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Preference and Motivation Testing

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ABSTRACT

Since the early 1970s, scientists have used preference tests (tests that require animals to choose between two or more different options or environments) as a means of answering questions about animal welfare. Preference tests have been used to establish animals' preferences for common housing options such as ambient temperature, illumination and preferred types of bedding and flooring; to improve the effectiveness of devices such as loading ramps and nest boxes; and to clarify how strongly animals avoid various aspects of confinement and methods of restraint.

To use preference research to answer questions about animal welfare, three issues need to be addressed. First, we must ensure that experiments do adequately reflect the animals' preferences. The preferences of an animal are likely to vary with the animal's age and experience, the time of day, environmental conditions, and the animal's on-going behaviour; therefore, preference experiments must be comprehensive enough to identify the relevant sources of variation. Experiments must also avoid confounding preference with familiarity, and avoid spurious results arising from the use of particular testing procedures and response measures. Second, to draw inferences about animal welfare from preference research requires that we establish how strongly an animal prefers a chosen option, avoids an unpref erred one, or is motivated to perform a certain behaviour (nest-building, exploration) that is prevented in some environments. Various methods to assess preference and motivation strength have been proposed. Third, the environments preferred by an animal will often, but not always, promote its welfare in the sense of health and psychological well-being. However, preferences may not correspond to welfare if the choices fall outside the animals' sensory, cognitive and affective capacities, or if animals are required to choose between short- and long-term benefits.

Future priorities for preference testing include more emphasis on identifying the factors underlying animals' preferences, greater integration of preference research with other indicators of animal well-being, more reliance on the natural history of the species as a source of hypotheses about environmental preferences, and greater use of preference research in the design of animal environments.

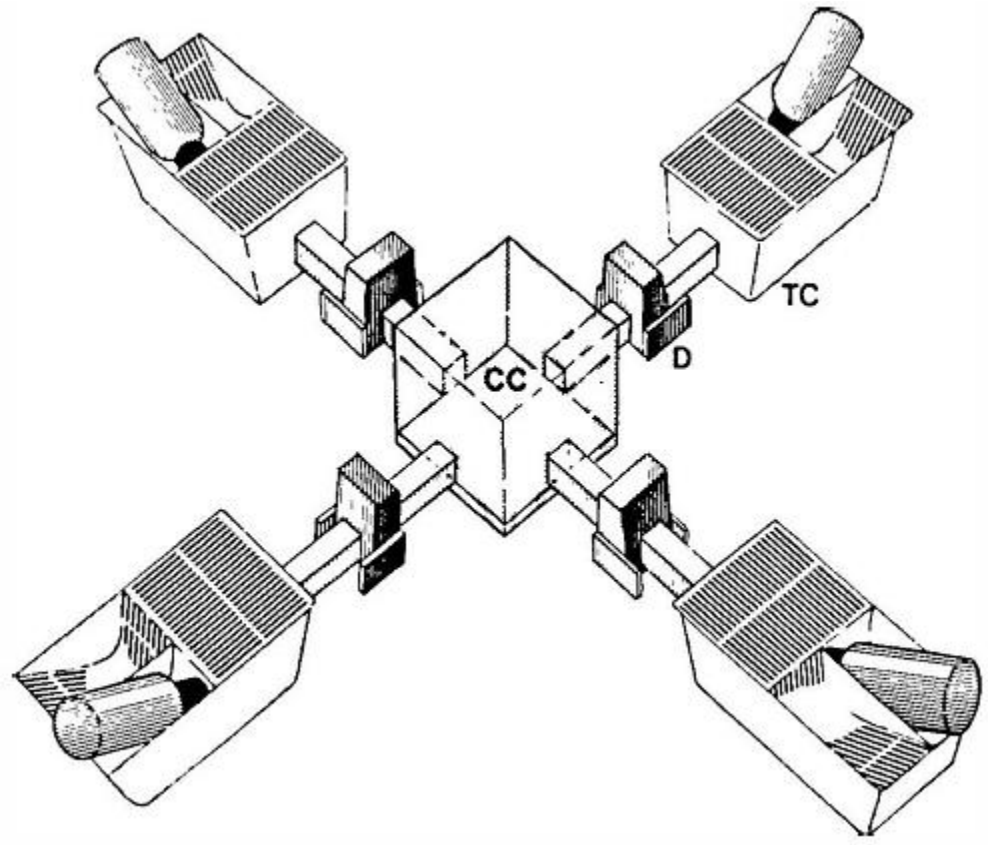
11.1. Introduction

According to legend, Saint Francis of Assisi once approached a fierce wolf that had been terrorizing the Italian, town of Gubbio, and offered the animal a choice: rather than continue in its wild ways, the wolf could choose to live within the town walls as a sedate and well-fed citizen. The wolf accepted the latter option and lived happily in the town for some time, but eventually the wolf's wild nature proved hard to reconcile with the choice it had made, and it fled from the town in misery and disgrace (Bruckberger, 1971).

Preference tests are commonly used as a tool in the study of animal welfare. Fundamental to this research is the assumption that animals make choices that are in their own best interests, and that a knowledge of the preferences

shown by animals will help us understand and improve their welfare. However, the story of Saint Francis and the wolf suggests that this assumption is not always so straightforward. This chapter reviews the use of preference testing in animal welfare research, and attempts to answer the question raised by the story of Saint Francis and the wolf: under what conditions do the choices made by an animal serve as a reliable guide to its welfare?

Fig. 11.1. A four-choice housing system for preference tests with mice, as described by Blom *et al.* (1992). The apparatus includes four test cages (TC) radiating from a central cage (CC). Four detector units (D), using red light emitting diodes, record the movement of animals along the passageways leading to the test cages. Behaviour in the cages was also monitored by video recording.



11.2. Early Use of Preference Testing

The naturalistic study of animal behaviour is an important precursor to preference testing. The fact that birds perch on branches or wires, and that mice burrow in fields or walls, provides information about the environments that these animals prefer. If collected in a systematic and quantitative way – for example by identifying the sizes of branches that birds do and do not use for perching - such observations can be a starting point for designing animal environments and a source of hypotheses for more controlled preference experiments.

Similarly, traditional laboratory studies of behaviour have provided significant insights into animals' preferences, although such work was often done as basic research on animal motivation. For example, S.A. Barnett and colleagues monitored the movements of rats and mice in a residential maze where food, water, nesting material, and other resources were available in different compartments. The apparatus was used to study how exploration, feeding and other behaviour is influenced by deprivation, genetic differences and different stages of the reproductive cycle (Barnett and McEwan, 1973; Barnett and Smart, 1975; Cowan, 1977). Such methods (Fig. 11.1) are now being applied more specifically to questions about animal welfare (Nicol, ·1986; Blom *et al.,* 1992).

Surprisingly, the formal proposal to study animals' environmental preferences as a component of animal welfare research arose from a British parliamentary committee. The ethologist W.H. Thorpe was one of the members of the 'Brambell Committee' formed in the United Kingdom to investigate the welfare of intensively housed farm animals. In his appendix to the committee's report, Thorpe (1965) proposed what became an agenda for using scientific of stress, indicators of pain and discomfort, studies of motivation that might be thwarted in confined animals, and research into the cognitive powers of animals. He also mentioned the intriguing possibility of 'asking' animals about their environmental preferences. The example that Thorpe cited was a chance observation:

> In the early part of 1964 a group of African buffalo were captured in a region of Kenya where their natural existence was no longer tolerable or possible, and were taken for release in the Nairobi National Park ... During the process of transport and preparation for release, they were of course kept in pens or yards much like those in which domestic cattle are kept. When the time came for their release in the new environment, they showed many signs of distaste for it. They would return toward human habitations toward nightfall and try to enter the paddocks where they had been. One even tried to walk through the French windows of the office of the Director of the Kenya National Parks. The natural assumption is that the unfamiliar National Park, reeking of lion, leopard and other dangerous and uncomfortable neighbours, must have seemed a very unfriendly place; far inferior to the luxurious though restricted quarters they had become used to inhabiting! (Thorpe, 1965, pp. 73-74)

Thorpe concluded that because these animals had experienced a range of living conditions, we could legitimately 'ask' them which they preferred.

Appropriately enough, the first actual experiment using preference testing to resolve a farm animal welfare issue arose from one of the more specific recommendations of the Brambell Committee. The committee had concluded that the flooring materials used for hens in cages were often unsatisfactory. The committee was particularly critical of 'chicken wire' flooring (fine-gauge wire netting of a hexagonal pattern) which, it suggested, 'the bird's foot is not well adapted to grip' (Brambell, 1965, p. 21). Instead, the committee recommended that the cage floor should consist of a heavy-gauge rectangular metal mesh.

To obtain the hens' own view of this recommendation, Hughes and Black (1973) tested the preferences· of hens for different types of flooring. They housed hens in cages consisting of two sections, each floored in a different material (Fig. 11.2). They offered various materials in pair-wise choices, and simply observed how much time the birds· spent on the different flooring products. The results indicated that the hens had no strong preferences or aversions for the different materials, but their overall preference was for, rather than against, the fine-gauge 'chicken wire' which the Brambell Committee had deemed unsuitable.

Other early preference testing tried to answer broader questions. Dawkins (1977) used preference testing to· ask whether hens prefer battery cages to large pens or outdoor runs. In one experiment she gave hens free access to cages and to larger pens for 12 hours, and observed the time that the hens spent in each environment. Perhaps surprisingly, the hens spent considerable time in the cages. She then did a series of trials in a T-maze where turning in one direction caused hens to spend the next 5 minutes in a battery cage, while turning in the other direction led to 5 minutes in an outdoor run. With this procedure, the hens tended to select the outdoor run.

Since these early examples, environmental preference testing and related measures have been used for an impressive variety of purposes in animal welfare research. Simple uses include establishing preferences for ambient temperature (Morrison *et al.,* 1987), for illumination levels (Baldwin and Start, 1985; van den Broek *et al.,* 1995), and for common materials such as types of bedding (Hunter and Houpt, 1989; Blom *et al.,* 1993) and flooring (Marx and Mertz, 1989). The methods have also been used to identify which design features of animal housing and handling equipment are significant to the animals themselves. Such knowledge has allowed more effective design of loading ramps (Phillips *et al.,* 1989), nest boxes (Hurnik *et al.,* 1973), roosts (Muiruri *et al.,* 1990) and other equipment. The methods have also been used to assess how strongly animals seek to avoid noise and vibration (Stephens *et al.,* 1985) and various forms of restraint (Rushen, 1986a).

Despite these successes, preference testing has remained a controversial tool in animal welfare research. In fact, the ink had barely dried on the earliest reports of preference testing when debate broke out over what we can actually conclude from the technique. Initially Duncan (1978a); and subsequently others (e.g. van Rooijen, 1982; Hutson, 1984), provided many criticisms of preference testing, and these stimulated major changes in how preference tests are conducted and interpreted (reviewed by Dawkins, 1980, 1983b; Duncan, 1992a; Fraser et al., 1993; Fraser, 1996). Three main issues are involved, two of them mainly methodological and one mainly conceptual, as we describe in sections 11.3 to 11.5 below.

11.3. Ensuring that Experiments Adequately Reflect Animals' Preferences

The first and most basic concern is that preference experiments must accurately capture and identify the animals' true preferences, and this requires attention to several points about how we design and conduct preference research.

11.3.1. Asking suitably complex questions

One criticism of the early preference research is that simple experiments of the type described above underestimate the complexity of animals' environmental preferences. On the surface it might seem reasonable to ask whether pigs prefer pens with straw bedding or pens with bare concrete floors. However, in an initial experiment designed to answer this question (Fraser, 1985), pigs gave very inconsistent results, and further research showed that the pig's degree of preference for straw depends on a variety of factors. Specifically, pigs appear strongly attracted to straw for foraging, but are relatively indifferent to the presence of straw when using a feed or water dispenser; they either prefer or avoid a straw-bedded surface for resting, depending on whether the environment is cool or warm; and preference for straw increases sharply just before parturition when sows normally make nests (see Steiger et al., 1979; Fraser, 1985; Marx and Mertz, 1989; Fraser et al.; 1991; Arey, 1992). To deal with this complexity, we need not a simple experiment to determine whether pigs prefer straw, but a more comprehensive study of how the preference is influenced by features of the environment and by the animal's condition and behaviour. Even when the ultimate objective is to decide what kind of housing is best on average for a certain type of animal, research methods that ignore relevant variables are likely to give contradictory results.

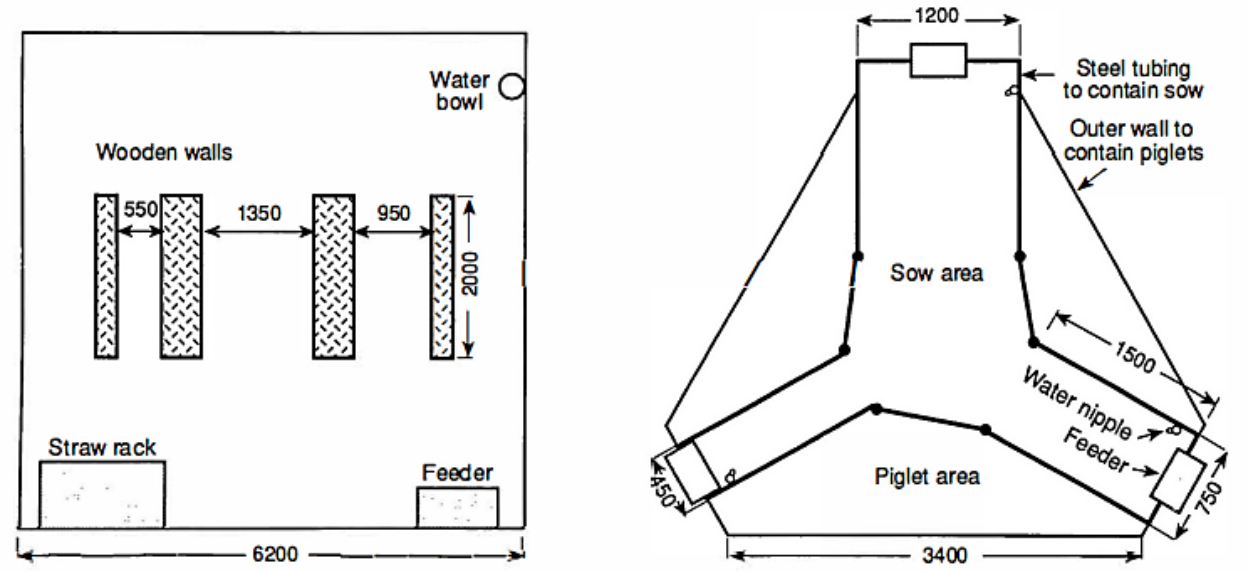
Asking more complex questions about animal preferences puts certain demands on experimenters. First, experiments must cover sufficient variation to monitor animals' preferences under a range of fluctuations in both the environment and the animal's condition. Brief tests in a T-maze, as used in the 1970s, have given way to methods such as continuous video or electronic monitoring over periods of days or weeks. For example, van den Broek et al. (1995) electronically monitored the movements of gerbils during 48-hour periods in an apparatus that provided different levels of illumination in different compartments; they found that the animals had a clear preference for low light intensities for sleeping but not at other times. Second, experiments should be designed so that individual differences and other variability in the animals' responses can be interpreted. Nicol (1986) noted that when given a range of cage sizes, hens invariably spend some time in the less favoured cages. She proposed that these differences might occur because preferences genuinely vary between individuals or over time, or simply because the birds tend to move about, monitoring the environment periodically, or for other reasons. These different possibilities can be tested with appropriate experimental designs.

11.3.2. Avoiding spurious results

In a given experiment, the particular apparatus or response measure used may have unexpected effects on the preferences ·that animals show. Fig. 11.3 illustrates a case where different procedures - both designed to test whether sows would prefer a narrow or wide enclosure for farrowing - resulted in contradictory results. Experiments described by Baxter (1991) used four solid, parallel partitions to create three open-ended stalls of different widths in the centre of a large room. Sows housed in this room for farrowing tended to use the narrowest stall more often than the wide ones, and Baxter (1991, p. 12) concluded ‘that sows have a significant preference for small farrowing sites.’ Phillips et al. (1992) used an apparatus consisting of three farrowing stalls radiating from a central hub area. Under these conditions, sows showed a very strong preference for the widest stall ahead of narrower alternatives. Why did the two experiments give contradictory results? The stalls, used by Baxter (1991) were enclosed by solid walls on two sides and were open at the ends; therefore, the narrow stalls provided more visual enclosure than the wider ones and may have been preferred for this reason (see Phillips et al., 1991). Alternatively, the fact that sows could walk straight

through the stalls used by Baxter (1991), but had to back out of those used by Phillips et al. (1992), might have affected their choice of stall width.

Fig. 11.3. A plan of experimental apparatus designed to test the size of enclosure that sows prefer for farrowing. At left, a large room with four solid, wooden partitions forming three open-ended stalls 550, 950 or 1350 mm wide (from Baxter, 1991). Sows placed in the room could choose to farrow in any stall at will, or in other parts of the room. At right, three farrowing stalls, 450, 750 or 1200 mm wide, radiating from a central area where the sow could exit from one stall and enter another (from Phillips et al., 1992).



A further concern arises when an animal is required to perform some 'instrumental' or 'operant' response (i.e. a task such as pressing a lever or pecking a key) in order to obtain a reward (see Lagadic, 1989). Certain instrumental responses are appropriate for certain types of reward but not for others (Hinde and Stevenson-Hinde, 1973). For example, it is natural for hens to find food by pecking and to enter a new area by walking. However, in an experiment by Lagadic and Faure (1987), hens were required to peck a key in order to activate a motorized barrier and thus enlarge their cage. In such an experiment, can we trust the result as a true reflection of the hen's motivation to have additional space? Or would alternative responses (e.g. walking rather than pecking) have given different results? The traditional instrumental responses used by experimental psychologists studying motivation for food and water (key-pecking, lever-pressing) often bear little natural relation to the kind of rewards used in research on animal welfare; hence, such methods need to be carefully investigated and validated.

These various examples illustrate the need for 'constructive replication', whereby the main features of an experiment are repeated using somewhat different methods, to ensure that the conclusions are not unduly influenced by a particular experimental apparatus or the manner in which a preference is expressed.

11.3.3. Determining the effects of experience on preferences

Experimental designs also need to take account of the animals' previous experiences (Hughes, 1976b; Petherick et al., 1990). In the simplest cases, animals may show a temporary avoidance of, or attraction to, unfamiliar options, but these temporary reactions must not be used to infer longer-term preferences. For example, Dawkins (1980) noted that hens housed in cages tended, in initial preference trials, to select a cage over an outdoor run, but a few minutes of exposure to the run was enough to overcome this initial reaction. In other cases, preferences may undergo longer-term change as the animals gain experience of the different options. For example, Phillips et al. (1996) housed sows for three weeks in a preference apparatus where the animals could choose to be on different types of flooring. Initially the sows strongly preferred concrete flooring, with which they were familiar, to metal and plastic products. However,

this preference waned after several weeks as the animals gained experience of the different alternatives. In this case, the animals may have needed prolonged exposure to the options to become confident in walking and going through their normal postural changes on the different surfaces.

11.4. Assessing the Strength of Animals' Preferences

A preference shown by an animal in a choice experiment may be a weak preference, like a preference for grapes over cherries, or a strong preference, like a preference to live in a house rather than a dungeon. Denying animals access to their preferred options presumably affects welfare more if the preference is strong rather than weak. Thus, in addition to establishing what an animal prefers, we also need some indication of preference strength. As expressed by Dawkins (19836, p. 23):

> Just because an animal prefers one thing to another or chooses one set of conditions over another, this cannot be taken to mean that it necessarily suffers if it has to make do with its least preferred state . . . What we need is a way of calibrating the various signs of welfare and suffering in a quantitative way.

A related concern arises from the experimental designs used in most preference testing. As noted by Fraser *et al.* (1993, pp. 108-109):

> In most other types of research, the variation attributable to the treatment is compared with extraneous variation, due to individual animals or groups, to location effects, time effects, and so on. In preference tests the different options are usually presented to the same animals at the same time and in almost the same place.

Consequently, preference tests generally minimize extraneous variation, and may detect statistically significant differences even where the magnitude of the preference is small.

In the simplest approach to establishing preference strength, experimenters have tried to determine whether a preferred environment is sufficiently rewarding that an animal will learn to perform some operant or other instrumental response to obtain access to it. For example, having established that hens prefer floors with litter instead of bare wire, Dawkins and Beardsley (1986) tested whether hens would learn to peck a key or break a photobeam to gain access to a cage with litter. If the animal can be trained in such a way, then the motivation to be in that environment must be more than trivial.

Such experiments, however, do not provide a quantitative scale for comparing the strength of different preferences. Consequently, Dawkins (1983a) proposed that we might assess the strength of one preference by 'titrating' it against a second, well understood preference for a reward such as food. In one experiment, Dawkins trained hens to enter two cages from a common choice point. One cage contained litter (to permit dust-bathing) but no food, while the other contained food but no litter. Dawkins then required the hens to choose between the two cages after zero, 3 or 12 hours of food deprivation. The results suggested that the hens' motivation for dust-bathing, under the given conditions, was about as strong as their motivation to eat when food had been withheld for 3 hours.

In a further refinement, Dawkins (1983a, 1990) proposed that motivation testing could be blended with a concept used by economists to assess the importance of a commodity to human consumers:

> Commodities for which a given percentage increase in price results in a decrease in the quantity demanded are said to have *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 *inelastic demand* and may be called necessities . . . Elasticity of demand is a key concept for the study of animal welfare . . . because it shows how important different environments or commodities are to the animals themselves. (Dawkins, 1990, p. 6)

To apply this concept to animals, a commodity such as food can be provided in response to some work ('price') that the animal has to perform, and the 'price' can then be varied experimentally. Commodities that are very important to the animal should show relatively inelastic demand; that is, the animal should work harder and harder to maintain a

given level of reward if the reward is very important. By establishing the elasticity of demand, we should be better able to judge the importance that animals attach to food, companionship, bedding, exercise and other features. Technical and other difficulties in using the method have been noted by Dawkins (1990), Dantzer (1990), Mench and Stricklin (1990) and others.

In research to date, various methods have been used to vary the 'price' that animals must pay for commodities. Matthews and Ladewig (1994) used an *operant* response to vary price. In their experiment pigs were required to press a nose-plate to receive either food or social contact with another pig. As the number of presses needed to obtain food was increased from 1 to 30, the pigs compensated by pressing more and more, and thus obtained a fairly constant amount of food. When social contact was the reward, the pigs failed to compensate for the increasing price and received fewer rewards. An alternative approach is an *obstruction test* which requires animals to overcome some obstacle in order to gain access to a reward. Petherick and Rutter (1990) described a computer-controlled push-door that they used to measure the amount of 'work' that hens would expend to obtain food, and Duncan and Hughes (1988) used a similar method to measure hens' motivation to enter a nest box for laying. The dangers of obtaining spurious results because of artefacts are discussed by Petherick and Rutter (1990). In *limited time tests,* the experimenter increases the price of commodities by reducing the amount of time available to obtain them. For example, Dawkins (1983a) placed hens for several hours per day in an apparatus consisting of one cage furnished with food and water, and a second, adjoining cage containing only litter. She gave the birds 2, 4 or 8 hours in the apparatus, and they had no access to food or litter at other times. When the birds had 8 hours in the apparatus, they spent considerable time with the litter, but when time was limited to 2 hours, the birds reduced the time they spent with litter in order to feed.

Finally, measures of motivation strength can also be applied to situations that animals avoid. For example, Rushen (1986a) used *aversion testing* to assess the welfare implications of electro-immobilization of sheep. Electro-immobilization involves use of a pulsed, low-voltage current passed through the body to immobilize an animal. Some veterinarians had claimed that the technique reduces the distress that animals experience during restraint for procedures such as shearing. Rushen trained sheep to move along a runway to a pen where they were restrained in various ways with and without electro-immobilization. He showed that over repeated trials, sheep that received the electrical treatment at the end of the runway became more difficult to move along the runway than those that were restrained without electro-immobilization. The usefulness and validity of various behavioural measures of aversion are discussed by Rushen (1986b) and Rutter and Duncan (1991, 1992).

11.5. Clarifying the Link between Preferences and Welfare

Even when we have accurately identified an animal's preferences and assessed their strength, we need to clarify the conceptual issue of how an animal's preferences relate to its welfare. For this, we need to be reasonably clear on what we mean by welfare.

For present purposes, we will consider two key components of animal welfare (see Chapter 2). The first is based on the *subjective experiences* of the animal and involves reasonable freedom from prolonged or intense pain, discomfort, frustration and other unpleasant states, together with positive experiences such as comfort and contentment. The second component is based on the *biological functioning* of the animal and involves freedom from disease, injury, and malnutrition, and other threats to normal health and survival.

Presumably an animal's preferences are closely linked to its subjective experiences at the time of making the choice. For example, we assume that animals will in general seek out environments in which they find comfort, contentment and other positive experiences, and will avoid environments in which they suffer. As noted by Dawkins (1980, p. 91): 'Animals may not be able to talk, but they can vote with their feet and express some of what they are feeling by where they choose to go.'

However, the link between preferred environments and positive subjective experiences may break down if the short-term and longer-term consequences of the choice are in conflict. As Duncan (1978a, p. 198) noted:

> Animals . . . cannot be expected to weigh up the long-term consequences of their decisions as would human beings, and make rational choices accordingly. In fact there is an increasing volume

> of evidence . . . to show that animals prefer an immediate reward compared to an equal or even larger reward sometime in the future.

Duncan's example involved hens which are given 'trap-nests' in which to lay eggs. After entering a trap-nest, the bird cannot escape until it is released by a handler and thus may remain trapped without food, water and social contact for several hours after oviposition. The fact that hens continue to use the nests does not necessarily mean that they do not mind being held in the trap-nests, nor that their preference for laying in a nest box outweighs their aversion to being restrained. Rather, the hens' behaviour on entering the nest may simply reflect their motivation at the time, and not the future consequences of the action.

The link between preferences and the biological functioning of the animal is perhaps more complex. For an animal of a wild genotype developing and living in an environment similar to that in which the species evolved, we expect natural selection and ontogenic development to produce a set of environmental preferences that promote the health and survival of the individual and its offspring. Exceptions may arise, however, if an artificial environment creates challenges for which the animal's evolution and ontogenic development have failed to prepare it, or if the animal has been genetically altered in relevant ways through selective breeding.

The simplest problems arise if animals are exposed to potential dangers or benefits that are beyond their sensory and affective capacity. Many fish species successfully avoid being harmed by certain aquatic pollutants, such as copper, simply by swimming away from contaminated water (Giattina and Garton, 1983). However, fish generally fail to avoid certain other contaminants, such as phenol, selenium, even at *levels* that cause serious damage or death (Giattina and Garton, 1983; Hartwell *et al.,* 1989). Presumably the fish never *evolved* or developed the capacity to detect these contaminants, and in these cases their preferences fail to protect their health.

A similar limitation may occur if a choice requires a level or type of cognitive ability that the animal does not possess. Rats rapidly learn to avoid a poisoned food on the basis of its flavour, but not if colour or pellet size is its distinguishing feature (McFarland, 1985). In this case the rats presumably can detect all the distinguishing stimuli, but do not readily associate symptoms of poisoning with the visual properties of the food:

As these examples show, an animal's preferences will not always promote its welfare in the long term. Perhaps the best safeguard is to base preference research on the types of choices that the species arguably *evolved* the capacity to make, and that the individual animals are accustomed to making in their normal lives.

11.6. Future Directions for Preference Research

For the future, we propose that preference and motivation research needs to develop in four directions. First, instead of simple, empirical comparisons of different environments or materials, preference research needs to identify the primary factors influencing the preferences that animals show. Two approaches have been used for this purpose (Fraser *et al.,* 1993). In a *multivariable approach,* preferences or preference rankings are established among a large number of options which differ in numerous features, and statistical analysis is used to indicate which features are most closely related to the animals' preferences. For example, Farmer and Christison (1982) established the preferences of young pigs for a variety of flooring products,' and also measured many attributes of the products, including the amount of traction they offered, the degree of heat loss through the material, and the abrasiveness of the surface. Statistical analysis then showed that weaned pigs tended to choose high-traction floors, whereas very young piglets chose floors that would not conduct heat away from the body (Christison and Farmer, 1983). Alternatively, in a *serial factor approach,* a series of preference experiments is conducted, each one testing preferences for different levels of a single design feature. For example, Phillips *et al.* (1988) exposed pigs to ramps of different designs. In one experiment, the ramps differed only in slope; in another they differed only in level of illumination; in another they differed in width, and so on. The animals showed clear preferences when the slope and traction of the surface were varied, but they seemed indifferent to variation in other features. By using such methods to identify the primary factors mediating animals' preferences, we have a better chance of extrapolating appropriately beyond the particular range of options tested.

A second challenge will be to integrate preference research with other measures used in animal welfare assessment. In theory, animals kept in environments that they strongly prefer ought to experience less discomfort and frustration,

and this should lead to lower *levels* of stress, and perhaps greater health, longevity and reproduction. However, most preference research to date has been done somewhat in isolation from other types of animal welfare research, and the wider animal welfare impacts of providing animals with preferred environments have been too little studied.

Third, a knowledge of the natural history of a species could be better used to provide guidance for preference research. The environments preferred by sows for farrowing are probably quite similar to the nest sites that sows seek in nature (Phillips *et al.,* 1991). Likewise, features of cage design preferred by laboratory rodents, of perches preferred by birds, or of enrichment devices preferred by captive primates may well resemble the features of such items used by those species or their wild ancestors living in natural environments. Thus, a knowledge of natural history could help investigators identify potentially important variables in advance, and the power of controlled experimentation could then establish the relative importance to the animal of the variables that characterize the environments they use in nature.

A fourth challenge will be to make better use of environmental preference testing in the design of new animal environments. Duncan (1992b) suggested that many 'alternative' systems of animal production, designed to meet animal welfare concerns in the 1970s and 1980s, were actually more inspired by public perceptions of animal welfare rather than the 'real needs' of the animals. Concerning systems for hens, he noted:

> During this era, two approaches dominated. One was the ' back to nature' approach which advocated keeping hens on free-range or semi-extensively in spite of the fact that the associated problems of predation, exposure to inclement weather, parasite infestation and general disease control were still within living memory. The other was the 'let's build them a palace' approach which tried to incorporate *every* conceivable requirement into the birds' environment. (Duncan, 1992b, p. 476)

In contrast to these approaches, a solid understanding of animals' environmental preferences and the strength of those preferences should allow us to design environments that cater to the priorities of the animals themselves.

11.7. Coda

So, when the wolf of Gubbio chose to live in the town rather than in the wild, could we have concluded that its choice provided objective information about its welfare, and that the wolf would live a happier life in the town? As a preference test, this situation was seriously flawed in two respects. First, the choice offered to the wolf failed to take account of the complexity of the animal's environmental preferences; the town might meet the wolf's needs at certain times but not others. Second, the choice, with its requirement to balance the immediate advantages of a free dinner against the long-term constraints of urban living, probably fell outside the animal's ability to weigh up present and future outcomes. These deficiencies may not have troubled Saint Francis, as he could allegedly converse with animals in their own languages. For those of us who lack this gift, the careful design of environmental preference tests will remain an important manner of understanding an animal's reactions to the environments in which they are kept.

11.8. Conclusions

Preference and motivation testing provide useful information on the reactions of animals to methods of handling and housing and to other features of their environment.

The environmental features preferred by an animal are likely to vary with its age and experience, its reproductive state, its on-going behaviour and other variables. Preference research must be comprehensive enough to identify these sources of variation.

To draw inferences about an animal's welfare from preference research, the strength of the animal's preferences needs to be known. Various methods to assess preference and motivation strength have been developed.

Great care is needed over the methods of preference and motivation testing. Particular test procedures or response measures may have unexpected impacts on the preferences that animals show. Research must also avoid confounding preferences and familiarity.

Animals' preferences, as revealed by preference tests, often identify environmental features that will promote their welfare. However, the link between preferences and welfare may break down if the choices offered in preference tests fall outside the animals' sensory, cognitive and affective capacities or if animals are required to choose between short-term and long-term benefits.

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