ARTICLES

The Convenient Disregard for the *Rattus* Species in the Laboratory Environment: Implications for Animal Welfare and Science

ELENA T. CONTRERAS
Long Island University College of Veterinary Medicine, New York

BERNARD E. ROLLIN
Colorado State University

Abstract: This article encourages a rethinking of how rats are regarded within the laboratory research environment. The rat's remarkable intellect and cognitive capacities are well known yet conveniently ignored. An understanding of the five domains of animal welfare and the telos of the rat necessitate that the rat's circumstances, namely habitat accommodations, in the research arena be reassessed. The rat-ness of being a rat must be considered, celebrated, and elevated to significantly higher standards. We advocate for a new research paradigm if one continues to "use" the extraordinary Rattus *species.*

Key Words: animal welfare, five domains, habitat, housing, rats used in laboratories, natural environment, *Rattus norvegicus*, research

RAT CAPABILITIES AND THE NATURAL ENVIRONMENT

The scientific community recognizes that rats possess intelligence, advanced cognition, keen senses, and extensive emotional responses (Balcombe, 2010; Davis, 1996; Makowska & Weary, 2013; McBride, 2017). Studies have repeatedly revealed rats' intellectual capacities exemplified by their abilities to understand time, space, and numbers; to solve complex puzzles; and to demonstrate conceptual learning, recognition, discrimination, metacognition, and generalization (Davis, 1992, 1996; Davis & Albert, 1986; Davis & Bradford, 1986; Foote & Crystal, 2007; Murphy et al., 2008). They are inquisitive with episodic memories (Babb & Crystal, 2006; Barnett, 1976; Beran, 2014; Renner, 1987). Rats also exhibit causal reasoning, motivation, and judgment-making based on perceptions

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(Blaisdell et al., 2006; Makowska & Weary, 2016; Perry & Felsen, 2012). Such studies have substantiated rats' notable intellect and cognition.

In their natural environments, rats live in colonies. They are very social and playful animals (Balcombe, 2006; Bartal et al., 2011; Makowska & Weary, 2013; Pellis & Pellis, 1998; Vanderschuren et al., 1997). Their wide emotional spectrum reveals capacities for altruism, empathy, cooperation, and reciprocity (Bartal et al., 2011; Dolivo et al., 2016; Dolivo & Taborsky, 2015a, 2015b; Mendl et al., 2009; Preston & de Waal, 2002). Rats also experience joy, happiness, and optimism as well as regret, despair, and pessimism (Balcombe, 2006; Carstens & Moberg, 2000; Harding et al., 2004; Makowska & Weary, 2013; Panksepp & Burgdorf, 2003; Sharp et al., 2003; Steiner & Redish, 2014; Wurbel, 2001).

Free-living rats occupy large home ranges with varied underground dwellings. Depending on whether a free-ranging rat lives within a city, rural agriculture, a sewer, or a watershed, home ranges can vary from city blocks to 200 meters (Heiberg et al., 2012), and some estimates extend to 5,000 meters (Balcombe, 2010; Calhoun, 1963; Jackson, 1982; Peplow, 2004; Stroud, 1982). Rats also thrive within environmental complexity. The natural behavior of rats is to explore, forage, nest, dig, and burrow, and they often modify and/or expand their burrows thus diversifying their environments. During their activities of daily living, they also stand upright often and climb (Balcombe, 2006; Barnett, 1976; Huck & Price, 1976; Makowska & Weary, 2016; Price, 1977).

RATS IN RESEARCH

Rodents are widely used in research laboratories. The brown or Norway rat, *Rattus norvegicus*, is the rat species most often used, serving as the model in millions of scientific publications (Iannaccone & Jacob, 2009). In the United States, rodents comprise an estimated 90% of all vertebrate animals used in laboratory research with a yearly range from 12 million to more than 80 million (Carbone, 2004; Knight, 2011; Orlans, 2000; Speaking of Research, n.d.; Statistic Brain, 2016). No accurate count of the number utilized in the United States exists, however, because there is no counting mechanism. The Animal Welfare Act (AWA; 1966, 2002) is a U.S. federal statute that instructs the U.S. Department of Agriculture (USDA) regarding the oversight of animals in research facilities. A 2002 amendment to the AWA (Farm Security and Rural Investment Act, 2002) revised the definition of "animal" so that it excluded rats bred for research (Cohen, 2006).

As a result of the AWA amendment, rats are not considered animals, not counted in USDA laboratory animal numbers, and not protected under the AWA itself, despite multiple amendments and suits filed to overturn this exclusion. Proponents of rodents' exclusion from the AWA might espouse that other organizations such as the National Institutes of Health, the Association for Assessment and Accreditation of Laboratory Animal Care, or local institutional animal care and use committees already have oversight of the rodents used in U.S. laboratories (Smith, 2002). However, these organizations

cannot adequately monitor welfare of the millions of rodents involved in research each year (Carbone, 2004; Orlans, 2000; Rollin, 2017).

We do not suggest that inclusion of rats in the AWA would remedy or improve their situation or usage in the laboratory, but rather the purposeful exclusion of rats from consideration in the AWA exemplifies, at least in the United States, the indifference toward treatment of and concern for the rat. Similarly, the questionable utility, morality, and ethics concerning the usage and termination of lives of rats or other nonhuman animals in laboratory research will not be addressed here, and we rather refer the reader to other resources that present compelling arguments regarding those topics (Herrmann & Jayne 2019; Knight, 2017; Linzey & Linzey, 2018). In the current climate, innumerable individuals, institutions, organizations, and governing bodies are steadfast in their assurances of the necessity of animal experimentation (Carbone, 2004; Linzey & Linzey, 2018; Rossi & Garner, 2018); therefore, the rat will likely be a captive research subject for the foreseeable future. We must therefore currently ask ourselves *how* the rat is to exist in the research environment to which we have relegated them (Carbone, 2004). Until rats are no longer used in the laboratory context, our intent will be to attend to the needs of the captive, confined rats used in laboratories.

In the typical laboratory research environment, rats are housed in "shoebox" containers (hereafter referred to as "rat boxes" and "rat-in-box") and stacked in rows on moveable racks that are approximately 5 feet tall and 5 feet wide (Figure 1; Institute of Laboratory Animal Resources (ILAR), 2011; Suckow et al., 2006). For grouped rats weighing up to 300 grams, the recommended minimum size for habitat space is a floor area of 1.87 meters squared and a height of 0.18 meters. Similarly, the U.K.'s guidelines (Code of Practice for the Housing and Care of Animals Bred, Supplied or Used for Scientific Purposes, 2014) suggest a minimum floor area of 0.08 meters squared for an adult rat weighing 600 grams or 0.045 meters squared for group-housed animals. These standards are hundreds or thousands of times smaller than a rat's home range. Furthermore, an adult rat can rise on hind legs reaching approximately 30 centimeters; the rat would therefore be unable to stand on their hind legs at these minimum cage heights. These minimum requirements cannot satisfy rats' basic locomotor needs.

Solitary or paired housing is also common in the research laboratory (Balcombe, 2006; ILAR, 2011; Suckow et al., 2006). As discussed, such housing does not accommodate the rat's need for social relationships and social structure. Different iterations of these and other guidelines have been published for decades. They provide minimum recommendations that inadequately address rats' needs.

ILAR's (2011) guide also recommends:

> All animals should be housed under conditions that provide sufficient space as well as supplementary structures and resources required to meet physical, physiologic, and behavioral needs. Environments that fail to meet the animals' needs may result in abnormal brain development, physiologic dysfunction, and behavioral disorders (Garner, 2005; van Praag et al., 2000; Wurbel, 2001) that may compromise both animal well-being and scientific validity. The primary enclosure or space may need to be enriched to prevent

FIGURE 1: Traditional housing for rats used in laboratories (Photo credit: © iStock.com/fotografixx).

> such effects. . . . An appropriate housing space or enclosure should also account for the animals' social needs." (p. 51)

Despite these recommendations by which most U.S. research facilities likely claim to abide, rat boxes (Figure 1) are unquestionably deficient in meeting rats' physical, physiologic, behavioral, and social needs. Are the ramifications of inappropriate living conditions resulting in physiologic dysfunction, abnormal brain development, and invalid studies conveniently ignored? Is there a misunderstanding or lack of knowledge regarding the animals, and thus a misinterpretation of guidelines? A recent study evaluated research laboratory scientist and staff perceptions regarding increasing cage height for rats (Mazhary & Hawkins, 2019). Despite scientific evidence to the contrary as discussed above, some of the respondents in the study's survey had inaccurate perceptions about rat behavior and welfare and thus felt that increasing cage height for rats was unnecessary and potentially detrimental for the rats.

It is difficult to comprehend how the environments of the animals used in the laboratories—the rodents, that are used, by far, more extensively than any other research animals—fail to meet minimum recommendations. If minimum recommendations are not implemented for the animals that are used in 90% of research, why do the guidelines exist at all? Or perhaps the guidelines are not necessary for the rats in at least the United States,

since they are not animals according to the USDA, although we presume that we should reconsider their use as subjects if they are more akin to inanimate objects than animals.

If one is an astute observer and has ever been in a laboratory research facility that houses rats, one might notice that many of the rats appear to be curious animals with a desire to "escape" or explore what lies beyond their tiny rat boxes. One might wonder how the rats feel about living in small rat boxes for eternity. Why do we take the rat-in-box for granted? Why do veterinarians and researchers not give much, if any, thought to the rat-in-box? Why do animal care laboratory workers, generally well-intentioned, compassionate people, also accept that the rat-in-box is an appropriate manner to keep these animals? Are we all merely indoctrinated into blind acceptance? Do we not understand the complexities and needs of the rat? Do we rationalize their needs and wants? Do we not care?

TELOS AND THE FIVE ANIMAL WELFARE DOMAINS

"Telos" (Rollin, 1981, 2012), derived from Aristotelian philosophy, is an animal's, or human's, essence or nature, defined by the interests that matter to the animal or human. Telos of an animal constitutes that animal's animalness; for example, what does it mean to BE a rat, having ratness, or to BE a lizard, having lizardness? There are biological species differences, but telos refers to a differentness that also encompasses a philosophical gestalt of the emotional and mental well-being of an animal and their contentment with their situations and experiences. Satisfaction of telos leads to happiness. Conversely, impediment of telos leads to unhappiness—the animal experiences an undesirable state, and this may be characterized by frustration, boredom, anxiety, discomfort, or illness (Armstrong & Botzler, 2016; Rollin, 1981, 2012).

As an example of telos, we would likely agree that a gazelle is *meant* to run since their biology encompasses the unique capacity for high-speed running. However, does the gazelle also *need* to run to be happy and enjoy a fulfilling life, and would the thwarting of running cause distress as characterized above? Or does the gazelle just have an *interest* in running, but they do not depend on running for happiness? We consider the animal's telos to be embodied by the former: whether or not the animal has the *need* to do x, y, and z as a necessity for happiness and whether the lack thereof results in unhappiness and frustration.

Defining telos for any species is not straightforward. The essence of humanness or human nature is a continual philosophical debate. Similarly, and as profoundly, a rat's telos, or ratness, is unclear. What makes a rat a rat, in essence or ratness? And what aspects of ratness fashion a happy rat? If we were to imagine what might constitute telos for a rat as per the plethora of studies that have used rats as models and based on personal experiences with rats, we would suspect that such a rat life would be rife with environmental complexity and stimulation of the rat's exploratory and inquisitive nature; the rat would thrive in discovering new pathways and puzzles to unravel. The rat's need for ratness would also likely include hopping, jumping, and traveling throughout large

areas with both vertical and horizontal diversity and burrowing through tunnels and creating structures for themselves and social comrades. Relatedly, ratness would also likely include social groups with opportunities to play and experience joy, affection, and companionship. A rat's telos would likely also be encompassed within the rat's ability to experience a myriad of scents, sounds, tastes, and tactile encounters unique to the rat and about which we, as humans, are not aware. If even this simple characterization of rat telos were true, it must therefore be concluded that a rat's telos is not considered, respected, nor fulfilled on any level in the standard laboratory research environment. Consequently, impediment of telos leads to unhappiness; the animal without the ability to fulfill telos experiences an undesirable state characterized by frustration, boredom, anxiety, discomfort, and/or illness (Armstrong & Botzler, 2016; Rollin, 1981, 2012). The rat's experience without consideration of telos is discussed further below.

The Farm Animal Welfare Council (1979) defined five freedoms necessary for appropriate animal welfare, taking into consideration the animal's physical and mental state and sense of well-being. These are (a) freedom from hunger and thirst; (b) freedom from discomfort; (c) freedom from pain, injury, or disease; (d) freedom to express normal behavior; and (e) freedom from fear and distress. In relation to the concept of telos, if any of these freedoms is violated, that directly violates the animal's telos. More recently, there has been a shift toward the five domains of (a) nutrition, (b) environment, (c) health, (d) behavior, and (e) mental state (Mellor, 2016). This new paradigm allows for assessment of welfare compromise and enhancement. Within the five domains, quality of life assessments can be made, positive states are encouraged, and the focus is on thriving instead of survival (Mellor, 2016, 2017; Mellor & Beausoleil, 2015; Webster, 2016).

If we are concerned with animal welfare, suffering, and quality of life, we must not just ensure that animals are merely fed and free of outward pain and illness. We must go beyond those needs and consider the telos of the animal, their wants and needs to be who they are at their potential, and their opportunities to experience *positive* feelings (Carbone, 2004; Rollin, 2012; Sapontzis, 1990). We must consider the animal's life within the five domains. Denial of the importance of any of these entails suffering. Rollin (1990) proposed enactment of the rights principle that advises that research be conducted while maximizing an animal's potential to live their life according to their telos. The paradigms of telos, the five welfare domains, and the rights principle need also be applied to the rat.

PUBLIC PERCEPTION OF RATS

The rat is a frequently maligned species (Corrigan, 2006; Himsworth et al., 2013; Jackson, 1980; Sullivan, 2004; Walsh, 2014). The general public perception of the rat consists mostly of negative images of infectious diseases, trash scavenging, pestilence, and the propensity to kill or eat humans if given the opportunity, as so portrayed in the 1970s horror and science fiction cult classics *The Food of the Gods* (Gordon, 1976) and *Ben* (Karlson, 1972). Fortunately, other less gruesomely terrifying movies have also entertained audiences. *Ratatouille* (Bird & Pinkava, 2007), a light-hearted computer animated Pixar film,

portrayed rats with intelligent, humorous anthropomorphism. The critically acclaimed animated film *The Secret of NIMH* (Bluth, 1982) told a story of super intelligent rats that had escaped from research laboratories at the National Institutes of Mental Health, where they were used in experiments endowing them with super intelligence akin to that of humans. The multifaceted public perception of rats creates difficulties in garnering public support for reform for rats used in laboratories. Since the rat is not a charismatic species, despite animated films such as *Ratatouille*, the public does not rally around their injustices in the laboratory world as they would do for more "adorable" animals.

The public's conception of animal suffering at the hands of research likely dredges up egregious images of physical animal torture. Many individuals are likely infrequently aware of the other, overwhelmingly pervasive and normalized form of suffering in the laboratory research environment—the captivity and confinement in abhorrently sparse conditions depriving animals of all their needs other than food and water that might be adequately provided. As stated previously, this article's purpose is not to address the ethics of animal research per se, but rather, the purpose is to attend to the problematic confinement and living conditions to which they are relegated *if* they continue to be used in research. We must be more cognizant of the additional and profound suffering that occurs because the rats live in a constant state of deprivation of their telos and positive experiences, thus impacting their five freedoms and welfare domains. "Being forced to live under conditions for which they are not suited is a far greater source of suffering for laboratory animals than are the experimental manipulations performed on them which have elicited the bulk of social concern thus far "(Rollin, 1990, p. 33).

RATNESS AND THE ALTERNATIVE REALITY IN THE LABORATORY

One might think that once a "lab rat" always a "lab rat," or perhaps since the rat has been used and bred in lab conditions for many decades, that the "lab rat" has lost its ratness. That notion is far from the truth. Reminiscent of *The Secret of NIMH*, a short documentary, *The Laboratory Rat: A Natural History* (Berdoy, 2002), followed rats released from the laboratory into a free-ranging natural environment outdoors (Berdoy, 2002). A veterinary scientist commented that "they went from shuffling, like they do in a cage, to hopping around just like wild rats within a few days" (Peplow, 2004). These findings showed that rats are rats with ratness despite being bred to live in rat boxes and spending their lives there. We can also deduce that the rat therefore needs to engage in ratness behaviors to be a rat.

One study (Makowska & Weary, 2016) evaluated whether rats used in laboratories were motivated to engage in natural behaviors that were not possible in typical lab cages but that were possible in seminaturalistic habitats (Figure 2). They found that the seminaturalistic habitat rats consistently engaged in multiple natural behaviors that they were unable to perform in the typical lab cages. The rats were motivated to burrow, build, and maintain burrows, suggesting that maintenance and performance of such natural behaviors were critical components for their well-being. The rats also often climbed,

FIGURE 2: Seminaturalistic cage (Reproduced from Makowska & Weary, 2016, published by the Royal Society under the terms of the Creative Commons).

and standing upright was the most common behavior; it occurred 180 times per day in 3-month-old rats and 75 times per day in 13-month-old rats in the seminaturalistic habitats. Climbing, standing, and upright stretching behaviors were behaviors in which rats needed to engage and that embodied ratness. None of these behaviors, however, were able to be performed by rats in the typical laboratory cages. The rats in the standard cages spent much of their time in lateral recumbency stretching; the authors suggested that the rats likely performed lateral stretching behaviors in these cages due to stiffness, immobility, and forced sedentary behavior. They concluded that standard lab cages prevented natural behaviors necessary and important to the rat, thus contributing to poor welfare and unmet needs for the rats.

The above studies and others suggest that the conditions to which rats are subjected in their rat boxes fashion lives of compromised welfare and suffering. Considering it has also been found that rats experience optimism and pessimism based on their living conditions (Harding et al., 2004), this raises the question of whether we have relegated the rat-in-box to living in a state of persistent pessimism.

Rats in research laboratories live with chronic deprivation and stress; their five freedoms and welfare domains are therefore impacted. By reviewing 80 published studies, Balcombe et al. (2004) evaluated stress potentially experienced by animals used in the laboratory such as rats during routine laboratory sampling or activities perceived to be benign or tolerable.

They found that routine procedures such as blood draws were acutely stressful for animals, and when rats were present when these procedures were performed on other animals, that led to further stress in the rats (Sharp et al., 2002, 2003). Others have found similar stress responses to seemingly benign procedures such as being transported between rooms in either carry boxes or their home cages (Dallmann et al., 2006; McBride, 2017). Procedures considered benign and routine result in significant fear, stress, and distress.

It is somewhat disconcerting that after each enlightening discovery is made regarding the rat's cognitive, intellectual, or emotional abilities and needs, as a surrogate for human study, the rat is merely returned to their rat box stacked among hundreds of others. It would seem that after such discoveries, an ethical dilemma would exist concerning how to provide for the rat's basic needs. Is the inattention to the suffering and to the lack of telos being experienced by the rat due to indifference, ignorance, lack of empathy for the rat, habit and indoctrination, an unsubstantiated claim of standardization of subjects and environments, or a combination of all? Whatever the reasons for the negligence of tending to rat telos or ratness in the research environment, if one merely stops to consider the rat in the natural environment, one cannot deny that animal welfare is seriously compromised in the welfare domains of environment, behavior, and thus affective mental state in the rats used in laboratories. These rats therefore suffer with a very poor quality of life.

RATNESS: IMPLICATIONS FOR SCIENCE

Whether or not researchers believe in the rights of rats to express ratness, our presumption is that it would be the very rare researcher who would abandon their rat research model because of any of the aforementioned presumptions, despite glaring evidence of animal suffering and poor welfare. Our suspicion is that they would merely don the "researcher cap" and proceed along with the day, the week, the year, likely justifying and rationalizing as has been done every other day. The researcher might state, "It's for the good of science," "It's for a higher cause," "It's to help save human lives and decrease human suffering," or "Humans are the superior species, worthy of more rights than a mere rat." Therefore, one might feel that all hope is lost and the opening of the eyes to the telos of the rat, ratness, and rat needs and behaviors are all for naught. We do not believe this is so, however. We approach the possibility of change from a perspective that appeals to the research community and scientists.

The aforementioned stressors, including regular laboratory procedures, environmental changes, deplete environments, lack of mental stimulation, thwarting of natural behaviors, social stressors, and additional stressors, have physiological effects on rats. Such stressors alter hormonal, immunologic, physiologic, cognitive, and behavioral responses, and the consequences are rarely predictable although commonly present (Balcombe et al., 2004; Baldwin & Bekoff, 2007; Hermes et al., 2009; Knight, 2017; Moberg & Mench, 2000; Wurbel, 2001). Thus, if all physiologic and biologic normal parameters are altered with the rat-in-box, how could the rat be a valid model for translational medicine? Or immunology? Or physiology? Or pathology?

If the researcher does not understand the subject, the rat, and how the rat responds in basic biologic, physiologic terms, results will be invalid, unreliable, and useless. One must understand the normal behaviors, environment, and physiologic adaptations that the subject utilizes to survive and thrive in the subject's environment. If one does not appreciate normal, one cannot recognize abnormal. As an example, rats' eyes are very sensitive to normal light, and overexposure can sometimes result in ocular discomfort, ocular secretions, and hiding behavior (if the rat has somewhere to hide), and it can also lead to retinal damage (Burn, 2008). In the 1990s, experiments were conducted on rats to determine if bright light therapy could alleviate or assuage depression or seasonal affective disorder in humans (Giroux et al., 1991; Humpel et al., 1992; Overstreet, 1993). Rats were used as the model to test the hypotheses regarding humans. The experiments showed that light had no effect on rat "depression"; however, the model to test the premise for the hypotheses was entirely flawed since, as noted, rats' physiologic and behavioral adaptations and responses to light differed markedly from those of humans. Furthermore, the light destroyed the rats' ocular photoreceptors in at least one of the studies (Burn, 2008). One cannot utilize a species as a translational model for another species if one does not understand how the behavior and physiology operates in and sustains the "model" species. This type of hubris leads to potentially dangerous conclusions based on flawed and meaningless science.

As further testament to imprudent and poorly designed experiments without consideration of the subject's natural behavior and physiologic environment, many experiments are conducted in the daytime and during bright conditions. Conducting experiments during these non-rat times alters the rat's normal sleep-wake cycle and circadian rhythm, thus leading to brain alteration and stress. If the normal environment in which studies are being conducted are contributing to cognitive alterations, stress, and thus physiologic consequences, how can any findings from the study be considered meaningful, much less translational? Inattention to the rat's needs—physiologic, environmental, mental, and emotional—relegates findings meaningless. Furthermore, since rats are contained in such unnatural and detrimental environments, it seems counterintuitive that they could serve as a comparable model for anything other than pathology due to unfavorable environments, deprivation, and chronic stress.

Rats also forage, and this behavior serves in the development of cognitive and psychomotor strength in the rat (Balcombe, 2010); therefore, if rats cannot forage, their cognitive capacities decline. As discussed, rats are also inquisitive creatures and require environmental complexity. When they are subjected to their unnatural and impoverished rat-box environments, brain developmental deficits occur (Balcombe, 2006; Bennett et al., 1969; Rosenzweig et al., 1969). These can then lead to other deficits compromising health and memory and cause further chronic stress and resultant pathology such as increased neophobic responses and inability to adapt to situations successfully (Balcombe, 2006). If cognitive, psychomotor, and neurological developmental deficits occur among rats contained in rat boxes, experimental results will be skewed toward findings related to a maladapted model.

Altered physiologic states due to mental deprivation, frustration, and stress in markedly unnatural environments cannot result in consequential findings in translational science. This is especially true if the research goals are to study behavioral responses or cognition, learning, hormonal, physiologic, pathologic, healthy, or immunologic states as they relate humans. Considering that the aim of most, if not all, research using rats consists of one or more of the above, it seems counterintuitive to use rats in such a manner. Even ILAR's 2011 guide states, as mentioned above, "Environments that fail to meet the animals' needs . . . may compromise both animal well-being *and scientific validity* [emphasis added]" (p. 51).

If a researcher wanted to study rats in unnatural environments for the sake of rat knowledge and innate rat intelligence, nonratness, and the misery and stress endured by rats, then there might be a reason for that researcher continuing as such, although that researcher would still understand little about true ratness.

Some might argue that using the rat as a model requires simplistic standardizations of hundreds of rows and columns of identical rat boxes so that all rats are housed in the same manner, experiencing everything identically, thus resulting in less variability in the data and experiments. However, this theory has limited supporting evidence (Wurbel, 2007). In one study, rodents who existed in the barren tiny boxes had a plethora of behavioral, mental, and physiologic abnormalities that would otherwise not have been present if they were in a natural environment; thus, the barren unnatural environment led to abnormalities that resulted in more, not less, variance in the data (Wolfer et al., 2004; Wurbel, 2007).

In a recent popular news article (Lahvis, 2017; Williams, 2017), the typical "lab rat" paradigm was brought into question. One of the interviewees, Dr. Garet Lahvis, a neuroscience biomedical researcher, stated that researchers are guilty of a huge mistake in that the typical rat models are not valid for their research objectives. He stated, "We keep studying rodents . . . in cages to understand human beings that are not in cages" (Lahvis, 2017; Williams, 2017, p. 2). Another of the interviewees, Dr. Kathleen Pritchett-Corning, a university laboratory animal veterinarian, stated that animals are not "furry test tubes. . . . The more you can respect the biology, the behavior, and what [an animal] needs, the better you're going to find your results in terms of getting honest answers about the translatability of your work to the human platform" (as cited in Williams, 2017, p. 2). As those aware of rat welfare issues, we should commit to implementing not only more humane environments, but also more reliable and valid studies if performed on millions of animals every year.

RAT HABITAT REVISITED

If we agree that the rat suffers in its current position in the world of animals used in laboratories and that the rat's nature should be respected and protected if relegated to the laboratory existence, the rat should be housed with respect to its telos and ratness. In order to decrease suffering and introduce or increase positive experiences, it is likely

most tenable to refine existing standards and guidelines with the welfare of the individual rat, as a being, at the forefront.

There have been trends toward increasing environmental enrichment in the laboratory, although to a lesser degree for the rat. Enriching a tiny rat box with a toy or even doubling the size of the rat box still falls far short of even approaching rat telos and ratness; such improvements or enrichment would merely serve as less impoverishment. The rat would still have minimal to no ability to burrow or nest, no control over the environment, no satisfaction of exploratory needs, and an inability to perform other natural and necessary behaviors. In addition, all other stressors inherent in the laboratory environment, such as noises, lights, and scents, would concomitantly add to the stress and poor welfare of the rat if rat telos is not understood, appreciated, and considered fully.

Laboratory facilities that house rats should allow for a full range of rat behaviors in more naturalistic environments. Even starting with a simple facility such as that in Figure 2 (Makowska & Weary, 2016) would be a vast improvement over current conditions. The goal would be to eventually arrive at an even more natural environment. This is possible and has been implemented in some laboratories and studies (Balcombe, 2010; National Centre for the Replacement Refinement and Reduction of Animals in Research, n.d.; RISE Research Institutes of Sweden, n.d.; Schumann et al., 2014; Wurbel, 2007). In order to better understand and more accurately account for behaviors, other researchers have used and support more naturalistic models including very large open outdoor pens in lieu of the biased and unnatural laboratories (Balcombe, 2010; Dell'Omo et al., 2000; Latham & Mason, 2004; Schumann et al., 2014; Wurbel, 2007). Furthermore, animal welfare organizations and institutions are increasingly exploring and implementing alternative and more natural environments for rodents (King, 2019; Lahvis, 2018; National Centre for the Replacement Refinement and Reduction of Animals in Research, n.d.; RISE Research Institutes of Sweden, n.d.).

Critics of a more rat-friendly habitat might claim that the variation would be too substantial and could not be controlled. This is a faulty assumption, however, since current protocols, due to their lack of consideration for normal physiologic and behavioral parameters of rats, can lead to increased unpredicted variation (Wurbel, 2007). Just because we do not know what a normal rat needs, and we do not know how the abnormal rat affects our data, that does not then imply that we may proceed on in ignorant bliss without knowing what we do not know. Implementing improvements to achieve biologically and species-appropriate environments would result in rats who function, behave, and live in a more characteristic manner of ratness. Healthy, normally functioning and behaving rats create predictable studies and results. Considering and respecting rat telos will lead to better science. Such studies would be considerably more useful and credible than current traditional studies. Current studies are ripe with scientific invalidity due to the alterations of nearly all biology and physiology in the rat that spends their chronically stressed life in an impoverished tiny rat box among rows and columns of hundreds of other chronically stressed rats in identical tiny rat boxes (Wurbel, 2001, 2002).

Other criticisms against transitioning rats used in laboratories to more naturalistic environments might include concerns due to increased cost and concomitant space, staff, and time limitations. Species-appropriate environments would undoubtedly be more of a visible financial burden at the outset; however, one must also question how many billions of dollars have already been spent using the traditional and very flawed rat model. Why would it be more economically justified to funnel grants and funding and billions of dollars to continue to support suspect and invalid findings and conclusions in blatantly unsound models? Although one could argue that, considering the flawed studies using such models, perhaps no rats should be used in research in which the outcome does not directly relate to the rat and the rat's well-being. We again reiterate that such arguments are addressed in other writings (Herrmann & Jayne, 2019; Linzey & Linzey, 2018; Knight, 2019) and not here.

As long as the rat is used in the laboratory, the initial monetary expenses for suitable habitats would be considerably outweighed by the results that might be magnitudes more tenable. The increased budgets for more appropriate environments might also ultimately decrease the current superfluous purchasing, using, and disposing of millions of rats each year for research that potentially serves minimal benefit (Knight, 2011, 2017; Linzey & Linzey, 2018). It could be argued that the compromised health, welfare, and telos of the rats that produce fallacious results and failed experiments consequently promulgate the unnecessary overutilization and subsequent discarding of millions of rats used in laboratories.

The other aspect that one must consider is that the general public might further support such research if the public witnesses the consideration of the welfare, needs, and happiness of the animals used in labs. Although, again, rats are not necessarily a charismatic species, and thus the public's attitudes and investment in the care and welfare of rodents used in laboratories must be fostered. However, we believe that our society generally gravitates toward those industries and organizations that provide humane and compassionate animal care and handling. Considering the seemingly pervasive distrust of science in the United States currently, garnering favorable public opinion would be beneficial for the scientific community. If rats live within enriching and stimulating environments, then research facilities could also be more transparent, ideally.

CONCLUSIONS

Much of the public's backlash toward animal research likely directs itself at the shocking and blatant physical suffering of charismatic animals in atrocious experiments. The ugly truth, however, is that equal if not greater amounts of suffering and cruelty are endured by the millions of rats used in laboratories due to the impoverished, maladaptive, and stressful conditions in which they must live for their entire lives, every minute of every day. The chronic frustration, fear, despair, discomfort, and helplessness that rats endure in their inordinately inappropriate and unethical rat-box environments epitomize the antithesis of the telos of a rat. THAT is the suffering.

The typical rat used in the laboratory of today is an unfortunate representation of the lackadaisical indifference that many have toward the welfare, suffering, experience, and sentience of a noncharismatic yet truly remarkable and magnificent species. When the rat's telos is thwarted, the rat suffers, and science suffers. The rat-in-box experiences stress, fear, hopelessness, helplessness, boredom, frustration, neuroticism, aggression, cognitive deficits, despair, and compromised health. The rat and science thus both fail with purposeless meaninglessness. On the other hand, the rat in a naturalistic habitat experiences a range of invigorating physical activities, exercises, postures, stimulating curiosities, explorations, games, and social relationships and thus joy, happiness, contentment, relaxation, cognitive expansion, optimism, and enhanced immune function and health. The rat and science thus both achieve meaning and purpose. It is only through an understanding of, deference to, and celebration of the telos of the rat and the rat's needs as a rat that both science and the rat will be able to flourish together.

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