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HUMAN FACTORS, PSYCHOLOGICAL FACTORS, AND AFFIRMATION OF CONTINUITY

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The papers in this issue have presented a wealth of information from a variety of studies about factors that influence behavior. A key question has been and remains, "To what degree can one generalize from studies of nonhuman animal behavior to humans?" In years past, it has been argued that the study of animal behavior can tell one something about basic conditioning and learning phenomena that might apply to humans, but the emphasis was on the word *basic*. The argument maintained that the really important behaviors and capacities that differentiated humans from all other animals (e.g., complex learning, thinking, logic, and particularly *language*) had no meaningful parallel or analogue in animals.

The archaic Cartesian framework of viewing animals as *beast machines* without feeling and cognition (Descartes, 1637) pervades the human view of animals even to this day. It denies animals the status needed to ensure their humane care, survival, and respect. Taken literally, it would totally constrain most research in comparative psychology. The Cartesian attitude towards animals is one that can serve to foster neglect of animals and, by implication, disregard for their welfare and survival as species.

The Cartesian framework is, of course, incompatible with the Darwinian principle of continuity, the essence of evolution (Darwin, 1871). Evolution could not produce *Homo sapiens* as a species apart from other animals. Evolution could produce, or select for, human characteristics only on the basis of what had been put in place as adaptive characteristics in other mammals (Darwin, 1872). Thus, the principle of continuity in evolution suggests the probability that closely related life forms will have similar anatomies, similar biologies, and even similar psychologies. That *Homo sapiens* and the chimpanzee, *Pan*, are very closely related in terms of DNA suggests that similarities might be detected in comparative stud-

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ies of their psychology (Andrews & Martin, 1987). But would they reveal similarities in processes of language?

Although the field of ape-language research has been very controversial, a recent controlled study (Savage-Rumbaugh, Murphy, Sevcik, Williams, & Rumbaugh, 1992) reveals that, given appropriate early rearing, the chimpanzee can come to comprehend human speech at least at the level of a 2½ year-old child and to employ grammar in its productive use of symbols so as to achieve communication at least at the level of a 1½ year-old child. The chimpanzees were reared essentially as though they were human infants and, consequently, had the opportunity to hear speech and to observe the consequences of the use of speech and visual symbols. Thus reared, the chimpanzees' comprehension of language far outpaced their productive use of symbols in a manner reminiscent of the human child's comprehension of speech far outpacing its ability to talk. It would appear that the rearing environment of the chimpanzees had enabled the brain to express a fuller potential for functional plasticity and in a direction that approximates that for the human child. Early exposure to language apparently set the cognitive stage for later acquisition of linguistic skills.

The point of these findings is that there is now strong evidence for continuity between chimpanzees and humans *even for language*. Consequently, it is no longer justifiable to argue that the study of animal behavior cannot assist in understanding human behavior because humans and only humans have language!

Developing new research methodologies that measure basic parameters of psychological functions in human and nonhuman animals should be a primary focus of future scientific endeavors. Science has been, and always will be, a function of available techniques and technology. Fortunately, several comparative psychologists have now learned how to use advanced computer technology in ways that allow for *direct and equitable* comparisons to be made between the competencies of animals and humans (Hopkins, 1991; Hopkins, Morris, & Savage-Rumbaugh, 1991; Rumbaugh, 1990; Rumbaugh, Richardson, Washburn, Savage-Rumbaugh, & Hopkins, 1989; Washburn, Hopkins, & Rumbaugh, 1989; Williams, Haddad, & Strobel, 1989). Perhaps most poignant is the development of software that permits one to teach monkeys, apes, and humans the rules of complex tasks entailing elaborate operations on the part of the individual.

Both authors of this paper independently demonstrated, with their colleagues, that nonhuman primates can learn to use joysticks to control complex events on a monitor (Williams, 1988; Rumbaugh et al., 1989). Individuals will even work just for the opportunity to manipulate their physical/perceptual world and to engage in a cognitively challenging task for reasons other than obtaining food and drink (personal observation). Animals are not motivated solely by their physiological need for food

and nourishment. As is true for humans, they have need to seek change, to obtain challenge, experience visual stimulation, and so on.

Forcing animals to attend to a task is no longer necessary and is, in fact, ill-advised. Tasks can be designed so as to become intrinsically motivating to nonhuman primates (Williams, 1990). Their behavior, in this context, reveals that we have profoundly underestimated their capabilities to date because of the limitations set forth by traditional methodologies and earlier technology.

New technology, coupled with highly creative frameworks advanced by authors of the papers in this issue, is bound to increase our knowledge in new and exciting ways. This is perhaps especially true regarding what we can learn about the complex cognitive abilities of humans in environments where, because of risks and costs of operations, it would seem prudent to first employ animals as models.

A new day is at hand—a day that has very strong and positive implications for the study of human factors. It is a day which allows for a great deal to be learned about human factors through the study of animal behavior, if one goes about such studies with the advantages of a comparative psychological perspective.

Validation of this view is certain. The questions that remain, and they are very difficult questions, address the specifics. In other words, in what situations and to what degree can we extrapolate from the behavior—the psychology of a primate—to the behavior of a human? Generally there will be limits imposed upon extrapolations from animal to human data and vice versa. Notwithstanding, within those limits, good science and good preparations can be made for subsequent enhancement of the human endeavor.

Human factors as a specialty, from our perspective, might well become a subsystem of *comparative psychological factors*. In the article by David Washburn, we find convincing support from several experiments for the belief that all organisms possess several common cognitive competencies that differ only in quantitative dimensions. These shared cognitive competencies have been clearly defined and efficiently studied in tasks requiring humans and nonhumans to interface with computers. For example, his data suggest that monkeys and humans both may function as predictor-operators if given the appropriate training. Because this conclusion directly conflicts with an earlier suggestion that only humans possess this capability, it follows that other areas of cognitive function should be reviewed and reconsidered with new research techniques availed by computer technology. Assuming that monkeys can now serve as valid models of human psychomotor performance, we can now seek to understand the quantitative complexities surrounding the interfacing of animal (both human and nonhuman) to machine. The more we understand the mechanisms and processes by which other organisms solve problems, organize their perceptual world, direct their attention, and recall and

utilize past experiences, the better we may understand ourselves and our unique abilities as well as our limitations associated with mental retardation, brain damage, aging, and so on.

This case is clearly presented in the article by Duncan White which describes the contributions of the cat to comparative psychology and thus to human factors. These contributions are impressive in the areas of learning, vision, audition, and medical science. But one can immediately see from the references that little research has been conducted recently, especially in the areas of learning and problem solving. There is no doubt that the cat has been an acceptable model for addressing many questions in medical science and psychology. We now need to focus the attention more on addressing specific questions in comparative psychology using the new computer technologies previously described. Changing the topography of the response to suit the cat's specific anatomy is no obstacle. Once this is achieved, we might well access cognitive competencies on a level never before realized. Models of foraging behavior, cost-benefit ratios, decision-making strategies, prediction, memory, and visual/spatial tracking are examples of areas that could be addressed with the new methodologies. This should result in a wealth of knowledge again applicable to both humans and animals.

Along with advanced technology comes the need for new theoretical approaches, experimental designs and procedures, and novel implementations. Roger Thomas has convincingly reminded us all of the bi-directionality of scientific applications between human and nonhuman animals. We should not be constrained by the idea that animals can serve only as models for human questions; humans can serve as models to test questions evolving from animal research. This bi-directionality can only serve to help validate results and to shed light on new perplexing cognitive issues, especially those of counting and oddity/sameness-difference concept hierarchies.

In due course, future studies, like those in this issue, will likely conclude what many have suspected for a long time, and that is that the essence of psychology is *general comparative psychology*, not just human behavior. Such studies will also serve to underscore the perspective that animal research should be carried out with a new sense of continuity that binds us more closely—far more closely—than Descartes could ever allow or envision. By accepting this approach, we will develop a greater appreciation for animals and will come to value and respect our relationship with them. Such a perspective should serve the survival interests of all!

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