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Behavioral Science and the Cause-Effect Trap

The cognitive and biological sciences have discovered a lot about vision and motor control, but these discoveries are limited to mechanisms. No one even thinks of asking why a person looks at a sunset or reaches for a banana, and how such decisions are made. The same is true of language. A modern generative grammar seeks to determine the mechanisms that underlie the fact that the sentence I am now producing has the form and meaning it does, but has nothing to say about how I chose to form it, or why.

—Noam Chomsky (1996, pp. 9–10)

The scientific investigation of animate behavior began just about 120 years ago, using the founding of Wilhelm Wundt's psychological laboratory in 1879 as its date of birth. That is a short period of time compared with the other well-established sciences such as chemistry, physics, and even biology. Yet the science of animate behavior is arguably more complex than these older sciences. So it should not be too surprising that behavioral science has not had significant breakthroughs comparable with those of other sciences, such as the periodic table in chemistry, quantum theory in physics, or cracking the genetic code in biology.

But just such a breakthrough may now be within view as a small but growing group of behavioral scientists have started to explore the behavioral implications of Darwin, and a still smaller but also growing group has begun to take into consideration the implications of Bernard for understanding behavior. Indeed, for the first time we now have within our grasp a fundamental materialist understanding of the what, how, and why of animate behavior.

To a reader not well acquainted with the academic and professional literature in psychology and cognitive science, the synthesis provided here might well appear reasonable and uncontroversial. Of course a living organism controls aspects of its physical surroundings. If it did not, it would not be able to survive and reproduce in an uncaring and often hostile world. Clearly, its behavior is purposeful, whether or not the organism itself is consciously aware of its purposes. Its evolutionary past provides important clues as to what aspects of its environment it controls, and why and how it does so. And even the use of purposeful within-organism variation and selection by living organisms to solve problems for which biological evolution could not have prepared them in advance might seem a reasonable hypothesis, especially when growing evidence such as that reported in chapter 9 is considered. But, as noted throughout the previous chapters, this Bernardian and Darwinian view of behavior is not widely accepted among behavioral scientists for whom the one-way cause-effect perspective continues to dominate theory and research.

We will see in this chapter just how pervasive and dominant this simple cause-effect perspective remains. This will be accomplished by surveying several of this century's most cited and influential behavioral scientists and theorists and showing how their theories of behavior are in one way or another fundamentally incompatible with insights that originated with Bernard and Darwin. We will see that each of these individuals has either ignored or rejected one of the three lessons that biology has for behavioral science that were described at the beginning of the previous chapter, namely, the basic Darwinian, extended Darwinian, and extended Bernardian lessons.

Rejecting the Three Lessons: From Piaget to Pinker

Piaget's Disdain of Darwin

With the possible exception of Sigmund Freud, no twentieth-century European psychologist is better known and has had more impact on psychology than Jean Piaget (1896–1980). Prolific in research and writing from the age of ten until shortly before his death (with more than thirty books published as author or co-author), Piaget began his career as a biologist specializing in mollusks, like the snails inhabiting the lakes of his native Switzerland. But a job in Paris administering intelligence tests to children sparked a life-long interest in the development of human mental abilities and knowledge. He called this study "genetic epistemology," with *genetic* referring not to the genome but rather to a concept of the development of thought as internally guided cognitive growth.

Piaget employed a mélange of in-depth questioning and ingenious experiments to probe the perceptual and thought processes of young children, discovering that they are different not only in degree from that of adults, but in kind. He also concluded that each child goes through an invariant series of cognitive stages, each stage requiring a major overhaul of the preceding one. For example, from the perspective of a young infant an object exists only if it can be presently seen, felt, heard, or smelled. At this age, removing a desired object from the child's senses usually results in the infant abandoning all efforts to find and obtain it. But the child soon develops "object permanence," so that she is now able to seek and find objects that were hidden while she was watching. From a Piagetian perspective, the child is like a little scientist who is constantly developing and testing new theories about the world, rejecting old theories when a new one is discovered that is better at making sense of the world and meeting her needs.

It might be expected that Piaget's early training as a biologist, combined with his interest in the development of human cognitive abilities, would lead him to embrace the basic and extended Darwinian lessons of biology for psychology. Au contraire, his disdain of Darwinian ideas was such that he rejected natural selection as accounting for biological evolution. In the year that he received his *doctorat* in natural sciences he wrote (1918/1976, p. 40):

> But natural selection cannot explain evolution. . . . The heredity of acquired traits is an experimental fact. . . . Hachet Souplet, by training cats, formed habits that were transmitted to later generations. . . . We can then decide in favor of Lamarckism without any qualms, without excluding natural selection as a secondary or accidental factor.

Fifty-eight years later, when Lamarckian evolution had been thoroughly discounted and evolution by Darwinian natural selection had become the central pillar of biology, Piaget remained unimpressed (1976; quoted in Vidal, Buscaglia, & Vonèche 1983, p. 87):

> Either chance and selection can explain everything or else behavior is the motor of evolution. The choice is between an alarming waste in the shape of multitudinous

and fruitless trials preceding any success no matter how modest, and a dynamics with an internal logic deriving from those general characteristics of organization and self-regulation peculiar to all living beings.

And yet while he rejected Darwin's theory of evolution, he did, if unwittingly, make use of Darwinian ideas. For example, in discussing instinctive behavior, the following passage is one that could have been written today by an ethologist, sociobiologist, evolutionary psychologist, or behavioral ecologist (1967/1976, p. 844):

Instinct is always at the service of the three fundamental needs of food, protection against enemies, and reproduction. If, with migration or various modes of social organization, instinct seems to pursue secondary ends, they are only secondary as being interests grafted onto the three main ones and still dependent upon them, so that in the last resort they are subordinated to the survival of the species and, as far as possible of the individual.

The major themes of Piaget's theory of cognitive development can also be understood from a Darwinian perspective. He stated that the two major ways in which children (as well as adults) interact with their world are through assimilation and accommodation. Assimilation refers to incorporation of sensory experience into a preexisting thought structure called a schema. For example, a child having seen sparrows and robins and able to recognize them as members of the category *bird* would likely include the first blackbird she sees in this same category. She might also attempt to assimilate the first observed butterfly into her bird schema since it shares certain similarities with other members of this category. However, calling a butterfly a bird would likely result in a correction by an adult or older child, "That's not a bird, it's a butterfly!" This would lead to accommodation of the child's thought so that butterflies and birds would be treated as different concepts, each with its own label and distinguishing characteristics. Assimilation thus is a process that involves the adjustment of perceptions to fit already developed knowledge, whereas accommodation involves modification of previously existing knowledge to fit new perceptions better.

But a parent cannot simply transmit the meanings of new words to a child. Instead, the child can only know that some sort of error has been made and that, according to her parent, the current object in view is not a bird but a butterfly. The parent's remark does not tell the child *why* it is a butterfly and not a bird. Is it because it is yellow and the other flying creatures she has seen are brown and black (but then what of canaries?)? Is it because it stops to sip nectar from flowers, while the other flying animals do not (but then what of hummingbirds?)? Or is it because the child has only seen birds in the afternoon, and it is now morning (but then what of the bird that gets the worm?)? Clearly, the child must make some sort of guess as to how to modify her bird schema and create a new butterfly one. This guess may well be initially wrong, but by continuing to generate and test additional hypotheses, she will eventually come to the notions of bird and butterfly that are shared by the adults of her speech community. Such necessary cumulative variation and selection (or trial and error elimination) is, of course, a form of within-organism selection, even if Piaget did not recognize it as such.

But why should a child even bother to change her way of thinking or using language to bring it closer in line with how others around her think and speak? Why should it bother her if what she calls a bird others call a butterfly? Why should she care if, when a ball of clay is rolled and stretched into a skinny sausage, she sees the sausage as containing more clay than it did as a ball because it is longer? Surely, she must have certain basic developmental goals selected by evolution because of their usefulness for living in a physical environment that includes other humans. One of these is to use words the same way others use them so that she can both understand and be understood. Another is to have a consistent, noncontradictory understanding of the environment.

Piaget referred to this process of keeping mental schemas and perceptions consistent with each other as equilibration. Equilibration is a form of cognitive regulation or control in which the competing processes of assimilation and accommodation are used to achieve the goal of cognitive *coherence*. As he explained (1958/1976, p. 833):

> . . . it must be stressed that the equilibration process which thus constitutes an intrinsic characteristic corresponds, in living beings, to specific needs, tendencies, or functions and not merely to an automatic balance independent of the activities of the subject. Thus, in the case of higher cognitive functions, there exists a tendency to equilibrium which manifests the need for coherence.

We see therefore that for Piaget, human cognitive development is driven by a basic human need for cognitive coherence, not by external environmental factors in the form of stimuli or rewards. He also recognized the circular nature of the causality required by his theory (1975/1976, pp. 840–841):

> In biological or cognitive equilibrium . . . we have a system in which all parts are interdependent. It is a system which could be represented in the form of a cycle. *A* has its influence on *B*, which has its influence on *C*, which has its influence on *D*, which again influences *A*. It is a cycle of iterations among the different elements. It also has a special feature of being open to influences from the outside.

But Piaget did not seem to have an accurate extended Bernardian understanding of animate behavior, stating that "It is true, of course, that stimuli give rise to responses" (1970/1972, p. 5), explaining that (1970/1972, pp. 5–6):

> The stimulus unleashes the response, and the possibility of response is necessary for the sensitivity to the stimulus. The relationship can also be described as circular which again poses the problem of equilibrium, an equilibrium between external information serving as the stimulus and the subject's schemes or internal structure of his activities.

Although Piaget used the word circular to describe the relationship between stimulus and response, he nonetheless appeared to be saying that stimuli lead to responses as mediated by the individual's internal cognitive structure. He did not recognize that it is not a stimulus that leads to response but rather the difference between the perceived stimulus (perception) and intended stimulus (reference level). Elsewhere, he referred to the process of self-regulation as providing "internal reinforcements" for behavior (quoted in Evans 1973, p. 67), further evidence for his misunderstanding of the nature of self-regulating feedback-control systems that do not "reward" specific actions but rather vary actions to control their perceptual inputs.

Despite Piaget's disdain of selectionist mechanisms and incomplete understanding of feedback-control systems, he does appear to have recognized to some degree the importance and power of combining Bernard with Darwin to derive a mechanism capable of a form of directed or purposeful evolution in changing old knowledge to fit new perceptions (that is, accommodation). This is indicated by his statement ". . . accommodation is carried out by gropings, and these are a prime example of feedbacks in which an action is corrected in terms of its results" (1967/1977, p. 847).

It is not surprising that a biologist turned developmental psychologist would find biological ideas of use in his psychological research and theorizing, and Piaget did just that. What is surprising is that while he drew on the lessons of Bernard and Darwin, he did so without recognizing their full importance.

His view of cognitive growth appears to recognize the goal-directed nature of development that can only be accounted for by a form of circular causality. But although his theory of cognitive development can certainly be seen from extended Bernardian and extended Darwinian perspectives, he never provided explicit working models as to how such development is goal-directed. Neither did he discuss the concept of an internally specified reference level and how it operates to maintain what he called cognitive equilibrium. He often pointed out how young children behave in a groping manner when learning skills and modifying their mental schemas to control aspects of their environment, but he provided no evidence of having understood animate behavior as the control of perception, or of having recognized the necessity of within-organism Darwinian selection for cognitive development.

Piaget was able to take some important preliminary steps leading out of the cause-effect trap, but he did not come close to escaping it completely.

Skinner's Skewed Selectionism

B. F. Skinner, introduced in chapter 3 and discussed further in chapter 7, remains one of the best-known psychologists of the twentieth century, and he certainly ranks as the most influential American psychologist of all time. His theory of radical behaviorism is no longer in vogue among psychologists and cognitive scientists, but his theory of behavior and how it is modified continues to be highly influential, especially among applied psychologists who attempt to change or otherwise control the behavior of other animals or people.

Skinner, unlike Piaget, had no qualms about accepting evolution by natural selection as the process responsible for life in all its varied forms. Nonetheless, he did not look to evolutionary theory for clues concerning animal and human behavior, and in this respect he rejected the basic Darwinian lesson. For him, evolution provided animals and humans with a general learning mechanism, namely, operant conditioning, by which behaviors were selected (or eliminated) as a result of their consequences for the organism. Thus an animal could be taught to do just about anything that was physically possible if reinforcement for the desired behavior was appropriately applied. That Skinner was not particularly concerned about behavioral differences among species, or even those between humans and animals, is indicated by the fact that he "conducted most of his research on animals and wrote most of his books about people" (Kohn 1993, p. 6). But we recognized in chapter 7, in discussing the phenomenon of instinctive drift, that different species clearly behave differently, and that an organism's evolutionary past plays an important role in influencing behavior and determining how and the extent to which the organism's behavior can be modified.

Although Skinner ignored the basic Darwinian lesson with respect to species-specific behavior, he was nonetheless keenly interested in extending the lesson to account for his theory of operant conditioning that involved spontaneous generation of behavior and its selection (or elimination) as determined by its consequences. But his exclusive concern with observable behavior led him astray. Since he denied the importance of internal mental events in accounting for behavior, he could not apply the extended Darwinian lesson to the variation and selection of mental processes or thought trials (Campbell's vicarious or substitute selection processes described in chapter 9).

As for the extended Bernardian lesson—animate behavior is the purposeful control of perception—Skinner rejected it outright. Chapter 3 described how he denied the central role of purpose in animate behavior, believing instead that "motives and purposes are at best the effects of reinforcements" (1974, p. 56). In other words, in keeping with the one-way cause-effect perspective, purposes were somehow caused by the environment rather than being generated from within the organism as a reference level or a standard for a perception. In keeping with his view that behavior is caused by environmental factors, he went so far as to even deny that he himself had feelings of personal involvement and purpose in his own work. He commented that after finishing his book *Beyond Freedom and Dignity*, "I had the very strange feeling that I hadn't even written the book. . . . [It] just naturally came out of my behavior not because of anything called a 'me' or an 'I' inside" (quoted in Kohn, 1993, p. 7).

Further evidence that he did not appreciate the importance of the extended Bernardian lesson is indicated by his serious misunderstanding of the operation of control systems, as shown in his discussion of the behavior of a "homing device" (1974, p. 56):

> Goals and purposes are confused in speaking of purpose in a homing device. A missile reaches its target when its course is appropriately controlled, in part by information coming from the target during its flight. Such a device is sometimes said to "have purpose built into it," but the feedback used in guidance (the heart of cybernetics) is not reinforcement, and the missile has no purpose in the present sense."

This statement may provide an important insight into Skinner's way of thinking about behavior, control, reinforcement, and purpose. By stating that "a missile reaches its target when its course is appropriately controlled, in part by information coming from the target during its flight," he sees the missile as an object being controlled by external factors, including the "information from the target," which is analogous to perceptual input in living organisms. He shows no recognition that the missile is actually varying its course as necessary to *control* its perception (or sensing) of the target. He then rejects the notion that such a control system "has purpose built into it," using the curiously circular reasoning that the negative feedback used by the system "is not reinforcement," and since purpose is always the result of reinforcement, the missile can have no purpose! Succumbing to the behavioral illusion of believing the missile's behavior is caused by environmental disturbances, he could not appreciate that such a homing device does in fact display purposeful behavior in varying its actions as necessary to reach its goal. This is exactly what it was designed to do, and in this respect the heat- (and therefore target-) seeking missile engages in purposeful behavior just like that of James's air-seeking frog and Shakespeare's Juliet-seeking Romeo.

Skinner's influence on behavioral science remains considerable. He was the principal influence in promoting a version of the behavioral illusion that can be described as the reinforcement illusion—the belief that an organism's behavior is controlled by environmental reinforcement. Although he is gone and his brand of behaviorism is not nearly as popular as it once was, the reinforcement illusion remains as one of the most influential and pernicious ideas from behavioral science, giving testament to the continued legacy of one-way cause-effect thinking as applied to animate behavior (see Kohn 1993).

Chomsky's Baseless Biologizing

Noam Chomsky not only revolutionized the study of language but also had a major impact on the cognitive and behavioral sciences. In his 1959 review of Skinner's book *Verbal Behavior*, he pointed out that just about every sentence a person produces is a novel combination of words that neither the speaker nor anyone else has ever uttered before. Therefore, language behavior cannot, as Skinner proposed, be the result of a fixed repertoire of utterances that were somehow reinforced in the past. Instead, language competence must be the result of a set of mental instructions or rules that permit the speaker to produce (and understand) an infinite number of novel sentences using the finite resources of the human brain. His convincing argument for a cognitive theory of human language helped to make it respectable once again to go beyond observable behavior and consider the types of mental knowledge and processes involved. For this achievement he is considered to be one of the founders of the cognitive revolution in psychology.

Chomsky also maintained that human language competence is essentially innate because every normal child rapidly develops competence in his native language without requiring formal instruction. Given the apparently large gap between what a child hears (the "poverty of the stimulus") and what he eventually comes to know about his language, such knowledge ("universal grammar") must be innate. The child uses experience only to guide him in deciding which variety of language is used in his environment.

Such an innatist view might lead one to expect Chomsky to accept a Darwinian account of the evolution of human language. But instead he has remained quite unimpressed by Darwinian accounts of evolution of any kind, saying (1988, p. 23):

> evolutionary theory appears to have very little to say about speciation, or about any kind of innovation. It can explain how you get a different distribution of qualities that are already present, but it does not say much about how new qualities emerge.

This is quite a remarkable statement, since it shows that one of the most influential intellectuals of our time appears blind to the basic Darwinian lesson of how, through the evolutionary process of cumulative variation and selection, innovations of all types are generated, tested, selected, and refined.

But there is probably a good (for Chomsky) reason why he rejects a Darwinian account of human language. Recall the "poverty of the stimulus" view that a child's language knowledge must be innate since there is no way that a child could attain complete knowledge of his language based solely on what he hears spoken. But the very notion of a stimulus implies a one-way cause-effect view of learning in which what the child hears somehow transmits knowledge of the language. This is made quite clear when he states (1997, p. 13):

> Evidently each language is a result of the interplay of two factors. One of them is whatever the genetically determined initial state is, and the second is the course of experience. We can rephrase that observation without changing anything by thinking of the initial state of the language faculty as a kind of device which operates on experience and turns it into the language that is attained, which we can think of as being just a state of the language faculty. Looked at that way, which just rephrases the observation, the initial state of the language faculty you can think of as kind of an input/output device, the kind one knows how to study: an input/output device where the input is the course of experience, and the output is the language obtained, that is, the state of the language faculty obtained.

If Chomsky were to recognize that language is an adaptive human ability and that the only reasonable nonmiraculous explanation for its emergence is a Darwinian one, he would have to confront the possibility that a process of learning involving within-organism variation and selection (the extended Darwinian lesson) might make it possible for the child to acquire language in a creative, evolutionary manner without the need for an innate universal grammar. So from this perspective it is not surprising that he rejects both the basic and extended Darwinian lessons. But it does put him in the rather odd position of advocating an innate biological basis for human language while rejecting the only understood process by which it could have evolved.

What about the extended Bernardian lesson? Whereas Chomsky indicated in his review of Skinner (1959, p. 554) that he believes people's wants, likes, and wishes have an influence on behavior, he has provided no theory to explain how these factors operate. In fact, he has always insisted that the study of the structure of human language (syntax) has little to do with the meaning (semantics) and communicative use of language. In all of his prolific writing about language that revolutionized the field of linguistics, he never recognized human language as an important form of purposeful behavior or one of the most powerful tools our species has developed for controlling our environment. He has not only restricted his own linguistic research to investigation of the formal structural properties of language (syntax), but as shown in the opening quotation of this chapter, he believes that explanations for questions concerning the why of human behavior are simply outside the realms of science.

Chomsky should then be surprised to learn that at least some behavioral scientists *are* asking why (and how and what) questions concerning animal and human behavior and answering such questions using Darwinian- and Bernardian-inspired explanations. It cannot be denied that Chomsky has made important contributions to our understanding of the structural aspects of language. But the next revolution in the science of human language will have to await someone of his intellectual powers who recognizes the evolutionary (Darwinian) nature of language's origin and acquisition, the purposeful (Bernardian) nature of its use, and the control-system mechanisms that account for the latter.

Dennett's Dangerous Darwinism

Daniel Dennett, director of the Center for Cognitive Studies at Tufts University near Boston, may well be the most widely read philosopher alive today. His 1991 book *Consciousness Explained* sold over 200,000 copies, an amazing number for a book written by a philosopher about the nature of human consciousness and related puzzling phenomena of the human mind. This was followed in 1995 by *Darwin's Dangerous Idea*, in which the theory of natural selection was explained, defended, and applied to a wide range of phenomena, many of them outside the bounds of biological evolution.

Dennett finds Darwin's theory to be not only dangerous since it demolishes many of our traditional beliefs about the origin and meaning of life, but also fascinating and extremely useful for explaining instances of apparent design. Darwin's idea is a "universal solvent, capable of cutting right to the heart of everything in sight" (1995, p. 521).

Dennett also recognizes that our evolutionary past played an important role in shaping the types of behaviors and mental characteristics that we share as a species, although he is cautious about attributing to evolution what is more likely the result of cultural and other environmental influences. He clearly has learned the basic Darwinian lesson that biology has to offer behavioral and cognitive science.

But Dennett goes further with this dangerous idea than most cognitive scientists, behavioral scientists, and philosophers would care or dare to go by seeing in Darwinian natural selection a model for the actual operation of the human brain. He refers to humans as "Popperian creatures" (1995, p. 375) since we can generate varied thoughts and hypothesis and test them mentally using within-organism selection. He might just as well have used the descriptor "Campbellian creatures" since his view of cognitive problem solving is similar to that of Donald T. Campbell, who (as discussed in chapter 9) considered human creative thought and problem solving to involve variation and selective retention. (It is curious that Dennett makes no reference to Campbell's important works that describe human thought as a Darwinian process.) So Dennett is clearly mindful of the extended Darwinian lesson and remains perhaps the best-known living philosopher to appreciate the importance and power of within-organism cognitive selection.

Dennett appears to have learned at least a part of the extended Bernardian lesson, too. He realizes that there is something special about systems that act as "agents" having goals they pursue and achieve by their actions. He refers to these as "intentional systems" and defines them thus (1996, p. 34):

> *Intentional systems* are, by definition, all and only those entities whose behavior is predictable/explicable from the intentional stance. Self-replicating macromolecules, thermostats, amoebas, plants, rats, bats, people, and chess-playing computers are all intentional systems—some much more interesting than others.

But this smacks of circularity since it defines an intentional system as one whose behavior appears to be intentional! Better would be to define an intentional system as one whose actions serve to control some aspect of its environment, varying its behavior as necessary in the face of disturbances. But it does not appear that Dennett fully appreciates that an intentional system (what we have been calling a control system) uses circular causality to control its inputs by varying its behavior, and that consequently the purposeful (intentional) behavior of living organisms can be understood as the control of perception.

So although he appears to have some appreciation of the extended Bernardian lesson, Dennett makes no mention of its most important modern applications, such as those provided by William Powers (see chapter 6). Neither in *Darwin's Dangerous Idea* nor in *Kinds of Mind* (1996) does he make explicit mention of Bernard, cybernetics, feedback control, control theory, or perceptual control theory to account for the purposeful behavior of his intentional agents.

Nonetheless, among all the individuals reviewed in this chapter, Dennett comes closest to fully recognizing the lessons of biology for behavioral and cognitive science. The basic and extended Darwinian lessons he has both learned well and taught to many others through his lectures and his writings. And he at least partly appreciates the extended Bernardian lesson. When he fully appreciates it, Dennett will see that Bernard's big idea ranks with Darwin's dangerous one in importance for understanding the behavior of living organisms.

Picking on Pinker

Steven Pinker, director of the Center for Cognitive Neuroscience at the Massachusetts Institute of Technology, is one of today's most influential and popular cognitive scientists (for an informative profile of Pinker, see Hayashi 1999). His first book for general readers, *The Language Instinct* (1994), offered a scientific yet entertaining account of the wonders of human language and became a best seller. In its sequel with the bold title *How the Mind Works* (1997), he attempted to describe the workings of the human mind as physical processes occurring within the brain, a brain whose design can be understood only by taking into account its evolutionary past.

It is clear from *How the Mind Works* that Pinker has embraced the basic Darwinian lesson that our fundamental goals, preferences, and mental abilities—including human language—were shaped by natural selection. In this respect he differs from his MIT colleague Chomsky who, we noted, rejects the basic Darwinian lesson as it applies to human language. His paper written with Paul Bloom, "Natural language and natural selection" (1990), is a thorough and convincing argument for a Darwinian view.

In chapters 5 through 8 of *How the Mind Works,* Pinker moves beyond language matters and tackles many issues in evolutionary psychology using his characteristically engaging and entertaining style. That a recent book about the mind by a leading cognitive scientist should devote so many pages to evolution and its role in shaping human cognition and behavior is a hopeful sign that the basic Darwinian lesson will finally be accepted by many mainstream behavioral and cognitive scientists. But what about the other lessons—the extended Darwinian and extended Bernardian lessons—that biology has to offer these fields of study?

Being such a knowledgeable and influential proponent of the basic Darwinian lesson, we might well expect Pinker to embrace or at least give fair consideration to the extended Darwinian lesson. After all, if the process of cumulative variation and selection among organisms can produce such marvelously adapted creatures (such as ourselves) and organs (such as our eyes and brains), we might expect a similar process to be used within organisms to adapt to changing conditions for which biological evolution could not have prepared them.

Surprisingly, Pinker completely ignores the considerable theorizing and research on selectionist processes within the brain as summarized in chapter 9, and this despite numerous references throughout his book to Dennett, who is an important proponent of the extended Darwinian lesson. Instead, Pinker appears quite hostile to the notion that some form of cumulative variation and selection might be employed by human brains in the form of the variation and selection of synapses or ideas, or that cultural evolution (as in the development within societies of traditions, technology, or science) could also involve Darwinian processes.

For example, he dismisses the perspective offered by psychologists Elizabeth Bates and Brian MacWhinney, who "view the selectional processes operating during evolution and the selectional processes operating during [learning] as part of one seamless natural fabric" (quoted in Pinker 1997, p. 206). "The implication," Pinker commented, "is that there is no need for specialized mental machinery" (1997, p. 206). But why does the existence of Darwinian mental processes imply no need for specialized mental machinery? The types of variations produced, the mechanism by which they are produced, and the criteria and mechanisms for selection and retention would most certainly be different (and involve different parts, or modules, of the brain) for different types of learning, such as learning how to ice skate versus learning vocabulary in a foreign language. We know that our immune system uses variation and selection of lymphocyte cells to produce new antibodies, but this does not mean that selectionist brain processes must also employ lymphocytes! Pinker should be relieved to know that the extended Darwinian lesson is not incompatible with the modular view of the mind-brain that he and many other cognitive scientists embrace.

He concludes his chapter 4 with another argument against the extended Darwinian lesson, using the example of the stomach (1997, p. 210):

> The stomach is firmly grounded in biology, but it does not randomly secrete variants of acids and enzymes, retain the ones that break down food a bit, let them sexually recombine and reproduce, and so on for hundreds of thousands of meals. Natural selection already went through such trial and error in designing the stomach, and now the stomach is an efficient chemical processor, releasing the right acids and enzymes on cue.

But despite Pinker's straw-man argument, the extended Darwinian lesson does not tell us that all within-organism processes have to be Darwinian, only those that result in new solutions to new problems that our evolutionary ancestors did not confront (such as writing symphonies, breaking the genetic code, or ice skating). Through among-organism selection, biological evolution may have discovered some very useful processes, such as the production of digestive enzymes or the ability to see colors, that may be completely non-Darwinian in their current operation (see figure 9.3). But this does not mean that there are no within-organism Darwinian processes whatsoever. The obvious counterexample to Pinker's digestion example is once again the human immune system since it functions almost exactly as Pinker says the stomach does not, producing each day millions of new antigens by genetic recombination and mutation, selecting the ones that work best, and using them to generate still more novel antibodies over many generations. This within-organism Darwinian process allows the immune system to come up with adaptive solutions to the new problems posed by viruses and bacteria never encountered before. So whereas some mental processes may well be comparable with digestion in their directness, others are undoubtedly much more similar to antibody production, namely, those that we use to create new solutions to new problems. Pinker rightly exposes as a non sequitur the belief that the products of evolution have to look like evolution. But he counters with a non sequitur of his own that since *some* products of evolution do not look like evolution then *none* of them do.

But perhaps he is actually somewhat less hostile than even he realizes to the extended Darwinian lesson. In his discussion of creative geniuses such as Mozart, Einstein, and van Gogh, he made the following observations (1997, p. 361).

> Geniuses are wonks.
>
> [Geniuses] are either discriminating or lucky in their choice of problems. (The unlucky ones, however talented, aren't remembered as geniuses).
>
> They work day and night and leave us with many works of subgenius.
>
> Their interludes away from a problem are helpful . . . because they are exhausted and need the rest (and possibly so they can forget blind alleys).
>
> The epiphany is not a masterstroke but a tweaking of an earlier attempt.
>
> They revise endlessly, gradually closing in on their ideal.

Here Pinker is trying to get across the idea that geniuses are really not that different from more ordinary people like (probably) you and me. In doing so, he must emphasize the errorful, gradual, and groping nature of their achievements, coming quite close to what could be considered a selectionist, extended Darwinian account of creativity, not unlike that considered in chapter 9.

Turning to the extended Bernardian lesson, it is interesting that in chapter 2 of his book, Pinker uses the same passage from William James quoted in chapter 3 of this book, about Romeo wanting to put his lips on those of Juliet and his circumventing all obstacles to do so. He follows this quotation with the statement that "intelligence . . . is the ability to attain goals in the face of obstacles" (1997, p. 62). This certainly appears to be preparing the stage for the extended Bernardian lesson.

But nowhere in his book does he describe a model that can account for the very type of purposeful behavior that he takes as an indispensable indication of intelligence. He makes no mention of feedback control, cybernetics, Wiener, or control systems. No discussion of how a mechanical system (which he adamantly insists the brain is) can be designed to possess a goal and continuously act on the world so that its perceptions match the internally specified reference level that contitutes the goal. No explanation of how an organism's purposeful behavior serves to control perception. Pinker's ignorance, avoidance, or rejection of such concepts pushes him perilously close to embracing a dualist mind-body philosophy (1997, p. 315):

> Goals and values are one of the vocabularies in which we mentally couch our experiences. They cannot be built out of simpler concepts from our physical knowledge in the way "momentum" can be built out of mass and velocity or "power" can be built out of energy and time. They are primitive or irreducible, and higher-level concepts are defined in terms of them.

It's enough to make one wonder if Pinker ever used a thermostat or drove a car with cruise control.

One of the major themes in *How the Mind Works* is that the brain is a computing device, orders of magnitude more complex than any electronic computer yet created, but a computing device nonetheless. So how does the brain get involved in behavior? According to Pinker, not by using the means at its disposal (such as muscles attached to bones) to manage its environment by controlling the perceptions provided by its sensory systems, but rather by using inputs to control its outputs, the interpretation of behavior based on one-way causality. This is especially clear in the most detailed example he provides of behavior (1997, pp. 11–12):

> Controlling an arm presents a new challenge. Grab the shade of an architect's lamp and move it along a straight diagonal path from near you, low on the left, to far from you, high on the right. Look at the rods and hinges as the lamp moves. Though the shade proceeds along a straight line, each rod swings through a complicated arc, swooping rapidly at times, remaining almost stationary at other times, sometime reversing from a bending to a straightening motion. Now imagine having to do it in reverse: without looking at the shade, you must choreograph the sequence of twists around each joint that would send the shade along a straight path. The trigonometry is frightfully complicated. But your arm is an architect's lamp, and your brain effortlessly solves the equations everytime you point. And if you have ever held an architect's lamp by its clamp, you will appreciate that the problem is even harder than what I have described. The lamp flails under its weight as if it had a mind of its own; so would your arm if your brain did not compensate for its weight, solving a near-intractable physics problem.

Pinker's later mention of inverse kinematics and inverse dynamics (1997, p. 31) makes it clear that he views the brain's role in behavior as specifying outputs in the form of joint angles and muscle forces based on sensory inputs. But he might have had second thoughts about his analysis if he had paused to consider how the angles of the architect's lamp were computed. Of course, they were not computed at all, their resulting angles and velocities being determined automatically by simply moving the lamp to where you wanted it to be! This is basically how a control system analysis would account for how you are able to move your hand to where you want it to be, automatically compensating for the combined weight of hand and arm. And this is exactly what Powers's "Arm 1" demonstration does (described in chapter 6), using interconnected control systems to permit a robot to point to a target anywhere in reachable space (and even allowing the user to turn gravity on and off to see how the system so quickly and easily compensates). Pinker and others who may be skeptical that such seemingly complex behavior can be generated without having to solve a "near-intractable physics problem" required by the input-output Newtonian analysis of the behavior have only to download the program at *www.uiuc.edu/ph/www/g-cziko/twd* and run it on an IBM-compatible personal computer (even a slow, outdated 286 machine with no math coprocessor will suffice). Or simpler still, he can attempt to touch with his finger a small faintly glowing object in an otherwise completely darkened room (so that he cannot see his finger). He will then realize that without continuous visual feedback provided by seeing the target, his finger, and the space between them, the act of reaching for an object cannot be reliably performed.

But although he does not heed the extended Bernardian lesson, Pinker at least recognizes the importance of desires and beliefs (the latter we can understand as higher-level perceptions) in understanding human behavior (1997, pp. 63–64):

> In our daily lives we all predict and explain other people's behavior from what we think they know and what we think they want. Beliefs and desires are the explanatory tools of our own intuitive psychology, and intuitive psychology is still the most useful and complete science of behavior there is. . . . It is not that common sense should have any more authority in psychology than it does in physics or astronomy. But this part of common sense has so much power and precision in predicting, controlling, and explaining everyday behavior, compared to any alternative ever entertained, that the odds are high that it will be incorporated in some form into our best scientific theories. . . . No science of mind or brain is likely to do better. That does not mean that the intuitive psychology of beliefs and desires is itself science, but it suggests that scientific psychology will have to explain how a hunk of matter, such as a human being, can have beliefs and desires and how the beliefs and desires work so well.

This is, of course, exactly what modern developments of the extended Bernardian lesson provide in the form of perceptual control theory and its working models of behavior as described in chapter 6. Pinker clearly understands the need, but it appears that the allure of the cause-effect trap is such that even a mind as keen as his fails to see the Bernardian-inspired materialist solution to the puzzle of purposeful behavior that he is seeking.

Finally, he has made some comments concerning the combination of the extended Bernardian and extended Darwinian lessons, that is, how by combining within an organism both Bernardian and Darwinian processes, a very useful form of directed or purposeful evolution can emerge. Here his words indicate a belief that biological evolution cannot be purposeful, as well as a failure to recognize the distinction between among-organism (basic Darwinian) and within-organism (extended Darwinian) selection.

Pinker correctly points out that "felt need," such as a giraffe's "need" for a long neck, has no role in the among-organism selection of biological evolution and that to believe otherwise would be Lamarckian (1997, pp. 206, 207):

> They [needs] are met only when mutations appear that are capable of building an organ that meets the need, when the organism finds itself in an environment in which meeting the need translates into more surviving babies, and in which that selection pressure persists over thousands of generations. Otherwise the need goes unmet. Swimmers do not grow webbed fingers; Eskimos do not grow fur.

True enough. But swimmers might well begin to evolve webbed fingers (and Eskimos fur) if some human had the bizarre desire and means to breed swimmers and Eskimos for these characteristics in the way that farmers have been breeding animals and plants for hundreds if not thousands of years to meet their needs to produce more food for less cost and labor.

Pinker then moves on to within-organism selection (1997, p. 207):

> I have studied three-dimensional mirror-images for twenty years, and though I know mathematically that you can convert a left shoe into a right shoe by turning it around in the fourth dimension, I have been unable to grow a 4-D mental space in which to visualize the flip.

He seems to be concluding here that since he cannot achieve a certain mental ability, *no* mental abilities can arise as the result of the needs of the owner of a human brain. Not only is his logic obviously faulty, but the reader has only once again to refer to chapter 9 to see how within-organism selection of antibodies, ideas, images, and synapses can meet new needs when embedded in a control system that contains an internal goal, a means to try out new actions on its environment, and a way to compare the continuing consequences of its actions with its goal.

How the Mind Works is well worth reading. In addition to Pinker's engaging treatment of the basic Darwinian lesson, his discussion of both the potential and problems of connectionism as a model of brain functioning (see his section "Connectoplasm" in chapter 2) should be of considerable interest to cognitive scientists and others interested in the inner workings of the human brain.

But the book falls far short of its ambitious title by ignoring or rejecting the extended Darwinian and Bernardian lessons and their combination. As a result Pinker neither accounts for how the mind is able to use behavior to satisfy its desires nor explains its remarkably adaptive ability to come up with creative solutions to problems. With this impoverished view of the mind as an input-output computing device, it is perhaps not surprising that Pinker's final message is a rather negative one, doubting that the human mind will ever be able to truly understand itself. In this respect he may be right. But the extended Bernardian and Darwinian lessons provide renewed hope. Given the strong desire (that many humans have) to understand the puzzle of our own minds, plus a remarkable Darwinian computational engine (that all humans have in the form of a human brain) capable of generating and testing many possible solutions to this puzzle, it may just be a matter of time—perhaps just another generation or two—before such understanding is ours. After all, as Dennett has observed (1995, p. 377), "we today—every one of us—can *easily* understand many ideas that were simply unthinkable *by the geniuses* in our grandparents' generation!"

The Cause-Effect Trap

I cannot pretend to have done justice to the important work of these five influential behavioral scientists by my cursory summaries and interpretations of their theories about human behavior. I hope nonetheless to have shown that none of them completely embraces all three of biology's lessons

Table 11.1
Acceptance of Bernardian and Darwinian lessons for animate behavior

Behavioral Scientist	Basic Darwinian Lesson	Extended Darwinian Lesson	Extended Bernardian Lesson	Score
Piaget	No	No	Partly	0.5
Skinner	No	Partly	No	0.5
Chomsky	No	No	No	0.0
Dennett	Yes	Yes	Partly	2.5
Pinker	Yes	No	No	1.0

for behavioral science. Table 11.1 provides a summary of the extent to which each man gave evidence of understanding the basic Darwinian, extended Darwinian, and extended Bernardian lessons. In addition, I could not resist (although I probably should have) assigning each one an overall score based on their demonstrated appreciation of biology's three lessons for behavior. Dennett comes closest to having learned all the lessons (scoring 2.5 out of 3), but Chomsky, considered by many to be the most important intellectual figure of the second half of the twentieth century, winds up with a big fat zero since he appears to have learned not a single one!

William T. Powers, whose perceptual control theory was discussed in chapter 6, comes closer than Dennett in appreciating the three lessons, but he has reservations about the basic Darwinian lesson. This is at least partly due to his belief that Darwin's theory of evolution by natural selection is incomplete, since organisms may have means of controlling their rate of mutation in response to environmental stresses (Powers 1995). So while I chide him for having only partly accepted the basic Darwinian lesson, it could turn out that his view of evolution as a feedback-control process is actually more complete and accurate than current Darwinian theory (see Rutherford & Lindquist 1998 for evidence consistent with Powers's view of evolution).

It therefore appears that Powers and perhaps some others influenced by him are the only behavioral scientists who have been able to free themselves completely from the one-way cause-effect trap. While they constitute only a tiny minority of today's behavioral scientists, I hope that this book will encourage others to join them.[1]

I conclude this chapter with a list of quotations from other influential scholars and scientists from the second half of the twentieth century to provide evidence that it is not only the five prominent individuals discussed above who have ignored or rejected biology's three lessons for behavioral science and therefore remain in the cause-effect trap.

> The typical problem of higher behavior arises when there is a delay between stimulus and response. What bridges the S-R gap? In everyday language, "thinking" does it: the stimulus gives rise to thoughts or ideas that continue during the delay period, and then cause the response. (Donald Hebb 1972, p. 84)

> It is possible to step back and treat the mind as one big monster response function from the total environment over the total past of the organism to future actions . . . (Allen Newell 1990, p. 44)

> If the external environment is represented in the brain with high-dimensional coding vectors; and if the brain's "intended" bodily behavior is represented in its motor nerves with high-dimensional coding vectors; then what intelligence requires is some appropriate or well-tuned *transformation* of sensory vectors into motor vectors! (Paul M. Churchland 1995, p. 93)

> Behavior is not randomly emitted; it is elicited by information which is gleaned from the organism's external environment, and, proprioceptively, from its internal states. . . . *the mind is a description of the operation of a brain that maps information input onto behavioral output*. (Leda Cosmides & John Tooby 1987, p. 283)

> Learning must be a matter of finding the right connection strengths so that the right patterns of activation will be produced under the right circumstances. (James L. McClelland, David Rumelhart, & Geoffrey E. Hinton 1986, p. 32)