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THE CAT (*Felis catus*) AS AN EXAMPLE OF THE CONTRIBUTION THAT COMPARATIVE PSYCHOLOGY HAS MADE TO HUMAN FACTORS

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ABSTRACT: Human factors is an area of psychology, which systematically applies information about human behavior to designing environments for human use. The contribution that comparative psychology has made to human factors is demonstrated in this article using the example of the cat, which shows many of the neurophysiological and overt behaviors observed in humans. The article begins with a summary of exemplary basic research which illustrates similarities between the cat and humankind. The summary is followed by a discussion of various applications of these data to improve the human condition.

Human factors (ergonomics; engineering psychology) is the systematic application of information about human behavior. The objectives of this discipline are to improve the effectiveness and efficiency of human activities, and to improve certain desirable human conditions such as health, safety, and satisfaction (McCormick & Sanders, 1982). Human factors applies research data in such issues as development, mobility, vision, and socialization to realistic settings, modifying the environment to maximize the efficiency of human performance (Smith, 1990). Knowing how the human operates (i.e., the characteristics and needs of the "user") is fundamental to designing environments for human use, optimizing the relationship between technology and humankind, and facilitating the improvement of human life.

Comparative psychology is the study of similarities and differences in adaptive capacities between human and nonhuman animals, in an attempt to discover general laws of behavior in the context of evolution

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theory (Hodos & Campbell, 1969). Through this process, comparative psychology acquires insights into human behavior.

The cat (*Felis catus*) is a particularly appropriate species for this purpose. Cats are relatively tractable, amenable to human interaction (Imada, Tsukahara, & Imada, 1987; Mertens & Turner, 1988), inexpensive to maintain, and demonstrate many neurophysiological and overt behaviors observed in humans and other animals. As a result, the cat offers researchers an opportunity to control and manipulate the internal and/or external "human" environment, in ways that are ethically sound but not possible with humans of contingency-deficient computer simulations. Though nonhuman animal models of human behavior have their limitations (Lockery & Stich, 1989), data from neuroanatomical and neurophysiological investigations of the cat's central and peripheral nervous systems corroborate what is known about the human.

Research employing the cat to understand humankind is both diverse and voluminous. The specific areas of research overlap extensively, making an organized comprehensive overview elusive. On the other hand, the extent to which these areas interact indicates the richness of the contribution that cat-related research has made to our understanding of the human animal.

The purpose of this article is not to provide an exhaustive review of the cat literature, but instead to demonstrate the contribution that comparative psychology has made to human factors. Toward this end, exemplary basic research illustrating the many similarities between the cat and humankind will be discussed. Then attention will be given to the application of these data to improve the human condition.

SIMILARITIES BETWEEN CATS AND HUMANS

Learning, Memory, and Problem-Solving

Although the cat has not been used extensively as a research model to address learning, memory, and problem-solving processes, this general research area is mentioned first for two fundamental reasons. The first is the historical significance of Thorndike's puzzle box (1911) and K.U. Smith's 1930's visual discrimination studies. The second reason is that cat research, apart from neurological investigations, often uses a learning/performance task. In these cases the cat has been shown to perform in ways that are strikingly like human performance under similar conditions. For instance, both species are capable of visually discriminating between the members of at least seven test item pairs randomly presented in the same test session. In addition, cats and humans demonstrate a curvilinear rate of learning these discriminations as a function of test item complexity, with eight-sided figure pairs being the easiest (White & Ward, 1988). Bourassa and Weiden's (1985) investigations of orienting responses and detection of thalamic stimulation also demonstrated that mechanisms of perceptual learning in the cat are consistent with those reported in humans. Bourassa and Weiden concluded by suggesting that input to cerebral cortex from sensory organs in either species is not a sufficient condition to produce conscious experience or discrimination.

Vision

The most extensive, and probably the most well-known, use of the cat as a model of human behavior is in the area of vision research. For example, behavioral experiments have revealed that cat and human spatial vision are comparable in several important ways. Both species possess stereoptic vision (Fox & Blake, 1971), both resolve about a five octave range of spatial frequencies (Blake, Cool, & Crawford, 1974), both show a trade off between spatial resolution and temporal resolution (Blake & Camisa, 1977), and both demonstrate a decline in acuity with retinal eccentricity (Blake & Bellhorn, 1978). Blake (1988) has noted that many of the hallmarks of mammalian vision were first discovered and explored in the cat. Some notable examples are retinal ganglion cells' center/surround organization (Kuffler, 1953), cortical neurons' orientation selectivity and massed binocularity (Hubel & Wiesel, 1962), and the existence of parallel pathways originating with retinal X-, Y-, and W-cells (Shapley & Perry, 1986). Other similarities between the human and cat visual systems, resulting from analogous neuroanatomical and neurophysiological components, include contour and movement adaption, aftereffects, and recovery responses to prolonged stimulation with moving test items (Vautin & Berkley, 1977). These results continue to encourage the use of the cat to determine trigger features of human visual neurons.

Similarly, neural mechanisms for velocity discrimination in the cat have been suggested as a model for human motion perception (Orban, Kennedy, & Maes, 1981). Responses of feline X-cells of the LGNd to a small flashing test probe are likewise comparable to results from similar human psychophysical tests used clinically (Essock, Lehmkuhle, Frascella, & Enoch, 1985). These X-cell responses indicate that the size of a concentric background can have a pronounced influence on the sensitivity of both human and cat observers to a small probe.

Still other areas of cat vision research have addressed human depth perception (Mitchell & Baker, 1973) and flicker perception (Tyler, 1975), saccade awareness suppression (Riggs, Merton, & Morton, 1974) and main sequence saccades (Nelken, Heit, & Bridgeman, 1981), motion detection (Pasternak & Merigan, 1980), contrast sensitivity (Albrecht & Hamilton, 1982), the effects of positive and negative lens aberrations (Sivak & Kreuzer, 1983), vernier acuity (Swindale & Cynader, 1986), discrimination ability as a function of texture (Wilkinson, 1986), spatiotemporal aspects of the visual scene (Stanford, 1987), and subjective contour discrimination (Orban, De Weerd, & Vandenbussche, 1990). In all these areas, the cat has displayed visual performance similar to that of humans.

Principles of visual development in cats also apply to humans. For example, Mitchell (1989) noted that an abrupt onset of stereopsis, and possibly vernier acuity, has been observed in both species; and visual acuity, as assessed with grating, develops gradually in primates and kittens. Similarly the development of cognitive performance, such as object permanence, has been observed in kittens and the flexibility of this animal's cognitive ability has been displayed, for example, by novel problem solving of visible displacement tests (Dumas & Dore, 1989). Though analogous behavior does not ensure analogous underlying mechanisms responsible for those behaviors (Innis & Staddon, 1989), similar behaviors do suggest similar adaptive capabilities and provide useful predictive models of behavior.

Audition

Though less attention has been given to the cat as a model for human audition, useful similarities exist. For example, comparable cat and human auditory vertex potentials have been found on a number of neuroanatomical and neurophysiological dimensions (Buchwald, Hinman, Norman, Huang, & Brown, 1981) and suggest that scalp-recorded frequency-following responses could be used to ascertain low-frequency hearing sensitivity in uncooperative humans (Gardi, Merzenich, & McKean, 1979). Similarly, psychophysical methods investigating pitch perception of the cat have produced results which parallel human data (Chung & Colavita, 1976). Other auditory research employing the cat as a model for human behavior has been conducted in areas of binaural interaction (Hoppe & Langford, 1974), interaural intensive and temporal disparities (Wakeford & Robinson, 1974), sound localization (Kuwada, Yin, & Wickesberg, 1979), and auditory nerve-fiber responses to spoken-stop and nasal consonant-vowel syllables presented in four different levels of speech-shaped noise (Geisler & Gamble, 1989). This latter study found that consonants, being of smaller amplitude, are more affected by noise than are vowels.

Peripheral Nervous System

The peripheral nervous system of the cat has been found to be a valid model for neural mechanisms of human tactile and vibrotactile sensation (Hamalainen, 1983). The cat has also been used as a model to reconstruct the functional events occurring in nerves at the site of stimulation when human subjects reported pain relief (Swett & Law, 1983). In addition, the cat model has been used in kinesthetic research to acquire insights into information regarding body part position, location, motion, speed, and direction (Burgess, Wei, Clark, & Simon, 1982). Such information is thought to contribute to body image (Gregory, Morgan, & Proske, 1988) and cognitive map construction (Mergner, Anastasopoulos, Becker, & Deecke, 1981).

Other Areas

Other areas of cat research, resulting in a better understanding of human (i.e., "user") characteristics, include: gustation (Boudreau, Oravec, & White, 1981), motor function (Frederickson, Smylie, Howell, & Lenig, 1978), split-brain behavior (Lepore, Ptito, Provencal, & Bedard, 1985), stroboscopic motion perception (de Bruyn & Orban, 1989), time perception (Macar, Vitton, & Requin, 1984), emotions (Bear, Rosenbaum, & Norman, 1986; Piazza, Crescimanno, Benigno, & Amato, 1986), sleep (Koridze & Nemsadze, 1982; Sinton & Petitjean, 1989), and evolution (Rush, 1988).

Comparative Research Summary

This overview of exemplary basic research illustrating similarities between cats and humans shows how the cat is a rich and varied source of knowledge about human neural functioning and behavior. As such, the cat is a valuable comparative model for suggesting useful modifications in environmental contingencies that result in improved human performance. To date, medicine has benefited most from the cat as a research model. These applications will be discussed along with other issues such as psychological, social and ecological welfare.

IMPROVING THE HUMAN CONDITION

Medical Models

The similarities between cat and human capabilities and behavior have been exploited to create better human conditions. For example, the cat is used extensively as a medical model to gain insight into the nature and treatment of human physiological and behavioral abnormalities. To illustrate, the cat is a valuable clinical model for understanding the neural mechanisms of cardiovascular disorders that may commonly accompany psychological stress (Tashiro, Tanaka, Fukumoto, Hirata, & Nakao, 1986). It has also been used to assess recovery following mild to moderate head trauma (Hayes, Clifton, & Kreutzer, 1989) and plasticity following gross and selective insult to the nervous system (Burgess, Villablanca, & Levine, 1986; Cornwell, Herbein, Corso, Eskew, & Warren, 1989). Other examples of the cat's substantial clinical impact are in developmental monocular deprivation. The regimens of part-time reverse occlusion, which optimize recovery from the visual deficits induced by monocular deprivation in kittens, are similar to the patching of a good eye in order to induce the strengthening of a "lazy eye." This therapy is also like the patching regimens that promote the development of good vision in human infants following early corrective surgery for congenital unilateral cataracts (Mitchell, 1989). In addition, the cat has been used to develop a visual prosthesis for blind humans (Pollen, 1977) based on analogous cellular activity underlying visual perceptual events. Furthermore, similar visual pathways (i.e., "M" for fast-moving course visual forms and "P" for spatial detail of stationary or slow-moving visual forms) have clinical implications for diseases like glaucoma, Alzheimer's, and anisometropic amblyopia (Bassi & Lehmkuhle, 1990). Other clinical applications take advantage of the fact that P300, a measure of specific cortical activity, which is characteristic of both cats and humans, is a key to aging and disease processes. For instance, P300 changes functionally with age and is missing in Alzheimer's (Harrison & Buchwald, 1985).

Similar neurological investigations using cats have provided insights into other diseases such as "locked-in" syndrome (Zernicki, 1986) and hyperkinetic syndromes like Parkinson's Disease, Huntington's Chorea, and Gilles de la Tourette's Disease (McKenzie, Gordon, & Viik, 1972). Knowledge of (a) deficits in cognition and learning as a function of basal ganglia pathology (Olmstead, Villablanca, Marcus, & Avery, 1976), (b) chronic pain (Swett & Law, 1983), and (c) specific components of generalized corticoreticular epilepsy (Gloor & Testa, 1974) have likewise come from cat research. In addition, this clinical model of human behavior has been used to investigate sleep deprivation and its effects in learning (Koridze & Nemsadze, 1982) as well as specific characteristics of sleep as manifested by sex and aging (Bowersox, Baker, & Dement, 1984) and depression (Beersma, Daan, & Van den Hoofdakker, 1984).

Cat models have indicated that degeneration of neural pathways is not required for the development of profound cognitive and motor impairments that characterize progressive dementia. Neurotransmitter-specific alterations are enough to cause diseases like Alzheimer's (Colye, Singer, McKinney, & Price, 1984). Similarly, when cats were administered psychoactive drugs (i.e., LDS, STP, DMT, psilocybin, and mescaline) in minimal doses, behavioral effects closely corresponded to those elicited by humans under similar conditions (Jacobs, Trulson, Stark, & Christoph, 1977). The cat has provided other examples of neurotransmitter-based aberrations as a model of amphetamine-induced psychosis and catatonic schizophrenia (Sudilovsky, 1975). Identification of auto-antibody against receptor sites for chemical transmitter substances in septal neurons of the cat also give support to the concept of schizophrenia as an immunological disorder (Garey, Heath, & Harper, 1974). In addition, feline somatosensory cortical responses to lithium carbonate levels, which were within the range used clinically, mimic responses elicited in humans (Heninger & Sheard, 1976) and provide a model for further insight into the neurological bases of mania and depression.

Other Uses

Though knowledge of underlying neurological mechanisms is fundamental to understanding behavior, these mechanisms do not always predict the specific behaviors that they underlie (Innis & Staddon, 1989). A knowledge of environmental contingencies, identified as adaptive pressures on the animal, is also essential to predicting and facilitating behavior. With this awareness, and encouraged by the successful application of the cat as a medical model for treating human disorders, researchers have observed other cat behaviors that are potentially relevant to our species. For example, maternal protein restriction during late gestation and lactation in cats disrupts the development of orientation behavior in kittens by impairing locomotor function and increasing emotional responsiveness (Gallo, Werboff, & Knox, 1984). This condition further disrupts the development of mother-kitten social interactions and retards attachment formation (Gallo, Werboff, & Knox, 1980). Observations like these encourage health organizations to look for sources of potential protein restriction in human mothers (e.g., poor diet, natural catastrophes, political decisions) that could have grave consequences for the family unit and society.

Another interspecies behavioral analogy arises from the observation that cats are more active and self-groom more often when they receive attention (George, 1985). These behaviors are both indices of and contributors to the maintenance of good health. The knowledge regarding the effects of attention on personal health, coupled with studies suggesting that cats and humans have strong natural and learned affinities for one another (Imada, Tsukahara, & Imada, 1987; Mertens & Turner, 1988), has led to a treatment for humans who describe themselves as lonely and inadequate. These patients have reported an improved sense of self-worth, happiness, and productivity when given the responsibility of caring for a cat as a pet (Mahalski, Jones, & Maxwell, 1988). In this case, improvement of the human condition is achieved efficiently and economically by exploiting interspecies similarities and differences; cats are less intrusive on the person's private life and less demanding of time, space, effort, and money, than would be an employed human companion. Pets are also a popular subject of conversation, thereby facilitating social interaction.

Knowledge of the similarities and differences between species has led to the use of cats as sentinels of environmental conditions that threaten human health and encumber human performance (Schneider, 1972). Periodic monitoring of livestock, pets, and research animals has provided early warnings of potential health hazards (Glickman, 1991). Cats, for example, age faster, have a higher metabolism, and are more susceptible to low doses of toxins than humans. Thus the interaction effects of aging and exposure to low toxicity in human living or work environments can be detected and treated in the early stages of development (Davidson, Parker, & Beliles, 1986).

Application Summary

As noted, there are many and diverse applications of our knowledge regarding the similarities and differences between cats and humans. Evidence in specific areas of human factors (e.g., medical, psychological, social, and ecological issues) illustrates the usefulness of our knowledge regarding the underlying contingencies of human behavior, derived from comparative studies using the cat.

CONCLUSION

At first glance, cross-species generalizations may seem suspect because species' classification is often a function of differences in biology and behavior. The apparent differences between cats and humans is striking. However, there are many practical uses of nonhuman animal models of human behavior, as well as many uses of the similarities and differences between species to improve the quality of life. For example, as noted in this article, numerous experiments using cats have suggested evidence of similar adaptive capabilities and similar mechanisms of perceptual learning. Also, many useful applications of knowledge, acquired from cats, in the areas of mental and physical health, have been demonstrated.

The cat is only one of a myriad of nonhuman animals studied by comparative psychologists. In this way, the cat has served yet another purpose: to provide a wealth of studies that suggest the magnitude of contributions comparative psychology has made, and will continue to make, to human factors.

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