

Motivation and insight in wolf (*Canis lupus*) and Alaskan malamute (*Canis familiaris*): Visual discrimination learning

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Hand-reared wolves performed better than Alaskan malamutes and maternally reared wolves on Wisconsin General Test Apparatus (WGTA) measures of oddity learning. Differences between the two groups of wolves are interpreted as motivational. Differences between the hand-reared wolves and the malamutes contradicted predictions that dogs should perform better than wolves on training tasks and suggested that the WGTA tasks are amenable to either trial-and-error ("associative") solutions typical of training-task performance or complex cognitive ("insight") solutions more typically observed in problem-solving performance. Accordingly, the hypotheses were tested that (1) insightful solutions produce more rapid acquisition than noninsightful (i.e., associative) solutions, and (2) wolf performance exhibits more insight than does malamute performance. Both hypotheses were confirmed.

Frank (1980) hypothesized that wolves (*C. lupus*) should perform better than domestic dogs (*C. familiaris*) on experimental problem-solving tasks that call into play such complex cognitive capacities as insight into means-ends relationships, serial organization of behavior, cognitive mapping, imagery, and foresight; and that dogs should perform better than wolves on experimental training tasks, which were formally distinguished from problem-solving tasks by three criteria: in training tasks, (1) cues are arbitrarily determined by the experimenter, (2) reinforcement is administered by the experimenter, and (3) the to-be-learned behavior has no perceptible, functional connection with the reinforcement.

Experimental tests of these hypotheses were reported by Frank and Frank (1986) and include performance comparisons of four Eastern timber wolf (*C. l. lycaon*) pups with four Alaskan malamute (*C. familiaris*) pups on a series of seven age-graded training tasks. The malamutes performed significantly better than the wolves on five of the tasks and marginally better ($p = .067$) on one. However, the results of the seventh training task—a measure of visual discrimination learning—narrowly failed significance in the opposite direction.

Although most of these results support Frank's (1980) second hypothesis, the wolf pups were less socialized to

humans than were the malamutes, which may have contributed to their relatively poor performance. Environmental feedback in the training tasks was mediated by a human training agent, whereas feedback in the problem-solving tasks resulted directly from the animal's transactions with the test apparatus. Insofar as socialization implies sensitivity to human behavioral cues (see Scott, 1980) or that training is an interactive "game" (cf. Pryor's, 1981, 1986, treatment of operant conditioning as a communication paradigm), such procedures would tend to favor the more socialized domestic pups.

We believe that the incomplete socialization of the wolf pups resulted from early and continuous contact with an adult, foster mother wolf. The entire training-task program was therefore replicated with wolf pups that were wholly hand-reared and thoroughly socialized to humans. In the present paper, we examine the replication of the visual discrimination experiment that yielded anomalous differences in the original study.

METHOD

Subjects

Maternally reared wolves. The four pups used in the original study were acquired at 11 days (± 24 h) of age from the Carlos Avery Game Park, Forest Lake, MN. They were fostered on a mature, maiden wolf approximately 67 days after ovulation. The pups and foster mother were housed in a 1.8 \times 1.2 m den-box inside a 3.7 \times 5.8 m barn with access to a 3.7 \times 1.5 m outdoor pen. The foster mother wolf lactated for 7 weeks after the pups were introduced, but milk production was minimal, and the pups were bottle fed until 38 days of age.

To reduce interference with socialization reported in wolf pups that remain in contact with adult wolves (Klinghammer & Goodmann, 1986), pairs of pups were removed from the foster mother 12 h per day until

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6 weeks of age. During these periods, they interacted only with one another and with the experimenters. From 6 to 9 weeks of age, only the least socialized individuals received a full 12 h of human contact, and at 9 weeks of age, human interaction with all subjects was reduced to approximately 6 h per day plus the time spent in testing. Despite the early socialization regimen, by 20 weeks of age the wolves were nearly as wary of humans as were pups reared without human contact.

Hand-reared wolves (*C. l. lycaon*). The 7 wolf pups used in the replication study were acquired at 8 days (± 12 h) of age from the Ross Park Zoo, Binghamton, NY. They were housed in a 3 \times 4 m air-conditioned laboratory at the University of Connecticut's Biobehavioral Sciences complex from 9 days of age to 47 days of age. Prior to 6 weeks of age, the pups were allowed no contact with other canids, and every effort was made to maximize their exposure to people. In addition to 20 h of daily contact with one of more of the experimenters, the pups interacted with a cadre of volunteers from the university community and their families.

Further details of the wolf pups' maintenance and disposition are reported elsewhere (Frank & Frank, 1982; Frank, Hasselbach, & Littleton, 1986).

Dogs. Four 10-day-old (± 48 h) Alaskan malamute pups were fostered on the same female wolf that had reared the 4 wolf pups the preceding year. They were introduced to the foster mother approximately 77 days after ovulation and were subjected to the same rearing regimen as the wolf pups, with minor exceptions noted elsewhere (Frank & Frank, 1985).

Apparatus and Procedure

A three-position Wisconsin General Test Apparatus (WGTA; see Figure 1) was constructed on the basis of the design described by Fox (1971, pp. 192-193). The compartment in which the pups were tested was .9 \times .9 \times .9 m. Eight metal bars were mounted in the front of the box, with three equally spaced openings that could be adjusted according to the size of the subject's head. A guillotine-type screen (.60 \times .60 m) that concealed the experimenter from the subject was mounted on a cantilevered shelf that extended 45 cm from the bars. The shelf was also equipped with tracks that supported a stimulus tray (.60 \times .38 m) with three food wells (5 \times 5 \times 2.5 cm) spaced 10 cm apart.

Habituation and shaping. Testing began on the Monday nearest the subjects' 15-week birthday. On Day 1, food was placed in all wells, and the subjects were allowed to extract it and eat ad lib. Fifteen shap-

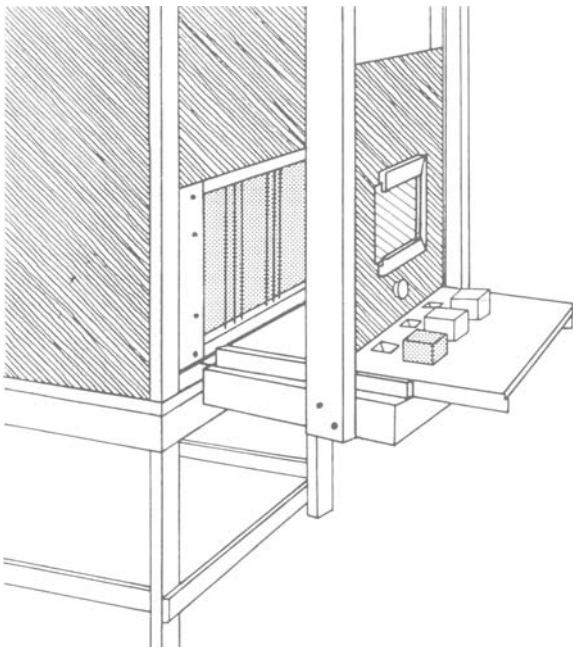


Figure 1. Wisconsin General Test Apparatus for the visual discrimination test.

Table 1
Trials to Criterion in Visual Discrimination Learning
for Wolves and Alaskan Malamutes

| | Maternally Reared Wolves (N=4) | Hand-Reared Wolves (N=7) | Malamutes (N=4) |
|------------------|-----------------------------------|-----------------------------|--------------------|
| Discrimination | | | |
| Mean | 82.5 | 55.71 | 97.5 |
| $\hat{\sigma}^2$ | 2275.0 | 278.57 | 225.0 |
| Reversal | | | |
| Mean | 191.25 | 117.86 | 150* |
| $\hat{\sigma}^2$ | 806.25 | 1082.14 | 300* |

*During the course of reversal learning, one of the malamute pups died, but since the correlation between the number of trials to criterion on initial discrimination and reversal was 1.0 for the 3 surviving pups, an estimate of his reversal score was calculated by regression on his initial discrimination score.

ing trials were administered on Day 2. Food was placed in one well and either a white or a black wood block (10 \times 10 \times 5 cm) was placed at the edge of the well furthest from the subject. Food was placed in each of the three wells five times in random order. The same procedure was followed on Day 3, but the block covered half of the well; the subject could see the food but had to displace the block to reach it. On Day 4, the block covered the well entirely.

Initial discrimination. Discrimination-learning trials began on Day 5 and proceeded for 2 weeks or until the subject reached criterion. Fifteen trials were administered daily, and criterion was defined as 85% correct responses over 2 consecutive days (26 successes in 30 trials). On each trial, the stimulus tray was withdrawn behind the screen, food was placed in one of the three wells, and the well was covered by a block of the same color to which the subject had been shaped. The empty wells were covered by blocks of the opposite color.¹ The screen was then raised far enough to clear the blocks and the tray slid forward until the food wells were 5 cm from the bars, with one well centered in front of each opening. The experimenter observed the subject through a one-way mirror in the screen and recorded a success if the subject displaced the correct (odd) block.

Reversal learning. The day following the subject's criterion performance (or the following Monday if criterion was achieved on a Friday), the task was reversed. For pups that had initially been rewarded for displacing the white block, food was placed under a black block and the two empty wells were covered with white blocks. Pups that had initially learned to displace the black block were presented two black blocks and one white block. Criterion was again defined as 85% correct responses over 2 consecutive days.

RESULTS AND DISCUSSION

Socialization and Motivation in WGTA Performance

Means and variance estimates for the subjects in the original and replication study appear in Table 1. Significance probabilities for *t* tests reported in the text are based on directional hypotheses.

In the original study, the only significant difference was in reversal learning, favoring the Alaskan malamutes ($t = 2.4, p < .025, df = 6$). Because this was consistent with the hypothesis under test, it occasioned little attention. In the replication study, however, the hand-reared wolves performed better in reversal learning than both the maternally reared wolves ($t = 3.9, p < .005, df \cong 9$)² and the Alaskan malamutes ($t = 2.1, p < .05, df \cong 8$).³ We therefore suggest that the performance observed in the original study may have resulted from differences in motivation, rather than differences in learning.

One possibility is that food reinforcement had greater incentive value for the hand-reared wolves than for the maternally reared wolves. Frank et al. (1986) noted that their hand-reared and maternally reared wolf pups exhibited early differences in feeding behavior. The maternally reared pups were apathetic feeders from the very first day, but the hand-reared wolf pups, like the Alaskan malamute pups, were voracious. The general inappetence of the maternally reared pups was also apparent in their relative indifference to (and occasional rejection of) food reward proffered during testing. This observation is consistent with a report by Frank and Frank (1988) that food reinforcement had less incentive value for maternally reared pups than did social reinforcement when food and social interaction with a congener were administered separately on two problem-solving tasks. In contrast, food reward was eagerly accepted by the hand-reared wolves and the malamutes.

Alternatively, it is possible that food reward for wolves is essentially symbolic and has little or no incentive value apart from its significance as a form of social interaction. Pryor (1981, 1986), in this regard, suggested that food reward for cetaceans serves only as a signal to the subject that the to-be-learned behavior has been correctly performed and that the motivation is intrinsic in the satisfaction of correct performance. It is similarly conceivable that the hand-reared pups discerned the experimenters as packmates and the experimental tasks as some form of "conspecific" play, or that the food reward had acquired social reinforcement properties as a consequence of the rearing regimen. This would be consistent with the pervasive differences between the maternally reared and the hand-reared pups' social orientation toward the experimenters, their cooperativeness, "interest" in the tasks, desire to please, and so forth, described by Frank et al. (1986).

Insight and WGTA Performance

Maternally reared wolves performed better than malamutes in discrimination learning (see Table 1), but the difference was not significant at the .05 level. In the replication, hand-reared wolves performed significantly better than malamutes both in discrimination learning ($t = 4.3$, $p < .005$, $df \cong 9$) and, as discussed above, in reversal learning.

If these measures were appropriately construed as training tasks, the results contradict the hypothesis that dogs should perform such tasks better than wolves. However, the WGTA tasks depart in two respects from the criteria by which we differentiated training from problem solving: (1) although it is true that there was no perceptible, functional connection between the cues and the to-be-learned behavior, there was a visible spacio-temporal connection; and (2) although the cues were arbitrarily determined by the experimenter, reinforcements were intrinsic to the task. Moreover, unlike the other training tasks in the program, WGTA performance involves elements of both discovery and repetition, by which Dominowski (1977) characterized problem solving and training, respectively.

It is therefore possible that this particular task was amenable either to the sort of "insight" learning tapped by the problem-solving tasks or by the sort of "trial-and-error" learning tapped by the other training tasks. Accordingly, our results remain consistent with Frank's (1980) hypotheses if the wolves' solutions exhibited a greater degree of "insight" than the malamutes' solutions and if "insightful" strategies were more successful (i.e., yielded more rapid learning) than trial-and-error strategies.

Koffka (1925) pointed out that the hallmark of insight is a sudden, discontinuous increase in the frequency of correct responses (a "sharp descent" in errors; p. 164), as contrasted with gradual, incremental increases that characterize associative, trial-and-error learning. To test the hypothesis that the wolves performed more insightfully than the malamutes, we noted the first day on which each subject achieved greater than chance performance at the .05 level (Day C) and calculated the percentage increase from the preceding day (Day C-1). For $N = 15$ and $p = .333$, the critical value is nine correct responses (significance probability = .03). Percentage increases were multiplied by 100 to eliminate decimals, and the re-scaled increases totaled for wolves and for malamutes: $\text{Sum}_w = 1187$, $\text{Sum}_m = 217$. A Fisher's randomization test (Siegel, 1956, pp. 152-156) of the difference between the sums supports the hypothesis ($p = .046$). This analysis was confined to the reversal stage of the experiment because initial discriminations were shaped and the subjects in all three groups performed nine or more correct responses on the first day of discrimination learning, thereby making our index of insight inapplicable.

To test the second hypothesis, that "insight" produces faster overall learning does than trial and error, comparisons were made between "insightful" and "noninsightful" subjects. Reversal learning performance was defined as insightful if the subject's score on Day C was at least double its score on Day C-1. The dependent variable in all of these analyses is the number of trials to criterion (26 successes over 2 successive days). To eliminate confounding by motivational factors discussed above, performance data for the maternally reared wolves were not included in these analyses.

If residual, nonmotivational performance differences are attributable to insight, insightful subjects should perform better than noninsightful subjects, both across and within species. Only one malamute met our insight criterion, so it was not possible to test differences between insightful and noninsightful malamutes, but the other comparisons suggested by this implication are reported in Table 2 and support the hypothesis.

Conversely, one should find no interspecies differences between insightful individuals or between noninsightful individuals. Only one malamute exhibited insightful performance, so we could not compare insightful wolves and malamutes, but the difference in mean trials to criterion between noninsightful wolves ($N = 3$) and noninsightful malamutes ($N = 3$) was not statistically significant ($t = 1.1$, $df \cong 4$).

Table 2

Trials to Reversal Criterion for Insightful versus Noninsightful Subjects

| Subjects | | Insightful | | Noninsightful | | t | df |
|----------|-----------|------------|------------------|---------------|------------------|-------|-----|
| Wolves | Malamutes | M | $\hat{\sigma}^2$ | M | $\hat{\sigma}^2$ | | |
| 4 | 1 | 108.0 | 1,057.5 | | | 2.44* | ≅ 7 |
| 3 | 3 | | | 147.5 | 307.5 | | |
| 4 | - | 101.3 | 1,106.3 | | | 2.00† | ≅ 6 |
| 3 | - | | | 140.0 | 300.0 | | |

*.01 < p < .025. †.025 < p < .05.

SUMMARY AND CONCLUSIONS

This experiment was undertaken as part of a replication study investigating the possible contribution of differential socialization to differences in training-task performance between wolves and Alaskan malamutes. The second objective of the experiment was to clarify anomalous results obtained in the original study, in which wolves, contrary to the experimenters' predictions, performed better than malamutes in a test of visual discrimination learning. The results suggest the following conclusions: (1) Unlike the other training-task experiments in the program, WGTA discrimination and reversal learning are amenable to either trial-and-error solutions or insight solutions more typically observed in problem-solving performance; (2) insightful solutions achieve more rapid acquisition than trial-and-error solutions; (3) wolves exhibit greater insight than the malamutes in WGTA performance; and (4) failure of the wolves to perform significantly better than malamutes in the original study was a motivational artifact arising from their socialization regimen.

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NOTES

1. In the original experiments, a liberal portion of food was also smeared into a groove cut in the underside of the unrewarded pair of blocks to prevent olfactory location of the food reward. This practice was refined in the replication study by placing food in compartments that were countersunk into the blocks and fitted with wire mesh floors. To further reduce possible exploitation of olfactory cues, the WGTA used in replication was equipped with a transparent, Plexiglas, guillotine-type door located behind the bars. The door was lifted to allow the subject access to the tray only after the subject indicated its choice by orienting toward one of the blocks for 3 sec.

2. For comparisons in which $N_1 \neq N_2$, df was calculated as recommended by Welch (1947) to compensate for unequal population variances:

$$\nu = \frac{[(\hat{\sigma}_1^2/N_1) + (\hat{\sigma}_2^2/N_2)]^2}{\frac{(\hat{\sigma}_1^2/N_1)^2}{N_1 + 1} + \frac{(\hat{\sigma}_2^2/N_2)^2}{N_2 + 1}} - 2.$$

When $\nu > N_1 + N_2 - 2$, the latter, more conservative, value was used.

3. $\nu \cong 10$, $N_1 + N_2 - 2 = 9$. One additional degree of freedom was subtracted for fitting the estimated datum, as explained in the footnote to Table 1.

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