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Choice by Rats for Enriched Versus Standard Home Cages Plastic Pipes, Wood Platforms, Wood Chips, and Paper Towels as Enrichment Items

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CHOICE BY RATS FOR ENRICHED VERSUS STANDARD HOME CAGES: PLASTIC PIPES, WOOD PLATFORMS, WOOD CHIPS, AND PAPER TOWELS AS ENRICHMENT ITEMS

by

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The purpose of the present study was to determine whether simple additions to the home cages of rats made those cages preferable to standard housing arrangements. Results indicated that the majority of rats preferred cages with wood platforms, wood chips, and paper towels to otherwise identical cages without these items. Wood chips were not, however, practical with the cages used in the present study. Plastic pipes caused no problems but were not preferred by the majority of individual animals. Both wood platforms and paper towels created no problems and appeared to be useful as enrichment items. The latter were preferred to the former in a direct comparison.

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Choice by rats for enriched versus standard home cages: Plastic pipes, wood platforms, wood chips, and paper towels as enrichment items

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Anita Lynn Bradshaw

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INTRODUCTION

The appropriate care of nonhuman research subjects has become a topic of major concern to psychologists (e.g., Bowd, 1980; Dawkins, 1990; Feeney, 1987; Gallup & Suarez, 1980, 1985; Hineline, 1986; Miller, 1985; Segal, 1982). Such concern is not a recent development. Historically, animal activists have forced many investigators to respond to criticisms regarding the ethics of research with nonhumans. Among those who did so were Charles Darwin, Ivan Pavlov, Edward Thorndike, and John Watson (Dewsbury, 1990).

Evidence is widely available that Darwin was concerned about the appropriate care of nonhumans inside and outside of the labaoratory; for example, he was a regular contributor to the Royal Society for the Prevention of Cruelty to Animals (Clark, 1984). He publicly condoned the use of nonhumans in physiological research (e.g., before the Royal Commission on Vivesection) but also responded strongly regarding the conditions to which experimental subjects were exposed. Darwin favored strong punishment for anyone conducting physiological research without first rendering the animal insensible. His views were not accepted unconditionally, however, and he was criticized by antivivisectionists for his moderate position (Dewsbury, 1990).

The humane treatment of dogs was an issue of concern to Pavlov, who favored the species as a research subject. In a monument to the dogs used in his experiments, he had inscribed, "The dog, man's helper and friend from pre-historic times, may justly be offered as a sacrifice to science; but let this always be done without unnecessary suffering" (in Cuny, 1965, p. 25). He also wrote:

> When I dissect and destroy a living animal, I hear within myself a bitter reproach that with rough and blundering hand I am crushing an incomparable artistic mechanism. But I endure in the interest of truth, for the benefit of humanity (quoted in Babkin, 1949, p. 162).

However, Pavlov was criticized in the popular press. One of his most vitriolic critics was George Bernard Shaw, who wrote (1947):

> The existing law is clear on the point that if you keep a dog you must not illtreat it; and as Pavlov not only illtreated his dogs horribly but assumed that as a scientist he could do so with impunity, he brought the police up against the very troublesome public question of how far they should tolerate, and even enforce, practices which both common law and common sense class as criminal and detestable (p. 212).

The popular press was also critical of the work of John Watson. Dewsbury (1990) recounts a long series of reports in the lay literature which condemned the research involved in a study by Watson entitled "Kinesthetic and Organic Sensations: Their Role in the Reactions of the White Rat to the Hampton Court Maze" as trivial and inhumane. The paper was presented first at a conference and in abstract form, and prior to the publication of the paper Watson was accused of, among other things, conducting surgery on rats without benefit of anesthesia. These accusations were unfounded according to the methods reported in the published version of the study (Watson, 1907).

Controversy regarding the use of nonhumans has not been limited to exchanges between persons on opposite sides of the issues. Researchers themselves have been involved in disagreements regarding the appropriate use of nonhuman subjects. For example, repeated disagreeable exchanges occurred between William James and his former student, Walter Bradford Cannon, concerning ethical standards in vivisection (Dewsbury, 1990).

A more recent example of dissension within the field of psychology is an essay in The Psychological Record which directs criticism against experimental psychologists for ignoring such issues (Bowd, 1980). Bowd states, "The time has come for psychologists to reevaluate their beliefs regarding the treatment of laboratory animals. . . . There are contradictions inherent in the traditional arguments provided by psychologists in justification of their treatment of animal subjects" (p. 209). In response, Gallup and Suarez (1980) assert that "the ethical issues of animal research deserve more careful attention from psychologists" (p. 211) despite their observation that the incidence of psychological work with nonhumans comprised only 7.47% of all psychological research as reported for a one-year period in Psychological Abstracts. They further contend that "Bowd has created some serious distortions and false impressions about psychological research with animals" (p. 211).

To date, accusations that psychological researchers inflict pain and suffering upon nonhuman research subjects have not abated. In fact, they currently are "unprecedented with respect to the scope and extent of media coverage" (Dewsbury, 1990, p. 324). Many countries are currently establishing or revising legislation regarding the treatment of farm animals, zoo animals, and animals used in research (Dawkins, 1990).

Although a wide spectrum of opinion exists, there appears to be general agreement among lay people and researchers alike that nonhumans deserve at minimum to be housed under conditions that minimize discomfort and ensure health, and standards for such housing have been promulgated by the American Psychological Association (1985) and the National Institutes of Health (1985).

These standards understandably allow for housing conditions that do not closely resemble the natural environment. For example, bare wire cages, even if they are large and clean and provide ready access to food and water, are obviously unlike the usual habitat of rats. Whether this is significant is moot. Some authors have, however, suggested that the treatment of laboratory animals can be improved by enriching the environment in various ways (Champoux, Hempel, & Reinhardt, 1987; Novak & Suomi, 1988). One way in which environmental enrichment can improve housing conditions is by making them more preferable to the animals.

Domjan (1987) notes that "biological theory suggests that organisms select among their various options so as to get the most out of life in some sense" (p. 563). Similarly, Segal (1990) contends that:

> It makes eminently good sense to suppose that species that have survived the rigors of natural selection would be bound to seek contact with things that are in the main good for them and to shun contact with things that are in the main bad for them.
>
> Animals do in fact learn to act in ways that result in reinforcing consequences (access to appetitive stimuli, escape from aversive stimuli) and learn not to act in ways that result in punishing consequences (contact with aversive stimuli, loss of appetitive stimuli). It is surely reasonable to suppose that, by and large, events that function as reinforcing consequences (= "good" = "promote well-being" = "enhance fitness") and to suppose that, by and large, events that function as punishing consequences (= "bad" = "promote suffering" = "threaten fitness"). (I mean the equal signs to be taken

> literally; that is to say, I regard these as synonymous expressions.)
>
> I don't want aversive stimulation (I act to keep aversive stimulation away from me); I do want appetitive stimulation (I act to put myself in contact with appetitive stimuli). I assume that other species with nervous systems have the same fundamental biobehavioral motivational and emotional mechanisms, for I think contacting appetitive stimuli and avoiding noxious stimuli is a chief function of the nervous system--it's what evolution gave us a nervous system for (p. 36).

The present study used a free-operant choice procedure to study the preference of rats for alternative environmental arrangements in which one environment is "enriched" and one is not. Choice procedures are commonly used by behavioral psychologists to study preference as controlled by both quantitatively different reinforcers such as schedules of reinforcement (e.g., de Villiers, 1977; Herrnstein, 1961) and qualitatively different reinforcers such as unlike foods (e.g., Matthews & Temple, 1979).

Interestingly, choice procedures have been used quite extensively to examine preference in farm animals. For example, animals have been given choices between different types of flooring (Hughes, 1976; Hughes & Black, 1973; Irps, 1983; Ponteaux, Christison, & Stricklin, 1983; van Rooijen, 1985), different temperatures and light levels (Baldwin & Start, 1985; Morrison & McMillan, 1985; Richards, 1976), and different kinds of food (Matthews & Temple, 1979).

In one such study, a choice between alternative living environments, of which one might be said to be "enriched," was evaluated by Dawkins (1977). Domestic hens were given a choice between a commercial battery cage and a large pen, and a battery cage and an outside hen-run. The strength of the preference was then evaluated by "pitting" the preferred environmental condition against food and access to companions.

A procedure was used whereby twelve Sykes Tinted hens were removed from their normal housing (a shed), and individually placed in a 2.6 m by 0.82 m inside pen with wood shavings covering the floor. At the end of the pen, two battery cages with .38 m by .43 m wire mesh floors were placed level with the pen. The birds remained in the apparatus for 12 hours, and were observed for five minutes each hour to determine where they were located (i.e., the pen or one of the battery cages).

Despite the smaller floor area of the battery cages, no significant preference was found one way or the other. The authors suggested that two considerations might have accounted for the apparent lack of preference. One was the salience of the difference between the battery cage and the pen. A second was the method used to assess preference. Previous findings (Hughes, 1976) indicated that constantly modifiable access, as compared to a situation in which the choice was irrevocable for several hours, influenced the preference of domestic hens for wire or litter floors.

To assess the importance of these considerations, a second experiment was arranged in which access to both a 1.83 m by 0.76 m outside run and a hut on wheels containing three battery cages was provided. Hens were placed in a starting area in which both environmental arrangements were visible, and once a choice was made, the hen was confined to that area for 5 minutes. They were then placed back in the starting area and exposed to 23 additional trials. Two groups of hens were tested. One group had battery cages as home cages and the other group had outside runs as their home environment. Under these conditions, all hens significantly preferred the outside run; however, the battery-caged hens did so only after several trials of exposure to the outside run, indicating the significance of the home cage environment.

Two final manipulations involved assessment of preference for the outdoor run when hens were required to forego known reinforcers in exchange for access to the run. Except for the addition of six forced exposures to the choice conditions and testing only on the seventh trial, the procedures remained the same. In one manipulation, hens chose between a battery cage adjacent to two other cages containing one bird each, and an outside run. In this condition, 9 out of 10 birds chose the run by themselves over the battery cage near other birds. In the other manipulation, birds had a choice between a battery cage containing a trough of food and an outside run containing no food. Trials were conducted prior to the delivery of daily food provisions. Although the effect was not statistically significant, 7 out of 10 birds chose the run without food. Dawkins concludes that hens prefer an outside run over a battery cage, but that the strength of this preference is unclear.

The purpose of the present study was to evaluate whether rats preferred cages enriched by the addition of plastic pipes, wood platforms, wood chips, and paper towels to otherwise identical wire-mesh cages similar to those used in many laboratories. These items were chosen because they are inexpensive, easily presented, and not obviously harmful. Moreover, a possible mechanism of reinforcement was apparent for each: The towels and the wood chips provided nesting material, which has been shown to act as a reinforcer for female mice and hamsters (Jansen, Goodman, Jowaisas, & Bunnell, 1969; Roper, 1973), the plastic tubes allowed for "hiding," and the wood platforms avoided contact with the wire floor and allowed for chewing.

To assess preference, rats were given concurrent access to each of two sides of their home cage. One side was enriched, the other was not. Five times per day over a 10-day period, the side occupied by each rat was determined. In the final manipulation of the study, subjects were given a choice between two sides of a cage, one containing paper towels, the other containing a wood platform. The cage side containing each of these items was preferred in the first part of the study, and each of them was problem-free. Thus it was of some interest to see which item was preferred when paper towels and wood platforms were offered together.

METHODS

Subjects

Fifty male Sprague-Dawley rats served as subjects. Subjects were between 0.5 and 1 year of age at the beginning of the study. All of them had been used briefly in behavioral studies. Housing conditions and the maintenance of subjects are described in the procedures section.

Apparatus

Ten stainless steel cages (Unifab, Kalamazoo, MI) were used. Each cage was 48 cm long, 30 cm deep, and 20 cm high. The back and side walls were solid. The front wall and floor consisted of square wire mesh with individual wires separated by 1.3 cm. A fiberboard partition 18 cm high divided the cage into two equal sides, each 24 cm long and 30 cm deep. To allow subjects to pass from one side to the other, a square hole (7cm by 7cm) was cut from the top center of the partition. Two water bottles were mounted on the front of the cage. Water bottles were located 10 cm from each side wall with spouts 4 cm above the cage floor. A 13 cm high and 20 cm long wire mesh feeder constantly filled with Purina

Rodent Chow #5001 (Purina Mills, St. Louis) was centered horizontally on the front of the cage. Placement of water bottles and the feeder allowed equal access to water and food from either side of the partition. Individual cages were located in a climate-controlled colony area maintained at approximately 74° F. During the course of the study, the colony area was constantly illuminated.

Four enrichment items were used: 1-ply brown paper towels 33 by 26 cm, red cedar wood chips (American Wood Fibers, Jessup, MD), 18 cm lengths of 7.6 cm-diameter white plastic (polyvinylchloride) pipe, and 20 cm by 20 cm squares of 0.6-cm thick plywood. To prevent wood chips from falling through the wire-mesh cage floor, hardware cloth was attached by metal clips to the outside of the cage bottoms.

Procedure

In the present study, rats were given a choice between two sides of a wire-mesh cage. During the initial investigation, one side of the cage provided access to food and water but was otherwise barren. This side approximated typical housing conditions. The other side was identical in all respects with the exception of one item intended to "enrich" the environment. For randomly-selected groups of 10 rats, these items consisted of wood chips, paper towels, wood platforms, and lengths of plastic pipe. Each enrichment item was placed on the left side of five cages and on the right side of the five remaining cages. Wood chips were smoothed to a depth of about 2.5 cm, paper towels were placed at the back of the cage in a group of 15, wood platforms were laid flat on the cage floor, and lengths of plastic pipe were placed horizontally in the approximate center of the appropriate side. Each enrichment item was placed in cages one day before observations were begun.

Data were collected by direct observation. Observations were made five times per day, at 9:00 a.m., 12:00 noon, 3:00 p.m., 6:00 p.m., and 9:00 p.m. At these times, a single observer recorded which side of the cage each rat occupied (i.e., standard or enriched). Observations were made over the course of 10 consecutive days. During this time, paper towels were replaced if dampened from the water spouts. Despite the hardware cloth cage bottoms, wood chips frequently fell from the cage. When this occurred, they were replaced to a depth of 2.5 cm.

In the final manipulation, a group of 10 rats was given a choice between wood platforms and paper towels. Rats chose both of these items relative to the unenriched side, and both were simple to arrange. Choice between these items was arranged and measured as described above, with the exception that paper towels were placed on one side of the cage (the left for five animals, the right for the remaining five) and the wood platforms were placed on the other side.

For the study as a whole, on 18% (460 of 2,500) of observations, a second observer independently recorded data. Independent observations were arranged for each of the five groups of subjects. The minimum number of independent observations made for a group of rats was 70 of 500; the maximum was 110 of 500. In every case, the data recorded by the two observers were identical (i.e., interobserver agreement was 100%).

RESULTS

Figures 1 through 4 show the results of giving rats a choice between a standard housing condition and a condition enriched by the addition of plastic pipes (Fig. 1), wood platforms (Fig. 2), wood chips (Fig. 3), and paper towels (Fig. 4). Data for individual rats and mean group data are shown across days. Each letter represents data for an individual rat. Group means are indicated by open squares connected by lines. It is apparent from these data that, regardless of the specific enrichment item, rats generally preferred the enriched side of the cage to the alternative side. For all animals and observations, the side of the cage with plastic pipe was occupied on 273 of 500 observations (55%), the side with the wood platform was occupied on 358 of 500 observations (72%), the side with wood chips was occupied on 355 of 500 observations (71%), and the side with paper towels was occupied on 351 of 500 observations (70%). There was, however, considerable variation in the behavior of individual subjects. Table 1 shows for each subject the percentage of observations on the enriched side with each enrichment item. With each item, some subjects occupied the barren side during the majority of observations.

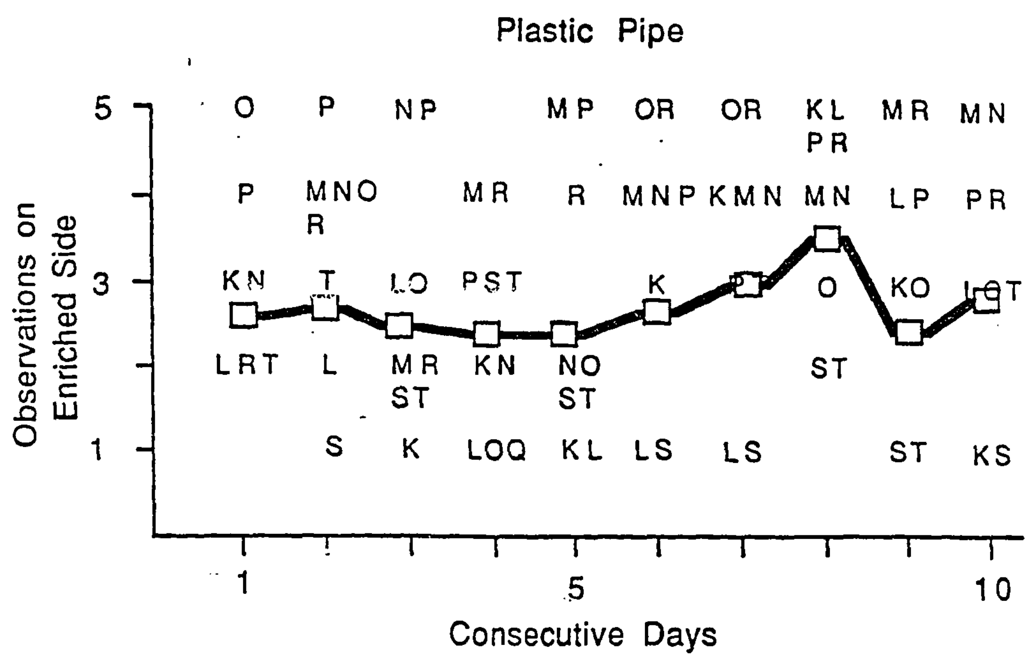

Figure 1. Daily Group Means and Number of Observations That Rats K, L, M, N, O, P, Q, R, S, and T Occupied the Side of a Home Cage That Contained a Piece of Plastic Pipe When the Other Side was Identical but did not Contain That Item.

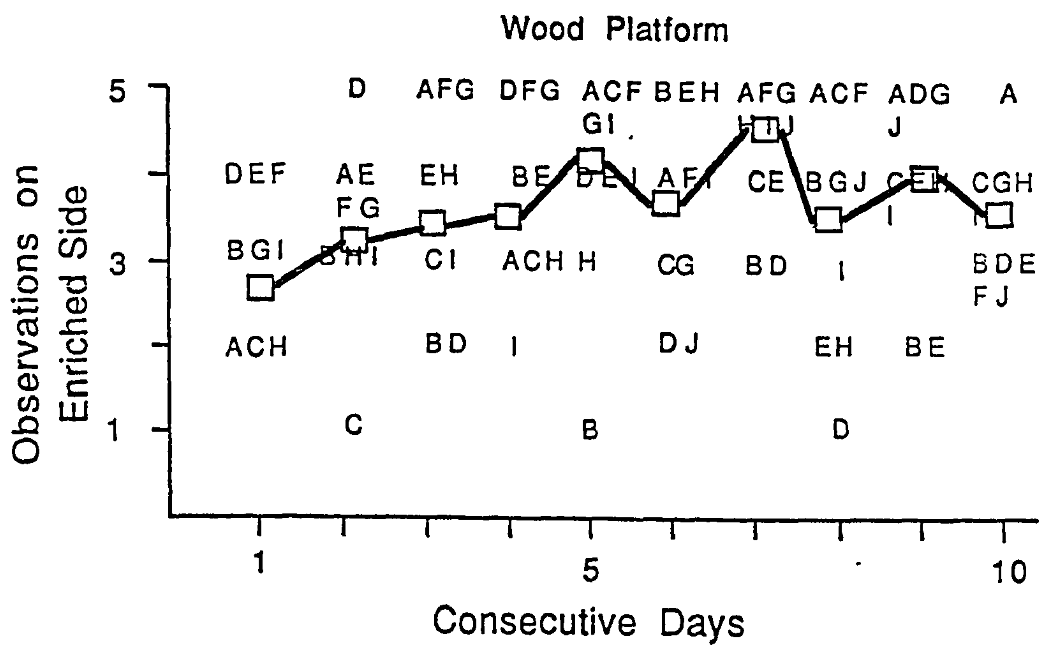

Figure 2. Daily Group Means and Number of Observations That Rats A, B, C, D, E, F, G, H, I, and J Occupied the Side of a Home Cage That Contained a Wood Platform When the Other Side was Identical but did not Contain That Item.

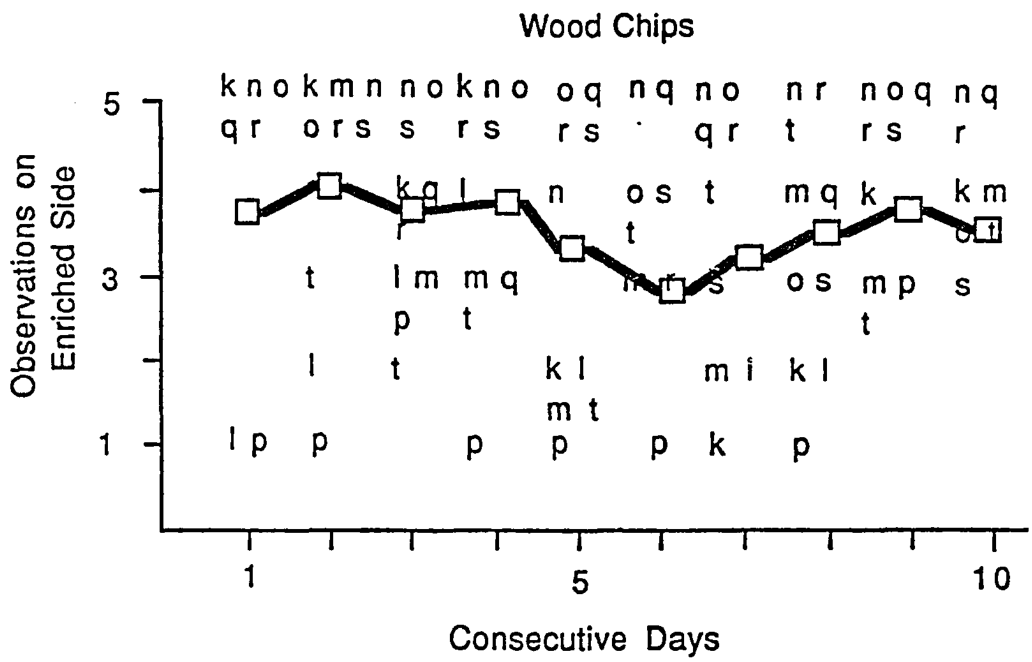

Figure 3. Daily Group Means and Number of Observations That Rats k, l, m, n, o, p, q, r, s, and t Occupied the Side of a Home Cage That Contained Wood Chips When the Other Side was Identical but did not Contain That Item.

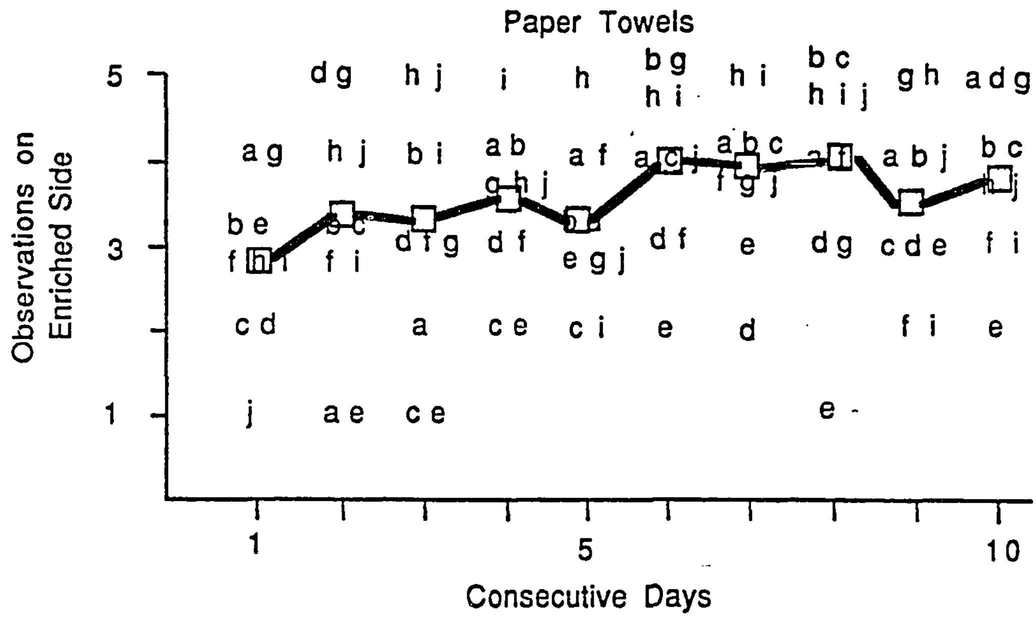

Figure 4. Daily Group Means and Number of Observations That Rats a, b, c, d, e, f, g, h, i, and j Occupied the Side of a Home Cage That Contained Paper Towels When the Other Side was Identical but did not Contain That Item.

Table 1

Percentage of Observations on the Enriched Side for Individual Subjects

Enrichment Item	Subject									
Plastic	K	L	M	N	O	P	Q	R	S	T
Pipe	46	46	84	66	68	84	2	80	28	42
Wood	A	B	C	D	E	F	G	H	I	J
Platform	86	60	68	68	72	88	86	70	72	46
Wood	k	l	m	n	o	p	q	r	s	t
Chips	64	32	64	98	92	24	90	94	84	68
Paper	a	b	c	d	e	f	g	h	i	j
Towels	72	78	60	64	42	64	82	90	74	76

This occurred with 5 subjects when plastic pipes were present, 1 subject when wood platforms were used, 2 subjects when the wood chips were present, and 1 subject when paper towels were available. When the behavior of individual subjects is considered, the plastic pipe was not obviously preferred. This was not the case with the other enrichment items, which were preferred by the majority of subjects.

The data in Figure 1 were analyzed statistically by means of chi-square tests, in which the actual number of times each rat occupied the enriched side was compared with the number expected by chance (i.e., 25 of 50 observations). These analyses indicated that the preference for the enriched side was significant for each of the enrichment items ($df = 9$, $p < .01$).

Figure 5 shows the results when subjects were given a choice between paper towels and wood platforms. A strong and statistically significant (chi-square, $df = 9$, $p < .01$) general preference for paper towels was evident. Overall, the side with paper towels was occupied on 351 of 500 observations (70%). Each rat occupied the side with paper towels on the majority of observations. The percentage of observations on the side with paper towels for individual rats was 92 (subject U), 60 (V), 100 (W),

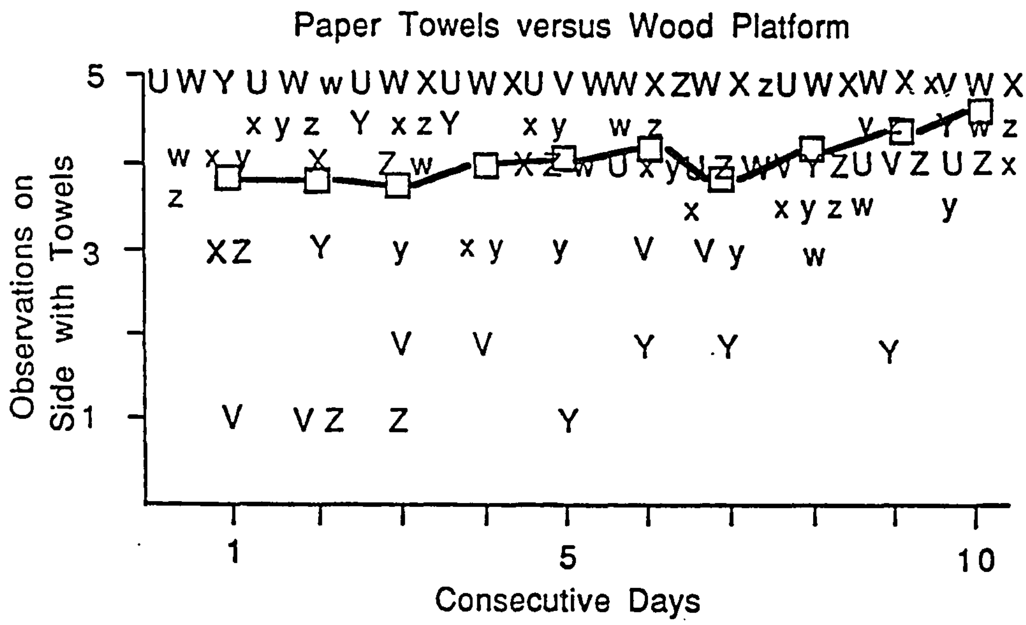

Figure 5. Daily Group Means and Number of Observations That Rats U, V, W, X, Y, Z, w, x, y, and z Occupied the Side of a Home Cage That Contained Paper Towels When the Other Side Contained a Wood Platform.

92 (X), 70 (Y), 68 (Z), 80 (w), 86 (x), 76 (y), and 94 (z).

DISCUSSION

The relationship between human experimenter and nonhuman subject is a complex and assymetrical one that concerns many people. There is general agreement among researchers that subjects deserve appropriate treatment. But what, beyond compliance with federal and local guidelines, constitutes appropriate treatment for a given subject? As Hineline (1986) notes,

> Whatever the bases for undertaking research with animals--and for many purposes there are no adequate alternatives (e.g., see Gallup & Suarez, 1985)--there is agreement that housing conditions and experimental procedures should be humanely and responsibly arranged. Yet in attempting to do this, one discovers that identifying "best practice" is not a straightforward matter (p. 124).

Preference does not encompass all aspects of an animal's welfare, but, as noted by Dawkins (1990), "An animal's preferences (for certain foods and temperatures, numbers of social companions) give a first indication of its view of the world" (p. 5). Dawkins contends that the concepts used in behavioral economics provide a productive framework for examining animal welfare. Behavior in certain choice situations is said to reflect "elastic demand" or "inelastic demand" (Hursh, 1984; Lea, 1978; Staddon, 1980) and this is considered by Dawkins as a critical feature of animal welfare:

> In economics, price elasticity is the ratio of the percentage change in consumption to the percentage change in price. It is calculated by holding everything else--income and prices of other commodities--constant, and varying the price of the commodity in question. Commodities for which a given percentage increase in price results in a decrease in the quantity demanded are said to have an elastic demand and are sometimes called luxuries; those for which a given percentage increase in price results in little change in the quantity demanded are said to have an inelastic demand and may be called necessities. There is clearly a continuum between elastic and inelastic demand, but economists use a slope of -1 as the boundary. (An alternative is to measure income elasticity: the percentage change in demand in response to a given change in "income" or the total time available to the animal for performing its entire behavioural repertoire.) (Dawkins, 1990, p. 6)

The cost of an item can be assessed by experimentally manipulating response requirements for that item. Put another way, by increasing response requirements, the strength of the establishing operation for an item can be measured as strong or weak. For example, under appropriate levels of deprivation, the establishing operation for food appears to be relatively strong or inelastic (Collier, Hirsch, & Hamlin, 1972; Collier, Johnson, Hill, & Kaufman, 1986; Hogan, Kleist, & Hutchings, 1970; Hursh, 1984; Marwine & Collier, 1979). The establishing operations for other reinforcers, for example, access to a rival (Hogan et al., 1970; Thompson, 1964), and light (Findley, 1959) appear to be weaker; that is, they show elastic demand.

Responding occurs regardless of the cost of the item if the demand is inelastic and the demand curve will be relatively flat: the demand curve for elastic commodities will have a steep slope. Dawkins (1983, 1990) proposes that the demand curves for an item help determine the importance of that item to welfare in the following way.

> Since food is essential to survival, and prolonged deprivation leads to clinical symptoms of ill health, a comparison between the slopes of the demand curves for feeding and for other activities can be used as a welfare yardstick. Commodities with demand curves similar to that of food can be regarded as essential to welfare. From the animal's point of view, they are as important as food and should have top priority in the design of animal housing. (p. 7)

Dawkins is suggesting that items for which an animal shows inelastic demands should be given top priority. This notion is supported indirectly and independently in that demand curves often coincide with other measures of welfare. For example, hens in battery cages will continue to meet response requirements as they are raised when the contingency of additional space is in effect (Lagadic & Faure, 1987). This evidence of what is important to the animal (i.e., more space) is consistent with other criteria which evaluate the importance of additional space. For instance, crowded conditions are correlated with brittle bones, leading to a high risk of breakage (Wabeck & Merkley, 1974) and with increased plasma-corticosteroid levels (Cunningham, van Tienhoev, & de Goeijen, 1987), indicators of stress.

Dawkins (1990) concedes that other measures of welfare are necessary in addition to preference testing and demand curves. Several problems exist with regard to using choice as the only measure of welfare. An obvious consideration addressed by Duncan (1978) and van Rooijen (1984) is that the long-term consequences of the choice (e.g., physical health) may or may not be in the best interest of the organism. A related problem is consistent preference may not be assumed. In suggesting that this technique can be used with a wide variety of species and stimuli, the determination of what establishing operations will be in effect at what time will be extremely complex but certainly critical. Another problem pointed out by Novak and Meyer (1990) is that

> because commodities or environmental conditions frequently exist on a continuum, a curve showing either an elastic or an inelastic demand might be obtained depending on the region of the continuum being studied. For example, the opportunity to move from a small cage to a moderately sized cage might be of considerably higher value to many primates than the move from a middle-sized to a large cage. Thus, sufficient sampling of the continuum may be necessary for sound conclusions to be drawn. (p. 31)

These potential problems emphasize that measures of welfare cannot be solely determined by preference and the strength of that preference. Such findings must be interpreted with care and supported by other data before sound conclusions concerning an animal's average well-being are drawn.

Nonetheless, preference data are surely valuable. For example, the purpose of the present study was to determine whether simple additions to the home cages of rats made those cages more preferred, and in that sense "better," than standard housing arrangements. Results indicated that the majority of rats preferred cages with wood platforms, wood chips, and paper towels to otherwise identical cages without these items. Wood chips were not, however, practical with the cages used in the present study, for they fell through the cage floor unless hardware cloth was attached to it. When this was done, cage cleaning was difficult. Thus, wood chips did not appear to be useful as enrichment items. Plastic pipes were also not useful, in that they caused no special problems but were not preferred by the majority of individual animals.

Neither paper towels nor wood platforms caused problems, and cages containing each of these items were preferred to standard cages. Thus, it appears that researchers interested in providing reinforcing enrichment items for rats could make use of either of these items. Of course, before so doing, investigators should secure approval from appropriate regulatory agencies. Adding enrichment items to home cages is not standard practice and may be inconsistent with the recommended practices of some regulatory bodies.

Although the procedures employed in the present study were adequate to provide a gross index of preference, each subject was only observed 50 times across the course of a 10-day period. This may have increased the likelihood of sampling error. Appreciable individual differences were evident in the data, and it is possible that results would have been more consistent across subjects had continuous observation been arranged. But it is also possible, and in fact likely given the magnitude of the across-subjects differences in behavior under some conditions, that subjects differed in their actual preference. If so, the variables accounting for the differences are unknown. Even under conditions where across-subjects variability was relatively small, as when paper towels were compared to wood platforms, preference typically was not exclusive. This suggests that there were multiple sources of reinforcement in the environment, in addition to those associated with enrichment items. It is possible that the relative desirability of a particular enrichment item depended on the activity in which a subject was engaging at a particular time, and that subjects differed with respect to the time allocated to particular activities. Further, and finer-grained, research is required to evaluate this possible explanation of individual differences.

A point of interest in the present data concerns the strong preference exhibited for paper towels over wood platforms. When these items were used singly as enrichment items, comparable preference was observed. With paper towels, rats were on the enriched side in 70% of the observations, whereas they were on the enriched side in 72% of the observations when wood platforms were used. Given this, and assuming that transitivity held with respect to preference, subjects should have been essentially indifferent when offered a choice between paper towels and wood platforms. They were not. This indicates that, under the conditions of the present study, choice for one alternative relative to the other could not be predicted accurately on the basis of choice for each item relative to a third alternative. Put differently, intransitivity of preference was evident. The theoretical implications of intransitivity for theories of choice, and the conditions under which it characteristically occurs, have been considered elsewhere (e.g., Fantino & Navarick, 1974; Navarick & Fantino, 1974).

The present data indicate that rats have a pronounced preference for paper towels as enrichment items.

Does this imply that, if regulatory agencies approve, researchers who work with rats should add paper towels to their home cages? Not necessarily. Paper towels allow for a significant species-typical behavior, nest building, and rats in the present study immediately constructed nests that they occupied during most observations. The availability of towels did them no apparent harm and increased their behavioral options. Nonetheless, as Novak and Suomi (1988) discussed, there are many variables that must be considered in evaluating how a laboratory environment affects a given subject.

Novak and Suomi proposed four criteria for establishing the "psychological well-being" of nonhuman primates. The first of these criteria is evaluation of a subject's physical health. This could range from external signs such as the condition of an animal's coat and appearance of the eyes, to internal measurements, which might include physiological variables such as blood profiles associated with immune function. The absence of physical abnormality is not a sufficient condition to establish well-being, but it is probably necessary.

A second criterion, which has been suggested by a number of researchers, concerns an animal's behavioral repertoire. Although complex, the general concept is that an animal should be able to engage in as much species-typical behavior as possible (e.g., see Markowitz & Spinelli, 1986). Interpretation of data regarding the repertoire exhibited by an animal is, however, less than easy. Identification of the responses which constitute an adequate or ideal "species-typical repertoire" is not a straightforward matter. For instance, it could be argued that a wide or diverse range of responses is the important factor, and this presents the problem of quantification in terms of how wide or diverse the range of responding must be to be considered appropriate.

Absence of stress is a third dimension that Novak and Suomi propose as relevant to well-being. This criterion rests on the assumption that a state of stress cannot exist concurrently with contentment and happiness. Although a precise definition of stress that is agreed upon by all researchers is not available (Friend, 1980; Levine, 1985; Mason et al., 1976; Ursin, 1982), hormonal measurements are typically used in nonhuman primates. The reason for this is that behavioral habituation to a stressor may occur while hormonal effects continue to occur.

Unfortunately, the relation between environmental conditions and hormonal changes does not lend itself to a simple interpretation in terms of welfare. Several factors must be considered. Stress may or may not be harmful in every instance, and the argument can be made that some stressors may actually be beneficial to organisms. Moreover, the complete absence of stress is a condition that probably never occurs in the natural environment of the animal, and if stress is entirely eliminated, what is left may be a continually bored animal. The physiological correlates of boredom have not been studied widely, but it may be as undesirable as the presence of stress.

A final criterion suggested by Novak and Suomi (1988) is competency in meeting environmental demands. For example, recovery from trauma, responsiveness to naturally occurring environmental stimuli, and the degree to which a particular strategy is adaptive in obtaining food or deterring antagonists are possible evaluation measures. The question remains, however, as to whether an animal that copes effectively automatically experiences psychological well-being.

Novak and Suomi conclude that the above four features represent legitimate bases upon which to judge the existence of psychological well-being in nonhuman primates. They used these criteria to evaluate the relative advantages of several alternative environmental arrangements for nonhuman primates in terms of their relative effectiveness in promoting psychological well-being. The environments they evaluated are single cage housing, pair housing, group housing in indoor pens, and group housing in outdoor enclosures.

With regard to single cage housing, the physical health of monkeys is superior. Disease, incidence of wounds, and incidence and severity of degenerative joint disease are lower than in free-ranging monkeys (Kessler, Turnquist, Pritzker, & London, 1986). The only detriment resulting from this type of environmental arrangement in terms of physical health appears to be a tendency toward obesity. Species-typical behavior, however, is greatly limited in such arrangements, especially with regard to complex physical interaction. The earlier the animal is exposed to this arrangement, the more likely that an increased incidence and severity of bizarre, stereotypic and autistic-like behavior will occur.

Stresses that are encountered in group living are essentially absent for singly-caged animals, but resilience to change may also be minimized (Levine, 1985). Major and exaggerated stress reactions may occur as a result of cage changes or standard husbandry procedures when early rearing experiences are impoverished (Kraemer & McKinney, 1979). These reactions are relevant to competence, in that species normal coping strategies are not given the opportunity to develop. As a result, monkeys may respond to these stressful situations with strange and bizarre patterns of behavior (Goosen, 1981).

Animals housed in pairs have nearly the same physical well-being of singly-caged animals, although they have the advantages of mutual grooming, and increased physical activity. The main drawbacks in terms of physical health are an increased likelihood of wounding, transmission of contagious diseases, and undernourishment in the less dominant partner. Most species-normative social behaviors occur in this situation although a prolonged arrangement between the same two individuals may lead to a decline in social interaction and an increase in general passivity. Stress may either be worsened in the case of incompatability or excessive aggression by the dominant member of the pair, or reduced via the presence of a social partner acting as a buffer in the presence of environmental changes (Stanton, Patterson, & Levine, 1985).

Group-housed monkeys in indoor pens experience a level of physical health comparable to pair-housed monkeys, although the incidence of wounding, undernourishment, and the chance of contracting a contagious disease are increased. Group pens provide space for increased exercise. With distributions of monkeys containing members of different kin, age, and sex, high levels of complex social interaction occur. In submissive animals, however, the chance of limited behavioral repertoires due to restriction by other group members is present. Stress effects can be greater or smaller in the group situation. Greater buffering may occur in large groups, but aggression, and resultant stress, may also be greater.

If the group is housed in a pen that is both indoors and outdoors, a contribution to the animal's overall level of health may be increased due to seasonal changes in coat, weight, and hormone levels. However, risks of injury as a result of insects or other outside hazards are also increased. The opportunity to escape to the inside or outside in the case of aggressive encounters may reduce stress, but if the breeding season is intensified by seasonal events, stress may be heightened. Variation in behavioral repertoires and coping strategies may also be precipitated by seasonal events.

If the group is entirely housed in a naturalistic outdoor enclosure, the physical costs and benefits will be similar to those in an indoor-outdoor setting. Foraging for nutrients and vegetation may occur although, if toxins are present, significant health risks will be posed. A wide range of species-typical behaviors usually occur in these environments. Highly complex social interactions usually occur when groups are representative in terms of age, sex, and kinship. New coping strategies are likely to occur as a result of these additional behavior patterns. Large groups may also result in increased buffering. As a result of the size and complexity of the enclosure, escape and avoidance opportunities may result in a reduction of stress for low-ranking animals. The main hazard of this environment is the potential for serious fights (Samuels & Henrickson, 1983).

These same dimensions of physical health, behavioral repertoire, stress, and coping strategies are relevant to the well-being of rodents, and merit attention. Preference for a given condition cannot unconditionally guarantee welfare and should not be interpreted as doing so. All of the considerations discussed in the context of interpretation of choice and demand curves cannot be dismissed without evaluating the importance of each one in a particular situation. Preference is only one of several important dimensions that should be considered in evaluating alternative living arrangements for any species.

Appendix A

Investigator Certification

INVESTIGATOR CERTIFICATION

Title of Project Do Rats Prefer an Enriched Environment?

If any of the above procedures are changed, I will submit a new protocol.

I understand that any failure to comply with the *Animal Welfare Act*, the provisions of the *DPHS Guide for the Care and Use of Laboratory Animals* and requirements set down by the IACUC may result in the suspension of my animal studies.

	Psych.	4/12/90
Signature: Principal Investigator	*Department*	*Date*

REVIEW BY THE INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE

____ Disapproved ✓ Approved ____ Approved with the provisions listed below

Provisions:
or
Explanation

Alan Poling	4/21/90
IACUC Chairperson	*Date*

Researcher's Acceptance of Provisions:

	4/21/90
Signature: Principal Investigator	*Date*
IACUC Chairperson Final Approval	*Date*

Approved IACUC Number 0035

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