

Prediction and Preparation: Pavlovian Implications of Research Animals Discriminating Among Humans

Hank Davis

Abstract

A growing body of evidence suggests that animals of various species can discriminate among the humans with whom they have regular contact. This discriminative ability has considerable implications for research. Because animal life is hedonistic, there is a strong incentive for animal subjects to predict the events that bring them pleasure and pain. Many research settings attempt to deliver hedonic stimuli under strictly regulated conditions without formal warning. Nevertheless, the possibility remains that the presence of a particular human may signal delivery of an important event, thus allowing the animal to prepare for its occurrence. In Pavlovian terms, humans become “walking conditioned stimuli,” eliciting measurable conditioned responses from animal subjects. These preparatory responses may take behavioral, physiological, and/or motivational forms and modulate the effects of the variables under study. The discussion addresses practical implications of knowing that discrimination among humans by animal subjects may affect one’s research agenda.

Key Words: confounds; human discrimination; Pavlovian conditioning; person as CS; prediction; preparation; preparatory responses

It should surprise no one that animals can discriminate between the good and bad or the pleasurable and painful events in their lives. Moreover, regardless of where on the phylogenetic scale they exist, all forms of animal life are hedonists; they all are designed to seek pleasure and avoid pain.

The hedonic status of animals implies a collateral need for prediction. It is not sufficient to know what feels good or bad; it is necessary to anticipate such things. Animals can and do discriminate among the salient predictors of hedonic events in their lives, and they react to these predictors accordingly. Survival and the ability to reproduce require them to monitor those stimuli that precede life-enhancing or life-threatening events carefully.

To explain the conditions described above in a more technical way, every form of animal life on this planet is

programmed for Pavlovian conditioning (Domjan 1998). Everything and everyone, from molluscs to nuclear physicists, from jellyfish to brain surgeons, is the same in this regard: Their nervous systems do not want surprises. Natural selection has perfectly underscored the adaptive value of prediction, which is the foundation of Pavlovian conditioning. It is a nearly perfect case of Darwin and Pavlov working together toward a common goal—not to allow the organism to be surprised by an unannounced hedonic event. Let the organism detect and respond to the stimuli that typically precede an event. Pavlov called such predictors conditioned stimuli (CSs¹). They exist for a very simple purpose—to allow the organism to prepare for the hedonic event that follows.

Value of Preparation

The adaptive value of preparation is not difficult to understand. When one knows in advance that good things are likely to occur, one benefits from preparation because it makes them better. A delicious meal is rendered even more appealing when one builds up to it slowly, with one’s salivary juices flowing. Likewise, without belaboring the analogy, sex is preceded by foreplay for good reason. Pavlov is a common visitor to both the diningroom and the bedroom. Similarly, bad things will be less aversive when preparation is possible. Our bodies are designed to marshal their resources against impending insults. To prepare, they need warning. Thus, reliable predictors are always extremely valuable.

The classical Pavlovian literature is built on well-known examples: Dogs salivate in the presence of a metronome, which reliably precedes food. They have no intention of eating the metronome, but by salivating in its presence, they are well prepared to receive full benefit from the food that is likely to follow. The negative side of this equation is intuitively obvious: When a rat stands on a grid floor that periodically delivers painful electric shock, the rat notes the stimuli that precede shock delivery. The rat does not need to “think” or be well versed in Pavlovian theory to make the best of a bad situation. Conditioned stimuli lead to conditioned responses (CRs¹), which are preparatory in nature.

Hank Davis, Ph.D., is Professor of Psychology, the University of Guelph, Ontario, Canada.

¹Abbreviations used in this article: CR, conditioned response; CS, conditioned stimulus.

Although thought is possible, it is not necessary for this process to work exactly as it was designed.

Preparatory responses may take many forms, depending on the species and the circumstances. Preparation may be physical or psychological. In addition to a general state of fear, physical responses to aversive stimuli, especially among most laboratory animals, include fleeing or freezing (Bolles 1970). There is even a documented example of a rat using a warning stimulus as a cue to flip over on its furry and well-insulated back, leaving its naked foot pads pointed safely at the ceiling (Azrin and Holz 1966).

Animals are not equally clever or agile. Some resort solely to psychological preparation when warning stimuli are presented before aversive events. It is impossible to enter the mental world of a rat, or any nonhuman animal, and know what form psychological preparation for danger takes. Humans, however, report a variety of mental strategies when they are faced with signaled aversive situations. For example, a small child in a war-torn country may learn to close her eyes and “pretend she is not there” when an air raid siren (an ideal CS) signals a forthcoming bomb explosion. Such a strategy will not protect her body from shrapnel, but it may result in an attentional shift, which minimizes her fear. The clinical literature offers numerous examples of alterations in consciousness or perception associated with repeated patterns of childhood abuse. In any case, an extensive literature indicates that laboratory animals, like humans, actively prefer and will seek predictors of aversive events, even when those events cannot be avoided (Badia et al. 1979; Lockard 1963).

Humans as Predictors

What kind of stimuli make the best predictors of hedonic events? In laboratory settings, scientists have rarely addressed this question directly and have instead used a narrow range of events such as lights, tones, and buzzers. These stimuli are perfectly adequate to the task, and indeed there are thousands of experiments documenting how readily such stimuli serve as Pavlovian CSs (Domjan 1998). Nevertheless, in the real world—and even in the laboratory—the best predictors of hedonic events may not be lights and tones, but rather may be the people who present them. In the normal course of human events, which includes human-animal interactions, contact with a specific person may be the best predictor of what lies ahead for the animal. The essence of this view is expressed in the folksaying, “Animals do not bite that hand that feeds them.” Anyone who has worked closely with animals, whether at home or in agricultural or research settings, knows that most animals get to know the humans around them, welcoming those who feed or treat them well and fearing those who are likely to hurt them.

Did Pavlov make any allowance for this possibility, or was he fixated on buzzers and metronomes? To his credit,

Pavlov documented the occurrence of human-based conditioning and even cautioned about how its effects might intervene, often subtly, into laboratory settings. W. Horsley Gantt, the scientist who worked with Pavlov in Russia, later established his own laboratory in North America and advanced Pavlov’s work. The term they used for the procedure, “Person as CS,” is quite telling (Gantt et al. 1966). It makes clear that both Gantt and Pavlov were concerned with the effects of a particular person, rather than the general class “people.” But can this be?

Can animals discriminate among us well enough to use a single one of us as a CS or predictor of a forthcoming hedonic event? I believe the answer to both of these questions is yes. Yes, they can discriminate between or among us; and yes, they can and do use us as Pavlovian predictors. In *The Inevitable Bond: Examining Scientist-Animal Interactions*, Dianne Balfour and I (Davis and Balfour 1992) specifically document how such Pavlovian effects of human recognition might intrude into research situations with more than 20 different species. We deal with more than just the obvious examples of so-called “higher animals” such as canids and primates. We also report data on less obvious animal subjects such as iguanas and octopi, whose cognitive prowess is often underestimated (e.g., Bowers and Burghardt 1992; Mather 1992).

Reports of Discrimination by Animals

Since publication of *The Inevitable Bond: Examining Scientist-Animal Interactions*, my students and I have gone even farther back to basics, examining systematically which creatures are capable of discriminating between humans. As soon as such discrimination is formally documented, it will be a short logical step to argue that human stimuli can serve as Pavlovian, or for that matter operant, cues. In short, anyone working with these animals should be aware that their own presence may have a confounding effect on the research setting.

One of the reasons humans are such potent sources of prediction and control in research settings is that most laboratories are breeding grounds for unintended Pavlovian conditioning. First, laboratory routines are rich in both positive (e.g., the provision of food) and negative (e.g., the induction of pain) hedonic stimuli. Second, the laboratory is typically a world of regularity. Scientists and/or technicians are often part of these regularities, thus serving as ideal predictors for events that might otherwise remain surprising.

Note that we are not concerned with *how* discriminations among humans are made because it is well understood that sensory systems are prioritized differently in different species. For example, compared with the visual world of a pigeon, a rat’s sensory experience is largely olfactory. Similarly, the sensory coding of a human may be very different to a lizard and a llama, yet both may be capable of discriminating between different persons to predict important

events. In short, we have not focused on the *mechanism* of human discrimination. Instead, our concern in all of the research we report is whether or not humans *have been discriminably different* to the animal and, ultimately, the *possible implications* of such discrimination for the research process.

To date, we have demonstrated the ability to discriminate between humans in 11 different species including rats, chickens, llamas, rabbits, sheep, cows, seals, emu, rhea, penguins, and honeybees. (Note that there are similar reports from other laboratories, as well as a wealth of anecdotal reports [e.g., Hediger 1965; Slobodchikoff et al. 1991; Tanida et al. 1995]). Working with these subjects requires a number of experimental procedures. There are different ways to test for human recognition, and obviously a procedure that is well suited to testing rat subjects, for example, may be wholly inappropriate for testing cows or honeybees.

Our procedures are broadly categorized as follows: (1) preference testing, in which animals are allowed to choose between two people, one of whom has previously interacted with the animal; (2) operant discrimination training, in which people are used as cues to signal the availability versus nonavailability of reward for an operant response; we then compare the animal's rate of responding in the presence of the two persons; (3) habituation testing, in which the animal is exposed to a particular person until naturally occurring defensive behavior declines to a minimum level. As soon as habituation occurs, the animal is exposed to a new person. We are attempting to learn whether habituation generalizes to novel persons or is specific to the original individual.

We have used all three approaches in our investigation of human discrimination by animals. Below are samples of the results we have reported, beginning with our work with the ubiquitous laboratory rat.

Preference Testing

In our initial study (Davis et al. 1997), we assigned 26 rats to one of two handlers. Each handler spent 10 min "gentling" the animals one at a time—petting, talking to, and allowing each animal to climb on the body of the handler. After 14 such sessions, each rat was tested to determine whether it had a preference for the person with whom it had interacted during the previous 2 wk.

During testing, each handler sat blindfolded, arms crossed, at one end of a 6-ft-long table. We randomly selected individual rats, and a third person who had no prior contact with either the rats or the handlers carried them from their home cages into the test room. This person placed the rat on the table midway between the two handlers facing 90° away from both and allowed the rat to explore freely until it had made a "choice." We strictly defined and enforced the criterion for a choice, which consisted of the animal climbing onto the body of the handler and remaining with all four paws off the table for a minimum of 20 sec. Pilot work had

revealed that both components of the criterion were essential. For example, rats often explored one or both of the handlers briefly, placing their two front paws on the handler's arm while sniffing the person's skin, or climbed briefly onto the person but jumped off well before the 20-sec criterion.

The results were clear: 24 of the 26 subjects correctly chose the handler with whom they had previously interacted. A typical pattern of behavior during the test trial consisted of a brief, even cursory sniff of the preferred handler, followed by extensive exploration of the novel person at the other end of the table. When such exploration was complete, typically within 1 or 2 min, the subject returned to its original handler and climbed, often without hesitation, onto its person, typically sitting on the handler's shoulder by the end of the trial.

It is worth examining what happened in the case of the two subjects who chose the "wrong" person. In the case of the first subject, it was learned after testing that there had been an "incident" during one of the initial handling sessions that was probably traumatic for both handler and rat. The rat had accidentally fallen off the handler's body and had been chased across the floor of the testing room, where she was ultimately retrieved under duress from her hiding place under a table. This singular incident had not been reported until after testing was complete and attempts were being made to account for this subject's anomalous behavior during testing. (After briefly sniffing the "familiar" handler who had chased her, the rat climbed directly onto the novel person and remained there.) The "incorrect" choice of the second animal reflects no such dramatic episode. The handler described this rat as the least fearful, most "social" animal encountered during initial interactions. The animal's behavior reflected none of the neophobia and apprehension about contact with a stranger typical of most rats.

To determine how well rats had remembered a particular person, we retested eight original animals that remained in our colony. We took the subjects from their home cages after 5 mo of inactivity and exposed them to the original two handlers using an identical preference test. All subjects chose the person with whom they had originally interacted, despite the 5-mo hiatus from contact with that person.

We next explored whether preference for a familiar human required the full 14 days of interaction used in our initial study. We repeated the procedure using only five 10-min sessions and found that once again, rats preferred the familiar person, even though there appeared to be far less basis for this familiarity. In our final study, we exposed the animal to only a single 10-min interaction with its handler before preference testing. All animals again chose the person with whom they had previous contact, despite the fact that this interaction lasted merely 10 min.

Collectively, these results demonstrate that rats are well able to discriminate between individual humans and, despite their curiosity about novel persons, prefer contact with an individual with whom they have safely interacted in the

past. It is notable that their preference for a familiar human remains intact at least 5 mo after the last contact. Perhaps the most striking feature of these results stems from the final experiment in the series. One may question how a single 10-min experience with a person can result in a measurable preference. It is worth noting that rats, like many other laboratory animals, are essentially a prey species. Their rich repertoire of defensive behavior (Bolles 1970) attests to the fact that rats are now and have in the past been hunted and exterminated in large numbers by most organisms with whom they share a habitat. Although it means little in terms of human experience, 10 min of contact in which they experienced no harm may be a sufficiently notable experience in a rat's world to create a preference.

Although some human observers are likely to anthropomorphize such preferences in terms of "friendship" or "love," the underlying dynamic may be little more than "you spent 10 min with me and did not try to kill me." This is not to say that rats, or other laboratory/prey species, are not capable of forming meaningful bonds with humans. Indeed, we have previously demonstrated that laboratory rats will work in a Skinner box for petting by a preferred human in the absence of traditional reward such as food or water (Davis and Perusse 1988). It is unlikely, however, that romantic notions like friendship have much to do with the behavior demonstrated in our experiments. Regardless of whether the rat's preference for a particular human is driven by love or by relief at not being harmed, it does underscore the fact that this species can tell human caretakers or technicians apart and that they can use individual members of our species to predict important events.

Operant Discrimination

The animal learning literature contains thousands of experiments reporting stimulus control of operant behavior (Cattania 1968). The vast majority of these cases involve the use of lights and tones as discriminative stimuli. For example, a pigeon might be trained to make a key peck response in a Skinner box in the presence of a red light and to withhold this response whenever a green light is presented.

In our experiments, instead of the red light (S+), we have simply substituted a particular person, in whose presence we reinforced behavior. Similarly, a second person has been used to signal the absence of reinforcement (S-). We have conducted such experiments using rabbits (Davis and Gibson 2000), chickens (Davis and Taylor 2001), cattle (Taylor and Davis 1998), and sheep (Davis et al. 1998). In each of these subjects, it was necessary to tailor the form of the operant response and the nature of the reward directly to the species. The one constant was the nature of the discriminative stimuli—two persons matched for sex, physical appearance, and clothing. To be certain there was nothing inherently appealing or aversive about either stimulus person, both served as S+ for half of the subjects and S- for the other half.

Our work with rabbits is typical of the approach we took using operant discrimination. We trained 12 female New Zealand white rabbits to make contact with an orange ball that was suspended from the roof of the cage. For each response, we rewarded subjects with a small piece of freshly cut apple. Before each trial, one of the two handlers stood immediately in front of the cage and placed her left hand over a small opening in the front of the cage. We thus provided subjects with both visual and olfactory cues before and during each trial. We reinforced responses in the presence of the S+ person and never in the presence of the S- person. Initially, we reinforced each response with food. As soon as the rate of responding became stable, we delivered rewards on a variable ratio ("VR") 3 schedule.

Discrimination training consisted of alternating 1-min exposures to the S+ person, during which responses continued to be rewarded, with 1-min exposures to the S- person, in whose presence responses were never reinforced. We collected data during two test sessions that differed from training sessions in three important ways: (1) We randomized the sequence of S+ and S- trials, rather than alternating them between S+/S- conditions. (2) We randomly varied trial durations between 30, 45, and 60 sec, rather than having them remain fixed at 60 sec. (3) We never presented a reward during the two test sessions, thus assuring that any difference in responding to S+ and S- reflected what the rabbits had previously learned about the persons, rather than the presence of reinforcement during the test.

The results clearly indicate that all rabbits were discriminating between the two humans. There was significantly more responding in the presence of the S+ person. Even the lowest S+ to S- ratio reflected a sevenfold difference in response rate. We observed that S+ to S- ratios were as high as 46:1, and four subjects failed to respond altogether in the presence of the S- person. In addition to the significant difference in response rates, subjects also revealed marked differences in the behavior they directed to the stimulus persons. These observations are similar to ones made during our operant discrimination work with chickens, cattle, and sheep. All of these animals also tended to show greater generalized arousal when the S+ person was positioned in front of their cage. In contrast, rabbits (as well as chickens, sheep, and cows) occasionally turned from the front of the test area and faced the rear wall for the entire trial when the S- person appeared.

These data reveal not only that individual persons are readily discriminable to the animals we tested, but also that people may take on emotional or motivational properties that reflect the conditions with which they have been associated. In short, humans may serve all the stimulus functions of bells, buzzers, and metronomes. It goes without saying that few researchers would present such inanimate stimuli in an unsystematic manner during their research. It makes no less sense to be vigilant about the presence of persons without considering their potential function as discriminative or conditioned stimuli.

Habituation of Defensive Behavior

Many animals, including those commonly used in research and agriculture, retain a surprising degree of wariness about contact with human beings. Indeed, some investigators have argued that it may be difficult, if not impossible, to eliminate instinctive defensive patterns during routine encounters between humans and some animals (e.g., Caine 1992; Duncan 1992). In such cases, it may be futile or ill advised to use either preference testing or operant discrimination procedures to study human discrimination.

If such animals are wary or vigilant in their encounters with humans, why not put such behavior to use in the measurement of human discrimination? We have demonstrated in the case of penguins, emu, rhea, and llamas that behavior is measurably different in the presence of a familiar person (Davis et al. 2001; Taylor and Davis 1996). It is also possible to focus on how defensive behavior gradually declines as a novel person becomes familiar to an animal, as we have done in our work with seals (Taylor et al. 1998) and honeybees (Collis and Davis 2001). For example, both harbor and gray seals exhibit a general wariness when confronted by novel humans. Such behavior, especially in a population of captive animals, is likely to habituate over time.

Is such habituation specific to an individual person, or is it a generalized response to humans? When we examined this question experimentally, we found a normal course of habituation for behavior such as sniffing and visual orientation. We presented seals with six 15-min periods of exposure to a particular human at the perimeter of the tank over the course of 4 days, at which time the appearance of this person prompted only minimal exploratory behavior. As soon as habituation was complete, a novel person who was matched in appearance and dress with the former person entered the tank area. All measures of vigilance returned to initial levels, suggesting that although repeated exposure to a person was likely to result in habituation, any such decline in exploratory/defensive behavior was specific to the individual and not a generalized response to human beings.

Humans as Confounding Variables

Why does it matter whether animals can discriminate between humans? Presumably each of the animals we tested is capable of discriminating among conspecifics and does so routinely under natural conditions (e.g., Thor and Holloway 1982). Their ability to discriminate between humans is thus not altogether surprising. Its relevance to research, however, is another matter.

In the average animal laboratory, whether in psychology, zoology, biomedical science, genetics, nutrition, or veterinary medicine, animals are fed and occasionally caused pain. Despite the wide range of questions researchers pose, the answers come from a narrow range of dependent variables. Animals provide body fluids, tissue samples,

physiological indices, and/or behavior. Collecting these samples is part of the everyday routine to which animal subjects are subjected. Thus, for better or worse, laboratories are typically environments that are rich in hedonic experiences. As we noted before, many of these events are not formally predicted, thus instigating a search for prediction by the animals. Arguably, human beings are but one more class of stimuli that regularly impinge on the animal as it goes through its daily routine in the laboratory. The regular presence of particular humans in association with these hedonic events sets the stage for Pavlovian conditioning, as humans literally become “walking CSs.”

The experimental variables at work in most animal research are tightly controlled by the investigator. Any loss of this control opens the possibility of confounding variables, which are the ultimate enemy of rigorous science. No investigator would knowingly allow independent variables to occur randomly or capriciously within the research setting. Yet, a variable exists every time an investigator or technician appears. Like buzzers, lights, and metronomes, such persons—despite the fact that they have names and Social Security numbers—are also stimuli to the animal subjects. They may have histories of association with the variables whose primary effects are being tested, or at the least they may elicit motivational responses that directly interfere with or modulate the behavior under study. Consider two very simple examples based on anecdotal reports:

1. A technician named John reliably exposes a rhesus monkey to electric shock to measure stress-related elevations in plasma corticosterone. There is little doubt that John will collect elevated blood samples from his subject on the test day. But consider the kind of baseline blood values John is likely to obtain, even if he takes his samples on days when no shock is administered. John himself has become a CS paired with shock, and his presence alone will result in elevated blood values.
2. Clara is a graduate student working with salamanders. Although her thesis will focus on metabolic activity, Clara is initially concerned with settling her colony of animals into the laboratory. Every morning she approaches the salamanders, removes the wire mesh lid to the box in which they are kept, changes their water supply, and places fresh food in the enclosure. She has done this every day for 2 wk, when a personal commitment requires her to be away from the laboratory at the time she normally looks in on the animals. She makes arrangements to have a fellow graduate student take care of her animals during this unusual absence. She assures her colleague that the task is both brief and simple. As arranged, Clara’s replacement enters the laboratory, walks up to the salamander colony, and removes the lid to place food and water in the enclosure. Within seconds, salamanders are everywhere. Some have landed on the stunned graduate student; others are scampering across the floor. For the next hour, Clara’s friend tries to restore order to what only moments ago

was a peaceful colony. She wonders why Clara did not warn her that these were “wild” animals. Neither Clara nor her friend had considered the possibility that the habituation of defensive behavior had been specific to Clara. “I had no idea they could recognize me,” Clara tells her friend while apologizing for the unfortunate mishap.

These examples are simple and obvious cases whose effects are unlikely to be overlooked by most investigators. Conventionally, Pavlovian conditioning results in the secretion of bodily fluids such as saliva and can also direct overt behavior by energizing skeletal-muscular responses. However, scientist-induced changes in animal behavior and physiology may take many forms that are not always apparent before the fact. If one considers the range of physiological systems that are accessible to Pavlovian conditioning, the picture becomes more clear. In addition to the aforementioned pituitary-adrenal system, Pavlovian conditioning may also modulate heart rate and blood pressure, activate the immune system, or produce drug tolerance or endorphin release (e.g., Davis and Levine 1982; Fanselow and Bolles 1979; Siegel 1976). It is difficult to imagine biomedical research, for example, that is immune to this range of effects.

Motivational Conditioning

Examine some of the old photographs taken in Pavlov’s laboratory and you will notice that the dog is typically restrained in a harness. This device was used for a reason. When Pavlov presented a CS, depending on whether it was previously paired with food or shock, the dog was likely to experience hunger pangs or acute fear. In either case, the dog was unlikely to remain on the experimental table, waiting for an unconditioned stimulus to follow. Does the family dog sit calmly while the owner ceremoniously opens the kitchen cupboard and rattles a bag of kibble? Most pet dogs become highly aroused when owners present this sequence of Pavlovian dinnertime cues each evening. This example underscores a very important point: Pavlovian conditioned responses have a large motivational component. In laboratories, such motivation often involves aversive conditioning. For example, a CS paired with shock or some painful bioassay technique may produce fear. The fear CR has both emotional and behavioral dimensions. Either or both of these dimensions may interfere with, alter, or obscure what you are studying, whether it is behavioral or physiological. Animals may directly tie these motivational effects, which easily qualify as uncontrolled variables, to the presence of a particular person.

Although there is a clear cautionary note to this message, the overall picture is not one of gloom and doom. Certainly, we are not the first to raise these concerns. In 1963, McGuigan issued a similar warning about the unintentional effects of the experimenter to an audience of experimental psychologists (McGuigan 1963). Wolfle (1985)

echoes these concerns for the field of biomedical research, arguing persuasively that laboratory personnel are an essential part of the social environment of research animals and can produce measurable effects on their performance. Knowing in advance that animal subjects are capable of discriminating between humans in their environment, and using them as predictors, allows researchers to take such possibly confounding effects into account, both in the design of experiments and the analysis of data.

How surprising this message is to a researcher, even one with years of experience, probably depends on the animal being studied. Obviously, it is likely that more allowances will be made for so-called “higher” animals. It is not necessary to convince primatologists or scientists working with dogs that their animals will be highly attuned to human identity or regularities in laboratory routine. But not all research involves higher animals; in fact, relatively little of it does. For this reason, the data we have surveyed and the possibilities we have described need to be considered.

Cause for Optimism

There is reason to view the message of this paper with optimism. Human recognition and a positive working relationship between scientist and animal may actually facilitate data collection. As Wolfle (1985) argues, “It is not an overstatement to say that the right animal technician instills qualities in the animals that make them better and more reliable research subjects” (p. 450). Many examples of this premise exist in a variety of settings. When Viktor Reinhardt began work as Head Veterinarian at the Wisconsin Regional Primate Facility, he found that technicians and animals were often involved in an adversarial relationship. Collecting a blood sample from the tail of a rhesus monkey required a noisy and disruptive tug of war. The fact that these blood samples may have been destined for studies of stress rendered them all but useless. At the least, steroid values collected under such conditions were unnaturally elevated.

Reinhardt (1992) quickly established a barter system so that the presence of a particular technician signaled that a blood sample was required. The animal quickly learned to present its tail voluntarily for sampling, knowing that the technician would reward such behavior with a piece of apple. Wear and tear on both scientist and animal were reduced, and blood and tissue samples came to reflect the variables under study, rather than aversive conditions in the laboratory.

A positive scientist-animal relationship has also benefited the field of animal cognition. Using a close relationship with their subjects, Sally Boysen (1992) and Irene Pepperberg (2000) have extended the boundaries of what is known about the mental abilities of chimpanzees and African gray parrots, respectively. As noted above, Pavlovian CRs may have a strong motivational component. Research in animal cognition can be tedious and time consuming.

Subjects often become distracted or lose interest in participating, especially when frustrating concepts are being taught. Data reported both by Boysen with her chimpanzee subject Sheba and Pepperberg's studies with Alex the parrot underscore the value of a positive bond between researcher and subject. It goes without saying that neither of these scientists could routinely turn data collection over to a new investigator and expect their subjects to look quite as smart.

This situation should not call into question the validity of the data the scientists have collected. Although "Person as CS" might superficially be confused with subtle cuing, the two are entirely different. The latter is often referred to as the "Clever Hans" effect, named for a horse famous at the turn of the century for his reported knowledge of mathematics (Candland 1993; Davis 1993). Needless to say, Hans knew little about numbers but was extremely adept at reading subtle bodily cues from the person interrogating him. A striking feature of Hans' performance is that it did not matter who asked the questions. He was skilled at reading postural cues from anyone. When appropriate precautions were taken to preclude cuing, it became obvious that Hans knew virtually nothing about mathematics. A comparison between this clever horse and the subjects of Boysen and Pepperberg is quite telling. In the latter cases, performance does not transfer well to interrogation by a stranger. Moreover, appropriate control tests—well beyond anything Hans could have passed—reveal that both Sheba and Alex understand the subject matter they have been taught.

A Practical Agenda

What are the practical considerations of knowing that discrimination of individual humans might affect our research agenda? At the outset, it is wise to examine whether seemingly random procedural situations may contain sources of prediction. If we assume that persons are discriminably different to our subjects, we should ask whether any particular person is regularly and uniquely associated with the delivery (or absence) of important hedonic events. If they are, there is a good chance that Pavlovian conditioning has already taken place with that person serving as a CS. Whether this discrimination is always a problem depends on the kind of conditioned responses that are elicited by the appearance of this person. Remember that Pavlovian CRs take many forms, most of which are "invisible." To determine whether any of these conditioned physiological or motivational effects interfere with or modulate what you are formally studying, it is advisable to vary your laboratory routine to change the role of the CS person and evaluate whether this change has a measurable impact on your data. If making such an alteration in laboratory routine is difficult or impossible, at least expand your description of the protocol to include the possibility that person-based conditioning was a factor.

Many people prefer to approach the problem in reverse: They wait for anomalous patterns in their data to appear

before looking for unanticipated procedural confounds. They then have reason to examine how their results might be tied to a particular person who tests or maintains the animals. In the case of negative results or recalcitrant animals, the role or behavior of a technician might indeed be at issue. Wolfle (1985) elaborates this situation. In the case of satisfactory data and accommodating subjects, there is obviously less incentive to investigate or make changes. This situation is understandable, but unfortunate. Even when things are running smoothly, it is logical to know which variables are functionally related to the data you are reporting. In short, it may be appropriate to acknowledge the role that a scientist/technician-animal relationship might have played in an efficient laboratory. In the field of animal cognition, the research domain closest to my own experience, no single worker would assume that successful performance would remain unchanged if the primary caretaker or testing personnel were suddenly changed. It is simply not logical to assume, "The animal knows what she knows, and it makes no difference who asks the questions."

The general message of this paper—that animals can discriminate among humans and use individual persons in a variety of predictive ways—is not inherently surprising. The message is primarily newsworthy because it involves an interspecies situation, i.e., one species using another to understand better and to function in its world. Although animal researchers occasionally express misgivings when cautioned about their interactions with subjects, the dialogue about potential problems appears to be less constrained when human subjects are involved. For example, a social psychologist would not be surprised to learn that the persons he studied were also studying him (e.g., Rosenthal, 1976.) In short, it is common knowledge that human subjects are rarely if ever passive sources of data. Why should we expect any less of animal subjects?

References

- Azrin NH, Holz WC. 1966. Punishment. In: Honig WK, ed. *Operant Behavior: Areas of Research and Theory*. New York: Appleton Century Crofts. p 380-447.
- Badia P, Harsh J, Abbott B. 1979. Choosing between predictable and unpredictable shock conditions: Data and theory. *Psych Bull* 86:1107-1131.
- Bolles RC. 1970. Species specific defense reactions and avoidance learning. *Psych Rev* 77:32-48.
- Bowers B, Burghardt G. 1992. The scientist and the snake: Relationships with reptiles. In: Davis H, Balfour D, eds. *The Inevitable Bond: Examining Scientist-Animal Interactions*. New York: Cambridge University Press. p 250-263.
- Boysen S. 1992. Pongid pedagogy: The contribution of human-chimpanzee interactions to the study of ape cognition. In: Davis H, Balfour D, eds. *The Inevitable Bond: Examining Scientist-Animal Interactions*. New York: Cambridge University Press. p 205-217.
- Caine NG. 1992. Humans as predators: Observational studies and the risk of pseudohabitation. In: Davis H, Balfour D, eds. *The Inevitable Bond: Examining Scientist-Animal Interactions*. New York: Cambridge University Press. p 357-364.
- Candland DK. 1993. *Feral children and clever animals*. New York: Oxford University Press.

- Catania AC, ed. 1968. Contemporary Research in Operant Behavior. Palo Alto CA: Scott Foresman.
- Collis L, Davis H. 2001. Discrimination between a familiar and unfamiliar human by a hive of honeybees (*Apis mellifera*). Unpublished Honours Thesis, University of Guelph.
- Davis H. 1993. Numerical competence in animals: Life beyond Clever Hans. In: Boysen ST, Capaldi EJ, eds. The Development of Numerical Competence: Animal and Human Models. Hillsdale NJ: Erlbaum. p 109-125.
- Davis H, Ackerman C, Silver A. 2002. Discrimination between familiar and novel humans by Gentoo penguins (*Pygosceli papua/ellsworthii*), emu (*Dromaius novaehollandiae*) and rhea (*Rhea americana*). Zoo Biol (In Press).
- Davis H, Balfour D, eds. 1992. The Inevitable Bond: Examining Scientist-Animal Interactions. New York: Cambridge University Press.
- Davis H, Gibson J. 2000. Can rabbits tell humans apart? Discrimination of individual humans and its implications for animal research. Comp Med 50:483-485.
- Davis H, Levine, S. 1982. Predictability, control and the pituitary-adrenal response in rats. J Comp Phys Psych 96:393-404.
- Davis H, Norris C, Taylor A. 1998. Wether ewe know me or not: The discrimination of individual humans by sheep. Behav Proc 43:27-32.
- Davis H, Perusse R. 1988. Human-based social interaction can reward a rat's behavior. Anim Learning Behav 16:89-92.
- Davis H, Taylor A. 2001. Discrimination between individual humans by domestic fowl (*Gallus gallus domesticus*). Br Poultry Sci 42:276-279.
- Davis H, Taylor A, Norris C. 1997. Preference for familiar humans by rats. Psych Bull Rev 4:118-120.
- Domjan M. 1998. The principles of learning and behavior, 4th ed. New York: Brooks Cole.
- Duncan IJH. 1992. The effect of the researcher on the behavior of poultry. In: Davis H, Balfour D, eds. The Inevitable Bond: Examining Scientist-Animal Interactions. New York: Cambridge University Press. p 285-294.
- Fanselow MS, Bolles R. 1979. Triggering of the endorphin analgesic reaction by a cue previously associated with shock: Reversal by naloxone. Bull Psych Soc 14:88-90.
- Gantt WH, Newton EO, Royer FL, Stephens JH. 1966. Effect of person. Cond Reflex 1:18-34.
- Hediger H. 1965. Man as a social partner of animals and vice-versa. In Ellis PE, ed. Symp Zoo Soc Lond 14:291-300.
- Lockard JS. 1963. Choice of warning signal or no warning signal in an unavoidable shock situation. J Comp Phys Psych 56:526-539.
- Mather J. 1992. Underestimating the octopus. In: Davis H, Balfour D, eds. The Inevitable Bond: Examining Scientist-Animal Interactions. New York: Cambridge University Press. p 240-249.
- McGuigan FJ. 1963. The experimenter: A neglected stimulus object. Psych Bull 60:421-428.
- Pepperberg IM. 2000. The Alex studies: Cognitive and communicative abilities of grey parrots. Cambridge MA: Harvard University Press.
- Reinhardt V. 1992. Improved handling of experimental rhesus monkeys. In: Davis H, Balfour D, eds. The Inevitable Bond: Examining Scientist-Animal Interactions. New York: Cambridge University Press. p 171-177.
- Rosenthal R. 1976. Experimenter effects in behavioral research, 2nd ed. New York: Halsted.
- Siegel S. 1976. Morphine analgesic tolerance: Its situation specificity supports a Pavlovian conditioning model. Science 193:323-325.
- Slobodchikoff C, Kiriazis J, Fischer C, Creef E. 1991. Semantic information distinguishing individual predators in the alarm calls of Gunnison's prairie dogs. Anim Behav 42:713-719.
- Tanida H, Miura A, Tanaka T, Yoshimoto T. 1995. Behavioural response to humans in individually handled weanling pigs. Appl Anim Behav Sci 42:249-259.
- Taylor A, Davis H. 1996. The response of llamas (*Lama glama*) to familiar and unfamiliar humans. Int J Comp Psych 9:42-49.
- Taylor A, Davis H. 1998. Individual humans as discriminative stimuli for cattle (*Bos taurus*). Appl Anim Behav Sci 58:13-21.
- Taylor A, Davis H, Boyle G. 1998. Increased vigilance toward unfamiliar humans by harbor (*Phoca vitulina*) and gray (*Halichoerus grypus*) seals. Mar Mam Sci 14:575-583.
- Thor DH, Holloway WR. 1982. Social memory of the male laboratory rat. J Comp Phys Psych 96:1000-1006.
- Wolfe T. 1985. Laboratory animal technicians: Their role in stress reduction and human-companion animal bonding. Vet Clin North Am: Small Anim Prac 15:449-454.