two cycles during the experiment. In cycle 1, perineal inflation began on 28 August (in trial block 4) and turgescence was reached on 13 September (in block 9). Perineal deflation began on 15 September (in block 10) and ended on 19 September (in block 12). In cycle 2, inflation began on 2 October (in block 16) and turgescence was reached on 19 October (in block 23). Deflation began on 23 October (in block 24) and ended on 26 October (in block 25).

Fig. 2. Average trial duration for successive blocks of eight consecutive trials each.

With no perineal inflation, female-2 gave the tool to male-2 promptly, sat next to him while he got the pan, and ate an average of 17 percent of the food.

Shortly after the onset of inflation in both cycles, male-2 began to keep female-2 in his cage by sitting near the door and blocking it with his body when she tried to leave. If, during a trial, female-2 entered male-2's cage without the tool, she could not freely return to get it. When she brought the tool to male-2, she could not freely return to get it during the next trial. While male-2 was herding her in this way, female-2 paced continually, squealed frequently, and made many attempts to escape but could do so only when male-2 was sufficiently distracted to allow her to bolt through the door. This herding resulted in a transient increase in trial duration, reflected in trial blocks 5 and 17 in Fig. 2. As perineal inflation proceeded, female-2's behavior changed. She either did not enter male-2's cage at all after giving him the tool or entered and exited quickly, snatching only a few bits of food. This change in female-2's behavior countered male-2's herding but decreased the amount of food she got to eat. Yet she continued to bring the tool promptly to male-2.

During the terminal phase of female-2's inflations (when perineum size was 76 to 100 percent of maximum), average trial duration increased markedly to 1740 seconds ($N = 22$), significantly longer than the mean of 794 seconds ($N = 40$) for those passing trials after mastery when female-2 showed no perineal swelling (Mann-Whitney U test, one-tailed, $U = 319$, $z = 1.78$, $P < .05$). This increase is reflected in trial blocks 9 and 10 (for cycle 1) and 22 and 23 (for cycle 2) in Fig. 2. During the terminal inflation phase female-2 often ignored the tool for long periods as it lay loose in the male-1/female-1 cage or, if she did pick it up, she simply held or manipulated it before finally giving it to male-2. Additionally, male-2 took longer to get the pan with the tool. Again, during terminal inflation female-2 either did not enter male-2's cage after giving him the tool or entered briefly to snatch a few bits of food. Male-2 got 74 percent of the food during the terminal inflation phase but female-2's share dropped to only 5.2 percent.

On the second day of full turgescence in cycle 1 and the third day in cycle 2, female-2's behavior changed radically. She began to enter male-2's cage readily, present, and willingly copulate with him repeatedly. This sudden increase in copulation corresponded to the onset of perineal deflation and probably marked ovulation (*11*). Before this point in the cycle, I saw male-2 and female-2 copulate only twice, including one case in which male-2 forcibly achieved intromission. Mean duration of passing trials during deflation decreased sharply to 395 seconds ($N = 27$), significantly less than that when female-2 showed no perineal swelling (Mann-Whitney U test, one-tailed, $U = 350$, $z = 2.43$, $P < .05$). This decrease is reflected in trial blocks 11 and 25 in Fig. 2. I felt that male-2 was purposely leaving food for female-2 during deflation. He ate only 57.9 percent of the food during this phase, while she got 29.2 percent of the food. These changes served to compensate for the terminal phase disruption and to fully restore the cooperative relationship.

This experiment demonstrates that monkeys, at least baboons, have the capacity to learn cooperative tool use without training. The acquisition and mastery of the behavior by this baboon group does not appear to differ fundamentally from cooperative tool use by captive chimpanzees (*6*). That male-2 and female-2 worked sequentially rather than concurrently and that each manipulated the tool in a different but essential fashion is consistent with Crook's definition of cooperation (*1*) and repre-

sents more complex cooperative problem-solving than seen previously in monkeys.

Both chimpanzees and baboons are commonly used as models for inferences regarding the behavior of early hominids. Baboons may be conceived as models for a more primitive hominid grade than that represented by chimpanzees. Since cooperation involving tool use is thought to have been instrumental in hominization it is of interest that extant baboons are capable of such behavior. Sophisticated tool behavior may considerably predate the differentiation and radiation of hominids in the Pleistocene. The disruption of cooperative behavior due to female-2's estrous cycling lends credence to speculation that the nearly continuous sexual receptivity of the human female is an adaptation to social and economic cooperation between bonded heterosexual pairs.

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Impairment of Timing Behavior after Prolonged Alcohol Consumption in Rats

Abstract. *Prolonged alcohol consumption (5 months) concomitant with adequate nutrition was found to impair the acquisition and performance of timing behavior. Alcohol was administered in the form of a liquid diet containing 35 percent ethanol-derived calories as the only source of fluid and calories. One control group received the identical liquid diet with isocaloric substitution of sucrose for ethanol, and another control group received laboratory chow and water without restriction. Thirty days after ethanol was discontinued in the diet, the alcohol-consuming rats were severely impaired in acquisition and performance of timing behavior as compared to controls.*

Brain damage or impairment of learning and recent memory, or both, often associated with chronic alcohol ingestion have been attributed to malnutrition, especially thiamine deficiency (*1*). However, brain damage and associated mental deterioration have also been reported in alcoholic patients with no history or clinical evidence of malnutrition, head trauma, or exposure to other toxic agents (*2*). Proper control of nutritional, environmental, and genetic variables is difficult in studies involving alcoholic patients, however. Investigations of the long-term effects of alcohol in animals is thus clearly desirable since the above variables can be precisely controlled.

The potential brain toxicity of ethanol in the absence of malnutrition has been demonstrated previously in an animal model (*3*). We have reported that mice (*4*) or rats (*5*) consuming ethanol-containing liquid diets for 3 to 7 months were severely impaired in shock avoidance learning when tested 2 to 18 weeks after ethanol was omitted from the diet. In order to determine whether the alcohol-induced impairment of shock avoidance learning reflects a more general learning deficit that is not specific to the shock avoidance situation, it is necessary to investigate the effect of prolonged alcohol consumption on subsequent acquisition of other behavioral tasks quite different from shock avoidance.

The purpose of the present investigation was to determine whether prolonged alcohol consumption, concomitant with more than adequate nutrition, would result in impairment of the acquisition and performance of a differential reinforcement of low rate (DRL) task (*6*). The DRL task has sometimes been referred to as timing behavior (*7*) because reinforcement by a food pellet is contingent on lever presses spaced apart at some specified time interval. In the present experiment prolonged consumption (5 months) of alcohol, incorporated into a nutritionally adequate liquid diet (*5, 8*), severely impaired the acquisition and performance of DRL 30 days after alcohol was omitted from the diet.

Twenty-four male Sprague-Dawley rats (Carworth CFE strain), 90 days old, were reduced to 85 percent of their body weights (when they were fed freely) and were trained to press a bar (*9*) to receive 45-mg food pellets (P. J. Noyes Co.) on a continuous reinforcement schedule (CRF). After CRF training was completed, all rats were given water and laboratory chow (Ralston Purina Laboratory Chow) without restriction for 3 weeks. Following the 3-week refeeding period, the rats were weighed and divided into three groups of eight rats matched as closely as possible for weight. The experimental group received a liquid diet containing 35 percent ethanol-derived calories (the alcohol group). A control group for the liquid diet was individually pair-fed the identical liquid diet except for isocaloric substitution of sucrose for ethanol (the sucrose group). The liquid diets were the only source of calories and water for the alcohol group and sucrose control group during the 5-month experimental diet period. The preparation, composition, and documentation of the nutritional adequacy of the liquid diets have been presented in detail (*10*). A third group received laboratory chow and water without restriction (the lab chow group) throughout the 5-month experimental diet period. Consumption of the liquid diets was measured daily and each rat was weighed three times weekly (*11*).

After 5 months on the experimental diets all groups were changed to unlimited laboratory chow and water for 30 days. After the 30-day period of this feeding, all rats were again reduced to 85 percent of their body weights (when they were fed freely) and were maintained at that weight for the remainder of the experiment. All rats were then given 20-minute CRF ses-