The MIT Encyclopedia of the Cognitive Sciences

EDITED BY
Robert A. Wilson and
Frank C. Keil

(1999)

A Bradford Book

The MIT Press
Cambridge, Massachusetts
London, England

Library of Congress Cataloging-in-Publication Data

The MIT encyclopedia of the cognitive sciences / edited by Robert A. Wilson, Frank C. Keil.
p. cm.
"A Bradford book."
Includes bibliographical references and index.
ISBN 0-262-73124-X (pbk. : alk. paper)
1. Cognitive science—Encyclopedias I. Wilson, Robert A. (Robert Andrew) II. Keil, Frank C., 1952– .
BF311.M556 1999
153'.03—dc21 99-11115
CIP

distinctive feature of adaptationism is the thesis that organisms are frequently optimal. They argue that the adaptationist thesis should be empirically tested rather than assumed. Other authors, however, argue that adaptationism is not an empirical thesis, but a methodological one. Optimality concepts provide a well defined goal which it is equally illuminating to see organisms reach or to fall short of. Building models that yield the observed phenotype as an optimum is the best way to identify all sorts of factors acting in the evolutionary process (Maynard-Smith 1978).

There are several strands to antiadaptationism. One is the claim that many adaptive explanations have been accepted on insufficient evidence. Adaptationists claim that the complexity and functionality of traits is sufficient to establish both that they are adaptations and what they are adaptations for (Williams 1966). Antiadaptationists argue that adaptive scenarios do not receive confirmation merely from being qualitatively consistent with the observed trait. Some are also unsatisfied with quantitative fit between an adaptive model and the observed trait when the variables used to obtain this fit cannot be independently tested (Gray 1987). Many antiadaptationists stress the need to use quantitative comparative tests. Independently derived evolutionary trees can be used to test whether the distribution of a trait in a group of species or populations is consistent with the adaptive hypothesis (Brooks and McLennan 1991; Harvey and Pagel 1991). Other strands of antiadaptationism are concerned with broader questions about what biology should be trying to explain. Biology might focus on explaining why selection is offered a certain range of alternatives rather than explaining why a particular alternative is chosen. This would require greater attention to developmental biology (Smith 1992; Amundson 1994; Goodwin 1994). Another antiadaptationist theme is the importance of history. The outcome of an episode of selection reflects the resources the organism brings with it from the past, as well as the "problem" posed by the environment (Schank and Wimsatt 1986; Griffiths 1996). Finally, antiadaptationists have questioned whether the environment contains adaptive problems that can be characterized independently of the organisms that confront them (Lewontin 1982; Lewontin 1983).

See also ALTRUISM; EVOLUTION; SEXUAL ATTRACTION, EVOLUTIONARY PSYCHOLOGY OF; SOCIOBIOLOGY

—*Paul Griffiths*

References

Allen, C., M. Bekoff, and G. V. Lauder, Eds. (1997). *Nature's Purposes: Analyses of Function and Design in Biology.* Cambridge, MA: MIT Press.

Amundson, R. (1994). Two concepts of constraint: adaptationism and the challenge from developmental biology. *Philosophy of Science* 61(4): 556–578.

Brandon, R. (1990). *Adaptation and Environment.* Princeton: Princeton University Press.

Brooks, D. R., and D. A. McLennan. (1991). *Phylogeny, Ecology and Behavior.* Chicago: University of Chicago Press.

Cosmides, L., J. Tooby, and J. H. Barkow. (1992). Introduction: evolutionary psychology and conceptual integration. In J. H. Barkow, L. Cosmides, and J. Tooby, Eds., *The Adapted Mind: Evolutionary Psychology and the Generation of Culture.* Oxford: Oxford University Press, pp. 3–15.

Dawkins, R. (1996). *Climbing Mount Improbable.* London: Viking.

Dennett, D. C. (1995). *Darwin's Dangerous Idea.* New York: Simon and Schuster.

Goodwin, B. C. (1994). *How the Leopard Changed its Spots: The Evolution of Complexity.* New York: Charles Scribner and Sons.

Gould, J. A., and E. S. Vrba. (1982). Exaptation—a missing term in science of form. *Paleobiology* 8: 4–15.

Gould, S. J., and R. Lewontin. (1978). The Spandrels of San Marco and the Panglossian Paradigm: a critique of the adaptationist programme. *Proceedings of the Royal Society of London* 205: 581–598.

Gray, R. D. (1987). Faith and foraging: a critique of the "paradigm argument from design." In A. C. Kamil, J. R. Krebs and H. R. Pulliam, Eds., *Foraging Behavior.* New York: Plenum Press, pp. 69–140.

Griffiths, P. E. (1992). Adaptive explanation and the concept of a vestige. In P. E. Griffiths, Ed., *Essays on Philosophy of Biology.* Dordrecht: Kluwer, pp. 111–131.

Griffiths, P. E. (1996). The historical turn in the study of adaptation. *British Journal for the Philosophy of Science* 47(4): 511–532.

Harvey, P. H., and M. D. Pagel. (1991). *The Comparative Method in Evolutionary Biology.* Oxford: Oxford University Press.

Lewontin, R. C. (1982). Organism and environment. In H. Plotkin, Ed., *Learning, Development, Culture.* New York: Wiley, pp. 151–170.

Lewontin, R. C. (1983). The organism as the subject and object of evolution. *Scientia* 118: 65–82.

Maynard Smith, J. (1978). Optimisation theory in evolution. *Annual Review of Ecology and Systematics* 9: 31–56.

Orzack, S. E., and E. Sober. (1994). Optimality models and the test of adaptationism. *American Naturalist* 143: 361–380.

Reeve, H. K., and P. W. Sherman. (1993). Adaptation and the goals of evolutionary research. *Quarterly Review of Biology* 68 (1): 1–32.

Schank, J. C., and W. C. Wimsatt. (1986). Generative entrenchment and evolution. *Proceedings of the Philosophy of Science Association.* Vol 2: 33–60.

Smith, K. C. (1992). Neo-rationalism versus neo-Darwinism: integrating development and evolution. *Biology and Philosophy* 7: 431–452.

Williams, G. C. (1966). *Adaptation and Natural Selection.* Princeton: Princeton University Press.

Affordances

The term *affordance* was coined by JAMES JEROME GIBSON to describe the reciprocal relationship between an animal and its environment, and it subsequently became the central concept of his view of psychology, the *ecological* approach (Gibson 1979; Reed 1996; see ECOLOGICAL PSYCHOLOGY). An affordance is a resource or support that the environment offers an animal; the animal in turn must possess the capabilities to perceive it and to use it. "The affordances of the environment are what it offers animals, what it provides or furnishes, for good or ill" (Gibson 1977). Examples of affordances include surfaces that provide support, objects that can be manipulated, substances that can be eaten, climatic events that afford being frozen, like a blizzard, or being warmed, like a fire, and other animals that afford interactions of all kinds. The properties of these affordances must be specified in stimulus information. Even if an animal possesses the appropriate attributes and equipment, it may need to learn to detect the information and to perfect the activities that make the affordance useful—or perilous if unheeded. An affordance, once detected, is meaningful and has value for the animal. It is nevertheless objective, inasmuch as it refers to physical properties of the animal's niche (environmental constraints) and to its bodily dimensions and capacities. An affordance thus exists, whether it is perceived or used or not. It may be detected and used without explicit awareness of doing so.

Affordances vary for diverse animals, depending on the animal's evolutionary niche and on the stage of its development. Surfaces and substances that afford use or are dangerous for humans may be irrelevant for a flying or swimming species, and substances that afford eating by an adult of the species may not be appropriate for a member in a larval stage. The reciprocal relationship between the environmental niche and a certain kind of animal has been dubbed the "animal-environment fit."

Utilization of an affordance implies a second reciprocal relationship between perception and action. Perception provides the information for action, and action generates consequences that inform perception. This information may be proprioceptive, letting the animal know how its body is performing; but information is also exteroceptive, reflecting the way the animal has changed the environmental context with respect to the affordance. Perceiving this relationship allows adaptive control of action and hence the possibility of controlling environmental change.

It is the functioning and description of the animal-environment encounter that is at the heart of research on affordances. Research has addressed three principal questions:

1. Do human adults actually perceive affordances in terms of task constraints and bodily requirements? The reality of perceptual detection of an animal-environment fit has been verified in experiments on adult humans passing through an aperture, reaching for objects with their own limbs or tools, judging appropriate stair heights for climbing, chair heights for sitting, and so forth. J. J. Gibson said that "to perceive the world is to coperceive oneself." In that case, actors should perceive their own body dimensions and powers in relation to the requirements of the relevant environmental resource or support. Warren and Whang (1987) investigated adults' judgments of aperture widths relative to their own body dimensions. Both wide- and narrow-shouldered adults rotated their shoulders when doorways were less than 1.3 times their own shoulder width. Scaling of the environment in terms of the natural yardstick of eye-height (Mark 1987; Warren 1984) has also been demonstrated.

2. Can stimulus information specifying an affordance be described and measured? Can controlled actions of an animal preparing for and acting on an affordance be observed and measured? Gibson (1950) paved the way for this research by describing the optic flow field created by one's own locomotion when flying a plane. The specification by optical stimulus information of the time for a moving animal to contact a surface or a target object was described by Lee (1980), who showed that such information for an observer approaching a surface could be expressed as a constant, τ. The information is used in controlling locomotion during braking and imminent collision by humans (Lee 1976) and by other animals (Lee and Reddish 1981; Lee, Reddish, and Rand 1991). Effective information for heading (the direction in which one is going) has been described by Warren (1995) in terms of the global radial structure of the velocity field of a layout one is moving toward.

Research on the action systems called into play and their controllability in utilizing an affordance has been the subject of study for reaching, standing upright, locomotion, steering, and so on. (Warren 1995). The control of reaching and grasping by infants presented with objects of diverse sizes shows accommodation of action to the object's size and shape by hand shaping, use of one or both arms, and so forth (see Bertenthal and Clifton 1997 for many details). Research of the specification of the affordance in stimulus information, and on control of action in realizing the affordance, converges in demonstrating that behavior is prospective (planned and intentional) and that stimulus information permits this anticipatory feature.

3. How do affordances develop cognitively and behaviorally? Developmental studies of affordances, especially during the first year, abound (Adolph, Eppler, and Gibson 1993). The behavior of crawling infants on a visual cliff (Gibson and Walk 1960) suggests that even infants perceive the affordances of a surface of support and avoid traversal of an apparent drop at an edge. Subsequent research has shown that duration of crawling experience is significantly related to dependable avoidance of the cliff, supporting other research demonstrating that LEARNING plays a role in detecting and responding effectively to many affordances, at least in humans. Development of action systems and increased postural control instigate the emergence of new affordance-related behavior. Babies begin to pay ATTENTION to objects and make exploratory reaches toward them as posture gradually enables reaching out and making contact with their surfaces (Eppler 1995).

As an infant learns about the constraints involved in the use of some affordance, learning may at first be relatively domain specific. Research by Adolph (1997) on traversal of sloping surfaces by crawling infants demonstrates that learning which slopes are traversable and strategies for successful traversal of them is not transferred automatically to traversal of the same slopes when the infant first begins upright locomotion. New learning is required to control the action system for walking and to assess the safety of the degree of slope. Learning about affordances is a kind of perceptual learning, entailing detection of both proprioceptive and exteroceptive information. The learning process involves exploratory activity, observation of consequences, and selection for an affordance fit and for economy of both specifying information and action.

The concept of affordance is central to a view of psychology that is neither mentalism nor stimulus-response BEHAVIORISM, focusing instead on how an animal interacts with its environment. Furthermore, the concept implies neither nativism nor empiricism. Rather, genetic constraints characteristic of any particular animal instigate exploratory activity that culminates in learning what its environment affords for it.

See also COGNITIVE ARTIFACTS; DOMAIN-SPECIFICITY; HUMAN NAVIGATION; INFANT COGNITION; PERCEPTUAL DEVELOPMENT; SITUATEDNESS/EMBEDDEDNESS

—*Eleanor J. Gibson, Karen Adolph, and Marion Eppler*

References

Adolph, K. E. (1997). *Learning in the Development of Infant Locomotion.* Monographs of the Society for Research in Child Development.

Adolph, K. E., M. A. Eppler, and E. J. Gibson. (1993). Development of perception of affordances. In C. Rovee-Collier and L. P. Lipsitt, Eds., *Advances in Infancy Research.* Norwood, NJ: Ablex Publishing Co., pp. 51–98.

Bertenthal, B. I., and R. Clifton. (1997). Perception and action. In D. Kuhn and R. Siegler, Eds., *Handbook of Child Psychology* Vol. 2. New York: Wiley.

Eppler, M. A. (1995). Development of manipulatory skills and deployment of attention. *Infant Behavior and Development* 18: 391–404.

Gibson, E. J., and R. D. Walk. (1960). The "visual cliff." *Scientific American* 202: 64–71.

Gibson, J. J. (1950). *The Perception of the Visual World.* Boston: Houghton Mifflin.

Gibson, J. J. (1977). The theory of affordances. In R. Shaw and J. Bransford, Eds., *Perceiving, Acting and Knowing.* New York: Wiley, pp. 67–82.

Gibson, J. J. (1979). *The Ecological Approach to Visual Perception.* Boston: Houghton Mifflin.

Lee, D. N. (1976). A theory of visual control of braking based on information about time-to-collision. *Perception* 5: 437–459.

Lee, D. N. (1980). The optic flow field: the foundation of vision. *Philosophical Transactions of the Royal Society* B290: 169–179.

Lee, D. N., and P. E. Reddish. (1981). Plummeting gannets: paradigm of ecological optics. *Nature* 293: 293–294.

Lee, D. N., P. E. Reddish, and D. T. Rand. (1991). Aerial docking by hummingbirds. *Naturwissenschafften* 78: 526–527.

Mark, L. S. (1987). Eyeheight-scaled information about affordances: a study of sitting and stair climbing. *Journal of Experimental Psychology: Human Perception and Performance* 13: 683–703.

Reed, E. (1996). *Encountering the World.* New York: Oxford University Press.

Warren, W. H., Jr. (1984). Perceiving affordances: visual guidance of stair climbing. *Journal of Experimental Psychology: Human Perception and Performance* 10: 683–703.

Warren, W. H., Jr. (1995). Self-motion: visual perception and visual control. In W. Epstein and S. Rogers, Eds., *Perception of Space and Motion.* New York: Academic Press, pp. 263–325.

Warren, W. H., Jr., and S. C. Whang. (1987). Visual guidance of walking through apertures: body-scaled information for affordances. *Journal of Experimental Psychology: Human Perception and Performance* 13: 371–383.

Agency

See INTELLIGENT AGENT ARCHITECTURE; RATIONAL AGENCY

Aging and Cognition

Any discussion of the relations between aging and cognition must acknowledge a distinction between two types of cognition that are sometimes referred to as *fluid* and *crystallized* cognitive abilities (Cattell 1972) or INTELLIGENCE. Fluid abilities include various measures of reasoning (including both CAUSAL REASONING and DEDUCTIVE REASONING), MEMORY, and spatial performance, and can be characterized as reflecting the efficiency of processing at the time of assessment. In contrast, crystallized abilities are evaluated with measures of word meanings, general information, and other forms of knowledge, and tend to reflect the accumulated products of processing carried out in the past.

The distinction between these two types of abilities i important because the relations of age are quite different fo the two forms of cognition. That is, performance on crystal lized measures tends to remain stable, or possibly eve increase slightly, across most of the adult years, wherea increased age is associated with decreases in many measure of fluid cognition. In large cross-sectional studies age-relate declines in fluid abilities are often noticeable as early as th decade of the thirties, and the magnitude of the differenc across a range from twenty to seventy years of age is fre quently one to two standard deviation units. Although th average trends can be quite large, it is also important to poi out that individual differences are substantial because chr nological age by itself seldom accounts for more than 20 30 percent of the total variance in the scores.

The vast majority of the research in the area of aging a cognition has focused on fluid abilities. There appear to two primary reasons for this emphasis. First, many researc ers probably believe that explanations are clearly needed account for the differences that have been reported (as fluid abilities), but that a lack of a difference (as in cryst lized abilities) does not necessarily require an explanati And second, because fluid abilities are assumed to refl the individual's current status, they are often considered be of greater clinical and practical significance than cryst lized abilities that are assumed to represent the highest le the individual achieved at an earlier stage in his or her lif

Both distal and proximal interpretations of the a related decline in fluid cognitive abilities have been p posed. Distal interpretations focus on factors from earl periods in the individual's life that may have contributed his or her level of performance at the current time. Exa ples are speculations that the age-related declines are att utable to historical changes in the quantity or quality education, or to various unspecified cultural characteris that affect cognitive performance. In fact, comparisons the scores of soldiers in World War II with the norms f World War I (Tuddenham 1948), and a variety of time comparisons reported by Flynn (1987), suggest that average level of cognitive ability has been improving ac successive generations. However, the factors responsible these improvements have not yet been identified Neisser 1997), and questions still remain about the impl tions of the positive time-lag effects for the interpretatio cross-sectional age differences in cognitive functioning