

Chimpanzees (*Pan troglodytes*): Problem Seeking  
Versus the Bird-in-hand, Least-effort Strategy

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**ABSTRACT.** Fifteen adult chimpanzees were tested on a series of tasks that differed from standard two-choice object discrimination learning problems in one detail: a third choice was sometimes offered, and it consisted of clearly visible and readily accessible food. Even under conditions where they would have to score 100% on the discrimination learning tasks to get as much food as they could get by taking the “free” food, many of the chimpanzees worked on the problems. Individual differences were large and reliable. Frequency of response to a given problem also varied according to how accurately the animals were performing and increased markedly if the hidden food was made a few grams larger than the free food. The chimpanzees did not rely strictly on a “bird-in-hand” strategy or necessarily always work to get the maximum amount of food with the minimum amount of energy expenditure. Whether this is bad economics or good economics depends on the time scale on which one views adaptation.

**Key Words:** Discrimination learning; Problem seeking; Bird-in-hand; Least effort; Risk-sensitivity.

## INTRODUCTION

Is it an “error” for animals to forego directly visible food that is virtually in hand, or to take the longer, less direct or more difficult of two routes to get to food (HEBB & MAHUT, 1955; HAVELKA, 1956; OSBORNE, 1977)? It depends, of course, on what commodities they are maximizing or minimizing, the relative priorities they place on various commodities at any given time, and the time scale on which overall adaptation is measured. If one observes the decisions that chimpanzees actually make and infers what function they might be maximizing (an “inverse optimality approach”: cf. KREBS et al., 1981; MCFARLAND, 1977), it surely seems, for example, that: easily accessible food is often bypassed if the odds are high of finding a larger quantity elsewhere (MENZEL & DRAPER, 1965), or even if it will thereby be consumed by one’s own offspring (MCGREW, 1975). An indirect route is preferable over a direct one if in taking it one avoids the risk of losing one’s food to a more dominant group member or being attacked by a predator (GOODALL, 1986; MENZEL, 1974). Information about the environment that seems useless right now will not necessarily be useless tomorrow or next year, and must to some degree be acquired or sought out “for its own sake” — at least from a short-term point of view, and by animals whose biological requirements and proclivities for information acquisition have been so shaped by natural selection (ESTES, 1984; MARLER & TERRACE, 1984).

Here, we presented adult chimpanzees with a number of problems, most trials of which involved a choice between three objects: (A) a nonfood object under which a small slice of banana lay hidden; (B) another such object under which there was no food; and (F) a clearly visible and readily accessible (“free”) slice of banana. Except for the addition of the F object, the tasks were, in other words, standard two-choice object discrimination learning problems, such as have been used in innumerable previous primate studies since the 1930’s.

If the animals were operating strictly on a "least effort, bird-in-hand" principle, we would expect the frequency of response to the A and B objects to be 0, for the ability of chimpanzees to tell the difference between a slice of banana and (say) a tin can is at least equal to our own. Following HEBB and MAHUT (1955) and HAVELKA (1956), we shall call selection of the A and B objects "problem seeking." The question is whether any chimpanzees will forego free and certain food to work at the discrimination learning tasks, and under what conditions they do so.

## EXPERIMENT 1

The first experiment loaded the test conditions against problem seeking. On each trial, the "free" food and the food that was hidden under the A object were equal in size and quality; thus, if the animals worked the problem, they would have to pick the A object rather than B 100% of the time to get as much food as they would have obtained by taking the free food every time. In addition, the A and B objects were changed frequently enough that none of the animals would be likely to reach perfect performance.

## METHOD

### SUBJECTS

Three adult male and 12 adult female chimpanzees were tested. They ranged in age from 12 year to 35 year. All but one had been born and raised in captivity. All had had extensive prior test experience. A few nursery-reared infant chimpanzees, when first tested on similar tasks, had been observed to show signs of possibly confusing a banana with a junk object (i.e. pushing the banana away from themselves and searching the spot it had occupied, and raking the non-food object toward their already-opened mouth, with a finger), so we watched very carefully for these and any analogous behaviors in the present study. None were seen.

### APPARATUS

The apparatus was a Yerkes Laboratories version of the Klüver tray, which had been used in many prior studies. It consisted basically of a wooden tray that could be moved toward or away from the cage in which the animal was held, and an opaque guillotine door at the front of the apparatus, which could be lowered to prevent the chimpanzee from seeing the experimenter arranging the test objects and foods. The tray contained three food wells about 20 cm apart, 1.5 cm deep, and located 6 cm from its forward edge. When moved to its forward position, the tray rested directly against the cage wire, which was 6 cm mesh.

Thirty-six pairs of test objects were drawn from the pool of more than 1,000 that was maintained at the laboratory. None had been presented previously to the subjects. The objects in each pair differed from one another in multiple attributes (color, size, etc.).

The food consisted of slices of banana approximately 1.25 cm thick. If two slices were to be used on a trial they were matched by eye so as to be as equal as possible in size and coloration.

## PROCEDURE

The chimpanzees were tested in their home cages. They were maintained on ad lib laboratory chow and water, which was not removed during testing, but prior to test time on a given day they had not been given any fruit. Each day for six days they were presented six discrimination learning problems for 12 trials each. They were not permitted to touch more than one choice object per trial; i.e. a noncorrection procedure was used. Within a problem trials were spaced about 15 sec apart and between successive problems on a given day there was an interval of about 30 sec.

On trial 1 of each problem only the A and B objects were presented, without F. Half of the time both objects had food under them, and whichever object the chimpanzee selected was designated as the A object, and also baited with food on all subsequent trials. On the remaining half of the problems, neither test object had food under it on trial 1, and whichever object the chimpanzee had selected was henceforth the B object, the other one being designated as A and baited with food. These two conditions were presented in randomized balanced orders. It should be noted that they serve as a partial control for simple "curiosity" on subsequent trials.

Trials 2–11 were the crucial ones. Here the A and B objects were presented together with F.

Trial 12 was a post-test to determine how well the A vs. B object discrimination had been mastered. Here, only the A and B objects were presented, and the subjects were "forced" to choose between them.

On all trials the positions of A, B, and F were varied at random, with the provision that over each session each of these objects occurred equally often in each of the three locations.

## RESULTS AND DISCUSSION

Only one of the 15 chimpanzees (*Flora*) took the free food every time. The percentage of the 36 problems on which each individual made at least one response to either the A or B object ranged from *Flora's* 0 score to *Franz's* score of 83 (mean 41.11, S.D. 24.22). Analogously, the percentage of the 360 trials on which the animals responded to A or B rather than F varied from 0 to 32 (mean 11.44, S.D. 10.49). The subjects with the higher frequencies of response to the A and B objects did not distribute their responses equally across problems; on some problems they "worked" on a majority of the trials, and on others they always opted for the free food. Similarly, with some particular pairs of objects up to 10 of the 15 chimpanzees made at least one response to A or B, whereas on other problems none did.

Position biases might inflate an animal's problem seeking score in this test, especially since there were two nonfood test objects to only one free food. However, none of the 15 chimpanzees showed a position bias that was significant at the .05 level by chi-square test, and the correlation between their problem seeking scores and these chi-square scores for position bias was not significant ( $r = .39$ , d.f. = 13).

If bird-in-hand responding were the rule and the animals' responses to the A and B objects were only occasional, random departures from this rule, the overall proportion of trials on which they responded to A or B should enable one to also predict the frequency with which they would respond to these objects on two successive trials within a given problem.

In other words, on this null hypothesis, each animal's "expected" frequency of responding to A or B twice in a row is the square of its simple probability score, times the number of trials under consideration; and for all 15 animals combined, the expected total is the sum of these individual expected scores. For the 324 trials per animal which are appropriate for such an analysis (i.e. trials 3–11 within each of the 36 problems), the expected total for the sequence [A or B] → [A or B], calculated thus, is 113.54. The observed total frequencies of each possible two-trial response sequence are shown in Table 1. It may be seen that for the particular sequence in question the total is 207+40, or 247. The discrepancy between it and the expected total is large [chi-square(1)=156.89,  $p < .0001$ ]. Only 6 of the 15 individuals had large enough expected frequencies of this sequence to justify separate analysis of their data, but each of their chi-squares was statistically significant. It seems reasonable to conclude that responses to A and B were not random.

Three lines of evidence suggest that whether the animals would work the problems or take the free food depended heavily on their ability to hit the baited (A) rather than the unbaited (B) object. First, as Table 1 suggests, on trials 3–11 of any given problem the animals were more apt to respond to A or B on any given trial if, on the immediately preceding trial, they had responded to A rather than B [ $t(14)=2.57$ ,  $p < .05$ ]. Second, for the 14 animals that had made some responses to A or B on trials 2–11, the correlation between the number of A or B responses that each individual made and the percentage of these same trials that it had been "correct" (i.e. picked A, not B) was .58 ( $p < .05$ ); and the correlation between the number of A or B responses per problem actually worked and the percentage of "correct" choices was .71 ( $p < .01$ ). Thirdly, if an animal's response on trial 1 had been "correct" or rewarded with food, it engaged in more problem seeking on subsequent trials with the same pair of objects than if trial 1 was an "error" [ $t(14)=2.26$ ,  $p < .05$ ]. These last results are portrayed graphically in Figure 1.

The intra-problem decline in response to A and B objects, which is also shown in Figure 1, is significant [for trials 2+3 vs. trials 10+11,  $t(14)=3.32$ ,  $p < .01$ ]. No inter-problem trends were, however, apparent across the 36 problems.

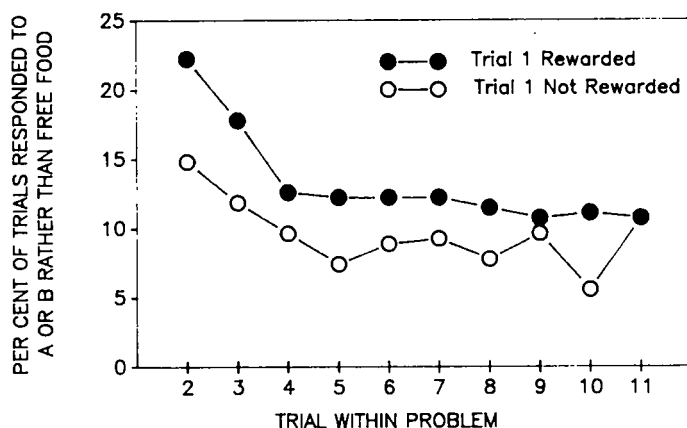


Fig. 1. Experiment 1: Intra-problem trends in problem seeking and the effects of having been "correct" or "incorrect" on the first trial of any given problem.

**Table 1.** Intra-problem sequences of response in Experiment 1\*

Response on trial N-1	Response on trial N		Total
	A or B	F	
A	207	205	412
B	40	108	148
F	271	4029	4300
Total	518	4342	4860

\*Total frequencies with which the 15 chimpanzees worked the problem or took free food on trial N, after having picked the A, B, or F object on trial N-1.

The differences between individual chimpanzees were both large and reliable. The correlation between individuals' choice of A or B objects in the problems on which trial 1 was rewarded and in the problems on which trial 1 was not rewarded was .92; for the first vs. the last day of the experiment the analogous correlation was .74 ( $p < .01$ ); and the data of the present experiment were also highly predictive of what individuals would do in the two subsequent experiments.

On the forced-choice of trial 12, the percentage of the 36 problems on which the animals correctly picked A rather than B was 64 (S.D. 12.31); 7 of the 15 animals were significantly ( $p < .05$ ) better than "chance." The group average is lower than the analogous score for trials 2–11, where if either A or B rather than F was picked, it was A 73% of the time; however, the difference falls short of statistical significance. *Franz* and *Kathy*, the star problem seekers, coincidentally scored 72 and 97% correct, respectively, on trials 2–11, and 86 and 89% correct, respectively, on trial 12. Unfortunately for them, they still got less food overall than did the star bird-in-handers.

Overall, the correlation between individuals' frequencies of response to either A or B on trials 2–11 and the frequency of their "correct" responses on trial 12 was .43 (ns) if the former count is in terms of number of problems, and .61 ( $p < .05$ ) if the count is in terms of number of trials. Given that animals who engaged in more frequent problem seeking obviously had had more practice than anyone with the same A and B objects that were used on trial 12, the only surprise here is that the correlations are not higher.

While the data furnish clear evidence that chimpanzees will engage in at least some problem seeking even in situations where a "least effort, bird-in-hand" strategy would gain them more food, it is of course obvious that none of the chimpanzees worked on all of the problems either, let alone on all trials. On the other hand, why should they? They were, after all, surely working for food too. In this respect, some of their behaviors seemed motivationally paradoxical. *Kathy* showed these behaviors more reliably than any of the other animals. If she picked the B object (and of course got no food) she might make a quick grab toward A as the tray was being withdrawn, scream on not being allowed to touch it, refuse to take a different piece of food that was (on a few occasions) offered by hand, to placate her, beat at the test apparatus, spit water over it, at the experimenter, or start a fight with the chimpanzee in the adjacent cage. Was it failure to get food (per se) that infuriated her, or was it the commission of what she herself perceived as being a "stupid error"? What role do onlookers (including the experimenter) play here, especially in those cases where they are obviously watching the subject, and might not remain totally impassive? And, of course, why didn't she just stick to the free food? The behaviors described above do, coincidentally, also occur even in tests where chimpanzees get food on every single trial (e.g. MENZEL, 1969), and in tests where they do not get food on any trial.

## EXPERIMENT 2

Experiment 2 examined the effect of varying degrees of familiarity, and practice, with particular sets of test objects upon chimpanzee problem seeking. Would the animals persist in responding to the A object on a given problem even after they had mastered the problem?

## METHOD

The 15 adult chimpanzees used in Experiment 1 were also tested here. First they were ranked from high to low on the number of trials in Experiment 1 that they had responded to the A or B objects rather than F. The top-ranking three were called "level 1," the next three "level 2," and so on. Then each member of each level was assigned, by a table of random permutations, to one of three different groups. Group 36 received 36 new object discrimination learning problems, just as they had in Experiment 1. Group 6 received the same number of trials, but on only 6 sets of objects; i.e. a full day's session of 60 trials per object, excluding the preliminary trial 1 and the "post-test" trial 12. Group 1 received the same, single, unchanged pair of nonfood objects throughout. In all other details, procedures were the same as in Experiment 1.

## RESULTS AND DISCUSSION

All 15 chimpanzees bypassed the free food on at least a few occasions. The percentage of the 36 blocks of 12 trials ("problems," for some animals) that they responded to A or B rather than F at least once was 49.44 (S.D. = 35.05) for Group 1, 10.56 (S.D. = 12.17) for Group 6, and 14.44 (S.D. = 12.79) for Group 36; and the percentage of the 360 trials that entailed problem seeking was 18.61 (S.D. = 25.50), 1.61 (S.D. = 1.99), and 2.22 (S.D. = 1.53), for the same three groups, respectively. By two-way ANOVA, the group differences are significant [ $F(2,8)=11.32$ ,  $p < .01$  for the first-mentioned dependent measure and  $F(2,8)=30.24$  for the log-transformed scores of the second measure]. The differences are attributable solely to Group 1 vs. Groups 6 and 36.

The five "levels" of subjects also differed from one another on both measures [ $F(4,8)=5.60$ ,  $p < .05$  and  $F(4,8)=17.81$ ,  $p < .01$ , respectively]. In other words, the animals' problem seeking scores in Experiment 1 were very good predictors of how they would respond here too. There was no significant interaction between "levels" and "groups."

All but one of the ten animals in Groups 6 and 36 showed a decline in problem seeking from their scores in Experiment 1, whereas only one of the five members of Group 1 did so. Indeed, Group 1's "level 1" subject, *Kathy*, responded to the A or B objects on 34 of the 36 blocks of 12 trials, and on a total of 225 critical choice trials — an increase of almost 100%. She also made a total of only two responses to B, which makes one wonder what the "problem" was that she was seeking. Apparently, problem novelty and uncertainty do not necessarily increase the rate of problem seeking, for if this were the case Group 1 should have shown the lowest, rather than the highest, frequencies of response to A and B rather than F.

Not surprisingly, Group 1 also showed the most accurate performance on the last, forced-choice, trial of each 12-trial block. After one or two sessions all members of this group in-

variably picked A rather than B. Groups 6 and 36 did not, however, differ from one another (mean percent correct = 52.78 and 59.44, respectively), and Group 6 performed much more poorly than one would expect from the performances of the same individuals in Experiment 1 and from the fact that they now received only one new problem per day. We have no explanation for this result, but it is consistent with the results on the problem seeking measures.

### EXPERIMENT 3

During the course of the previous experiments the animals often looked back at the free food after they had responded to the A or B objects, and in a few cases they tried to grab it instead of the food they had uncovered under A. In almost all of these cases the free food seemed to us slightly larger or better-looking than the other piece. Here, we accordingly exercised even greater care in this regard, and also systematically varied the sizes of the visible and the hidden foods. Given the acuity of chimpanzees' perception of food quantities (MENZEL & DRAPER, 1965; RUMBAUGH et al., 1987), we used small size differences. Stated otherwise, each of the present chimpanzees could readily consume 20 bananas per day, if given the opportunity, but the greatest size difference between the visible and the hidden foods that we used was roughly 1/1,000th of this quantity. If differences of a few grams can influence their decisions, they should obviously not have to rely upon a pure "bird-in-hand" strategy under more naturalistic, everyday situations either.

### METHOD

Twelve of the same 15 chimpanzees were tested. Each was given 36 new discrimination learning problems, 12 on each of three conditions: (SL) Small size of food for the F object, large size under the A object; (SM) Small size for F, medium under A; or (MM) Medium size for F, medium under A. As before, there was no food under the B objects. The 12 problems on each condition were given in succession, on two test days. On the basis of the pooled data of the two preceding experiments, the subjects were divided into two levels of problem seeking, and one high-scoring and one low-scoring subject was assigned at random to each of the six possible testing orders.

The foods were discs of banana 1.25 cm thick and either 2.64, 2.35, or 2.01 cm in diameter. They weighed an average of 7.12, 5.68, and 4.06 g, respectively, with no more than 5% variation from these means. Given these sizes, hypothetical animals that invariably worked the problem rather than take F would have to pick A rather than B 57% of the time under condition SL to get the same number of grams of food that they could have gotten by sticking to F, but responding to A 100% of the time would net them 75% more food than F. For condition SM, object A would similarly have to be picked on 71% of the trials for the animals to match a bird-in-hander, but 100% response to A would net them 40% more than F. Finally, for condition MM, as in the preceding two experiments, anything short of 100% choice of A or F would entail some loss of food.

Prior to commencing the tests, each animal was given one or two sessions of 50 trials in which it was offered a choice between two directly visible foods of the above sizes. Each animal took the larger of the two pieces at least 75% of the time.

## RESULTS AND DISCUSSION

Even though the size differences between visible and hidden foods were small, and only two sessions of practice were given with each condition, this was sufficient to produce a marked increase of problem seeking. Three of the high level animals and one of the low level animals in fact worked rather than take free food on 30 or more of the 36 problems and on 200 or more of the 360 trials; the top scores were 35 problems, and 273 trials. There was, moreover, no intra-problem decline in the frequency of problem seeking, as there was in the first experiment (cf. Fig. 1).

Table 2 shows the averaged data for the high and low level groups on each of the three food-size conditions, and on four dependent measures. On each of the two measures of problem seeking, ANOVA revealed significant main effects. [High vs. low level subjects  $F(1,22)=87.36$  and  $83.41$  for the number of problems worked and for the log-transformed number of trials worked, respectively. Food size conditions  $F(2,22)=6.59$  and  $9.44$ , respectively, for the same two measures.] The two conditions that entailed a larger food under the A object than for free food (SL and SM) produced more problem seeking than did condition MM [ $F(1,22)=12.75$  and  $15.17$ , respectively, for the two different measures]. Most of the animals also responded on more trials on condition SL than on condition SM, but this difference fell short of clear statistical significance [ $F(1,22)=3.70$ ,  $p < .10$ ].

The order in which the three test conditions were presented to the animals also had a strong effect on problem seeking [ $F(5,22)=11.26$  and  $14.27$  for the two different measures, respectively;  $p$ 's  $< .01$ ]. Those animals that received condition SL first "caught on" more quickly, and persisted in checking A and B for a time even after being shifted back to equally-sized foods; and those that commenced with MM tended instead to stick longest with a bird-in-hand strategy even when they were shifted to SM or SL. The subject whose score rose the most both in absolute value and in rank (*Betti*, heretofore a low-level responder) received the sequence SL - SM - MM. Clearly, the explanation of problem seeking does not lie in immediately-present variables alone, but must also take into account each individual's previous experiences (LOGUE, 1988).

Analyses were also made of the total amount of food, in grams, each animal obtained on trials 2-11 under each condition. In Table 2 this measure is expressed as a percentage of the amount that could have been obtained by responding invariably to F. Eleven of the 12 chimpanzees obtained more food overall in the SL condition than they would have obtained by sticking to F. In the SM condition only five did so, five taking a loss and two

**Table 2.** Summary of Experiment 3\*

Group		Condition SL				Condition SM				Condition MM			
		PS-P <sup>1)</sup>	PS-T <sup>2)</sup>	Amt <sup>3)</sup>	Tl2+ <sup>4)</sup>	PS-P <sup>1)</sup>	PS-T <sup>2)</sup>	Amt <sup>3)</sup>	Tl2+ <sup>4)</sup>	PS-P <sup>1)</sup>	PS-T <sup>2)</sup>	Amt <sup>3)</sup>	Tl2+ <sup>4)</sup>
High	Mean	77.8	53.8	128.0	79.2	69.4	41.5	106.0	77.8	54.2	23.6	95.0	69.4
	S.D.	32.8	31.4	21.3	17.3	39.0	32.4	12.2	15.5	38.8	26.8	6.7	18.0
Low	Mean	30.6	11.3	104.0	59.8	31.9	16.9	101.0	70.8	18.1	8.2	98.0	62.5
	S.D.	34.0	19.3	4.1	20.0	35.9	35.4	2.1	18.1	21.3	16.9	4.0	4.6
Total	Mean	54.2	32.5	116.0	69.5	50.7	29.2	103.5	74.3	36.1	15.9	96.5	66.0
	S.D.	40.3	33.3	19.3	20.5	40.8	34.8	8.8	16.5	34.5	22.8	5.4	13.0

\*Means and S.D.s of the six "high level" and six "low level" subjects in each of the three food-size conditions. 1) % of problems on which at least one response was made to A or B rather than F; 2) % of choice trials on which A or B rather than F was picked; 3) total amount of food obtained (g) expressed as % of the amount that could have been obtained by taking the free food on every trial; 4) % of the forced choices between A and B, on trial 12 of each problem, that A was picked.



**Table 3.** Intra-problem sequences of response in each of the three food-size conditions in Experiment 3\*:

Sequence	Food-size condition					
	Condition SL		Condition SM		Condition MM	
	High	Low	High	Low	High	Low
A – (A or B)	264	35	191	67	90	33
A – F	35	16	37	15	37	5
B – (A or B)	33	12	21	22	14	8
B – F	13	7	20	6	18	6
F – (A or B)	46	28	55	18	46	13
F – F	257	550	324	520	443	583

\*Total frequencies with which the six "high level" and the six "low level" subjects worked the problem or took free food on trial *N*, after having picked the A, B, or F object on trial *N-1*.

breaking even. And in the MM condition, seven took a loss and the remaining five broke even. Only *Franz* and *Kathy*, each of whom worked the SL problems on more than 100 of the 120 trials, came close to getting the maximum possible amount of food. However, ANOVA revealed no overall difference in food-getting between the 6 high- vs. the 6 low-level problem seekers, but rather a strong interaction of these "levels" with the specific test conditions [ $F(5,22)=13.04, p<.01$ ]. As Table 2 shows, on average the high-level animals fared far better than low-level animals in condition SL, only slightly better in SM, and worse in MM. On the forced choice of trial 12, they of course had the advantage under all food size conditions.

For purposes of comparison with Experiment 1, Table 3 shows the frequencies of various two-trial intra-problem sequences of response in the two levels of subjects and in each food size condition. As before, only trials 3–11 are considered here. It may be seen that the animals no longer typically switched to taking the free food on the trial following a response to the unbaited B object, and that responses to either A or B were typically followed by another such response. This strongly suggests (as does the phenomenon of problem seeking as such) that it is not the outcome of each single response that counts, but a more long-term net gain.

In this experiment, as in the previous ones, and as might be expected from studies on other species (CATANIA, 1980), the percentage of correct choices between the A and B objects was higher under the "free choice" conditions of trials 2–11 than on the forced-choice condition of trial 12; and here the difference is significant [means 83.33% vs. 70.17%,  $t(11)=2.76, p<.05$ ].

## CONCLUSIONS

Some readers might characterize the present chimpanzees as choosing the A and B objects "only" about 12% of the time, and view this average as evidence against, rather than for, problem seeking. This conclusion would, of course, be sound if there were little variation around this mean value, and if the expected probability of the behavior in question had been about fifty-fifty. But in fact neither of these conditions holds true. Under most of the conditions of testing, and on a bird-in-hand, least effort hypothesis, the expected probability that the animals would bypass the free food was in effect zero. No animal met this expectation overall; individual differences were not only very large but also highly reliable; and some individuals on some particular sets of objects scored 100% rather than 0.

Clearly, the bird-in-hand strategy is weaker than one might expect. It is also reversible under appropriate conditions (see also MENZEL & DRAPER, 1965). This does not necessarily contradict the principle that on average animals usually work to get the maximum amount of food with the minimum amount of energy expenditure, but it does complicate the picture, and highlight the importance of looking at more than averages if one wishes to fully account for decision-making behavior. The question is, of course: Why do individuals differ so markedly from one another?; How accurately and objectively do the animals, or we ourselves, perceive the test situation?; What is the precise cost-benefit ratio at which they switch between certain and probable rewards?; How are long-term gains weighted relative to short-term gains?; Is problem seeking really bad economics?

The answer to the last question is, we believe, "Yes, but only if one's theory of economics is overly simplistic." Among the chimpanzees that were studied here, we saw no evidence that the "high level" problem seekers were any less food-oriented than bird-in-handers. Instead, we would speculate that either the time scale on which they operated was a bit larger (cf. KAGEL et al., 1986), or that they included in their brand of economics some additional commodity. One such commodity, that has been posited in recent studies of foraging in nonprimate species, and that might be of particular interest to readers of this journal, is risk sensitivity (CARACO et al., 1980; BARNARD & BROWN, 1985; HAMM & SHETTLEWORTH, 1987). It is tempting to generalize from these studies to the present one. But such generalizations would be hazardous, for the situations that have been used thus far in the foraging studies are actually very different from the present ones. They amount, in the vocabulary of the 1960's, to tests of probability learning, whereas our tests were simple discrimination tasks involving 100% or 0% reinforcement on any given test object. Also, no training was required over the course of our study for the animals to discriminate perfectly between one of the alternative choice objects (free and visible food) and the other two. The amount of food that the animals actually received if they responded to the A and B objects did of course vary according to which one they picked, and this variability (or their general uncertainty, or perception of risk) in turn had further behavioral repercussions; but here we are talking about behavioral or psychological rather than environmental uncertainty, and the relationships between these two phenomena must be demonstrated empirically rather than assumed. In the meantime, here is one simple empirical prediction that might serve as a basis for comparing and contrasting problem seeking with risk-proneness or risk-aversion. We predict that, at least in the present sort of test apparatus, adult chimpanzees offered a choice between two objects, one of which always contains one piece of food and the other of which contains either zero or two pieces (at random), will, like many if not most other animals, quickly settle on taking the former object virtually every time, and that animals such as *Kathy* and *Franz* themselves would be no exception, and would be most unlikely to display the same levels of choices in the presumably opposite direction that they displayed here. In other words, problem seeking and gambling might entail many common features, but the differences are equally significant.

It would surprise us if problem seeking in the present sort of test could not be increased to virtually 100% by making the hidden food as much larger in quantity than the free food as the ratios used in tests of nonprimate species, and by giving the animals sufficient experience with the test conditions. By the same token, problem seeking could undoubtedly also be reduced to virtually 0-level, too, by penalizing the animals even further in terms of the payoff in food than they were penalized in the present experiments. As a comparison of the high-level and low-level groups suggests, it would obviously take greater differential payoffs in food than we offered to eliminate individual differences on this sort of task. The

reason for this surely does not lie merely in immediately-present variables such as food size, or even in species- and individual differences in perceptual acuity. It is hard to imagine, for example, that any animal would perceive a hidden piece of food as actually being larger than a visible one of precisely the same physical size, let alone that such an illusion would be magnified by experience; yet many of the present animals' performances would have to be described in such a fashion if immediate variables and perceptual factors alone were to be invoked.

According to most dictionaries, a problem is something about which one is in doubt, or uncertain. An important, and unanswered question is how the animals themselves recognize a problem as a problem (especially a solvable one), or assess their own degree of uncertainty. One way to get at it is to examine their sensitivity to the variability as well as the average values of environmental events — as in the foraging studies that are mentioned above — and to directly compare the procedures used in these studies with the present procedures. Another way might be to examine how accurately they know what constitutes a plausible hiding place for a particular size or class of object — given of course their own sensory equipment and momentary vantage point. We doubt, for example, that adult chimpanzees tested in the present apparatus would ever pick nonfood objects over visible food if the former objects did not either constitute possible containers of other objects or rest squarely over previously-seen hollows in the substrate, into which they could not for the moment see, and within which they had previously found hidden food. But we would not expect every animal to be that astute.

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