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Behavior Analysis and Farm Animal Welfare

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This article demonstrates that there is a role for behavior-analytic techniques in the area of farm animal welfare and provides examples of the kinds of work that can be done. Behavior-analytic procedures, specifically those used in the study of psychophysics, preference, and demand, can provide answers to three questions people concerned with the welfare of farm animals are likely to ask: What can the animals detect? What do they like and dislike? What will they work to attain or preserve? Such information certainly is necessary for making reasonable decisions about animal welfare, although it is not sufficient in and of itself.

Key words: animal welfare, psychophysics, preference, demand, farm animals

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Over 20 years ago, Kilgour (1976) suggested that a science of behavior could contribute to the production and welfare of farm animals, which are domestic species used to provide food, fiber, and traction power. Over 100 articles that describe operant behavior in farm animals have appeared (Kilgour, Foster, Temple, Matthews, & Bremner, 1991). Some, but by no means all, of these articles are concerned with welfare issues. Although welfare-related articles appear in a variety of outlets, most have been published in journals devoted primarily to animal husbandry (e.g., *Applied Animal Behaviour Science*), ethology (e.g., *Applied Animal Ethology*), or animal welfare (e.g., *Animal Welfare*) rather than to behavior analysis. Most presentations relevant to the topic are made at conferences that are unlikely to be attended by behavior analysts (e.g., the Fifth European Conference of Poultry Welfare, held in the Netherlands this year, or the annual conference of the International Society of Applied Ethology, last held in Canada). Because animal welfare is of growing worldwide concern and, probably unbeknownst to most behavior analysts, operant techniques have proven value in the area, the purpose of the present article is to describe how operant conditioning procedures have been used in assessing farm animal welfare.

Of course, the term *welfare* is ambiguous. Most scientists accept that how an animal behaves is relevant to the assessment of its welfare, but they also emphasize that multiple dimensions must be considered (e.g., Fraser & Broom, 1990; Hall, 1984; Kilgour, Matthews, Temple, & Foster, 1984; Robinson, 1993; Temple, 1994). For example, freedom to express most normal behaviors is considered as one of the five freedoms proposed by Webster and Nicol (1988) to be welfare requisites. (The others are freedom from hunger and malnutrition, freedom from thermal or physical distress, freedom from disease or injury, and freedom from fear.) Although these five freedoms are reflected in the animal husbandry laws of many European and Australasian nations, it is difficult to know how to measure or to weight each freedom (Temple, 1994). Each freedom is continuous—an animal may, for instance, be more or less hungry, fearful, or ill—and there is no simple metric for determining what out-

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comes are indicative of unacceptable treatment.

By analogy, choosing the "best" conditions for an animal's welfare is similar to choosing the "best" car. Many dimensions are fully definable (e.g., acceleration, top speed, number of passengers, presence of air bags, type of travel anticipated), but the relative weighting given to each feature will vary from person to person. Thus, because their relative weightings will be influenced by value judgments, it is impossible to obtain a single figure that will encapsulate all these dimensions. The issue of good or bad welfare is similar. How, for example, do we weight the relative value of freedom from disease against the ability to move around in an open environment? The process of weighting the various aspects is a social, not scientific, process. Nonetheless, as Appleby, Hughes, and Elson (1992) emphasize, the process requires data that describe the behavioral and physiological responses of animals to particular conditions.

If those data are to influence how farm animals actually are treated, they must be understood by producers, lawmakers, and the general public. Behavior-analytic procedures, specifically those used in the study of psychophysics, preference, and demand, can tell us what animals can detect, what their needs are, what they will work to obtain, and what they prefer in given contexts. This information has easily understood, and important, welfare implications.

Psychophysics

Because people have lived side by side with farm animals for millennia, it might be presumed that there is a reasonable amount of information about these animals' sensory abilities. In fact, this is rarely so, and some investigation of sensory capacity is often prerequisite to studying the behavior of farm animals. For example, commercial poultry sheds are loud; chickens and machines combine to produce a cacophony that most people find unpleasant. Whether chickens do likewise was unknown for many years, and the question has welfare implications. Some of the sounds characteristic of poultry sheds can be altered rather easily (e.g., by adding masking noise, or shielding fan motors). If such sounds are aversive to chickens, welfare might be enhanced by eliminating them. Obviously, to be aversive, sounds must be detected by the species in question. A search of the literature before 1984 revealed an analysis of the frequencies present in hens' cries (Fischer, 1975) as well as a report of evoked potentials from the cochlear nucleus in response to a range of tones (Hou, Boone, & Long, 1975). But, despite the long association between humans and chickens, there were no actual behavioral data concerning hens' hearing. Hence, as a precursor to examining the aversiveness of sound from a poultry shed, Temple, Foster, and O'Donnell (1984) assessed the ability of hens to detect tones ranging from 260 to 7000 Hz.

In brief, hens were trained in a discrete-trials procedure with food reinforcement to peck the left key of a two-key chamber if a pure tone was presented on a given trial and to peck the right key if no tone was presented. Each tone was presented at an intensity (determined empirically) that allowed for accurate discrimination. Probe sessions were then conducted with different intensities of the tone. Such methods were used to study a series of different tones. Results indicated that hens' hearing is similar in sensitivity to that of humans at tones ranging from 260 to 7000 Hz, with some loss of sensitivity at high frequencies. That is, at higher frequencies, tones had to be louder to be detected.

Knowledge of hens' hearing sensitivity formed the basis for selecting the frequencies and intensities used in studying hens' preferences for various sounds (Mackenzie, Foster, & Temple, 1993). Mackenzie et al. found that hens would turn off the sound of a dog's barking or hens' vocalizing in a commercial poultry shed when these sounds were presented at 90 dB. But they would not turn off pure tones when presented at the same intensity. Absent psychophysical data, these findings could indicate that (a) the pure tones were undetectable or (b) the pure tones were detectable but not aversive. Given the psychophysical data reported by Temple et al. (1984), however, the former interpretation is untenable. Therefore, the findings of Mackenzie et al. suggest that the type and intensity of sounds interact to determine their aversiveness. Both variables need to be taken into account in designing nonaversive housing arrangements for chickens.

There are no fundamental differences in the psychophysical techniques that are appropriate for use with farm animals and those that are used with other nonhuman species (e.g., Blough, 1966; Blough & Blough, 1977). There are, however, practical problems associated with studying operant behavior in any unfamiliar species, including (a) selecting appropriate responses, reinforcers, and establishing operations; (b) maintaining and manipulating subjects; and (c) manufacturing apparatus appropriate for recording responses, delivering reinforcers, and presenting stimuli. Kilgour et al. (1991) provide many examples of techniques that have proven to be useful for studying operant behavior in cattle, goats, chickens, horses, pigs, and sheep.

Demand

Simply demonstrating that a particular object or activity will serve as a reinforcer for a given animal suggests that the commodity is important, and may have welfare implications (Baldwin, 1983). As an example of work in this area, Baldwin and Ingram (1967, 1968) showed that pigs would respond to turn heaters on during the day, but would huddle and allow the temperature to fall at night. Furthermore, they would leave the heaters on during the day and respond to turn them off at night. Seemingly, from a welfare perspective, allowing the animals to adjust ambient temperature would be better than holding the temperature constant. Moreover, it would be no more costly to pork producers.

Although showing that a given stimulus functions as a reinforcer indicates that the stimulus is important to the animal, and therefore has welfare implications, this approach does not permit quantification of the relative importance of the stimulus in question. Increasing heat during the day and decreasing it during the night obviously mattered to the pigs studied by Baldwin and Ingram (1967, 1968), but how much did it matter relative to other potential changes in their world?

One way to index the importance of an object or event to an animal is to increase the amount of effort required to gain access to the commodity until the animal stops responding. This point is then used as an indication of the relative importance of the commodity or event. Duncan and Kite (1987), for example, gave hens increasingly heavily weighted doors to push for access to a nest box. They found that hens would push quite heavy weights and argued from this that nest boxes are very important to laying hens. Hence, in the interest of the birds' welfare, nest boxes should be provided.

Faure (1986) used a different approach to examine hens' selection of cage size and feeder length. He showed that groups of hens would respond (on keys) to extend the length of their living cage and feeder. In this experiment the living cage contained some keys ("effective") that extended the cage length and some keys that did nothing. If no pecks occurred on the effective keys, the cage was kept at a standard size. Moreover, the cage returned to this size unless pecking persisted. Faure found that hens responded on the effective keys, but not on the ineffective ones, and concluded that increased cage length maintained responding. He argued that the extra length was important to the hens because they worked to maintain it. Interestingly, the hens kept the cage at an average of 800 cm^2, which is considerably larger than the 450 cm^2 minimum allowed by European legislation at the time of Faure's study. These findings suggest that hens "desire" more space than they get in commercial poultry sheds.

Faure (1986) did not vary the number of responses required for cage movement over a range of values. Had he done so, it would have been possible to generate demand functions relating length to response requirement. Demand functions are a central concept in behavioral economics, and they provide a ready method for indexing the relative value of a reinforcer. Dawkins (1990) and Hursh (1980, 1984) suggested that the degree to which an animal may need to perform a particular behavior or have access to a particular commodity, and hence the welfare implications of that behavior or commodity, may be measured using the methods of behavioral economics.

Specifically, the importance of a commodity can be studied by increasing the amount of work an animal has to do to gain access to it (i.e., the price of the commodity) and examining the way consumption of the commodity changes. Price can be varied in a variety of ways, for example, by increasing the number of responses required (Hursh & Winger, 1995), by increasing the height of a barrier (Dawkins & Beardsley, 1986), or by increasing the force needed to push through a door (Duncan & Kite, 1987).

The log-log plot of consumption against price increases is termed the demand function. Inelastic demand, indicating a need, is shown by a function with a slope less steep than -1 (work increases as price increases), where the slope is a measure of the elasticity. Elastic demand, suggesting a luxury, is shown by a function with a slope steeper than -1 (work decreases as price increases). Many demand functions are curvilinear, and equations have been developed for describing such functions (Hursh, 1991; Hursh, Raslear, Bauman, & Black, 1989; Hursh & Winger, 1995). The interpretation of the welfare implications of curvilinear demand functions is not fundamentally different from the interpretation of linear functions: Reinforcers that sustain consumption as price increases have more important welfare implications than those that do so to a lesser degree.

A study by Matthews and Ladewig (1994) provides a simple example of how demand might be used to index welfare implications. They compared demand for different commodities in pigs by increasing the number of lever presses required to produce access to each of those commodities and measuring consumption (i.e., number of reinforcers earned). The pigs showed relatively well-maintained responding (inelastic demand) for food as the price (number of presses) increased. They showed slightly more elastic (although still inelastic) demand for access to a littermate, and quite elastic demand for access to the space where a littermate had been. Thus, as logic dictates, food was a strong need. Access to a littermate was also a need, albeit a less important one, and access to the space where a littermate had been was only a luxury. All else being equal, the welfare of pigs appears to be enhanced by making littermates available.

Behavioral economics is an important branch of behavior analysis, and it is noteworthy that concepts such as demand are being applied to the study of welfare. It is, however, important to recognize that many variables, including whether the economy is open or closed (e.g., Hursh, 1980, 1984), the schedule used to increase price (e.g., Foster, Temple, Cameron, & Poling, 1997), and the availability of substitutable commodities (e.g., Hursh, 1984, 1991), can influence the shape of demand curves.

Dawkins (1990) has suggested that demand for food (a known need) might be used as a baseline with which to compare demand for other commodities. If this is to be done, then the variables affecting the demand for food by a particular species need to be explored before comparisons are made. Moreover, care must be taken to use similar methods to measure demand for different commodities. Finally, it is important to recognize that some activities and commodities that do not sustain high levels of consumption can be quite important to an animal's welfare. For instance, access to dust-bathing materials appears to reduce parasites in chickens (Temple, 1994), and they will work hard once or twice each day for access to such materials. But they will not work for repeated access. Clearly, demand functions provide useful information about the relative importance of particular objects and events, but only when those functions are appropriately generated and interpreted.

Preference

Unless doing so is harmful or excessively expensive, it appears that the welfare of farm animals is enhanced if they are provided with access to objects and activities that they prefer (Dawkins, 1983; Temple & Foster, 1980). Probably the simplest way to measure preference is by allowing an animal access to two (or more) different environments, or the opportunity to engage in two (or more) different behaviors, and recording the time spent in each. As an example of this strategy, Hughes and Black (1973) put hens in a cage with two floors and measured the time spent on each. They found that the floor (firm, spaced wire) previously recommended by humans as optimal (Brambell, 1965) was not preferred. The one favored by the hens was chicken wire. Hughes and Black suggested that, although such a floor was springy, it provided more points of support for the hens' feet than did the firm, spaced wire, and was therefore preferred. These findings emphasize that humans and other animals may differ in their assessments of the world, and underscore the importance of measuring, not intuiting, how farm animals react to particular circumstances.

Although its use is reasonable in many cases, using the proportion of time allocated to an environment (or behavior) as a measure of preference can present some problems (Duncan, 1978, 1981). For example, domestic hens spend only a small portion of the day in egg laying, but during this time a nest might be a preferred option (Dawkins, 1990). Dawkins (1977) pointed out that when free access is used to assess preference, the environments the animals choose between need to be equal in size. If they are unequal, random wandering could be expected to bias results towards the larger. Although the proportion of time allocated might suffice as a measure of preference for some behaviors or environments, it should be interpreted with caution and probably only in the light of a detailed time budget for the behaviors of interest (Dawkins, 1990).

A second method of measuring preference is to use a T-maze to allow an animal access, usually for a specified period of time, to one of two environments. Dawkins (1977), for example, used a T-maze to study hens' choice between a wire cage and an outside run. She found that rearing environment influenced choice of environment. Hens reared in battery cages tended to choose battery cages rather than an outside run, and hens reared outside tended to favor the outside run. Dawkins (1982) also used a T-maze to study social preferences of hens. She found, among other things, that both flock- and cage-reared hens tended to choose a familiar hen to an empty cage and an empty cage to a strange hen.

One limitation of discrete-trials procedures, such as the T-maze, is that they characteristically do not yield graded measures of preference. That is, one outcome is likely to be chosen on nearly every trial, as long as there is some meaningful difference between them (e.g., Matthews, 1983). Another problem is that such procedures, as characteristically used in welfare studies, yield measures of group rather than individual performance (e.g., Lindberg & Nichol, 1996). Graded measures of preference are readily obtained in individual subjects that are exposed to concurrent schedules of reinforcement. Under concurrent schedules, two or more schedules, each associated with a particular response, are simultaneously available to the animal. The responses characteristically are topographically incompatible, and a reinforcer is not available immediately after switching from one schedule to the other. Behavior under concurrent schedules, in particular concurrent variable-interval (VI) schedules, has been extensively studied (e.g., Davison & McCarthy, 1988; de Villiers, 1977).

Performance under concurrent VI schedules is described well by the generalized matching equation (Baum, 1974, 1979), which provides a mathematical description of the relation between environmental inputs (reinforcers earned under each component schedule) and behavioral outputs (responses or time allocated to each component schedule). In general, the relative amount of behavior (or time) allocated to one of two alternative VI schedules increases in approximately direct proportion to the relative rate (or amount, or duration) of reinforcement earned under that schedule. This relation is termed *matching*. Any consistent tendency for an animal to respond more on one schedule than on the other, regardless of reinforcement rate, is termed *bias*. If bias is evident for one alternative schedule, then that schedule is preferred. The generalized matching equation allows the degree of bias to be quantified precisely.

A series of studies in which different foods were available to dairy cows under concurrent VI schedules provides an example of the use of bias as a measure of preference (Foster, Temple, Nair, Robertson, & Poling, 1996; Klopfer, Kilgour, & Matthews, 1981; Matthews & Temple, 1979). These studies indicate that some common, nutritional, and inexpensive foods are strongly preferred relative to others. On that basis, it may be in the interest of cows' welfare to be given at least occasional access to the preferred food.

Conventional concurrent-schedule procedures can be used to provide a sensitive and quantitative measure of preference between any two (or more) events that will maintain behavior and that can be delivered in small discrete quantities. There are, however, stimuli relevant to welfare considerations that either will not maintain behavior or cannot be delivered in small discrete units. McAdie, Foster, Temple, and Matthews (1993) and McAdie, Foster, and Temple (1996) have shown that concurrent schedules can be used to obtain measures of preference for such stimuli.

In an extension of research discussed previously (Mackenzie et al., 1993), McAdie et al. (1993), using hens, overlaid a range of recorded sounds (e.g., a dog barking, the sound of a train, and the sound of hens in a commercial poultry shed) on one of two equal concurrent VI schedules of food delivery. The sound came on when the animal responded on one key and remained on until a response occurred on the other key. For the first and third quarters of a session, the keys were lit red, and for the other two quarters they were green. The different colors were associated with reversals of the schedule associated with the sound. Thus, McAdie et al.'s procedure allowed assessment of any bias resulting from the sound. They found large biases that increased as the intensity of the sounds increased. Different sounds gave different biases independent of the overall intensity of the sounds. The biases were away from the sounds, and McAdie et al. argued that bias size with a particular sound reflected the preference of a hen for no sound relative to that sound. That is, the sounds were aversive, and their aversiveness increased with intensity. Interestingly, the largest bias was associated with the sound of hens in a commercial poultry shed.

Other variations of concurrent-schedule procedures are possible (see Temple & Foster, 1980), and it is even possible to use such schedules to study stimuli, such as access to a conspecific, that cannot readily be turned on and off (e.g., Walker, 1996). Obviously, concurrent schedules provide a powerful and precise tool for investigating preferences across a range of stimuli. It is, however, important to recognize that interpretations of concurrent-schedule data based on the matching equation may appear esoteric and inaccessible to nonspecialists, and will require translation.

Concluding Comments

Like other complex human behavior (see Skinner, 1953, 1974), how people talk about and otherwise act with respect to the treatment of farm animals depend on their personal histories and their current environments. Data generated (and, if necessary, interpreted) by behavior analysts are stimuli that may influence behaviors related to the treatment of farm animals. The primary strength of behavior-analytic procedures is that they provide quantitative information about how individual animals evaluate their world. Such procedures tell us what animals "like" and "dislike," and how strongly. Many, but by no means all, people have histories such that they believe that welfare is enhanced if (a) animals' contact with events they dislike is minimized and (b) animals are provided with access to events that they like (Temple, 1994). The relative welfare implications of particular events depend, in part, on how strongly they are liked or disliked. Of course, dimensions other than an animal's behavioral reaction to particular stimuli commonly are considered in evaluating welfare. It is unlikely that a welfare advocate would, for example, give an animal access to foods that diminished health or to conspecifics that caused bodily harm, even if such events were highly reinforcing. Nor would he or she be likely to forbid momentarily aversive injections of, for instance, antibiotics if such injections increased health and longevity.

For both producers and consumers of farm animals, economic considerations are likely to be weighed against welfare considerations. The emphasis placed on these dimensions varies greatly across individuals, probably as a function of their dissimilar histories. For instance, some egg consumers are of the opinion that free-range chickens live better lives than battery-cage birds, and are willing to pay premium prices for free-range eggs (Temple, 1994). Others are not, either because they have little concern with the well-being of hens or because they are not willing to pay to improve it. Such people are unlikely to be influenced by behavior-analytic, or other, data. Many consumers, it appears, are unaware of the conditions under which their eggs are, or might be, produced. How such people would respond to welfare-related data provided by behavior analysts and other scientists is difficult to determine at present. Social validation techniques similar to those used in applied behavior analysis (e.g., Geller, 1991; Kazdin, 1977; Wolf, 1978) could be used to determine the variables that make the goals, procedures, and outcomes of particular husbandry practices acceptable or unacceptable to producers, consumers, politicians, and others concerned with animal welfare. That they could be so used emphasizes that applications of behavior-analytic techniques to welfare-related issues are not limited to studies of psychophysics, demand, and preference, even though those areas have been the focus of most research to date. Evaluating animal welfare requires, first, an understanding of how animals react to particular environments and, second, an understanding of how humans react to animals' reactions. Behavior analysis has unrealized potential in both areas.

REFERENCES

Appleby, M. S., Hughes, E. O., & Elson, H. A. (1992). *Poultry production systems: Behaviour, management and welfare.* Oxford: C.A.B. International.

Baldwin, B. A. (1983). Operant conditioning in farm animals and its relevance to welfare. In D. Smidt (Ed.), *Indicators relevant to farm animal welfare* (pp. 117–120). The Hague: Martinus Nijhoff.

Baldwin, B. A., & Ingram, D. L. (1967). Behavioural thermoregulation in pigs. *Physiology and Behavior, 2,* 15–21.

Baldwin, B. A., & Ingram, D. L. (1968). Factors influencing behavioral thermoregulation in pigs. *Physiology and Behavior, 3,* 409–415.

Baum, W. M. (1974). On two types of deviation from the matching law: Bias and undermatching. *Journal of the Experimental Analysis of Behavior, 22,* 231–242.

Baum, W. M. (1979). Matching, undermatching and overmatching in studies of choice. *Journal of the Experimental Analysis of Behavior, 32,* 269–281.

Blough, D. S. (1966). The study of animal sensory processes by operant methods. In W. K. Honig (Ed.), *Operant behavior: Areas of research and application* (pp. 345–379). New York: Appleton-Century-Crofts.

Blough, D. S., & Blough, P. (1977). Animal psychophysics. In W. E. Honig & J. E. R. Staddon (Eds.), *Handbook of operant behavior* (pp. 514–539). Englewood Cliffs, NJ: Prentice Hall.

Brambell, F. W. R. (Chairman). (1965). *Report of the technical committee to enquire into the welfare of animals kept under intensive husbandry systems.* Command Paper 2836. London: H.M.S.O.

Davison, M. C., & McCarthy, D. (1988). *The matching law: A research review.* Hillsdale, NJ: Erlbaum.

Dawkins, M. S. (1977). Do hens suffer in battery cages? Environmental preference and welfare. *Animal Behaviour, 25,* 1034–1046.

Dawkins, M. S. (1982). Elusive concept of preferred group-size in domestic hens. *Applied Animal Ethology, 8,* 365–375.

Dawkins, M. S. (1983). The current status of preference tests in the assessment of animal welfare. In S. H. Baxter, M. R. Baxter, & J. A. C. McCormack (Eds.), *Farm animal welfare and housing* (pp. 20–26). The Hague: Martinus Nyhoff.

Dawkins, M. S. (1990). From an animal's point of view: Motivation, fitness and animal welfare. *Behavioral and Brain Sciences, 13,* 1–61.

Dawkins, M. S., & Beardsley, T. (1986). Reinforcing properties of access to litter in hens. *Applied Animal Behaviour Science, 15,* 351–364.

de Villiers, P. A. (1977). Choice in concurrent schedules and a quantitative formulation of the law of effect. In W. E. Honig & J. E. R. Staddon (Eds.), *Handbook of operant behavior* (pp. 233–287). Englewood Cliffs, NJ: Prentice Hall.

Duncan, I. J. H. (1978). The interpretation of preference tests in animal behaviour. *Applied Animal Ethology, 4,* 197–200.

Duncan, I. J. H. (1981). Animal rights—animal welfare: A scientist's assessment. *Poultry Science, 60,* 489–499.

Duncan, I. J. H., & Kite, V. G. (1987). Some investigations into motivation in the domestic fowl. *Applied Animal Behaviour Science, 18,* 387–388.

Faure, J.-M. (1986). Operant determination of the cage and feeder size preferences of the laying hen. *Applied Animal Behaviour Science, 15,* 325–326.

Fischer, G. J. (1975). The behaviour of chickens. In E. S. E. Hafez (Ed.), *The behaviour of domestic animals* (pp. 454–489). London: Balliére Tindall.

Foster, T. M., Temple, W., Cameron, B., & Poling, A. (1997). Demand curves for food in hens: Similarity under fixed-ratio and progressive-ratio schedules. *Behavioural Processes, 39,* 177–185.

Foster, T. M., Temple, W., Nair, V., Robertson, B., & Poling, A. (1996). Concurrent-schedule performance of dairy cows: Persistent undermatching. *Journal of the Experimental Analysis of Behavior, 65,* 57–80.

Fraser, A. F., & Broom, D. M. (1990). *Farm animal behavior and welfare.* London: Balliére Tindall.

Geller, E. S. (1991). Where's the validity in social validity? *Journal of Applied Behavior Analysis, 24,* 353–358.

Hall, W. F. (1984). *The behavior and welfare of farm animals.* Minneapolis: Humane Information Services.

Hou, S., Boone, M. A., & Long, J. T. (1975). An electrophysiological study on the hearing and vocabulation in *Gallus domesticus. Poultry Science, 52,* 159–164.

Hughes, B. O., & Black, A. J. (1973). The preference of domestic hens for different types of battery cage floor. *British Poultry Science, 65,* 9–18.

Hursh, S. R. (1980). Economic concepts for the analysis of behavior. *Journal of the Experimental Analysis of Behavior, 34,* 219–238.

Hursh, S. R. (1984). Behavioral economics. *Journal of the Experimental Analysis of Behavior, 42,* 435–452.

Hursh, S. R. (1991). Behavioral economics of drug self-administration and drug abuse policy. *Journal of the Experimental Analysis of Behavior, 56,* 377–393.

Hursh, S. R., Raslear, T. G., Bauman, R., & Black, H. (1989). The quantitative analysis of economic behavior with laboratory animals. In K. G. Gruneit & F. Olander (Eds.), *Understanding economic behavior* (Theory and Decision Library, Series A, Vol. 2, pp. 383–407). Boston: Kluwer Academic Press.

Hursh, S. R., & Winger, G. (1995). Normalized demand for drugs and other reinforcers. *Journal of the Experimental Analysis of Behavior, 64,* 373–384.

Kazdin, A. E. (1977). Assessing the clinical or applied significance of behavior change through social validation. *Behavior Modification, 1,* 427–453.

Kilgour, R. (1976). The contributions of psychology to a knowledge of farm animal behaviour. *Applied Animal Ethology, 2,* 197–205.

Kilgour, R., Foster, T. M., Temple, W., Matthews, L. R., & Bremner, K. J. (1991). Operant technology applied to solving farm animal problems. *Applied Animal Behaviour Science, 30,* 141–166.

Kilgour, R., Matthews, L. R., Temple, W., & Foster, T. M. (1984). Using operant test results for decisions on cattle welfare. In W. F. Hall (Ed.), *The behavior and welfare of farm animals* (pp. 205–217). Minneapolis: Humane Information Services.

Klopfer, F. D., Kilgour, R., & Matthews, L. R. (1981). Paired comparison analysis of palatabilities of twenty foods to dairy cows. *Proceedings of the New Zealand Society of Animal Production, 41,* 242–247.

Lindberg, A. C., & Nichol, C. J. (1996). Space and density effects on group size preferences in laying hens. *British Poultry Science, 37,* 709–721.

Mackenzie, J., Foster, T. M., & Temple, W. (1993). Sound avoidance by hens. *Behavioural Processes, 38,* 143–157.

Matthews, L. R. (1983). *Measurement and scaling of food preferences in dairy cows.* Unpublished doctoral thesis, University of Waikato, Hamilton, New Zealand.

Matthews, L. R., & Ladewig, J. (1994). Environmental requirements of pigs measured by behavioural demand functions. *Animal Behaviour, 47,* 713–719.

Matthews, L. R., & Temple, W. (1979). Concurrent schedule assessment of food preference in cows. *Journal of the Experimental Analysis of Behavior, 32,* 245–254.

McAdie, T. M., Foster, T .M., & Temple, W. (1996). Concurrent schedules: Quantifying the aversiveness of noise. *Journal of the Experimental Analysis of Behavior, 65,* 37–55.

McAdie, T. M., Foster, T. M., Temple, W., & Matthews, L. R. (1993). A method for measuring the aversiveness of sounds to domestic hens. *Applied Animal Behaviour Science, 37,* 223–238.

Robinson, D. (1993). *Poultry welfare—or human debacle. Proceedings of the Ninth Australian Poultry and Feed Convention.* Queensland, Australia: Australian Poultry Industries Association.

Skinner, B. F. (1953). *Science and human behavior.* New York: Macmillan.

Skinner, B. F. (1974). *About behaviorism.* New York: Knopf.

Temple, W. (1994). *A review of research into the welfare of hens in various housing and management systems for egg production.* Canberra, Australia: Working Group on Hen Housing.

Temple, W., & Foster, T. M. (1980). Applications of preference assessment in animal welfare. In M. Wodzicka-Tomaszewska, T. N. Edey, & J. J. Lynch (Eds.), *Behaviour in relation to reproduction, management and welfare* (pp. 191–193). 4th Review of Rural Science. New South Wales, Australia: University of New England.

Temple, W., Foster, T. M., & O'Donnell, C. S. (1984). Behavioural estimates of auditory thresholds in hens. *British Poultry Science, 25,* 487–493.

Walker, J. A. (1996). *Concurrent schedules: A method for measuring social preferences of hens.* Unpublished masters thesis, University of Waikato, Hamilton, New Zealand.

Webster, A. J. F., & Nichol, C. J. (1988). The case for welfare. In *Cages for the future* (pp. 11–21). Cambridge: ADAS.

Wolf, M. M. (1978). Social validity: The case for subjective measurement or how applied behavior analysis is finding its heart. *Journal of Applied Behavior Analysis, 11,* 203–215.