

Do Domestic Pigs in Controlled Environments Contrafreeload?

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Many experiments report that animals will work (lever press) for food in the presence of freely available identical food. This phenomenon has attracted the attention of applied ethologists because it seems to prove that animals have a need to express appetitive behavior. If this is the case, then it has implications for the provision of environmental enrichment for animals in captivity. In this experiment, we maintained 6 pigs in closed economy environments for three 120-hr choice periods in which they had continuous free access to operant and identical free food. In the experiment, we tested pigs using 2 different operant schedules, fixed ratio (FR) 5 and variable ratio (VR) 5. We used a VR schedule because many enrichment studies claim that unpredictability is an important characteristic that makes an enrichment device attractive. The results show that pigs exhibited a negligible level of contrafreeloading ($M \pm$ standard error of the mean proportion = 0.05 ± 0.01). Furthermore, there were no significant differences between FRs and VRs of reinforcement.

Contrafreeloading is said to occur when a nonhuman animal chooses to make a response to receive food when identical food is freely available at the same time (Osborne, 1977). A rat in a Skinner box pressing a manipulandum instead of eating identical food available from a dish would be said to be contrafreeloading. The contrafreeloading phenomenon has attracted the interest of psychologists because it appears to contradict least effort learning rules (Osborne, 1977), with ethologists because it appears to conflict with optimality theory (Forkman, 1991, 1993a, 1993b), and with applied ethologists because it suggests that animals have a behavioral need to express appetitive behavior (Hughes & Duncan, 1988).

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Our primary interest in this behavior related to whether domestic pigs have a behavioral need to express foraging behavior. Baxter (1983) suggested that if the endpoint of behavior (consummatory behavior) is adequately provided for, the animal will have no need to express the normally preceding appetitive behavior. Even if correct, this hypothesis may be impossible to test practically, as only the individual animal knows when the endpoint of behavior has been satisfactorily reached: Laying hens show considerable individual differences in their selection of dust baths (Cooper & Appleby, 1997).

Osborne (1977) proposed that animals prefer contrafreeloading only when they consume more than 50% of their food from the nonfree source. However, Inglis, Forkman, and Lazarus (1997) pointed out that the proposed figure is arbitrary and that it is more important to explain why contrafreeloading occurs at all. Jensen (1963) first reported the phenomenon in an experiment using rats and suggested that it occurred because of the intrinsic appeal of performing the operant. Osborne reviewed the phenomenon of contrafreeloading in relation to animal learning theory, as the phenomenon seemed to contradict the least effort rule of animal learning. Forkman (1991, 1993b) has investigated this phenomenon in relation to optimal foraging theory, as animals that contrafreeload are contradicting optimality theory. Recently, Inglis et al. (1997) reviewed the literature on this phenomenon in relation to *information primacy* (the motivation of an animal to gather information to build a mental construct of its environment) and developed a fuzzy model to predict how animals would react in a contrafreeloading situation. The information-primacy theory that Inglis et al. proposed received experimental support from a study on starlings (Bean, Mason, & Bateson, 1999).

In their reviews, both Osborne (1977) and Inglis et al. (1997) have shown that the contrafreeloading phenomenon is wholly compatible with learning and optimal foraging theory, respectively. Both emphasize that a number of factors are important for maintaining the performance of contrafreeloading. Following Inglis et al., the main factors are as follows:

1. A long prior training period with the operant manipulandum increases contrafreeloading.
2. Increasing deprivation levels of reinforcers reduces contrafreeloading.
3. Increasing effort required to obtain the reinforcers decreases contrafreeloading.
4. Increasing stimulus change associated with the reinforcer presentation increases contrafreeloading.
5. Greater environmental uncertainty increases contrafreeloading.
6. Barren rearing conditions reduce contrafreeloading.
7. Increasing ability to manipulate the environment increases contrafreeloading.
8. More natural foraging tasks increase contrafreeloading.

A number of articles published on environmental enrichment have reported that animals show contrafreeloading because they choose to gain food from an enrichment device when other food is freely available. However, these experiments cannot be described as investigations into contrafreeloading. In nearly all such experiments, the food available from the enrichment is different from that which is freely available (Shepherdson, Carlstead, Mellen, & Seidensticker, 1993; Schütz et al., 2002). Thus, the nutritional differences, especially as enrichment devices often use "treat foods," are a simpler explanation of the observed phenomenon. The conclusions of such enrichment studies are therefore spurious in suggesting that animals contrafreeload because they prefer to work for food.

It often has been argued that unpredictability makes an enrichment device attractive to an animal. Perhaps this relates to the information associated with the device (Inglis et al., 1997). Alternatively, unpredictability is associated with schedules of reinforcement (variable ratio [VR] and variable interval) that seem to have more reinforcing power than predictable schedules of reinforcement (Bateson & Kacelnik, 1997; Chance, 1998; Kacelnik & Bateson, 1997).

In this experiment, we tested the assumption of Hughes and Duncan (1988) that contrafreeloading is evidence that animals need to express appetitive behavior. We did this by testing experimentally the model of Inglis et al. (1997); specifically, we eliminated factors known to increase contrafreeloading (long training period on the operant manipulandum). Our reason was that nearly all studies of contrafreeloading have, if analyzed using the model of Inglis et al., been designed to promote the expression of contrafreeloading. We believe this has led to a widely held belief that contrafreeloading shows that animals prefer to work for food (Schütz et al., 2002; Shepherdson et al., 1993) when in reality, the level of contrafreeloading shown depends on experimental conditions (Inglis et al., 1997; Osborne, 1977). We predicted that the pigs in this experiment would show low levels of contrafreeloading on fixed ratio (FR) schedules of reinforcement and higher levels on VRs of reinforcement.

METHODS

Six Large White X Landrace female pigs (Cotswolds Pig Development Company, Lincolnshire, England) with an initial average body weight in kilograms \pm standard error of the mean (*SEM*) of 150 ± 5 kg were used as the experimental subjects. After weaning at 28 days old, these pigs were group reared in large pens containing straw. They were fed by the food being scattered into the straw and had no experience of human-induced food restriction.

Sixty days prior to experimentation, the pigs were moved to the experimental building (Hsia, 1981) and housed singly in holding pens (with a concrete floor that was semislatted and without the provision of straw) measuring 4.14 m^2 but with vi-

sual, auditory, and olfactory contact with other pigs. Throughout the experiment and the preexperimental period, the pigs were fed a diet designed to completely fulfill their nutritional needs. Each kilogram of the diet contained 13.2 MJ/DE, 170 g of crude protein, 53 g of fiber, and 870 g dry matter (pellet size in diameter was approximately 5 mm \times 20 mm in length). Food and water were available ad libitum at all times except preceding training periods when food was withheld overnight. Food was changed every 24 hr to ensure freshness. In the holding pens, pigs were always floor fed (a method different from that of the free food or the operant food presentation).

Experimental and holding rooms were cleaned out every day: All rooms were maintained on a 12:12 hr light:dark cycle and rooms were maintained at $20 \pm 2^\circ\text{C}$ (a thermal neutral temperature for the diet). Additional cleaning was done in the experimental rooms if an animal had defecated or urinated near, on, or into the experimental apparatus.

The experimental rooms (which had concrete floors and were semislatted and without straw) measured 4.6 m \times 4.6 m with a central area measuring 3.6 m \times 1.0 m penned off from the pigs. Thus, the space available to the pigs was in a U shape. The penned-off area contained the operant machinery. Each experimental room also contained a drinker in each corner, viewing windows, and a loudspeaker mounted above the operant machinery.

Along the outside of each side of the penned-off area, directly opposite each other, were two almost identical food bowls; mounted at 0.72 m above each of these was an operant manipulandum. We used the same food in the holding rooms and in the experimental rooms (see previously). The manipulandum was essentially a flat metal panel measuring 0.3 m² (Lawrence, Appleby, & MacLeod, 1988), which was inclined toward the animal at 45° . To operate the manipulandum, the pig had to push against the metal panel with a force of 356 N/m for a distance of 0.015 m. This amount of force gave the manipulandum a definite action and made unlikely operation by accidental touches.

Food was delivered into one food bowl from a modified calf feeder (Orby Engineering Ltd, County Armagh, Northern Ireland; modified by the Scottish Centre for Agricultural Engineering). Food was delivered into one food bowl when the subject had completed the operant schedule determined by the experimenter. The food reinforcer size was 30 g. A microcomputer controlled the entire setup. This computer also recorded all presses on the active operant panel along with all presses on the inactive operant panel, which had the free food directly below it. At all times, sound was played at 65 dB in the experimental room to block out any noise from the action of either panel or when the modified calf feeder delivered food. Thus, both sides appeared visually identical. There was no auditory stimulus change when food was delivered, although there was the visual stimulus of the food appearing when an animal had fulfilled an operant schedule.

Pigs were trained to the operant food in the following manner. To increase feeding motivation, food was withheld overnight. This level of food deprivation should not cause undue stress for an animal who normally is *ad libitum* fed. At 9:30 a.m. the next day, the animal was moved into the experimental room and locked into the side of the room containing the active operant panel. Initially, the operant ratio was set at FR2 or VR2; three pigs experienced FR2 first and three experienced VR2 first. After 4 hr of learning to use the operant device (which all pigs did within an hour of presentation), the operant ratio was switched to either VR5 or FR5 for the next 4 hr.

We considered that the pigs had learned to use the operant device when they responded rapidly on the manipulandum and gained at least 20 reinforcements during each training session. Pigs then were returned to their holding pen for 24 hr and *ad libitum* floor fed. Following this period, each pig was familiarized fully with both the operant and the free food source. Three of the pigs were locked into the side of the room with the free food (6,000 g) for 24 hr and then for the next 24 hr were locked into the side of the room with the active operant panel set to deliver food on a VR5. The other three pigs experienced the reverse order of experience with the food sources. There was no statistical difference in the amount of food pigs consumed on the 2 days. Pigs then were returned to their holding pens for 24 hr and floor fed *ad libitum*.

At the start of the experiment, pigs were moved to the experimental room prior to their food being replenished. In the experimental room, pigs had continuous access to both food sources. Food was replenished at each food source once every 24 hr when cleaning of the room and the weighing of food in the free food bowl took place. This was the first of three 120-hr continuous choice tests separated by 24 hr in the holding pen where subjects were *ad libitum* floor fed. The operant ratio was set either at FR5 or VR5. These ratios were chosen because pigs could learn quickly to gain reinforcers with them, thereby avoiding a long training period that could predispose the pigs to perform *contrafreeloading* (Inglis et al., 1997). The force required to operate the manipulandum was not great for a 150 kg pig. During the three test periods, three pigs experienced the operant ratio sequence FR5 to VR5 to FR5 and three pigs the reverse sequence. Thus, all pigs were exposed to a total choice time of 360 hr.

RESULTS

We calculated for each pig the average value per day for each operant schedule type (FR or VR) for the following variables:

1. Number of food reinforcements received.
2. Number of active operant panel responses.

3. Number of control panel responses made.
4. Proportion of operant food consumed.
5. Total amount of food consumed.

The data were analyzed using Wilcoxon matched paired tests. We found no significant differences between operant schedule types for any of the variables (Table 1). We therefore pooled the data to calculate the overall proportion of operant food consumed, which was $M = 0.048 \pm 0.010$ SEM. Each pig consumed operant food almost every day. Furthermore, there was no difference in the number of active operant panel responses when compared with control panel responses (Table 1).

DISCUSSION

In this experiment, pigs only demonstrated a negligible level of contrafreeloading. This is in contrast to most other species experimentally tested (Osborne, 1977), except domestic cats (Koffler & Coulson, 1971). However, our results are in agreement with the predictions of the fuzzy model of contrafreeloading proposed by Inglis et al. (1997) showing that levels of contrafreeloading expressed are dependent on experimental conditions. Furthermore, by using a complete diet with a species whose nutritional requirements are well understood, we were able to discount nutritional explanations of our results (Young, 1999).

The data from this study do not support the suggestion of Hughes and Duncan (1988) and those made in environmental enrichment studies that animals prefer to work for food. We were somewhat surprised that the VR did not result in higher rates of contrafreeloading, as we would have predicted from Inglis et al.'s (1997) fuzzy logic model of contrafreeloading. Perhaps the level of information available in a FR5 ratio was insufficient to stimulate information gathering. Given the demonstrated high levels of cognition that pigs possess, this may be a reasonable suggestion (Held, Mendl, Devereux, & Byrne, 2000). Alternatively, one could argue that during the experiment the pigs directed their foraging behavior toward a substrate such as the floor. Although we did not take formal behavioral observations, we did make causal observations every day during the experiments and never saw this behavior. In terms of enrichment devices, the data could be interpreted as supporting the idea that variability is unimportant; however, most enrichment devices have more variability than the operant device in this experiment. The Edinburgh Football designed by Young, Carruthers, and Lawrence (1994) delivers food randomly in time, space, and quantity. Thus, further experimentation is needed before conclusions about the attractiveness of enrichment devices in relation to variability of reward can be made.

TABLE 1
The Effect of Operant Ratio Type on Behavioral Aspects of Contrafreeloading by Pigs Offered a 30 g Food Reinforcer

<i>Individual</i>	<i>N</i> <i>(Days)</i>	<i>Treatment</i>	<i>No. of Operant</i> <i>Reinforcements^a</i>	<i>No. of Operant</i> <i>Panel Presses^a</i>	<i>No. of Control</i> <i>Panel Presses^a</i>	<i>% Operant</i> <i>Food Consumed</i>	<i>Total Food Intake</i> <i>(g)</i>
13	5	FR5	11.20 ± 1.48	60.20 ± 7.38	62.00 ± 11.09	4.00 ± 0.63	5604.00 ± 130.59
13	10	VR5	12.40 ± 0.95	65.90 ± 4.55	70.80 ± 2.81	7.80 ± 0.60	4880.00 ± 106.57
17	5	FR5	9.40 ± 1.57	48.20 ± 8.05	41.00 ± 2.72	5.60 ± 0.98	5031.00 ± 77.81
17	10	VR5	21.40 ± 2.69	104.90 ± 13.38	34.80 ± 1.52	11.90 ± 1.42	5064.00 ± 67.67
18	5	VR5	6.40 ± 0.85	40.20 ± 5.50	3.80 ± 1.70	6.80 ± 1.03	2691.00 ± 55.01
18	10	FR5	4.90 ± 0.51	24.80 ± 2.47	31.60 ± 8.10	5.20 ± 0.51	2726.00 ± 67.36
24	5	VR5	7.80 ± 2.47	36.80 ± 10.24	5.60 ± 0.76	5.60 ± 1.74	4527.00 ± 84.52
24	10	FR5	10.70 ± 0.57	55.50 ± 2.72	4.00 ± 0.44	6.10 ± 0.32	5360.00 ± 40.79
40	5	FR5	0.40 ± 0.09	3.20 ± 0.54	14.40 ± 2.77	0.40 ± 0.09	5340.00 ± 164.58
40	10	VR5	4.00 ± 0.57	14.60 ± 3.16	12.30 ± 1.64	2.20 ± 0.03	5675.00 ± 45.85
43	5	VR5	0.60 ± 0.18	4.80 ± 1.52	24.20 ± 6.04	0.40 ± 0.09	4704.00 ± 113.14
43	10	FR5	2.60 ± 0.32	15.00 ± 1.58	15.60 ± 1.39	1.70 ± 0.19	5040.00 ± 27.51
Overall <i>M</i>			7.65 ± 1.71	39.51 ± 8.57	26.67 ± 6.43	4.81 ± 0.96	4720.17 ± 274.39

Note. FR = fixed ration; VR = variable ration.

^aValues given are *M* ± standard error of the mean per day.

I. R. Inglis (personal communication, December 2001) suggested that the degree of species domestication may affect the level of contrafreeloading expressed. The more domesticated the species, the less contrafreeloading observed (Schütz, Forkman, & Jensen, 2001). This obviously would be an interesting hypothesis to investigate. Domestication undoubtedly changes many characteristics of animals (physiological, anatomical, and behavioral); however, we presently do not know which characteristic(s) changed by the process of domestication could affect the level of contrafreeloading expressed. This may be difficult to untangle, given that domestic pigs are considerably morphologically different from wild boar (their progenitor species) but are behaviorally similar (Stolba & Wood-Gush, 1989).

In terms of animal welfare, just because pigs only perform contrafreeloading at negligible levels does not mean, necessarily, that the behavior is unimportant to them. Veasey, Waran, and Young (1996) cautioned against making welfare assumptions based on how animals allocate their time. Although for an animal like a pig who in the wild would spend 25% to 75% of waking time foraging (Young, 1993), the level of contrafreeloading reported here seems low. However, nonhuman animals, like humans, will not necessarily choose what is best for their well-being (Dawkins, 1990). Chamove (1986) reported that despite their and medical staff's noting significant improvements in their behavior and well-being, human schizophrenic patients may not continue with occupational therapy. Perhaps, then, we need to admit that the expression, or lack of expression, of appetitive behavior may tell us little about the welfare of the animal offered such a choice. Therefore, we need experiments that measure the welfare benefits, if any, of contrafreeloading.

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REFERENCES

- Bateson, M., & Kacelnik, A. (1997). Starlings' preferences for predictable and unpredictable delays of food. *Animal Behaviour*, *53*, 1129–1142.
- Baxter, M. R. (1983). Ethology in environmental design. *Applied Animal Ethology*, *9*, 207–220.

- Bean, D., Mason, G. J., & Bateson, M. (1999). Contrafreeloading in starlings: Testing the information hypothesis. *Behaviour*, *136*, 1267–1282.
- Chamove, A. S. (1986). Positive short-term effects of activity on behaviour in chronic schizophrenic patients. *British Journal of Clinical Psychology*, *25*, 125–133.
- Chance, P. (1998). *Learning and behavior*. New York: Brooks/Cole.
- Cooper, J. J., & Appleby, M. C. (1997). Motivational aspects of individual variation in response to nest boxes by laying hens. *Animal Behaviour*, *54*, 1245–1253.
- Dawkins, M. S. (1990). From an animal's point of view: Motivation, fitness and animal welfare. *Behavioral and Brain Sciences*, *13*, 1–61.
- Forkman, B. (1991). Some problems with current patch-choice theory: A study on the Mongolian gerbil. *Behaviour*, *117*, 243–254.
- Forkman, B. (1993a). The effect of uncertainty on the food intake of the Mongolian gerbil. *Behaviour*, *124*, 197–206.
- Forkman, B. (1993b). Self-reinforced behaviour does not explain contra-freeloading in the Mongolian gerbil. *Ethology*, *94*, 109–112.
- Held, S., Mendl, M. T., Devereux, C., & Byrne, R. W. (2000). Social tactics of pigs in a competitive foraging task: The “informed forager” paradigm. *Animal Behaviour*, *59*, 569–576.
- Hsia, L. C. (1981). *Studies on social facilitation of the feeding behaviour of the pig*. Unpublished doctoral dissertation, University of Edinburgh, Scotland.
- Hughes, B. O., & Duncan, I. J. H. (1988). The notion of ethological need, models of motivation and animal welfare. *Animal Behaviour*, *36*, 1696–1707.
- Inglis, I. R., Forkman, B., & Lazarus, J. (1997). Free food or earned food? A review and fuzzy model of contrafreeloading. *Animal Behaviour*, *53*, 1171–1191.
- Jensen, G. D. (1963). Preference for bar pressing over free-loading as a function of number of unrewarded bar presses. *Journal of Experimental Psychology*, *65*, 451–454.
- Kacelnik, A., & Bateson, M. (1997). Risk-sensitivity: Crossroads for theories of decision-making. *Trends in Cognitive Sciences*, *1*, 304–309.
- Koffler, K., & Coulson, G. (1971). Feline indolence: Cats prefer free to response-produced food. *Psychometric Science*, *24*, 41–42.
- Lawrence, A. B., Appleby, M. C., & MacLeod, H. A. (1988). Measuring hunger in pigs using operant conditioning: The effect of food restriction. *Animal Production*, *47*, 213–220.
- Osborne, S. R. (1977). The free food (contrafreeloading) phenomenon: A review and analysis. *Animal Learning Behavior*, *5*, 221–235.
- Schütz, K., Forkman, B., & Jensen, P. (2001). Domestication effects on foraging strategy, social behaviour and different fear responses: A comparison between the red junglefowl (*Gallus gallus*) and a modern layer strain. *Applied Animal Behaviour Science*, *74*, 1–14.
- Schütz, K., Kerje, S., Carlborg, O., Jacobsson, L., Andersson, L., & Jensen, P. (2002). QTL analysis of a red junglefowl X White Leghorn intercross reveals trade-off in resource allocation between behavior and production traits. *Behavioral Genetics*, *32*, 423–433.
- Shepherdson, D. J., Carlstead, K., Mellen, J. D., & Seidensticker, J. (1993). The influence of food presentation on the behaviour of small cats in confined environments. *Zoo Biology*, *12*, 203–216.
- Stolba, A., & Wood-Gush, D. G. M. (1989). The behaviour of pigs in a semi-natural environment. *Animal Production*, *48*, 419–425.
- Veasey, J. S., Waran, N. K., & Young, R. J. (1996). On comparing the behaviour of zoo housed animals with wild conspecifics as a welfare indicator. *Animal Welfare*, *5*, 13–24.
- Young, R. J. (1993). *Factors affecting foraging motivation in the domestic pig*. Unpublished doctoral dissertation, University of Edinburgh, Scotland.
- Young, R. J. (1999). The behavioural requirement of farm animals for psychological well-being and survival. In F. L. Dolins (Ed.), *Attitudes to animals* (pp. 77–100). Cambridge, England: Cambridge University Press.

Young, R. J., Carruthers, J., & Lawrence, A. B. (1994). The effect of a foraging device (the "Edinburgh football") on the behaviour of pigs. *Applied Animal Behaviour Science*, 58, 145–152.