Preface

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Cognitive neuroscience, the study of brain-behavior relationships, is historically old in its attempt to map the brain. However, the discipline is flourishing, with an increasing number of functional neuroimaging studies appearing in the scientific literature daily. Unlike biology and even psychology, however, the cognitive neurosciences have only recently begun to apply evolutionary theory and methods. Approaching cognitive neuroscience from an evolutionary perspective allows scientists to apply a solid theoretical guidance to their investigations, and one that can be carried out in both humans and nonhuman animals. This book represents the first formal attempt to document the burgeoning field of evolutionary cognitive neuroscience.

Introduction to *Evolutionary Cognitive Neuroscience*

All organisms were and continue to be subject to the pressures of natural and sexual selection. These pressures are what formed all biological organs and hence also carefully crafted animal nervous systems—the seat of animal and human behavior, the means by which organisms employ information-processing programs to adaptively deal with their environment. This theory was first formalized by Darwin (1859) in his seminal book, *On the Origin of Species by Natural Selection*. Unlike the theoretical work of early psychologists and behavioral scientists suhc as, Skinner and Watson, which envisioned organisms as "blank slates" capable of making an infinite number of associations, evolutionary metatheory is beginning to shed light on this flawed theoretical approach to behavior analysis (see Buss, 2005; Barkow, Cosmides, & Tooby, 1992, 2005). In fact, many of the emerging studies are contending directly with the standard social science model of psychology, namely, that organisms possess general-purpose learning mechanisms and that biology plays

little if any role in the manifestation of behavior. Some of the first psychological studies to demonstrate that learning is not mediated by general-purpose learning mechanisms were conducted several decades ago and mark what might be considered the beginning of evolutionary thinking in psychology; they also contributed greately to what has become known as the cognitive revolution.

In his landmark study, Garcia discovered that animals learned to avoid novel food products that made them ill in as little as one learning or conditioning trial, something that had not been demonstrated with any other stimulus class previously. Labeled conditioned taste aversion, this effect describes an adaptive problem that has since been demonstrated in almost every species tested (the exception to this rule appears to be crocodilians; see Gallup & Suarez, 1988). This adaptation serves an important function: don't eat food that makes you ill, or you might not survive to reproduce and pass on your genes. In other words, being ill could result in a number of fitness disadvantages such as death, inability to avoid predation, inability to search and secure mates, and loss of mate value.

In a similar discovery, Seligman demonstrated what he referred to as prepared learning. Prepared learning is a phenomenon in which it is easier to make associations between stimuli that possess a biological predisposition to be conditioned because of a role these stimuli played in an organism's evolutionary history. Seligman and his colleagues demonstrated that it was much easier for humans (and animals) to form conditioned emotional responses associative fear responses, to evolutionarily relevant threats such as snakes, insects, and heights than it took to condition fear to present-day threatening stimuli that subjects were much more likely to be have encountered and be harmed by, such as cars, knives, and guns. In other words, it was easier to condition humans to fear snakes, spiders, and heights than it was to condition them to fear guns, cars, and knives.

These two series of studies demonstrated that psychological traits, like the design of bodily organs, were crafted by evolutionary forces into adaptations that allowed our ancestors to flourish. That is, the information-processing mechanisms designed to deal with situations such as poisonous food or potential threats to survival evolved as part of our ancestors' recurrent experience with such situations. These studies refute a key premise of the standard social science model, emphasizing that there is no general-purpose learning mechanism. Rather, all learning is a consequence of carefully crafted modules dedicated to solving specific evolutionary problems (see Barkow, Cosmides, & Tooby, 1992; Pinker,

2002). Our brains have evolved to be efficient problem solvers, and the problems they are designed to solve are those that our ancestors recurrently faced over human evolutionary history. Hence, those among our ancestors who were psychologically adaptated to solve these problems survived and passed the genes for those traits on to offspring.

Recently, evolutionary metatheory has been applied directly to investigations of the cognitive neuroscience kind. For example, O'Doherty, Perrett and their colleagues (2003) have begun to investigate neural correlates of facial attraction. O'Doherty and colleagues discovered that the orbitofrontal cortex appears to be activated when a person finds a face attractive, which suggests that facial attractiveness activates a reward system in the brain. Further, Baron-Cohen and colleagues have demonstrated that there is a neural module dedicated to processing socially relevant information. Baron-Cohen and colleagues demonstrated that the ability to conceive of others' mental states appears to be (1) a highly modularized neurocognitive process and (2) affected by certain neuropsychiatric pathologies (e.g., autism). Platek and colleagues have extended initial behavioral findings of sex differences in reaction to children's faces to the cognitive neuroscience arena, demonstrating sex differences in functional neural activation associated with reactions to children's faces. They found that males but not females showed activation in left frontal regions of the brain when viewing self-resembling child faces, suggesting that males inhibit negative responsed to children's faces as a function of facial (phenotypic) resemblance.

Perhaps the most convincing set of studies demonstrating evolved structures or modules dedicated to social interaction and exchange has come from Leda Cosmides, John Tooby, and their colleagues at the Center for Evolutionary Psychology in Santa Barbara, California. By modifying a logic problem known as the Wason Selection Task to reflect evolutionarily important social interactions (e.g., cheater detection), Cosmides, Tooby, and colleagues have demonstrated that the human brain appears to have evolved a cheater detection mechanism that is extremely efficient. They have furthered the evidence for a cheater detection module by showing that one can incur impairment (i.e., brain trauma) of performance on cheater detection problems but remain relatively unimpaired on other types of problem solving. Their data suggest that parts of the limbic system are implicated in the ability to detect cheaters in social interactions.

The investigation of an evolutionary cognitive neuroscience extends beyond humans, however. Marc Hauser, Brian Hare, and a number of other researchers have been studying social behavior and social exchange

in nonhuman primates and have demonstrated an apparent cognitive continuity among primate phyla in the ability to understand the mental states of others. Daniel Povinelli's ongoing research program has been particularly powerful at demonstrating phylogenetic and ontogenetic trajectories for the capacity for theory of mind and self-awareness among nonhuman primates.

These new investigations, by applying cognitive neuroscientific methods to answer questions posed from an evolutionary theoretical perspective, are crafting a new understanding of how the mind and brain evolved. In fact, they call into question much of the psychological investigation that was conducted throughout the twentieth century. This book is the first to present, in an organized overview, the way in which researchers are beginning to wed the disciplines of evolutionary psychology and cognitive neuroscience in order to provide new data on and insights into the evolution and functional modularity of the brain.

Each of the six sections in this book addresses a different adaptive problem. Part I consists of three chapters that outline the basic tenets of an evolutionarily informed cognitive neuroscience. These chapters discuss evolutionary theory as it can be applied to behavior and cognition, as well as modern technological advances and methods that are available to the cognitive neuroscientist for the investigation of the adapted mind.

In Chapter 1, Aaron Goetz and Todd Shackelford present an overview of the basic principles of evolution—natural and sexual selection, fitness, and adaptation—as they apply to behavior and cognition. In Chapter 2, Robin Dunbar expands on this presentation by describing a theory known as the social brain hypothesis and discusses the major social evolutionary forces that gave rise to big-brained humans and adaptive brains. Chapter 3, by Shilpa Patel and colleagues, outlines the current methodological approaches used in evolutionary cognitive neuroscience.

Part II broaches the topic of neuroanatomy from an ontogenetic and phylogenetic perspective. In Chapter 4, Valerie Stone considers why big-brained organisms have extended ontogenetic and brain developmental periods. In the following chapter William Hopkins considers hemispheric specialization in our closest living relative, the chimpanzee. In Chapter 6, J. Philippe Rushton and C. Davison Ankney review their studies on the relationship between brain size and intelligence. T. close Part II, Lori Marino in Chapter 7 discusses the current state of the science in cetacean brain evolution.

Part III tackles the topic of reproduction and kin recognition. Chapter 8, by Russell Fernald, discusses the degree to which social environments can exert effects on reproductive behaviors. He draws on studies in his own laboratory on fishes and other nonhuman organisms, as well as on classic studies of this effect. In Chapter 9, Steven Platek and Jaime Thomson describe their recent findings supporting a sex difference in neural substrates involved in the detection of facial resemblance, and discuss what these findings might mean for kin selection or detection and paternal uncertainty. In Chapter 10, Helen Fisher and J. Anderson Thomson, Jr., summarize their recent studies with fMRI to identify the neural correlates of romantic attraction and lust. In Chapter 11, David Newlin outlines his SPFit model for drug addiction, which posits that drugs of addiction capitalize on evolutionary predispositions for reward- and reproductive-based behavioral and neural mechanisms.

Part IV addresses two well-known and well-researched areas: spatial cognition and language. David Puts, Steven Gaulin, and Marc Breedlove in Chapter 12 discuss sex differences in spatial abilities, paying particular attention to the endocrinological aspects associated with sex differences. In Chapter 13, Ruben Gur and colleagues extend the discussion of the evolution of sex differences in spatial cognition by summarizing current literature showing sex differences in neural substrates involved in solving spatial tasks. To conclude Part IV, Michael Corballis in Chapter 14 describes a theory of language evolution that draws on recent findings in animal and human neuroscience, especially the discovery of mirror neurons.

Part V takes up the topic of self-awareness and social cognition. In Chapter 15, Laurie Santos and her colleagues summarize their recent research showing that nonhuman primates possess the capability for social cognition, such as rudimentary theory of mind. In Chapter 16, Farah Focquaert and Steven Platek discuss their theory about the evolution of self-processing, introducing evidence from the nonhuman primate literature as well as from their own functional neuroimaging studies. Simon Baron-Cohen in Chapter 17 then presents his systemizing—empathizing theory for the development of theory of mind and describes how the model can be used to help classify individuals along this spectrum, with particular reference to autism and autism spectrum conditions. In Chapter 18, the discussion of self-awareness and social cognition is taken different disection, to describe the evolution of deception. Sean Stevens, and colleages outline the "dark side of consciousness"

theory, which links the capacity for deception to an intact self-awareness. Finally, Stephen Kosslyn in Chapter 19 presents a new theory for human motivation in which he describes social prostheses and reconsidess the self in aget of this social network.

The volume concludes with Part VI, which considers the ethical implications for evolutionary cognitive neuroscience.

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