CHAPTER 4

MULTI

THE MODULAR NATURE OF HUMAN INTELLIGENCE

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EVOLUTIONARY PSYCHOLOGY

The goal of research in evolutionary psychology is to discover and understand the design of the human mind. Evolutionary psychology is an approach to psychology, in which knowledge and principles from evolutionary biology and human evolutionary history are put to use in discovering the structure of the human mind. Evolutionary psychology is not a specific subfield of psychology, such as the study of vision, reasoning, or social behavior; it is a way of thinking about psychology, which can be applied to any area of human behavior or competence.

In this view, the mind is a set of information-processing procedures (cognitive programs) that are embodied in the neural circuitry of the brain. Realizing that the function of the brain is information-processing has allowed cognitive scientists to resolve at least one version of the mind–body problem. For cognitive scientists, *brain* and *mind* are terms that refer to the same system, which can be described in two complementary ways — in terms of its physical properties (the brain) or in terms of its information-processing operation (the mind). Described in computational terms, the mind is what the brain does. The physical organization of the brain evolved because physical organization brought about certain adaptive information-processing relationships. These organic computer programs were designed by natural selection to solve adaptive problems faced by our hunter-gatherer ancestors and to regulate behavior so that adaptive problems were successfully addressed. This way of thinking about the brain, mind, and behavior is changing how scientists approach old topics and is also opening up new ones. This chapter is an introduction to the central ideas and research strategies that

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have animated evolutionary psychologists and to some of the common misconceptions that people often have about the field.

DEBAUCHING THE MIND — EVOLUTIONARY PSYCHOLOGY'S PAST AND PRESENT

In the final pages of *On the Origin of Species*, after Darwin had presented the theory of evolution by natural selection, he made a bold prediction: "In the distant future I see open fields for far more important researches. Psychology will be based on a new foundation . . ." Thirty years later, William James (1890) began to outline what evolution meant for the study of psychology in his seminal book, *Principles of Psychology*, one of the founding works in experimental psychology. James talked a great deal about *instincts*, a term used to refer, roughly, to specialized neural circuits that (1) are common to every normal member of a species; (2) are the product of the species' evolutionary history; and (3) are acquired by a species' particular program structure because a particular set of rules solved an adaptive problem for the organism. (For example, if one is without defenses and is chased by a predator, one runs away.) These instincts have been referred to by various terms — modules, cognitive programs, adaptive specializations, evolved circuits, innate procedures, mental adaptations, evolved mechanisms, natural competences, and so on. The thousands of evolved circuits in our own species constitute a scientific definition of *human nature* — the uniform architecture of the human mind and brain that reliably develops in every normal human just as do eyes, fingers, arms, a heart, and so on.

It was common during James' time, as it is today, to think that other animals are ruled by instinct but that humans have lost all or almost all their instincts and have come to be governed instead by reason and learning. According to this view, the replacement of instinct with reason is why humans are much more flexibly intelligent than other species. However, William James set this common-sense view on its head. He argued paradoxically that human behavior is more flexibly intelligent than that of other animals because humans have *more* instincts than other animals have, not fewer. Why should more instincts make humans more intelligent? James suggested that each module is a circuit with a distinct problem-solving ability tailored to particular piece of the world and relevant to a type of problem. The more such circuits one can link up, the broader the range of problems that can be solved. Humans tend to be blind to the existence of these instincts, however, precisely because they work so well — because they process information so effortlessly, automatically, and nonconsciously. They structure our thought so powerfully, James argued, that it can be difficult to imagine how things could be otherwise.

Humans take normal behavior so much for granted that they feel impelled to explain only *abnormal* behavior. For example, we usually do not ask why people breathe, eat, or are attracted to beautiful sexual partners — these responses are natural — instead, we ask why someone holds the breath, refuses to eat, or seems unmoved by the prospect of sex. As humans, we believe that normal behavior needs no explanation; but as scientists, explanation is in fact the goal: to describe all the programs or circuits in the human mind that cause humans to do all the normal things they do.

Blindness to our own instincts makes the study of psychology difficult because it makes the central object of study almost invisible. To get past this problem and to awaken ourselves to the real scientific task that confronts psychologists, James (1890) suggested that one try to make the "natural seem strange":

> It takes . . . a mind debauched by learning to carry the process of making the natural seem strange, so far as to ask for the *why* of any instinctive human act. To the metaphysician alone can such questions occur as: Why do we smile, when pleased, and not scowl? Why are we unable to talk to a crowd as we talk to a single friend? Why does a particular maiden turn our wits so upside-down? The common man can only say, *Of course* we smile, *of course* our heart palpitates at the sight of the crowd, *of course* we love the maiden, that beautiful soul clad in that perfect form, so palpably and flagrantly made for all eternity to be loved!
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> And so, probably, does each animal feel about the particular things it tends to do in the presence of particular objects. . . . To the lion it is the lioness which is made to be loved; to the bear, the she-bear. To the broody hen the notion would probably seem monstrous that there should be a creature in the world to whom a nestful of eggs was not the utterly fascinating and precious and never-to-be-too-much-sat-upon object which it is to her.
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> Thus we may be sure, that, however mysterious some animals' instincts may appear to us, our instincts will appear no less mysterious to them.

William James' views were a century ahead of their time; psychologists are only now beginning to explore the immensely intricate architecture of the human mind and to decode its programs. As James suggested, it took the emergence of the scientific study of animal minds, brains, and behavior (variously called **ethology**, animal behavior, behavioral ecology, or **sociobiology**) to propel the study of humans. Studying other species' contrasting competences and behaviors awakened researchers to a huge range of natural human competences and distinctive human behavior that had previously been ignored. Making the natural seem strange is unnatural, yet it is a pivotal part of the enterprise.

Until recently, most psychologists avoided the study of natural competences. Social psychologists, for example, were primarily interested in finding phenomena "that would surprise their grandmothers." Many cognitive psychologists spend more time studying how humans solve problems they are poor at (such as learning math or playing chess) than problems they are good at (for example, abilities to see, speak, regard someone as beautiful, reciprocate a favor, fear disease, fall in love, initiate an attack, experience moral outrage, navigate a landscape). Our natural competences are possible only because there is a vast and heterogeneous array of complex computational machinery supporting and regulating these activities. Just as modern personal computers come equipped with a variety of distinct programs to perform diverse tasks — a word processor, a spreadsheet, an address database, and so on — humans come equipped with a variety of task-specialized mental programs that switch off and on in different situations and cause us to fall in love, feel hungry, resent being cheated, deduce the meaning of a new word, and so on. The machinery works so well that humans do not realize that it exists; thus, we suffer from "instinct blindness." Psychologists are only now beginning to study some of the most interesting machinery in the human mind.

An evolutionary approach provides powerful lenses that correct for instinct blindness. It allows researchers to recognize what natural competences humans are likely to be equipped with; it indicates that the human mind is likely to contain a far vaster collection of these instincts, circuits, or competences than anyone even a decade ago suspected; and, most important, it provides specific and detailed theories of their designs. Einstein once commented "It is the theory which decides what we can observe." Evolutionary theory is valuable for psychologists who are studying a biological system of fantastic complexity because it allows researchers to observe evolved mental programs they otherwise would not have thought to look for, and so makes the intricate outlines of the mind's design stand out in sharp relief from the sea of incidental properties. Theories of adaptive problems can guide the search for the cognitive programs that solve them; knowing what cognitive programs exist can, in turn, guide the search for their neural basis (Figure 4.1).

THE STANDARD SOCIAL SCIENCE MODEL

Don Symons, one of the pioneers of evolutionary psychology, is fond of saying that you cannot understand what a person is saying unless you understand who that person is arguing with. Applying evolutionary biology to the study of the mind has brought most evolutionary psychologists into conflict with a traditional view of its structure, which arose long before Darwin. This view is no historical relic: It remains highly influential in psychology, anthropology, sociology, and the wider culture more than a century after Darwin and William James wrote. To understand evolutionary psychology, it is important to understand the view that evolutionary psychology is displacing; this view can be termed the **Standard Social Science Model** (Tooby and Cosmides, 1992).

Both before and after Darwin, a common view among philosophers and scientists has been that the human mind resembles a blank slate, virtually free of content until written on by the hand of experience. According to Aquinas, there is "nothing in the intellect which was not previously in the senses." Working within this framework, the philosophers known as the **British Empiricists** and their successors produced elaborate theories about how experience, refracted through a small handful of innate mental procedures, inscribed content onto the mental slate. David Hume's view was typical, and set the pattern for many later psychological and social science theories: ". . . there appear to be only three principles of connexion among ideas, namely *Resemblance*, *Contiguity* in time or place, and *Cause or Effect*."

Over the years, the technological metaphor used to describe the structure of the human mind has been consistently updated from blank slate to switchboard to general purpose computer to connectionist net, but the central tenet of the Empiricist views has remained the same. Indeed, it remains the reigning orthodoxy in most areas of psychology and in the social sciences. According to this orthodoxy, all the specific content of the human mind originally derives from the outside — from the environment and the social world — and the evolved architecture of the mind consists solely or predominantly of a small number of general-purpose mechanisms that are content independent; researchers refer to the mechanisms with terms such as learning, induction, intelligence, imitation, rationality, the capacity for culture, socialization, or simply culture.

According to this view, the same mechanisms are thought to govern how one acquires a language, how one learns to recognize emotional expressions, how one thinks about incest, or how one acquires ideas and attitudes about friends and reciprocity; indeed, they govern everything but perception, which is the conduit by which experience pours into the mind. The mechanisms that govern reasoning, learning, and

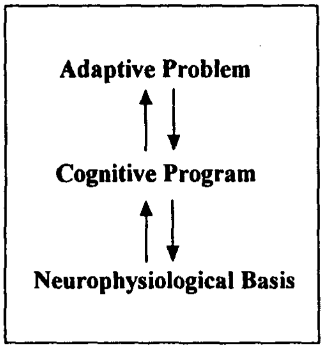

FIGURE 4.1

Three complementary levels of explanation in evolutionary psychology. Inferences (*arrows*) can be made from one level to another.

memory are assumed to operate uniformly, according to unchanging principles, regardless of the content they are operating on or the larger category or domain (that is, the topic) involved. For this reason, they are described as *content-independent* or **domain-general**. Such mechanisms, by definition, have no preexisting content built into their procedures, are not designed to construct certain mental contents more readily than others, and have no features specialized for processing particular kinds of content. Because these hypothetical mental mechanisms have no content to impart, it follows that all the particulars of what we think and feel are derived externally from the physical and social world. The social world organizes and injects meaning into individual minds, but the universal human psychological architecture has no distinctive structure that organizes the social world or imbues it with characteristic meanings. According to the Standard Social Science Model, the contents of human minds are primarily (or entirely) *free social constructions*, and the social sciences and human behavior are autonomous and disconnected from any evolutionary or biological foundation (Tooby and Cosmides, 1992). Humans are held to be the products of culture, not of instinct. Human nature is only the capacity to absorb culture — it has no other character.

Three decades of progress and convergence in cognitive psychology, evolutionary biology, and neuroscience have shown that this view of the human mind is radically defective. Evolutionary psychology provides an alternative framework that is beginning to replace the standard model. In the new view, all normal human minds reliably develop a standard collection of reasoning and regulatory circuits that are functionally specialized and, frequently, are designed to operate specifically within a particular domain (for example, sexual behavior, foods, navigation). That is, they are often **domain-specific**. The circuits organize the way humans interpret experiences, inject certain recurrent concepts and motivations into mental life, and provide universal frames of meaning that allow understanding of the actions and intentions of others. According to this view, beneath the level of surface variability, all humans share certain views and assumptions about the nature of the world and human action by virtue of evolved, universal cognitive programs. Concepts such as jealousy, friendship, beauty, and so on are not cultural inventions but, rather, cultural elaborations of universal features of the human mind.

BACK TO BASICS — FIVE BIOLOGICAL PRINCIPLES

How did evolutionary psychologists arrive at this view? When rethinking a field, it is sometimes necessary to go back to first principles, to ask basic questions: What is behavior? What do we mean by "mind"? How can something as intangible as a mind have evolved? What is its relation to the brain? The answers to such questions provide the framework within which evolutionary psychologists operate.

Psychology is the branch of biology that studies (1) brains, (2) how brains process information, and (3) how the brain's information-processing programs generate behavior. Psychology is a branch of biology because the human brain is a biological structure, a product of evolution. Once one realizes that psychology is a branch of biology, inferential tools developed in biology — its theories, principles, and observations — can be used to understand psychology. There are five basic principles, all drawn from biology, that evolutionary psychologists apply in their attempts to understand the design of the human mind. The five principles can be applied to *any* topic in psychology.

The principles organize observations in a way that allows one to see connections between areas as seemingly diverse as vision, reasoning, and sexuality.

Principle 1

The brain is a physical system functioning as a computer and has circuits designed to generate behavior appropriate to environmental circumstances.

The brain is a physical system whose operation is governed solely by the laws of chemistry and physics. What does this mean? It means that all thoughts and hopes and dreams and feelings are produced by chemical reactions going on in one's head (a sobering thought). Moreover, the brain's function is to process information. In other words, it is a computer that is made of organic (carbon-based) compounds rather than silicon chips. The brain is made of cells: primarily **neurons** and their supporting structures. Neurons are cells that were modified over the course of evolution so that they are specialized for the transmission of information. Electrochemical reactions cause neurons to fire.

Neurons are connected to one another in a highly organized way. One can think of these connections as circuits — just as a computer has circuits. The circuits determine how the brain processes information, just as the circuits in a computer determine how it processes information. Neural circuits in the brain are connected to sets of neurons that run throughout the body. Some neurons are connected to sensory receptors, such as the retinas of one's eyes. Others are connected to muscles. **Sensory receptors** are cells that are specialized for gathering information from the outer world and from other parts of the body; for example, you can feel your stomach churn because the stomach has sensory receptors on it, but you cannot feel your spleen, because it lacks receptors. Sensory receptors are connected to neurons that transmit the information to your brain. Other neurons send information from your brain to motor neurons. **Motor neurons** are connected to muscles; they cause muscles to move. This movement is called *behavior.*

Organisms that do not move do not have brains — trees do not have brains, bushes do not have brains, grasses do not have brains. In fact, some animals do not move during certain stages of their lives, and during those stages, *they* do not have brains. The sea squirt, for example, is a marine invertebrate (backbone-lacking) animal. During the early stage of its life cycle, the sea squirt swims around looking for a good place to attach itself permanently. Once it finds the right rock and attaches itself to it, it does not need its brain because it will never need to move again. So it eats (resorbs) most of its brain! (After all, why waste energy on a now useless organ? Better to get a good meal out of it.)

In short, the circuits of the brain are designed to generate motion — behavior — in response to information from the environment. The function of the brain, the "wet computer," is to generate behavior that is appropriate to your environmental circumstances.

Principle 2

Neural circuits were designed by natural selection to solve problems that ancestors faced during the species' evolutionary history.

To say that the function of the brain is to generate behavior that is appropriate to your environmental circumstances is not saying much, unless one has a definition of what appropriate means. What counts as appropriate behavior?

Appropriate has different meanings for different organisms. Humans have sensory receptors that are stimulated by the sight and smell of feces — to put it more bluntly, we can see and smell dung. So can a dung fly. But on detecting the presence of feces in the environment, a human's appropriate behavior differs from what is appropriate for the dung fly. On smelling feces, appropriate behavior for a female dung fly is to move toward the feces, land on them, and lay her eggs. Feces are food for a dung fly larva — therefore, appropriate behavior for a dung fly larva is to eat dung. And, because female dung flies hang out near piles of dung, appropriate behavior for a male dung fly is to buzz around the piles and try to mate; for a male dung fly, a pile of dung is a sexually exciting haunt, much as a disco or a bar might be for humans who live in Western societies.

But for human ancestors, feces were (and are) a source of contagious diseases. For humans, feces are not food. They are not a good place to raise children, nor are they a good place to look for a sexual partner. The appropriate behavior for a human is to move away from the source of the smell. Humans may also form the cross-cultural, universal *disgust expression* with facial muscles — the nose wrinkles to protect the eyes and nose from the volatiles, and the tongue protrudes slightly as if one were ejecting something from the mouth.

For humans, the pile of dung is disgusting. For a female dung fly, looking for a good neighborhood and a nice house for raising her children, the pile of dung is a beautiful vision — a mansion. (Seeing a pile of dung as a mansion — perhaps *that* is what William James meant by making the natural seem strange!)

The point is, environments do not, themselves, specify what counts as appropriate behavior. In other words, it is not a scientific explanation to say that "The environment made me do it!" In principle, a computer program or neural circuit could be designed to link *any* given stimulus in the environment to any kind of behavior. For feces, evolution has equipped two species with two different circuits that cause opposite responses for the same stimulus. So, the explanation for a behavior cannot be in the stimulus alone, but must also be in the nature of the circuits each species has. Which behavior a stimulus gives rise to is a function of the neural circuitry of the organism, which means that a designer of brains could have made a person who licks her chops and sets the table when she smells a nice fresh pile of dung.

But what did the actual, natural designer of the human brain do, and why? Why do humans find fruit sweet and dung disgusting? How did humans get the circuits they have, rather than the circuits the dung fly has?

In talking about a home computer, one can answer the question simply: The circuits were designed by an engineer, and the engineer designed them one way rather than another so they would solve problems that the engineer *wanted* them to solve — problems such as adding or subtracting or accessing a particular address in the computer's memory. Human neural circuits were also designed to solve problems, but they were not designed by an engineer. They were designed by the *evolutionary process* to solve problems that were important from an evolutionary standpoint during our evolutionary history.

Toward what good or end were evolved mental programs designed by natural selection to work? For one thing, natural selection does *not* work for the good of the species or for the perpetuation of the species, as many people think. *Natural selection* is a process in which a mutant or new design feature *causes its own spread through a population over multiple generations* (which can happen regardless of what such a spread does to the welfare or even the long-term survival of the species). To understand evolution, one could think of natural selection as the "eat dung and die" principle. All animals need neural circuits that govern what they eat — knowing what is safe to eat is a problem that all animals must solve. For humans, feces are not safe to eat — they are a source of contagious diseases. An ancestral human who had mutant neural circuits that made dung smell appetizing would increase the probability of contracting a disease. If that human got sick as a result, he would be too tired to find much food, too exhausted to go looking for a mate, and might even die an untimely death. In contrast, a person with different neural circuits — circuits that made him avoid feces — would get sick less often than persons lacking such circuits. He would therefore have more time to find food and mates and would live a longer life. The first person would eat dung and die; the second would avoid it and live. As a result, the dung-eater would have fewer children than the dung-avoider. Since the neural circuitry of children tends to resemble that of their parents, there would be fewer dung-eaters and more dung-avoiders in the next generation. As this process continued, generation after generation, the dung-eaters would eventually disappear from the population. Why? They ate dung and died out! The only kind of people left in the population would be the ones descended from the dung-avoiders (that is, persons with very complex and sophisticated disgust and food choice circuitry). No one who has neural circuits that make dung delicious would be left.

The reason humans have one set of circuits rather than another is that the circuits humans have were better at causing their own spread over many ancestral generations than were alternative circuits implementing alternative behavioral patterns. The inherited tendency to cause design features, such as neural circuits, to increase their own frequency over generations is the "good" (the "engineering goal") that governs which design natural selection builds into a species. The route by which design features are built is through increasing an individual's reproduction or the reproduction of family members — individuals who might be carrying the same design features. Adaptive problems are situations that interfere with an individual's reproduction or survival, or the survival and reproduction of an individual's relatives. The brain is a naturally constructed computational system whose function is to solve adaptive information-processing problems (such as face recognition, threat interpretation, language acquisition, navigation). Over evolutionary time, the brain's circuits were cumulatively added because they reasoned or processed information in a way that enhanced the adaptive regulation of behavior and physiology.

However, human circuits were not designed to solve *any* kind of problem. They were designed to solve *adaptive* problems. **Adaptive problems** have two defining characteristics. First, they are the problems that cropped up again and again during the evolutionary history of a species. Second, they are problems whose solution enhanced or facilitated the *reproduction* of individual organisms — however indirect the causal chain may be and however small the effect on number of offspring produced, because differential reproduction (and not survival itself) is the engine that drives natural selection.

Consider the fate of a circuit that had the effect, on average, of enhancing the reproductive rate of the organisms that sported it, but in so doing shortened the average lifespan of the organisms, for example, a circuit that causes mothers to risk death to save their children. If this effect were heritable, its frequency in the population would increase. In contrast, any circuit that had the effect of decreasing the reproductive rate of the organisms that had that circuit would eventually disappear from the population. Most adaptive problems have to do with how an organism makes its living or avoids difficulties: what it eats, what eats it, who it mates with, who it socializes with, how it communicates, how it avoids being attacked, and so on. The *only* kind of problems that natural selection can design circuits for solving are adaptive problems.

Obviously, humans now are able to solve problems that no hunter-gatherer ever had to solve — learn higher mathematics, drive cars, and use computers. Our ability to solve other kinds of problems is a side-effect or by-product of circuits that were designed to solve adaptive problems. For example, when our ancestors became bipedal — when they started walking on two legs instead of four — they had to develop a very good sense of balance. Indeed, we have in the inner ear very intricate mechanisms that allow us to achieve an excellent sense of balance. We can balance well on two legs while moving, which means that we can do other things besides walk — skateboard or ride the waves on a surfboard. Our hunter-gatherer ancestors were not tunneling through curls along the shores of what would become Kenya. That we can surf and skateboard is merely a by-product of adaptations designed for balancing while walking on two legs.

Principle 3

Most of what goes on in the mind is hidden; thus, most problems that seem easy to solve are actually very difficult to solve — they require very complicated circuitry.

Humans are not and cannot become consciously aware of most of the brain's ongoing activities. To illustrate by analogy, think of your brain as the entire federal government and as the *self* that is consciously experienced as *self* as the President of the United States. If you were the President, how would you know what is going on in the world? Members of the Cabinet, such as the Secretary of Defense, would tell you things — for example, that the Bosnian Serbs are violating their cease-fire agreement. How do members of the Cabinet know these things? Thousands of bureaucrats in the State Department, thousands of Central Intelligence Agency operatives in Serbia and other parts of the world, thousands of troops stationed overseas, and hundreds of investigative reporters are gathering and evaluating enormous amounts of information from all over the world. But you, as the President, do not — and in fact, cannot — know what each of the thousands of individuals were doing while each gathered the information during the course of a few months — what each of them saw, what each of them read, to whom each of them talked, what conversations were clandestinely taped, what offices were bugged. All you, as the President, know is the final conclusion that the Secretary of Defense has on the basis of the information that was passed to him. And all he knows is what other high-level officials passed to him. And so on. In fact, no single individual knows *all* the facts of the situation because the facts are distributed among thousands of people. Moreover, each of the thousands of individuals involved knows all kinds of details about the situation that were decided not important enough to pass to higher levels.

So it is with conscious experience. The only things a person becomes aware of are a few high-level conclusions passed on by thousands and thousands of specialized mechanisms: some that are gathering sensory information from the world, and others that are analyzing and evaluating the information, checking for inconsistencies, filling in the blanks, figuring out what it means.

Any scientist who is studying the human mind must keep this fact in mind. In figuring out how the mind works, one's conscious experience of self and of the world can suggest some valuable hypotheses; but the same intuitions can also be seriously misleading. They can fool a person into thinking that neural circuitry is simpler than it really is. For example, conscious experience tells you that seeing is simple: You open your eyes, light hits your retinas, and — voila! — you see. The process is effortless, automatic, reliable, fast, unconscious, and requires no explicit instruction. But the apparent simplicity is deceptive. Retinas are two-dimensional sheets of light-sensitive cells covering the inside back of the eyeballs. Figuring out only on the basis of the light-dependent chemical reactions occurring in the flat arrays of cells what three-dimensional objects exist in the world poses enormously complex problems — so complex, in fact, that no computer programmer has yet been able to create a robot that can see even remotely as well as humans do routinely. One sees with the brain, not just the eyes, and the brain contains a vast array of dedicated, special-purpose circuits, each set specialized for solving a different component of the problem. You need all kinds of circuits simply to see your mother walk, for example. You have circuits that are specialized for (1) analyzing the *shape* of objects; (2) perceiving the presence of *motion*; (3) detecting the *direction* of motion; (4) judging *distance*; (5) analyzing *color*; (6) recognizing an object as *human*; and (7) *identifying* the face you see as Mom's face, rather than someone else's. Each individual circuit is shouting its information to higher-level circuits, which check the facts generated by one circuit against the facts generated by the others, and resolve contradictions. The conclusions are then handed over to still higher-level circuits that piece the facts together and hand the final report to the President — your consciousness. But all this "president" ever becomes aware of is the sight of *Mom walking*. Although each circuit is specialized for solving a delimited task, the circuits work together to produce a coordinated functional outcome — in this case, your conscious experience of the visual world. Seeing is effortless, automatic, reliable, and fast precisely because humans embody this complicated, dedicated machinery.

Our intuitions can deceive us. Conscious experience of an activity as easy or natural can lead people to grossly underestimate the complexity of the circuits that make the experience possible. Doing what comes naturally, effortlessly, or automatically is rarely simple from an engineering point of view. To find someone beautiful, to fall in love, to feel jealous — all these events can seem as simple and automatic and effortless as opening our eyes and seeing, so simple that it seems like there is nothing to explain about such a natural response. But these activities feel effortless only because there is a vast array of complex neural circuitry supporting and regulating them. Other species face other problems, and so their minds compute other things: spider webs, bat echolocation, and so on.

Principle 4

Different neural circuits are specialized for solving different adaptive problems.

A basic engineering principle is that the same machine is rarely capable of solving two different problems equally well. Screwdrivers and saws, for instance, both exist because each solves a particular problem better than the other. Just imagine trying to cut planks of wood with a screwdriver or to turn screws with a saw.

Our body is divided into organs, such as the heart and the liver, for exactly this principle. Pumping blood throughout the body and detoxifying poisons are two very different problems. Consequently, the body has a different machine for solving each problem. The design of the heart is specialized for pumping blood; the design of the liver is specialized for detoxifying poisons. The liver cannot function as a pump, and the heart is not good at detoxifying poisons.

For the same reason, the mind consists of a large number of circuits that are *functionally specialized.* Some neural circuits are designed specialized for vision. Other neural circuits are specialized for hearing — all they do is detect changes in air pressure and extract information from it. They do not participate in vision, vomiting, vanity, vengeance, or anything else. Still other neural circuits are specialized for sexual attraction — that is, they govern what you find sexually arousing, what you regard as beautiful, who you'd like to date, and so on.

Humans have all these specialized neural circuits because the same mechanism is rarely capable of solving different adaptive problems. For example, all humans have neural circuitry designed to choose nutritious food on the basis of taste and smell — circuitry that governs our food choice. But imagine a woman who used the same neural circuitry to choose a mate. She would choose a strange mate indeed! (Perhaps a huge chocolate bar?) To solve the adaptive problem of finding the right mate, our choices must be guided by *qualitatively different standards* than those used to choose the right food or the right habitat. Consequently, the brain must be composed of a large collection of circuits, with different circuits specialized for solving different problems. One can think of each specialized circuit as a minicomputer that is dedicated to solving one problem. Such dedicated minicomputers are sometimes called *modules*. There is, then, a sense in which one can view the brain as a collection of dedicated minicomputers — a collection of modules. Of course, there must be circuits whose design is specialized for integrating the output of the dedicated minicomputers to produce behavior. So, more precisely, one can view the brain as a collection of dedicated minicomputers whose operations are *functionally integrated* to produce behavior.

Psychologists have long known that the human mind contains circuits that are specialized for different modes of perception, but until recently it was thought that perception and, perhaps, language were the only activities caused by specialized cognitive processes (Fodor, 1983). Other cognitive functions — learning, reasoning, decision-making — were thought to be accomplished by general-purpose circuits. Prime candidates were rational algorithms: ones that implement formal methods for inductive and deductive reasoning, such as Bayes' rule or the propositional calculus (a formal logic). **General intelligence** — a hypothetical faculty composed of a few simple reasoning circuits that are content-independent and for general purposes — was thought to be the engine that generates solutions to reasoning problems. The flexibility of human reasoning (that is, one's ability to solve many different kinds of problems) was thought to be evidence for the generality of the circuits that generate reasoning.

An evolutionary perspective suggests that human intelligence is not a product of a blank slate connected to content-independent mechanisms that operate according to rational algorithms (Tooby and Cosmides, 1992). Cognitive programs are designed to mesh with the features of the environments in which they evolved, and so they embody information about the stably recurring properties of these ancestral worlds. For example, the snake-phobia mechanism in humans embodies information about the abstract appearance of snakes and about the danger that snakes can pose. Similarly, human color-constancy mechanisms are calibrated to changes in natural — that is, Sun-caused — illumination; as a result, grass looks green at both high noon and sunset, even though the spectral properties of the light it reflects have changed dramatically. In contrast, **content-independent** (rational) problem-solving methods do not embody specific information about the structure of various domains of the world relevant to different problem types because content-independent methods, by definition, operate in the same manner regardless of what the situation is like or what the content of the problem is.

Figure 4.2 shows two rules of inference from the **propositional calculus**, a system that allows one to deduce true conclusions from true premises, no matter what the subject matter of the premises is — no matter what P and Q refer to. **Bayes' rule**, an equation

FIGURE 4.2

Two rules of inference of the propositional calculus. The rules are valid: Given true premises, they generate true conclusions. The rules are also content-independent: *P* and *Q* can stand for any proposition, no matter what it is about.

Modus ponens:	*an example:*
If P then Q	If you slept, then you had dreams
P	You slept
therefore Q	therefore you had dreams
Modus tollens:	
If P then Q	If you slept, then you had dreams
not-Q	You did not have dreams
therefore not-P	therefore you did not sleep

for computing the probability that a hypothesis is true given specific observations, is also content-independent. It can be applied indiscriminately to medical diagnosis, card games, hunting success, or any other subject. It contains no knowledge that is *specific* to the activity considered, so it cannot cause correct judgments that would apply to mate choice, for example, but not to hunting (that is the price of content-independence).

Evolved problem-solvers, in contrast, are equipped with "crib sheets": They come to a problem already knowing a lot about it. For example, a newborn's brain has response systems that expect faces to be present in the environment: Babies less than 10 minutes old turn their eyes and head in response to face-like patterns but not to scrambled versions of the same pattern with identical spatial frequencies (Johnson and Morton, 1991). Infants' brains make strong assumptions about how the world works and what kinds of things it contains, even at 2.5 months (the point at which infants can see well enough to be tested). The infant's brain assumes, for example, that the world contains rigid objects that are continuous in space and time, and the brain has preferred ways of dividing the world into separate objects (Baillergeon, 1986; Spelke, 1990). Ignoring shape, color, and texture, the infant's brain treats any surface that is cohesive, bounded, and moves as a unit as a single object. When one solid object appears to pass through another, the infants are surprised, just as an adult would be. A mind that was a blank slate — a truly "open-minded" system — would be undisturbed by such displays.

In watching objects interact, babies less than 1 year old distinguish causal events (objects causing others to move by bumping into them) from noncausal ones that have similar spatiotemporal properties (that is, objects that start and stop moving in sequence but do not touch each other); they distinguish objects that move only when acted on from objects that are capable of self-generated motion (the so-called inanimate/animate distinction); they assume that the self-propelled movement of animate objects is caused by invisible internal states — goals and intentions — whose presence must be inferred because internal states cannot be seen (Baron-Cohen, 1995; Leslie, 1988; 1994). Toddlers, like adults, have a well-developed "mind-reading" system that uses eye direction and movement to infer what other people want, know, and believe

(Baron-Cohen, 1995). (When this system is impaired, as in autism, the child cannot understand what others think.) When an adult utters a word-like sound while pointing to an object, toddlers assume the word refers to the whole object, not one of its parts (Markman, 1989).

If the evolved human mind lacked these privileged hypotheses about faces, objects, physical causality, other minds, word meanings, and so on, a developing child could learn very little about its environment. For example, an autistic child who has a normal IQ and intact perceptual systems is unable to make simple inferences about mental states (Baron-Cohen, 1995); children with Williams syndrome are profoundly retarded and have difficulty learning even very simple spatial tasks, but are good at inferring other people's mental states and complex language skills — some of their specialized reasoning mechanisms are damaged, but their mind-reading system is intact.

Different problems require different crib sheets. For example, knowledge about intentions, beliefs, and desires, which allows one to infer the behavior of persons, is misleading if applied to inanimate objects. Two cognitive programs with different crib sheets perform better than one when the crib sheet that helps solve problems in one domain is misleading in another area. Human minds evolved to understand inanimate objects differently than animate objects — entities whose behavior is caused by invisible internal states such as desires and beliefs, which suggests that many evolved computational mechanisms are domain-specific — activated in some domains but not others. Some mechanisms embody rational, content-independent methods, but others have special-purpose, inferential procedures that respond to content types — procedures that work well within the stable ecological structure of a particular domain even though they might lead to false or contradictory inferences if they were activated outside that domain. Activating programs designed to interpret behavior in terms of beliefs and desires when one is thinking about inanimate objects leads to confusion and error.

The more distinct crib sheets a system has, the more problems the system can solve. A brain equipped with a multiplicity of specialized inference engines can generate sophisticated behavior that is sensitively tuned to the varieties of problems generated by its environment. In this view, the flexibility and power often attributed to content-independent problem-solving methods is illusory. If all else is equal, a content-rich system can infer more than a content-poor one can.

Machines limited to executing rational procedures such as Bayes' rule, modus ponens (see Figure 4.2), and others derived from mathematics or logic are computationally weak compared to the system outlined above (Tooby and Cosmides, 1992). The theories of rationality these mechanisms embody are environment-free, that is, designed to produce valid inferences in *all* domains, regardless of the nature of the local world the organism lives in or the type of problem the organism is facing. The theories can be applied to a wide variety of domains because they lack any information that would be helpful in one domain but not in another. Having no crib sheets, no domain-specific information, there is little they can deduce about a domain; having no privileged hypotheses, there is little they can induce before their operation is hijacked by the necessity of considering an endless string of possibilities. The difference between *domain-specific* methods and *domain-independent* ones is akin to the difference between experts and novices: Experts can solve problems faster and more efficiently than novices because they already know a lot about the problem domain.

William James' view of the mind, ignored for much of the twentieth century, is being vindicated today. There is now evidence for the existence of circuits that are specialized for reasoning about objects, physical causality, number, the biological world, the beliefs and motivations of other individuals, and social interactions (Hirschfeld and Gelman, 1994). For example, it is now known that the learning circuits that govern the acquisition of language are different from circuits that govern the acquisition of food aversions, and both are different from the learning circuits that govern the acquisition of snake phobias (Garcia, 1990; Pinker, 1994; Mineka and Cooke, 1985; Ohman et al., 1985). Current literature is full of examples of how each species is governed by a multitude of distinct modules, instincts, or cognitive programs that guide learning differently for different topics.

Instinct is often thought of as the polar opposite of reasoning and learning. *Homo sapiens* is thought of as the rational animal — a species whose instincts were erased by evolution because the ability to reason and learn rendered them useless or harmful. But human reasoning circuits and learning circuits have the following five properties: (1) they are complexly structured for solving a specific type of adaptive problem; (2) they reliably develop in all normal human beings; (3) they develop without any conscious effort and in the absence of any formal instruction; (4) they are applied without any conscious awareness of their underlying logic; and (5) they are distinct from more general abilities to process information or behave intelligently. In other words, all have the hallmarks of what one usually thinks of as an instinct (Pinker, 1994). In fact, one can think of these special-purpose computational systems as *reasoning instincts* and *learning instincts*. These systems make certain kinds of inferences just as easy, effortless, and natural to humans as spinning a web to a spider or dead-reckoning to a desert ant (see Chapter 1). Students and social scientists often ask whether a behavior was caused by instinct or learning. A better question is, What are the design features of the instinct that caused the learning?

Principle 5

Modern skulls house Stone Age minds.

Natural selection, the process that designed the human brain, takes a long time to design a circuit of any complexity. The time it takes to build circuits that are suited to a given environment is so slow it is hard to even imagine — it is like a stone being sculpted by wind-blown sand. Even relatively simple changes can take thousands of generations.

For this reason, the environment that humans — and, therefore, human *minds* — evolved in was very different from the modern environment. Human ancestors spent more than 99% of their evolutionary history living in **hunter-gatherer** societies — our forebears lived in small, nomadic bands of a few dozen individuals who got all their food each day by gathering plants or by hunting animals. Each of our ancestors was, in effect, on a camping trip that lasted an entire lifetime, and the world of our foraging ancestors endured for millions of years.

Generation after generation, for 2 (or more) million years, natural selection slowly sculpted the human brain, favoring circuitry that was good at solving the day-to-day problems of our hunter-gatherer ancestors — problems such as finding mates, hunting animals, gathering plant foods, negotiating with friends, defending against aggression raising children, choosing a good habitat, and so on. Those whose circuits were bette designed for solving these problems consistently left more children, and so we and ou entire species are descended from them, not from others who lived during ancestra times but who lacked well-designed circuits.

Humans lived as hunter-gatherers *1000 times longer* than they lived in any other wa The world that seems so familiar to us, a world with roads, schools, grocery stores, fact ries, farms, and nation-states, has existed for only an eyeblink when compared to o entire evolutionary history. The computer age is only a little older than the typical college student, and the industrial revolution is a mere 200 years old. Agriculture first appeared in some regions of the globe only 10,000 years ago, and it was not until about 5000 years ago that as many as half the human population engaged in farming rather than hunting and gathering. Natural selection is a slow process; there simply have not been enough generations for it to select new circuits that are well adapted to postindustrial life.

In other words, our modern skulls house a Stone Age mind. The *key to understanding how the modern mind works* is to realize that its circuits were not designed to solve the day-to-day problems of a modern American; they were designed to solve the day-to-day problems of our hunter-gatherer ancestors. These Stone Age priorities produced a brain far better at solving some problems than others. For example, it is easier for us to deal with small, hunter-gatherer-band-sized groups of people than to deal with crowds of thousands; it is easier for us to learn to fear snakes than electric sockets, even though electric sockets pose a larger threat than snakes do in most American communities. In many cases, our brains are *better* at solving the kinds of problems our ancestors faced on the African savannas than they are at solving the more familiar tasks we face in a college classroom or a modern city. Saying that modern skulls house a Stone Age mind does not imply that our minds are unsophisticated. Quite the contrary — they are very sophisticated computers with circuits elegantly designed to solve the exotic kinds of problems our *ancestors* routinely faced.

Understanding that human modules, instincts, or cognitive programs evolved to solve the adaptive problems faced by our ancestors makes understanding the ancestral world important. Each cognitive program is an engineered device designed to solve problems by taking advantage of the stable structure of the problem environment. In the ancestral world, the so-called **environment of evolutionary adaptedness** (EEA), sweetness signaled nutrition, smooth skin indicated youth and health, objects moved in continuous smooth trajectories through three-dimensional space, and so on. Because mental adaptations or cognitive adaptations are designed to mesh with the relevant features of the EEA, understanding the engineering of the human mind requires understanding the structure of the EEA. Thus, the EEA is not a place or time as was the African savanna during the Pliocene or Pleistocene Epochs. The statistical composite of selection pressures — environmental properties — caused the design of an adaptation to be favored over alternative designs. The EEA for one adaptation, therefore, may be different from that for another. Conditions of terrestrial illumination, which form part of the EEA for the vertebrate eye, remained relatively constant for hundreds of millions of years (until the invention of the incandescent bulb). In contrast, the EEA that selected mechanisms that cause human males to provide food and other resources to their offspring — a situation that departs from the typical mammalian pattern — appears to be less than 2 million years old.

The five principles outlined here are tools for thinking about psychology and can be applied to any topic: sex and sexuality, how and why people cooperate, whether people are rational, how babies see the world, conformity, aggression, hearing, vision, sleeping, eating, hypnosis, schizophrenia, and on and on. The framework the principles provide links areas of study and saves one from drowning in irrelevant particulars. Whenever one tries to understand some aspect of human behavior, these principles encourage one to ask the following fundamental questions:

1. Where in the brain are the relevant circuits and how, physically, do they work?
2. What kind of information is being processed by the circuits?

3. What information-processing programs do the circuits embody?
4. What were the circuits designed to accomplish (in a hunter-gatherer context)?

UNDERSTANDING THE DESIGN OF ORGANISMS

Adaptationist Logic and Evolutionary Psychology

Phylogenetic Versus Adaptationist Explanations The goal of Darwin's theory was to explain phenotypic design: Why do the beaks of finches differ from one species to another? Why do animals expend energy attracting mates that could be spent on survival? Why are human facial expressions of emotion similar to the expressions of other primates?

Two of the most important evolutionary principles accounting for the characteristics of animals are (1) common descent, and (2) adaptation driven by natural selection. If all humans are related to one another and to all other species, by virtue of common descent, one might expect to find similarities between humans and their closest primate relatives. The **phylogenetic approach** has a long history in psychology — it prompts the search for phylogenetic continuities implied by the inheritance of homologous features from common ancestors.

An **adaptationist approach** to psychology leads to the search for adaptive design, which entails understanding how various design features constitute organic machinery designed by selection to solve a problem. Such a functional unit or mechanism is an adaptation. Although many adaptations are similar among closely related species (for example, eyes), adaptationism often entails the examination of niche-differentiated mental abilities unique to the species being investigated. Elephants have trunks, humans have language, bats have echolocation — none of these features are shared by other mammals. What makes the organized differences comprehensible is an adaptationist approach. A book by George Williams (1966), *Adaptation and Natural Selection*, clarified the logic of adaptationism. This work provided the tools that allowed the construction of modern evolutionary psychology. Evolutionary psychology can be thought of as the application of adaptationist logic to the study of the architecture of the human mind.

Why Does Structure Reflect Function? In evolutionary biology, several different levels of explanation are complementary and mutually compatible. Explanation at one level (for example, adaptive function) does not preclude or invalidate explanations at another level (for example, neural, cognitive, social, cultural, or economic). Evolutionary psychologists use theories of adaptive function to guide their investigations of cognitive and neural structures. Why is this possible? The evolutionary process has two components: chance and natural selection. Natural selection is the only component of the evolutionary process that can introduce complex *functional* organization into a species' phenotype (Dawkins, 1986; Williams, 1966).

The function of the brain is to generate behavior that is sensitively contingent on information from an organism's environment. The brain, therefore, is an information-processing device. Neuroscientists study the physical structure of such devices, and cognitive psychologists study the information-processing programs realized by that structure. There is, however, another level of explanation — a functional level. In evolved systems, form follows function. The physical structure of the brain is there because it embodies a set of programs; a program is there because its set of procedures causes the solution to a problem that the species' ancestors commonly encountered. The functional level of explanation is essential for understanding how natural selection designs organisms.

An organism's phenotypic structure can be thought of as a collection of design features — micromachines, such as the functional components of the eye or liver. Over evolutionary time, new design features are added or discarded from the species' design because of their consequences. A design feature causes its own spread across generations if it has the consequence of solving adaptive problems: for instance, cross-generationally recurrent problems, such as detecting predators or detoxifying poisons, whose solution promotes reproduction. As another example, if more sensitive retinas appeared in one or a few individuals by chance mutation and allowed predators to be detected more quickly, individuals who had the more sensitive retinas would produce offspring at a higher rate than would individuals who lacked the retinas. By promoting the reproduction of its bearers, the more sensitive retina thereby *promotes its own spread across generations*, until it eventually replaces the earlier-model retina and becomes a universal feature of that species' design.

Hence, natural selection is a feedback process that chooses among alternative designs on the basis of *how well the designs function*. It is a hill-climbing process in which a design feature that solves an adaptive problem well can be outcompeted by a new design feature that solves the problem better. This process has produced exquisitely engineered biological machines — the vertebrate eye, photosynthetic pigments, efficient foraging algorithms, color-constancy systems — the performance of which are unrivaled by any machines yet designed by humans.

By selecting designs on the basis of how well they solve adaptive problems, the process engineers a tight fit between the function of a device and its structure. To understand this causal relationship, biologists had to develop a theoretical vocabulary that distinguishes between structure and function. In evolutionary biology, explanations that appeal to the structure of a device are sometimes called *proximate explanations*. When applied to psychology, these explanations include those that focus on genetic, biochemical, physiological, developmental, cognitive, social, and all other immediate causes of behavior. Explanations that appeal to the adaptive function of a device are sometimes called *distal* or *ultimate explanations* because they refer to causes that operated over evolutionary time.

Knowledge of Adaptive Function Is Necessary for Carving Nature at the Joints An organism's phenotype can be partitioned into *adaptations* (present because they were chosen), *by-products* (present because they are causally coupled to traits that were selected — for example, the whiteness of bone), and *noise* (injected by the stochastic components of evolution). Like other machines, only narrowly defined aspects of organisms fit together into functional systems — most ways of describing the system do not capture its functional properties. Unfortunately, some have misrepresented the well-supported claim that selection creates functional organization as the obviously false claim that all traits of organisms are functional — something no sensible evolutionary biologist would ever maintain.

Furthermore, not all behavior engaged in by organisms is adaptive. A taste for sweet things may have been adaptive in ancestral environments in which nutrient-rich fruit was scarce, but it can generate maladaptive behavior in a modern environment flush with fast-food restaurants. Moreover, once an information-processing mechanism exists, it can be deployed in activities that are unrelated to its original function. For example, because we have evolved learning mechanisms that cause language acquisition, we can learn to write, which is the pairing of already learned words with arbitrary visual symbols. But these learning mechanisms were not chosen *because* they caused writing.

Design Evidence Adaptations are problem-solving machines, and they can be identified using the same standards of evidence that one would use to recognize a human-made machine: design evidence. One can identify a machine as a television set, not a stove, by finding evidence of complex functional design for that purpose — showing, for example, that the machine has many coordinated design features (for example, antennas, cathode ray tubes) that are complexly specialized for transducing television waves and transforming them into a color bit map (a configuration that is unlikely to have risen solely by chance), whereas the machine has virtually no design features that would make it good at cooking food.

Complex functional design is also the hallmark of living adaptive machines. One can identify an aspect of the phenotype as an adaptation by showing that (1) it has many design features that are complexly specialized for solving an adaptive problem; (2) the phenotypic properties are unlikely to have arisen by chance alone; and (3) they are not better explained as the by-product of mechanisms designed to solve some alternative adaptive problem. Finding that an architectural element solves an adaptive problem with reliability, efficiency, and economy is prima facie evidence that one has located an adaptation (Williams, 1966).

Design evidence is important not only for explaining why a known mechanism exists but also for discovering new mechanisms that no one had previously thought to look for. Theories of problems that our ancestors had to be able to solve — theories of adaptive function — play an important role in guiding the search for unknown mental characteristics and machinery.

Researchers who study species from an adaptationist perspective adopt the stance of an engineer. For example, in discussing sonar in bats, Dawkins (1986, pp. 21–22) says: "I shall begin by posing a problem that the living machine faces, then I shall consider possible solutions to the problem that a sensible engineer might consider; I shall finally come to the solution that nature has actually adopted." Engineers figure out what problems they want to solve and then design machines that are capable of solving the problems in an efficient manner. Evolutionary biologists figure out what adaptive problems a given species encountered during its evolutionary history and then ask, What would a machine capable of solving these problems well under ancestral conditions look like? Against this background, evolutionary biologists empirically explore the design features of the evolved machines that comprise an organism. Definitions of adaptive problems do not, of course, uniquely specify the design of the mechanisms that solve the problems.

Because there are often many ways of achieving any solution, empirical studies are needed to decide which mechanisms nature has actually adopted. The more precisely one can define an adaptive information-processing problem — the "goal" of processing — the more clearly one can see what a mechanism capable of producing that solution would have to look like. This research strategy has dominated the study of vision, for example, so that it is now commonplace to think of the visual system as a collection of functionally integrated computational devices, each specialized for solving a different problem in scene analysis, for judging depth, detecting motion, analyzing shape from shading, and so on. In our own research (discussed below), we have applied this strategy to the study of social reasoning.

Nature and Nurture — An Adaptationist Perspective

To fully understand the concept of design evidence, one must consider how an adaptationist thinks about nature and nurture. Debates about the relative contribution during development of nature and nurture have been among the most contentious in psychology. The premises that underlie these debates are flawed, yet they are so deeply entrenched that many people have difficulty seeing that there are other ways to think about these issues.

Evolutionary psychology is *not* just another swing of the nature-nurture pendulum. A defining characteristic of the field is the explicit rejection of the usual nature-nurture dichotomies — instinct versus reasoning, innate versus learned, biological versus cultural. What effect the environment has on an organism depends critically on the details of the evolved cognitive architecture of the organism. For this reason, coherent "environmentalist" theories of human behavior all, necessarily, make nativist claims about the exact form of evolved human psychological mechanisms. For evolutionary psychologists, the real scientific issues concern the design, nature, and number of the evolved mechanisms, not biology versus culture, genes versus learning, or other malformed oppositions.

Several different nature-nurture issues are usually conflated. It is useful to examine them separately because some are nonissues and others are real issues.

Focus on Architecture At a certain level of abstraction, every species has a universal, species-typical evolved architecture. For example, one can open any page of the medical textbook, *Gray's Anatomy*, and find the design of evolved architecture described down to the minutest detail — not only do all humans have a heart, two lungs, a stomach, intestines, and so on, but the book describes human anatomy to the particulars of specific nerve connections. This is not to say there is no biochemical individuality. No two stomachs are exactly alike — they vary in quantitative properties such as size, shape, and how much hydrochloric acid they produce. But all humans have stomachs, and all human stomachs have the same basic *functional* design — each is attached at one end to an esophagus and at the other to the small intestine; each secretes the same chemicals necessary for digestion; and so on. Presumably, the same is true of the brain and, hence, of the evolved architecture of our cognitive programs — of the information-processing mechanisms that generate behavior. Evolutionary psychology seeks to characterize the universal, species-typical architecture of these mechanisms.

Cognitive architecture, like all aspects of the phenotype from molars to memory circuits, is the joint product of genes and environment. But the development of architecture is buffered against both genetic and environmental insults so that it reliably develops across the ancestrally normal range of human environments. Evolutionary psychologists do not assume that genes play a more important role in development than the environment does or that innate factors are more important than learning. Instead, evolutionary psychologists reject these dichotomies as ill-conceived.

Evolutionary Psychology Is Not Behavior Genetics Behavior geneticists are interested in the extent to which *differences* between people in a given environment can be accounted for by *differences* in their genes. Evolutionary psychologists are interested in individual differences primarily insofar as the differences are the manifestation of an underlying architecture shared by all human beings. Because the genetic basis of complex adaptations is universal and species-typical, their heritability (of the eye, for example) is usually very low, not high. Moreover, sexual recombination constrains the design of genetic systems so that the genetic basis of any complex adaptation, such as a cognitive mechanism, *must* be effectively universal and virtually species-typical (Tooby and Cosmides, 1990b).

Thus, the genetic basis for human cognitive architecture is universal and creates a universal human nature that can be precisely characterized. The genetic shuffle of **meiosis** (in animals, sex-cell production) and sexual recombination can cause individuals to differ slightly in quantitative properties that do not disrupt the functioning of complex adaptations. But two individuals do not differ in personality or morphology because one has the genetic basis for a complex adaptation that the other lacks. The same principle applies to human populations — from this perspective, separate and distinct human races do not exist.

In fact, evolutionary psychology and behavior genetics are animated by two very different questions — evolutionary psychology by, What is the universal evolved architecture that we all share by virtue of being humans? and behavorial genetics by, Given a large population of people in a *specific* environment, to what extent can *differences* between the people be accounted for by *differences* in their genes? The second question is usually answered by computing a heritability coefficient, for example, on the basis of studies of identical and fraternal twins. To the question, Which contributes more to nearsightedness, genes or environment? (an example of the second type of question), there is no fixed answer. The heritability of a trait can vary from one place to the next precisely because environments *do* affect development in interaction with genotype.

A *heritability coefficient* measures sources of *variance* in a *population*. For example, in a forest of oaks, to what extent are differences in height correlated with differences in sunlight, all else equal? The coefficient tells nothing about what caused the development of an *individual*. Suppose that 80% of the variance in height in a forest of oaks is caused by variation in the oaks' genes. This does not mean that the height of the oak tree in one's yard is 80% genetic. (Did genes contribute more to the oak's height than sunlight did? What percentage of the oak's height was caused by nitrogen in the soil? By rainfall? By the partial pressure of CO_2? What could any of these assertions mean?) When applied to an individual, such percentages are meaningless because all the factors are necessary for a tree to grow — remove any one, and the height is zero.

Joint Product of Genes and Environment Confusing individuals and populations has led many people to define the nature-nurture question in the following way: What is more important in determining an individual organism's phenotype, its genes or its *environment*?

A developmental biologist knows that this is a meaningless question. *Every aspect of an organism's phenotype is the joint product of its genes and its environment.* To ask which is more important is like asking, Which is more important in determining the area of a rectangle, the length or the width? or, Which is more important in causing a car to run, the engine or the gasoline? Genes *specify* how the environment can regulate the development of phenotypes; the specific details of the actual environment an individual organism encounters causes one or another of the regulatory outcomes to emerge.

Indeed, the developmental mechanisms of many organisms were *designed* by natural selection to produce different phenotypes in different environments. The fact that the environment controls the outcome is the product of natural selection having selected genes that create a particular developmental contingency between environment and outcome. For example, certain fish can change sex. Blue-headed wrasse live in social groups consisting of one male and many females. If the male dies, the largest female turns into a male. The wrasse are *designed* to change sex in response to a social cue — the presence or absence of a male.

With a causal map of a species' developmental mechanisms, one can change the phenotype that develops by changing its environment. Imagine planting one seed from an arrowleaf plant in water and a genetically identical seed on dry land. The one in water would develop wide leaves, and the one on land would develop narrow leaves. Responding to this dimension of environmental variation is part of the species' evolved design. But this result does not mean that any aspect of the environment can affect the leaf width of an arrowleaf plant. Reading poetry to it does not affect its leaf width. By the same token, it does not mean that it is easy to get the leaves to grow into any shape — short of using scissors, one cannot get the leaves to grow into the shape of the *Starship Enterprise*.

Unfortunately, people often have mystical ideas about genes and what they do. For example, people think that genes are the equivalent of what philosophers call *essences* — the hidden, unchangeable nature of something that inevitably gives rise to surface properties regardless of the environment in which the genes develop. But **genes** are simply regulatory elements, molecules that arrange their surrounding environment into an organism through an extraordinary long chain of causation, that can be disrupted or altered at any number of points. There is nothing magical about the process: DNA is transcribed into RNA; within cells, at the ribosomes, the RNA is translated into proteins — the enzymes that regulate development. There is no aspect of the phenotype that cannot be influenced by *some* environmental manipulation. It just depends on how ingenious or invasive one wants to be. If a human **zygote** (a fertilized human egg) is dropped into liquid nitrogen, it will not develop into an infant. If particles are shot at the zygote's ribosomes in just the right way, it may influence the way in which the RNA is translated into proteins. By continuing this process, one could, in principle, cause a human zygote to develop into a cactus or an armadillo. There is no magic inevitability here, only long chains of causality organized by natural selection to build functional structures within environments that resemble ancestral environments.

Present at Birth? Sometimes people think that to show that an aspect of the phenotype is part of our evolved architecture, one must show that it is present from birth, but this confuses an organism's initial state with its evolved architecture. Infants do not have teeth at birth — they develop teeth long after birth. Does this mean infants learn to have teeth or are teeth the result of socialization? What about breasts? Beards? One expects organisms to have mechanisms that are adapted to their particular life stage, such as the sea-squirt example discussed earlier — after all, the adaptive problems an infant faces are different from those that an adolescent faces. The human brain and mind matures along specific trajectories in all normal environments, and cognitive programs (such as the mechanism that causes romantic love) do not have to be present at birth to be part of our universal evolved architecture.

This misconception frequently leads to misguided arguments. For example, people think that if they can show that there is information in the culture that mirrors how people behave, *that* information is the cause of their behavior. Thus, if people see that men on television have trouble crying, they assume that their example is *causing* boys to be afraid to cry. This idea usually accompanies anthropological urban legends about hypothetical distant cultures in which practices were completely different. But which is cause and which is effect? Does the fact that men do not cry much on television teach boys to not cry, or does it merely reflect the way boys normally develop? In the absence of research on the particular topic, there is no way of knowing. (To understand this viewpoint, consider how easy it would be, by the normal logic of such arguments, to deduce that girls learn to have breasts: (1) breasts are absent at birth, (2) there is considerable peer pressure during adolescence to have breasts, (3) girls are bombarded with images of glamorous adult women with emphasis on breasts, (4) the whole culture reinforces the idea that women should have breasts, therefore, (5) adolescent girls learn to grow breasts.) In fact, an aspect of our evolved architecture can, in principle, mature at any point in the life cycle, and this applies to the cognitive programs of our brain just as much as it does to other aspects of our phenotype.

Is Domain-Specificity Politically Incorrect? Sometimes people favor the notion that everything is learned, by which they mean "learned via general-purpose circuits," because they think this idea supports democratic and egalitarian ideals. They think this view means that anyone can be anything. But the notion that anyone can be anything gets equal support, whether our circuits are specialized or general. When one talks about a species' evolved architecture, one is talking about something that is *universal* and *species-typical* — something all humans have, which is why the issue of specialization has nothing to do with democratic, egalitarian ideals — all humans have the same basic biological endowment, whether in the form of general-purpose mechanisms or special-purpose ones. If all humans have a special-purpose, language acquisition device, for example (see Chapter 6), all humans are on an equal footing when learning language, just as they would be if they learned language via general-purpose circuits.

Innate Is Not the Opposite of Learned For evolutionary psychologists, the issue is never learning versus innateness or learning versus instinct. The brain must have a certain kind of structure for learning to occur — after all, 3-pound bowls of oatmeal do not learn, but 3-pound brains do. To learn, there must be a mechanism that causes learning. Since learning cannot occur in the *absence* of a mechanism that causes it, the mechanism that causes learning must *itself* be unlearned, that is, innate. Certain learning mechanisms must therefore be aspects of evolved architecture that reliably develop across the kinds of environmental variations that humans normally encountered during their evolutionary history. Humans must, in a sense, have innate learning mechanisms or learning instincts. The interesting questions are, What are the unlearned programs? What are their design features, What is the structure of their procedures? Are they specialized for learning a particular kind of thing or are they designed to solve more general problems? These questions bring us back to Principle 4.

Specialized or General-Purpose? One of the few genuine nature-nurture issues concerns the extent to which a mechanism is specialized for producing a given outcome. Most nature-nurture dichotomies disappear when one understands more about developmental biology, but this one does not. For evolutionary psychologists, the important questions are, What is the *nature* of human universal, species-typical, evolved cognitive programs? and, What kind of circuits do humans *actually* have?

The debate about language acquisition brings the issue into sharp focus: Do the same hypothetical, general-purpose cognitive programs that cause children to learn (for example, to ride a bicycle) also cause children to learn language, or is language learning caused by programs that are specialized for performing the task? This question cannot be answered a priori. It is an empirical question, and the data collected so far suggest the latter (see Chapter 6; Pinker, 1994; and the chimpanzee language debate in Chapter 3).

For any given observed behavior, there are three possibilities: (1) the behavior is the product of general-purpose programs (if such exist), (2) the behavior is the product of cognitive programs that are specialized for producing that behavior, or (3) the behavior is a by-product of specialized cognitive programs that evolved to solve a different problem. (Writing, which is a recent cultural invention, is an example of the latter.)

More Nature Allows More Nurture There is not a zero-sum relationship between nature and nurture. For evolutionary psychologists, learning is not an explanation — it is a phenomenon *that requires explanation.* Learning is caused by cognitive mechanisms and to understand how learning occurs one needs to know the computational structure of the mechanisms that cause learning. The richer the architecture of the mechanisms, the more an organism is capable of learning: Toddlers can learn English but large-brained elephants or the family dog cannot because the cognitive architecture of humans contains mechanisms that are not present in that of elephants or dogs. Humans cannot learn to echolocate as well as bats, despite far larger brains, because humans lack circuits that are part of bat neural architecture. Furthermore, learning is not a unitary phenomenon. The mechanisms that cause the acquisition of grammar, for example, are different from the mechanisms that cause the acquisition of snake phobias. The same explanation can be applied to reasoning.

What Evolutionary Psychology Is Not For the reasons discussed above, evolutionary psychologists expect that the human mind contains a large number of information-processing devices that are domain-specific and functionally specialized. The proposed domain specificity of many of the devices separates evolutionary psychology from the approaches to psychology that assume the mind is composed of a small number of domain-general, content-independent, general-purpose mechanisms — the Standard Social Science Model.

The domain-specificity view also separates evolutionary psychology from the approaches to human behavioral evolution in which it is assumed (usually implicitly) that so-called *fitness-maximization* is a mentally (though not consciously) represented goal, and that the mind is composed of domain-general mechanisms that can figure out what counts as fitness-maximizing behavior in any environment — even evolutionarily new environments (Cosmides and Tooby, 1987; Tooby and Cosmides, 1990a; Symons, 1987, 1992). Most evolutionary psychologists acknowledge the multipurpose flexibility of human thought and action but believe it is caused by a cognitive architecture that contains a large number of evolved expert systems that can be combined in powerful ways.

Reasoning Instincts — An Example

In some of our research, we have been exploring the hypothesis that human cognitive architecture contains circuits specialized for reasoning about adaptive problems posed by the social world of human ancestors. In categorizing social interactions, there are two basic consequences humans can have on each other: *helping* or *hurting*, that is, bestowing benefits or inflicting costs. Some social behavior is unconditional, for example, one nurses an infant without asking the infant for a favor in return. But many social acts are conditionally delivered, which creates a selection pressure for cognitive designs that can detect and understand social conditionals reliably, precisely, and economically (Cosmides, 1985, 1989; Cosmides and Tooby, 1989, 1992). Two major categories of social conditionals are social exchange and threat — conditional helping and conditional hurting — carried out by individuals or groups on individuals or groups.

We (Cosmides and Tooby, 1992) initially focused on social exchange for four particular reasons:

1. Many aspects of the evolutionary theory of social exchange (sometimes called *cooperation*, *reciprocal altruism*, or *reciprocation*) are relatively well developed and unambiguous. Consequently, certain features of the functional logic of social exchange could be confidently relied on in constructing hypotheses about the structure of the information-processing procedures that this activity requires.

2. Complex adaptations are constructed in response to evolutionarily long-enduring problems. Situations involving social exchange have constituted a long-enduring selection pressure on the hominid line. Evidence from primatology and paleoanthropology suggests that human ancestors have engaged in social exchange for at least several million years.

3. Social exchange appears to be an ancient, pervasive, and central part of human social life. The universality of a behavioral phenotype is not a *sufficient* condition for claiming that it was produced by a cognitive adaptation, but it is suggestive. As a behavioral phenotype, social exchange is as ubiquitous as the human heartbeat. The heartbeat is universal because the organ that generates it is the same everywhere. This is also a parsimonious explanation for the universality of social exchange: The cognitive phenotype of the organ that generates it is the same everywhere. Like the heart, its development does not seem to require environmental conditions (social or otherwise) that are idiosyncratic or culturally contingent.

4. Theories about reasoning and rationality have played a central role in both cognitive science and the social sciences. Research in this area can, as a result, serve as a powerful test of the central assumption of the Standard Social Science Model: that the evolved architecture of the mind consists solely or predominantly of a small number of content-independent, general-purpose mechanisms.

The evolutionary analysis of social exchange parallels the economist's concept of trade. Sometimes known as reciprocal altruism, social exchange is an "I'll scratch your back if you scratch mine" principle. Economists and evolutionary biologists had already explored constraints on the emergence or evolution of social exchange using game theory, modeling it as a repeated set of interactions known as the *Prisoners' Dilemma*. One important conclusion was that social exchange cannot evolve in a species or be stably sustained in a social group unless the cognitive machinery of the participants allows a potential cooperator to detect individuals who cheat, so that they can be excluded from future interactions in which they would exploit cooperators (Axelrod, 1984; Axelrod and Hamilton, 1981; Boyd, 1988; Trivers, 1971; Williams, 1966). In this context, a cheater is an individual who accepts a benefit without satisfying the requirements on which provision of the benefit was made contingent.

Such analyses provided a well-formulated basis for generating detailed hypotheses about reasoning procedures that, because of their domain-specialized structure, would be well designed for detecting social conditionals, interpreting their meaning, and successfully solving the inference problems they pose. In the case of social exchange, for example, the procedures led us to hypothesize that the evolved architecture of the human mind included inference procedures that are specialized for detecting cheaters.

To test this hypothesis, we used an experimental paradigm called the **Wason selection task** (Wason, 1966; Wason and Johnson-Laird, 1972). For about 20 years, psychologists had been using this paradigm (originally developed as a test of logical reasoning) to probe the structure of human reasoning mechanisms. In this task, the subject is asked to look for violations of a conditional rule of the form: *If P then Q*.

Consider the Wason selection task presented in Figure 4.3. From a logical point of view, the rule has been violated whenever someone goes to Boston without taking the subway. Hence, the logically correct answer is to turn over the *Boston* card (to see whether the person took the subway) and the *cab* card (to see whether the person taking the cab went to Boston). More generally, for a rule of the form *If P then Q*, one should turn over the cards that represent the values *P* and *not-Q* (to see why, consult Figure 4.2).

If the human mind develops reasoning procedures specialized for detecting logical violations of conditional rules, the answer would be intuitively obvious. But it is not. In general, fewer than 25% of subjects tested spontaneously make this response. Moreover, even formal training in logical reasoning does little to boost performance on descriptive rules of this kind (Cheng et al., 1986; Wason and Johnson-Laird, 1972). Indeed, a large literature exists showing that people are not very good at detecting logical violations of if-then rules in Wason selection tasks, *even when the rules deal with familiar content drawn from everyday life* (Manktelow and Evans, 1979; Wason, 1983).

The Wason selection task provided an ideal tool for testing hypotheses about reasoning specializations designed to operate on social conditionals, such as social exchanges, threats, permissions, obligations, and so on, because (1) it tests reasoning about conditional rules, (2) the task structure remains constant even if the content of the rule is changed, (3) content effects are easily elicited, and (4) a body of existing experimental results already existed, against which performance on new content domains could be compared.

For example, to show that people who ordinarily cannot detect violations of conditional rules can do so when the violation represents cheating on a social contract would constitute initial support for the view that people have cognitive adaptations specialized for detecting cheaters in situations of social exchange. To find that violations of conditional rules are spontaneously detected when they represent bluffing on a threat would, for similar reasons, support the view that people have reasoning procedures specialized for analyzing threats. Our general research plan has been to use subjects' inability to spontaneously detect violations of conditionals expressing a wide variety of contents as a comparative baseline against which to detect the presence of performance-boosting reasoning specializations. By seeing what content-manipulations switch on or off high performance, the boundaries of the domains within which reasoning specializations successfully operate can be mapped.

The results of these investigations were striking. People who ordinarily cannot detect violations of if-then rules can do so easily and accurately when the violation represents cheating in a situation of social exchange (Cosmides, 1985, 1989; Cosmides and Tooby, 1989; 1992). This is a situation in which one is entitled to a benefit only if one has fulfilled a requirement, for example, "If you are to eat those cookies, you must first

FIGURE 4.3

A Wason selection task. The rule expresses familiar terms and relations drawn from everyday life.

Part of your new job for the City of Cambridge is to study the demographics of transportation. You read a previously done report on the habits of Cambridge residents that says: **"If a person goes into Boston, then that person takes the subway."**

The cards below have information about four Cambridge residents. Each card represents one person. One side of a card tells where a person went, and the other side of the card tells how that person got there. Indicate only those card(s) you definitely need to turn over **to see if any of these people violate this rule.**

Boston	Arlington	subway	cab

fix your bed"; "If a man eats cassava root, he must have a tattoo on his chest"; or, more generally, "If you take benefit X, you must satisfy requirement Y." Cheating is accepting the benefit specified without satisfying the condition on which provision of the benefit was made contingent (for example, eating the cookies without having first fixed your bed).

When asked to look for violations of social contracts of this kind, the adaptively correct answer is immediately obvious to almost all subjects, who commonly experience a "pop out" effect. No formal training is needed. Whenever the content of a problem asks subjects to look for cheaters in a social exchange — even when the situation described is culturally unfamiliar and even bizarre — subjects experience the problem as simple to solve, and their performance jumps dramatically. In general, 65% to 80% of subjects solve the problem, the highest performance ever found for a task of this kind. They choose the "benefit accepted" card (for example, "ate cassava root") and the "cost not paid" card (for example, "no tattoo"), for any social conditional that can be interpreted as a social contract and in which looking for violations can be interpreted as looking for cheaters.

From a domain-general, formal view, investigating men eating cassava root and men without tattoos is logically equivalent to investigating people going to Boston and people taking cabs. But everywhere this reasoning ability has been tested (adults in the United States, United Kingdom, Germany, Italy, France, Hong Kong, schoolchildren in Ecuador, Shiwiar hunter-horticulturalists in the Ecuadorian Amazon), people do not treat social-exchange problems as equivalent to other kinds of reasoning problems. Their minds distinguish social-exchange contents and reason as if they were translating the situations into representational primitives such as "benefit," "cost," "obligation," "entitlement," "intentional," and "agent." Indeed, the relevant inference procedures are not activated unless the subject has represented the situation as one in which one is entitled to a benefit only if one has satisfied a requirement.

Moreover, the procedures activated by social-contract rules do not behave as if they were designed to detect *logical* violations *per se*; instead, they prompt choices that track what would be useful for detecting cheaters, regardless of whether this happens to correspond to the logically correct selections. For example, by switching the order of requirement and benefit within the if-then structure of the rule, one can elicit responses that are functionally correct from the point of view of cheater detection but are logically incorrect (Figure 4.4). Subjects choose the *benefit accepted* card and the *cost not paid* card — the adaptively correct response if one is looking for cheaters — *no matter what logical category the cards correspond to.*

To show that an aspect of the phenotype is an adaptation, one needs to demonstrate a fit between form and function: One needs **design evidence**. There are now a number of experiments comparing performance on Wason selection tasks in which the conditional rule either did or did not express a social contract. These experiments have provided evidence for a series of domain-specific effects predicted by our analysis of the adaptive problems that arise in social exchange. Social contracts activate content-*dependent* rules of inference that appear to be complexly specialized for processing information about this domain. Indeed, they include subroutines that are specialized for solving a particular problem within that domain: cheater detection.

The programs involved do not operate so as to detect potential altruists (individuals who pay costs but do not take benefits). They are not activated in social-contract situations in which errors would correspond to innocent mistakes rather than to intentional cheating. And they are not designed to solve problems drawn from domains other than social exchange — for example, they do not allow one to detect bluffs and double crosses in situations of threat, nor do they allow one to detect when a safety rule has been violated. The pattern of results elicited by social-exchange content is so distinctive that we believe reasoning in this domain is governed by computational units that are domain-specific and functionally distinct, what we have called **social contract algorithms** (Cosmides, 1985, 1989; Cosmides and Tooby, 1992).

There is, in other words, design evidence. The programs that cause reasoning in this domain have many coordinated features that are complexly specialized in precisely the

Consider the following rule:

Standard version: *If you take the benefit, then you pay the cost* (e.g., "If I give you $10, then you give me your watch.")
If P then Q
Switched version: *If you pay the cost, then you take the benefit* (e.g., "If you give me your watch, then I'll give you $10.")

	Benefit Accepted	Benefit Not Accepted	Cost Paid	Cost Not Paid
Standard:	*P*	*not-P*	*Q*	*not-Q*
Switched:	*Q*	*not-Q*	*P*	*not-P*

FIGURE 4.4

Generic structure of a social contract. The standard and switched versions express the same social contract. In solving such tasks, subjects choose the *benefit accepted* card and the *cost not paid* card, regardless of which logical category these correspond to. On a *switched* social contract, the choices correspond to the logical categories *Q* and *not-P*. This is the correct answer if one is looking for cheaters, but it is logically incorrect. The logically correct answer is to choose *P* and *not-Q*, no matter what they stand for. But choosing the *cost paid* card (*P*) and the *benefit not accepted* card (*not-Q*) on a switched social contract does not allow one to detect cheaters.

TABLE 4.1

Computational Machinery That Governs Reasoning About Social Contracts

Design Features

1. Machinery includes inference procedures specialized for detecting cheaters
2. Cheater detection procedures cannot detect violations that do correspond to cheating (for example, mistakes in which no one profits from the violation)
3. Machinery operates in situations that are unfamiliar and culturally alien
4. Definition of cheating varies lawfully as a function of one's perspective
5. Machinery is as good at computing the cost-benefit representation of a social contract from the perspective of one party as from the perspective of another
6. Machinery cannot detect cheaters unless the rule has been assigned the cost-benefit representation of a social contract
7. Machinery translates the surface content of situations involving the contingent provision of benefits into representational primitives (for example, benefit, cost, obligation, entitlement, intentional, and agent)
8. Machinery imports conceptual primitives even when they are absent from surface content
9. Machinery derives implications specified by the computational theory even when they are not valid inferences of the propositional calculus (for example, "If you take the benefit, you are obligated to pay the cost" implies "If you paid the cost, you are entitled to take the benefit")
10. Machinery does not include procedures specialized for detecting altruists (individuals who have paid costs but refused to accept the benefits to which they are therefore entitled)
11. Machinery cannot solve problems drawn from other domains (for example, does not allow one to detect bluffs and double crosses in situations of threat)
12. Machinery appears to be neurologically isolable from more general reasoning abilities (for example, it is unimpaired in schizophrenic patients who show other reasoning deficits)
13. Machinery appears to operate across a wide variety of cultures (including an indigenous population of hunter-horticulturalists in the Ecuadorian Amazon)

Alternative Hypotheses Eliminated

1. Familiarity can explain social contract effect
2. Social contract content merely activates rules of inference of propositional calculus
3. Social contract content merely promotes (for whatever reason) clear thinking
4. Permission schema theory can explain social contract effect
5. Any problem involving payoffs elicits the detection of violations
6. Content-independent deontic logic can explain social contract effect

Source: Adapted from Cosmides and Tooby, 1992.

ways one would expect if they had been designed by a computer engineer to make inferences about social exchange reliably and efficiently. They are configurations that are unlikely to have arisen solely by chance. Some design features are listed in Table 4.1, as are a number of by-product hypotheses that have been empirically eliminated (Cosmides and Tooby, 1989, 1992; Cosmides, 1985, 1989; Fiddick et al., 1995; Gigerenzer and Hug, 1992; Maljkovic, 1987; Platt and Griggs, 1993; Sugiyama et al., 1995).

The focus of evolutionary psychologists on adaptive problems that arose in our evolutionary past has led evolutionary psychologists to apply the concepts and methods of the cognitive sciences to many nontraditional topics —cognitive processes that govern cooperation, sexual attraction, jealousy, parental love, food aversions, timing of pregnancy sickness, aesthetic preferences that govern appreciation of the natural environment, coalitional aggression, incest avoidance, disgust, foraging, and so on (Barkow et al., 1992). By illuminating the evolved cognitive programs that give rise to our natural competences, the research is allowing, for the first time, the systematic discovery and characterization of human nature. The process of mapping the cognitive programs has increasingly indicated that the most distinctive feature of humans as a species — high intelligence — is not the result of mechanisms designed for general problem-solving. Instead, human high intelligence appears to be contrived from a tapestry of modules, each with a different kind of structured problem-solving expertise, which in interactive combination endow people with a zoologically unprecedented ability to analyze, understand, and solve problems.

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