Multidisciplinary Approaches and Assessment Techniques to Better Understand and Enhance Zoo Nonhuman Animal Welfare

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Published online: 30 Sep 2013.


To link to this article: http://dx.doi.org/10.1080/10888705.2013.827914

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Nonhuman animal welfare is a complex concept that encompasses an animal’s biological functioning, emotional states, and opportunities to experience a natural life, including the performance of natural behaviors. Further, animal welfare can be viewed as quality of life from the perspective of the animal and thus must consider the animal’s subjective experiences. Therefore, assessing and enhancing animal welfare should include multidisciplinary, scientific ventures that strive to create a complete picture of how animals’ bodies and minds respond to both aversive and pleasant situations. Practical assessment of animal welfare should include outcome-based measures from the animal that provide information about the individual’s welfare as well as resource-based measures that can help identify causes of or risk factors for poor welfare. Increasingly, scientists are examining the emotional states of animals as well as the impact of pain, pleasure, and consciousness on animal welfare. This article discusses approaches such as preference testing, instrumental

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learning, examination of space and resource use, and qualitative assessments of animal welfare that might be useful and practical for assessing and enhancing welfare in zoo settings.

**Keywords:** preference testing, instrumental learning, operant learning, qualitative assessment, animal-based assessment

Nonhuman animal welfare is a concept that is multidimensional in nature, encompassing an animal’s biological functioning, emotional states, and opportunities to experience a natural life, including the performance of natural behaviors (Broom, 1988, Fraser, 2009a; Würbel, 2009). The scientific study of animal welfare has become one of the most complex and comprehensive disciplines in biology (Dawkins, 2006). It has traditionally drawn on theories, concepts, and methods from evolutionary biology, behavioral ecology, physiology, and animal science to study and assess welfare (Würbel, 2009). In order to create a more complete picture of how animals’ bodies and minds respond to both aversive and pleasant situations, scientists are increasingly incorporating approaches from fields such as neurobiology, endocrinology, psychology, genetics, and immunology into their studies.

As a result of this complexity, any attempt to assess or enhance animal welfare is perforce a multidisciplinary scientific venture (Botreau, Veissier, & Perny, 2009; Hill & Broom, 2009; Hosey, Melfi, & Pankhurst, 2009). However, people, depending on their perspectives (e.g., training, culture, ethical views, etc.) may view different elements of welfare as more or less important to be either assessed or improved. This can result in different emphases on what constitutes a welfare problem or where efforts should be focused to improve the situation. Ultimately, good animal welfare should represent a good quality of life from the perspective of the animal, trumping the perspectives of the human scientists, caretakers, or policymakers (Scott, Fitzpatrick, Nolan, Reid, & Wiseman, 2003; Wickins-Dražilová, 2006). Thus, assessments of animal welfare need to be able to capture how an animal feels (Dawkins, 2001; Duncan, 2004; Mason & Veasey, 2010) and is able to cope with or adapt to his or her environment (Hill & Broom, 2009).

Historically, however, many researchers working in animal welfare shied away from addressing the emotional states of animals because it was considered difficult to scientifically examine animal feelings or consciousness (Dantzer, 2002; Fraser, 2009b). Advances in fields such as neuroscience, ethology, and cognitive and comparative psychology are making such studies feasible (Carter, 2001; Rushen, 2003), and increasingly scientists are studying how pain, suffering, pleasure, and consciousness impact animal welfare. Scientists are moving beyond examining degrees and causes of poor welfare to examining positive affect, good welfare, and animals’ abilities to adapt flexibly (Boissy et al., 2007; Bracke & Hopster, 2006; McMillan, 2005).
Practical approaches to assessing welfare often include both animal- and resource-based measures (Blokhuis, 2008; Mollenhorst, Rodenburg, Bokkers, Koene, & de Boer, 2005). Animal-based (or outcome-based) measures include the behavior and physical conditions of the animals themselves (see Table 1). Resource-based (or design-based) measures focus on what or how things are provided to the animals, such as space per animal, flooring type, how much and what kind of feed, temperature, or airflow. In recent years, the tendency has been to rely more heavily on animal-based measures as these reflect how the animal is responding to conditions rather than making assumptions about how environmental or management factors affect welfare (Barnett & Hemsworth, 2009; Grandin, 2010; Main, 2009). Because animal welfare is a characteristic of an individual, assessing welfare using animal-based measures provides a truer indication of animal welfare (Butterworth, Mench, & Wielebnowski, 2011). However, resource-based measures can and should also be used in conjunction with information about management practices to help identify the causes of animal welfare problems or indicate potential risk factors (Butterworth et al., 2011).

Validation and Contradiction

When any measure is used to provide insight into an animal’s welfare, it is critical that it is first validated with regard to what it actually means rather than making assumptions (Rushen, 2003). Many, if not all, of the measures listed in Table 1 have been validated by correlating them with other measures such as physiological stress responses or health outcomes that indicate that they do, in fact, provide information about an animal’s welfare. However, not all measures have been validated for all species, and thus it may be necessary to validate measures as they are used to study new species or situations.

For example, allogrooming is often considered a sign of affiliation between animals and is perceived as positive. Allogrooming may occur spontaneously, after one animal solicits it from another, or after an agonistic interaction (Sato, Sako, & Maeda, 1991). However, subordinate animals may become stressed when they are groomed by dominant members of their group (Boissy et al., 2007). There is also evidence that some animals (e.g., pigs) may allogroom more in barren environments than in enriched systems (de Jong et al., 1998). Further, some animals, such as sheep, may normally show very little allogrooming behavior; therefore, absence of allogrooming would not be a sign of poor welfare in this species.
TABLE 1  
Examples of Animal-Based Indicators of Welfare\(^a\)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Species</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical scores</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body condition</td>
<td>Cats, Cattle &amp; water buffalo, Sheep, Mice</td>
<td>Burkholder, 2000</td>
</tr>
<tr>
<td>Lesions/Injuries</td>
<td>Pigs</td>
<td>Smulders et al., 2006</td>
</tr>
<tr>
<td>Gait</td>
<td>Dairy cattle</td>
<td>Sprecher et al., 1997</td>
</tr>
<tr>
<td>Growth rate</td>
<td>Pigs</td>
<td>Smulders et al., 2006</td>
</tr>
<tr>
<td>Cleanliness</td>
<td>Pigs</td>
<td>Temple et al., 2011</td>
</tr>
<tr>
<td><strong>Behaviors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eating/Drinking</td>
<td>Dairy cattle</td>
<td>Huzzey et al., 2007</td>
</tr>
<tr>
<td>Urinating/Defecating</td>
<td>Pigs</td>
<td>Smulders et al., 2006</td>
</tr>
<tr>
<td>Vocalizing(^b)</td>
<td>Cattle &amp; pigs, Piglets, Cats, rats, &amp; sheep, Cattle, pigs, &amp; poultry</td>
<td>Grandin, 2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weary et al., 1998</td>
</tr>
<tr>
<td></td>
<td></td>
<td>See Boissy et al., 2007, for a review</td>
</tr>
<tr>
<td></td>
<td></td>
<td>See Manteuffel et al., 2004, for a review</td>
</tr>
<tr>
<td>Stereotypies</td>
<td>Elephants</td>
<td>Mason &amp; Veasey, 2010</td>
</tr>
<tr>
<td>Aggression</td>
<td>Pigs</td>
<td>Temple et al., 2011</td>
</tr>
<tr>
<td>Play(^b)</td>
<td>Bonobos, cats, cattle, harbor seals, meerkats, mink, pigs, rats, rhesus monkeys, sheep, sifaka, white-tailed deer, &amp; wolves</td>
<td>See Held &amp; Špinka, 2011, for a review</td>
</tr>
<tr>
<td>Grooming others(^b)</td>
<td>Cattle, horses, &amp; pigs</td>
<td>See Boissy et al., 2007, for a review</td>
</tr>
<tr>
<td>Grooming self(^b)</td>
<td>Birds, cattle, dogs, &amp; rabbits</td>
<td>See Boissy et al., 2007, for a review</td>
</tr>
<tr>
<td>Exploration</td>
<td>Pigs</td>
<td>Temple et al., 2011</td>
</tr>
<tr>
<td>Affiliative behavior</td>
<td>Pigs</td>
<td>Temple et al., 2011</td>
</tr>
<tr>
<td>Lying behavior</td>
<td>Dairy cattle</td>
<td>Plesch et al., 2010</td>
</tr>
<tr>
<td>Assessment of comfort</td>
<td>Pigs</td>
<td>Temple et al., 2011</td>
</tr>
<tr>
<td>Novel object test</td>
<td>Pigs</td>
<td>Smulders et al., 2006</td>
</tr>
<tr>
<td>Reactivity to humans</td>
<td>Pigs</td>
<td>Clouard et al., 2011</td>
</tr>
<tr>
<td>Heart rate variability</td>
<td>Cattle, goats, horses, poultry, &amp; sheep</td>
<td>von Borell et al., 2007</td>
</tr>
</tbody>
</table>

\(^a\)These are only selected examples. Some of these measures have been validated in other species, including exotic mammals and birds, although little validation has been done with fish, reptiles, or amphibians. \(^b\)Depending on the species and context, these variables could indicate poor or good welfare or coping responses to stressful situations. This underscores the importance of validating each variable for the species and context of interest.
Even in cases where the welfare measure is one that is commonly used, it is important to look at the context in which the measure is taken, not just at the resulting data. For example, levels of cortisol, a hormone commonly associated with stress, can increase in response to activities such as courtship or acquisition of food, both of which would seem to be related to good rather than poor welfare (Broom, 1988).

An additional problem can arise when multiple measures are used to assess welfare and the results appear contradictory. For example, de Jong et al. (1998) studied growing pigs in a typical pen or in a pen that provided the animals with straw and more space. The enriched pigs had greater cortisol concentrations; however, behavioral measures indicated better welfare for the enriched pigs. In their conclusion, the authors weighed the expression of the more normal behavioral profile in the enriched environment more heavily than the physiological evidence, recognizing that increased cortisol could indicate increased arousal rather than distress (de Jong et al., 1998). Such contradictions are fairly common and may arise as a result of the nature of the stressor; time and duration of the stressor and sampling; the animal’s psychological state, temperament, and past experiences; or differences in age, sex, breed, or species among others (Mason & Mendl, 1993). Different measures may need to be taken or different scales may need to be used to interpret responses depending on whether the challenge to welfare is acute or chronic (Broom, 1988).

Preference Testing

One method that is often recommended as a means of gauging what resources (or forms of resources) animals value is preference testing. When preference testing is conducted in a formal, structured way, animals are simultaneously presented with different choices at the ends of each arm of the maze—for example, to go outside or stay inside, to be alone or with group members, to climb on ropes or in a tree, or to forage in wood chips or straw. Preference testing can also be performed by giving an animal continuous access to different options over a longer period of time and examining time spent between the choices and the ways in which the animal interacts with them (Morisse, Boilletot, & Martencher, 1999).

If rabbits are housed in pens with wire and straw-bedded flooring, do the rabbits sleep on one flooring type more than the other? Do they nest build with the straw? As in the examples just presented, preference testing can be used to examine a range of resources and to examine various characteristics of the resources including the amount, quality, timing, context, or specific type of features preferred. Preference tests can also be used to gather information about animals’ perceptual abilities, such as whether or not they can distinguish between patterns or colors (Engeszer, Wang, Ryan, & Parichy, 2008).
Preference tests must be designed carefully to be sure that the animal is making the choice related to the options presented and is not choosing the option based on its location, familiarity, or underlying motivations that are unrelated to the resource being examined (Widowski, 2009). An underlying assumption of preference tests is that animals always make choices that are in their best interests. However, animals, like humans, may make choices that are fulfilling in the short term but are detrimental to their long-term health and welfare. They may also make inappropriate choices when their preferences are examined in contexts or for resources that are markedly different from the environment in which their species evolved (Fraser & Nicol, 2011). For example, animals typically prefer energy-dense foods, but such preferences could lead to obesity in a captive environment where less energy is expended.

Preference testing can also be done in a more informal manner and yield useful results. Examining the use of space, structures, and resources within a zoo exhibit is a form of preference testing, and there have been numerous zoo-based studies examining these behaviors (Hosey et al., 2009). A search of “exhibit use” or “postoccupancy evaluation” in Zoo Biology yielded over 800 hits, with studies covering species ranging from geckos to bison and shrikes to orangutans. Such studies can examine how animals use different areas and features in their enclosures by recording where the animal is and what he or she is doing throughout the day or following the introduction of conspecifics, enrichment, or exhibit features (Ross, Schapiro, Hau, & Lukas, 2009; Sanderson, Daigle, Stark-Posta, & Siegford, 2009). Such studies can be used to assess the appropriateness of the environment and resources, understand preferences and aversions, make changes to improve use of environment, and ideally improve welfare by increasing desired activities and behaviors.

However, in order to accurately assess preference and create a comprehensive picture of what an individual animal is doing, rather than generate a potentially misleading snapshot, data should be collected over varying times of day, in different seasons and weather conditions, and with varying levels of visitor activity. Data could be collected using substantial amounts of human time and effort as in the case of live or video-based observations of animal behavior. Alternatively, there are several types of software that can automatically track animal movements through space and generate information about the distance and speed at which the animals are traveling and when they are active versus inactive (e.g., the Chickitaizer as per Estevez, Mallapur, Miller, & Christman, 2010). Additionally, data on animal activity levels or movement around and location within exhibits could be collected remotely and automatically using animal-worn sensors, such as pedometers or GPS units (Leighty, Soltis, & Savage, 2010). Sensors that are capable of detecting specific animal behaviors and use of key resources are also in development (Quwaider, Daigle, Biswas, Siegford, & Swanson, 2010).
Instrumental Learning

In operant conditioning or instrumental learning tasks, an animal learns that his or her behavior causes a specific outcome (Skinner, 1963). Depending on the consequences of the behavior, the animal may be more or less likely to repeat the behavior again (Kilgour, Foster, Temple, Matthews, & Bremner, 1991). In research settings, instrumental learning tasks are commonly used to measure the strength of an animal’s motivation for something that he or she prefers, such as access to a particular resource or the ability to perform a certain behavior (Asher, Kirkden, & Bateson, 2009; Duncan & Kite, 1987; Lawrence & Illius, 1989; Swiergiel, 1997). Instrumental learning tasks can also be used to evaluate whether animals have particular perceptual abilities or to assess various types of cognition (Arave, 1996; Langbein, Siebert, Nurnberg, & Manteuffel, 2007). Kilgour et al. (1991) conducted a review of scientific studies in animals on the farm and found over 100 examples of preference and motivation tests using instrumental learning tasks in species ranging from dogs to pigs.

In a zoo setting, formal instrumental learning tests to assess motivation or perception could certainly be conducted; however, there is often substantial time involved in training animals to use the testing apparatuses. Alternatively, more natural types of instrumental learning paradigms could be used to assess motivation. For example, an animal caretaker may wish to use scatter feeding to increase the amount of time spent foraging or to increase an animal’s use of a particular area of the exhibit. In this case, the amount of time spent foraging would be the operant response. Over the course of several days, the caretaker could vary the amount of food scattered to determine the minimum amount of feed needed to motivate the animal to forage as desired. This would maximize the amount of work the animal has to do for the food—reducing the cost of such enrichment while increasing a desired behavior. Alternatively, this type of paradigm could be used to evaluate preference by assessing whether an animal would work harder to locate one type of food reward compared with another type (e.g., strawberries vs. peanuts or mealworms).

Assessing Emotions of Animals

In the past, researchers have often shied away from addressing emotions in animals. It was thought to be difficult, if not impossible, to scientifically examine animal feelings or consciousness. Further, it was thought that quantifiable measurements were more powerful and objective than descriptive statements or qualitative assessments (Fraser, 2009a). Additionally, researchers focused more on conducting controlled experimental studies that provided statistical measures of central tendencies, such as means and medians, rather than examining observations of natural occurrences and individual variability. However, advances in the
fields of neuroscience, ethology, and cognitive and comparative psychology are making studies of animal emotion scientifically feasible, and there are increasing calls for animal welfare research to incorporate animal emotions (Balcombe, 2009; Danzter, 2002; Fraser & Duncan, 1998; Rushen, 2003).

It is now possible to stimulate and measure activity of cells in the brain or create lesions in brain centers in order to observe changes in animal behavior and compare changes with those seen in humans (Fraser, 2009a). There is also a growing tendency to focus on individual differences rather than group means as animal welfare (and animal emotions) are very individual conditions (Fraser, 2009a). The development and validation of both qualitative tools for assessing emotions—positive and negative—in humans and detailed, qualitative narrative observations of animals has led to adaptation of these methodologies for use in animal welfare research (Dawkins, 2008; Fraser, 2009a; Shen-Miller, 2011).

As a result, scientists are now beginning to directly address questions of how pain, suffering, pleasure, and consciousness impact animal welfare and how individual animals express and experience these emotions (Boissy et al., 2007; Désiré, Boissy, & Vessier, 2002; Fraser, 2009a).

The studies of animal emotion that have been conducted have largely focused on the experience of negatives conditions: pain, fear, distress, and suffering. The issue of whether animals can suffer has been at the heart of the animal welfare and animal rights debates and has spurred much of the public outcry over animal use (Balcombe, 2009). And certainly, in order to have good welfare, prolonged or severe negative states should be avoided or minimized. However, the speed with which animals learn to do things that could be suspected of bringing them pleasure, such as dairy cattle learning to activate a mechanical grooming brush within 24 hr of its introduction, suggests that animals are strongly motivated to engage in pleasurable activities (DeVries, Vankova, Veira, & von Keyserlingk, 2007). If such strong motivation for pleasure exists, then depriving animals of opportunities to fulfill this motivation reduces their welfare and strengthens the moral argument for improving conditions in which humans keep them (Balcombe, 2009).

Behaviors such as withdrawal or flight from aversive stimuli and approach to positive stimuli can be used to assess emotional valence (i.e., whether the emotion is positive or negative); however, it may be difficult or impossible for animals in restricted environments to show approach or avoidance (Vandenheede, Bouissou, & Picard, 1998). Other behaviors such as elimination may not be shown consistently by individuals or occur too infrequently to be useful. Therefore, it may be more important to look at behaviors that are shown in a variety of contexts and that can be combined in complex ways to indicate a variety of emotional states, such as body posture or facial expressions (Veissier & Boissy, 2007). In sheep, forward ear posture and frequent transitions between ear postures have been related to negative affective states whereas passive ear
postures have been related to positive states (Reefman, Kaszas, Wechsler, & Gygax, 2009).

**Pain and Pleasure**

To practically assess pain or pleasure of animals in the zoo, direct observations of animals can convey considerable information. Changes in posture, facial expression, temperament, or vocalizations can be used not only to identify a general problem with an animal but also can sometimes be specific enough to indicate that the animal is experiencing pain (Morton & Griffiths, 1985). For example, discrete changes in posture have been linked to castration or tail docking without analgesia in lambs (Molony & Kent, 1997) and with lameness in dairy cattle (Sprecher, Hostetler, & Kaneene, 1997).

For many species, vocalizations with certain characteristics also appear to be honest signals of pain. For example, high-frequency, intense vocalizations appear to be reliable indicators of pain in young animals, such as piglets (Weary, Braithwaite, & Fraser, 1998). Recently, a mouse grimace scale was developed to help researchers identify pain in mice in the laboratory (Langford et al., 2010). A pictorial guide uses 18 images to show alterations in the positions of the ears, eyes, whiskers, nose, and cheeks produce various facial expressions related to no, moderate, or severe pain.

On the other end of the spectrum, far less scientific work has been conducted on animals’ capacity to experience pleasurable feelings and how such feelings are manifested (Balcombe, 2009). However, observations of play, affiliative behaviors such as allogrooming, and some specific vocalizations suggest that these are promising indicators that animals are experiencing positive emotions (Table 1; Boissy et al., 2007). Rats appear to laugh in the form of ultrasonic vocalizations that are emitted during play or tickling (Panksepp & Burgdorf, 2003). And tickling of rats by a human handler before a procedure appears to reduce the stress of injections, suggesting that this tactile sensation is pleasurable (Cloutier, Wahl, Panksepp, & Newberry, 2011).

Although play is commonly linked to the experience of positive emotions in animals, increased play is also seen following periods of deprivation or reduced parental care (Held & Špinka, 2011). This means that even a seemingly unambiguous measure may not always indicate clearly the assumed welfare state. Thus, for animal-based indicators of both pain and pleasure, it is important to reiterate the necessity of validating these indicators for the species of interest and in training observers to reliably detect and score these indicators.

In addition to examining whether an animal is in pain, it is also important to understand whether that painful condition has rendered the animal more sensitive to other unpleasant stimuli, which could further compromise his or her welfare (Whay, Waterman, Webster, & O’Brien, 1998). Nociceptive threshold tests can
assess how sensitive an animal is to a noxious stimulus, such as heat or pressure, following an injury or surgery. These tests are not designed to directly assess how painful the original insult was; rather, they assess whether the animal’s nociceptive threshold has been reduced, rendering the animal more sensitive to other uncomfortable stimuli, and thus more likely to suffer or experience pain where it might not be expected (Whay et al., 1998). Moreover, these tests can provide information about whether an animal already experiencing pain is likely to be hypersensitive and thus experience discomfort or stress in environments or in response to routine management procedures that normally do not reduce welfare.

The most common types of noxious stimuli used in nociceptive threshold tests are mechanical tests that apply physical pressure (e.g., Kemp, Nolan, Cripps, & Fitzpatrick, 2008) and thermal tests that apply heat, often via a laser beam (Herskin, Ladewig, & Arendt-Nielsen, 2009), to the limb of the animal until he or she shifts, steps, kicks, or withdraws the limb. Nociceptive tests have been used in dairy cattle to demonstrate hyperalgesia in response to lameness and mastitis (Kemp et al., 2008; Whay et al., 1998). Such tests have also been performed in pigs, poultry, sheep, and horses, most usually to examine the animal’s response to lameness. These tests could easily be conducted with zoo animals—following validation of the nociceptive response—in order to examine the impact of lameness or other painful conditions or procedures on welfare.

**Qualitative Assessment of Welfare**

At the beginning of this article, quality of life from the perspective of the animal was presented as central to accurately assessing and successfully improving animal welfare. The concept of quality of life moves the scope of animal welfare beyond alleviation of pain, distress, and suffering to a more holistic, dynamic approach that considers what animals like or prefer doing and whether they can do what they want to do (Wemelsfelder, 2007). Quality of life brings to the fore the notion of how things are done, not just the quantity of resources available or quantification of expression.

Currently, qualitative work is used extensively in human social science; however, this practice is still viewed with skepticism by those in the animal sciences (Fraser, 2009a; Shen-Miller, 2011). Ironically, people personally relate to animals as whole, integrated beings while trying to divorce this notion from the science that is done (Wemelsfelder, 2007). A human observer intuitively operates like a computer: accumulating, filtering, and integrating information (Wemelsfelder, Hunter, Mendl, & Lawrence, 2000, 2001). The observer may develop a sense that something is not quite right with an animal even though he or she may not be able to articulate exactly what has led him or her to this conclusion. Ultimately, what is likely happening is that the observer is detecting
subtle shifts in habitual patterns of behavior, noticing changes in emotion, or picking up on an animal’s particular mood (Wemelsfelder, 2007).

When observers conduct behavioral studies involving the quantitative recording of data—such as how many times the animal ate, what he or she ate, and for how long—the observers also come away with a qualitative impression of the animal that is not captured by the data (Stevenson-Hinde, Stillwell-Barnes, & Zunz, 1980). Early qualitative studies of animals involved examining stability of subjective assessments over time in rhesus monkeys (Stevenson-Hinde et al., 1980), recognizing pain and distress in laboratory animals (Morton & Griffiths, 1985), and assessing individual distinctiveness of domestic cats (Feaver, Mendl, & Bateson, 1986).

Formal qualitative assessments (QAs) of animal welfare have been developed using a whole-animal perspective in a structured way to observe and analyze behaviors, postures, and expressions in context (Wemelsfelder, 2007). This involves reading body language that reflects what it is like to be the animal at that moment. Thus, QA captures affect and behavior. In order to perform QA credibly, an observer requires experience, training, and practice. Additionally, familiarity with the species (and ideally with the individual) is critical.

A formal methodology for QA has been developed that allows for standardization, comparison of QA results with other measures, and statistical analysis. Briefly, observers are asked to observe animals and generate a list of descriptive terms, then rating scales are developed using each observer’s personal terms, and the observers watch the animals again and use the scales to rate what they observe. These scores are then analyzed using a multivariate statistical procedure called General Procrustes Analysis, which allows for the calculation of agreement between observers using different terms and identification of commonly perceived behavioral dimensions (see Wemelsfelder, 2007, for a more detailed description of the process).

Formal QAs have been performed on sheep, pigs, and cattle, and variations have been performed on dogs and horses (Minero, Tosi, Canali, & Wemelsfelder, 2009; Rousing & Wemelsfelder, 2006; Wemelsfelder, 2008; Wemelsfelder et al., 2001; Wiseman-Orr, Scott, Reid, & Nolan, 2006). These QA findings correlate well with quantitative behavioral and physiological measures, and QA results are consistent between and across observers (Wemelsfelder, 2007).

There is currently a great deal of interest from several organizations, including Commonwealth Scientific and Industrial Research Organisation in Australia, in incorporating QA into welfare assessments in a prominent way, for example, in assessments of cattle during transport (Stockman et al., 2011). Given the ability of observers to generate their own list of descriptors, the QA methodology should be easy to adapt for assessing animals in zoos. However, it is critical that the rigor of the procedure be maintained in terms of training, practice, and analysis in order for the results to be credible.
ENHANCING WELFARE OF ANIMALS IN ZOOS

Instrumental Learning

In addition to providing insight into animal motivation, perception, information processing, and learning, instrumental learning could be used as a way to improve zoo animal welfare (Manteuffel, Langbein, & Puppe, 2009). Rewarded instrumental learning could be used to enhance animal welfare by improving care and management practices, reducing behavioral problems, providing cognitive enrichment, and giving animals some control over their environments. Zoos commonly use positive reinforcement training to teach animals to stand and present body parts for examinations, to assist with administration of medication, and even to assist with breeding (e.g., Hosey et al., 2009; Savastano, Hanson, & McCann, 2003). Training such as training to stations can also be used to prevent behavior problems (e.g., fighting between group members over food; Schapiro, Bloomsmith, & Laule, 2003). Additionally, such learning opportunities could provide animals with mental stimulation, which might mediate age-related cognitive declines that could be problematic in aging zoo animals (Milgram, 2003; Valenzuela & Sachdev, 2009).

Although most zoos now present “enrichment” to some or all of their animals, not all forms of enrichment challenge animals physically or mentally (e.g., the enrichment might not require problem solving or development of a new physical skill). Yet, there is evidence that animals seek challenges. For example, several species of animals—including grizzly bears, gerbils, pigs, chickens, rats, and pigs—sometimes prefer to work for food rather than receive “free” food (i.e., contrafreeloading; Inglis, Forkman, & Lazarus, 1997; Langbein, Siebert, & Nürnberg, 2009; McGowan, Robbins, Allredge, & Newberry, 2010; Meehan & Mench, 2007). There is also evidence that problem-solving tasks can reduce fear, stress, and the expression of abnormal behaviors.

For example, growing pigs who master cognitive challenges associated with feeding show less fear and belly nosing (Puppe, Ernst, Schön, & Manteuffel, 2007), and piglets who learn to navigate a maze to return to their dam show less fear of humans later (Siegford, Rucker, & Zanella, 2008). Thus, in order to improve welfare more thoroughly, enrichment should go beyond promoting the physical expression of behaviors to encouraging more complex problem-solving behaviors in animals by presenting them with mental as well as physical challenges. However, in order to avoid frustration, which could reduce the animals’ willingness to interact with enrichment or lead to stress, the challenges or problems posed by the enrichment must be appropriate and solvable for the target species (Langbein et al., 2009; Manteuffel et al., 2009).

Giving animals the ability to exert control over their environment or situation has been demonstrated to help reduce stress and improve positive affect in a wide
range of species (Fraser & Nicol, 2011; Kilgour et al., 1991; Manteuffel et al., 2009). All animals, including those in zoos or on farms, learn to associate their behaviors with outcomes and thus can learn to gain control of their environment in ways that can improve their welfare (Arave, 1996; Kilgour et al., 1991; Rossi & Ades, 2008). For example, pigs and warthogs quickly learn that pushing the lever in a bowl drinker with their snouts will cause water to flow into the bowl, giving them the ability to get fresh water to drink (or play in) whenever they choose.

Many animals learn to push through flaps or swinging doors to access dens or to move between portions of their exhibit into another space. Animals such as snow leopards quickly learn to leap up on rocks or ledges in their exhibits to gain a better vantage point or access to a breeze or to distance themselves from visitors or other animals in the exhibit. Thus, giving an animal control in a zoo setting is often done unconsciously and can be as simple as allowing the animal to move between microclimates within an exhibit or to get water on demand by manipulating a drinker or providing different types of enrichment that could be interacted with as the animal chooses.

However, instrumental learning could also be used in other ways to give animals control over their environments. Animals could learn to manipulate switches to alter lighting or temperature (Ingram, 1975; Swiergiel, 1997). For example, in a study where laying hens were given the ability to have extra access to food and light by pecking keys, they were willing to work to open the feeder for an average of 92 additional minutes per day and to turn on the light for an average of 46 additional minutes per day (Taylor, Coerse, & Haskell, 2001). Hens who were unable to control these features of their environment spent more time resting and preening, which the authors postulate could be interpreted as inactivity or passivity and displacement behavior, respectively. Thus, hens who could control features of their environment might experience less stress and therefore experience better welfare (Taylor et al., 2001).

Instrumental learning paradigms could also be used to give animals tools that would allow them to communicate their needs. For example, a dog has been trained to use a keyboard with eight keys, each of which has an arbitrary symbol that is used to indicate walk, toy, food, crate, water, petting, urinating, or nothing (Rossi & Ades, 2008). The results of the study suggest that the dog presses the various keys in an intentional way that correlates with the motivational context.

There are several instances of chimpanzees using keyboards or markers on a language board to request items or interactions (Matsuzawa, 2003; Premack, 1990; Rumbaugh, 1977; Savage-Rumbaugh, 1990). Dolphins are also able to use arbitrary symbols in cognitive tasks to indicate whether objects are present or absent (Herman & Forestell, 1985). Although training animals to use keyboards or symbols may not be practical, it does demonstrate that species of several taxa are capable of complex abstract thought, which has implications for how
they are managed and what factors should be considered important for their welfare.

CONCLUSION

Many practical techniques for assessing and improving the welfare of zoo animals are based on animal behavior. However, they go beyond simply observing what the animal is doing and tallying up how often it happens. Innovative strategies for assessing animal welfare now provide insights into animal emotions (especially positive ones) and attempt to view the animal as a whole, integrated being. Methods for enhancing the welfare of zoo animals are increasingly going beyond providing good care of the body to stimulating the animal’s cognitive processes and providing animals with as much choice and control as possible within the confines of an exhibit. Zoos are moving from informal or unconscious assessment and enhancement practices to formal schemes for explicitly examining and enhancing animal welfare.

ACKNOWLEDGMENTS

I thank the Detroit Zoological Society, particularly Cynthia L. Bennett, Director of Animal Welfare, for inviting me to present at the “From Good Care to Great Welfare” forum.

REFERENCES


