9 Cultural Cognition

The Costs of Failing to See Cognition as a Cultural Process

In this book I have tried to provide a coherent account of cognition and culture as parts of a larger system. This view is not widespread in cognitive science. Yet, there are unnoticed costs in failing to see cognition as part of a cultural process.

Marginalization of Culture

Early in the development of cognitive science, culture was relegated to a peripheral role. As Gardner (1985) pointed out, culture, history, context, and emotion were all set aside as problems to be addressed after a good understanding of individual cognition had been achieved. It is unfortunate that many anthropologists have encouraged this view by thinking of culture as some collection of things. Tylor (1871) defined culture as "that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society." Goodenough (1957) gave cognitive anthropology its founding ideational definition of culture: "whatever it is one must know in order to behave appropriately in any of the roles assumed by any member of a society." This view has developed in cognitive anthropology over the years. Attempting to define a role for anthropology in cognitive science, D'Andrade (1981) proposed an intellectual distribution of labor in which psychologists would be responsible for the cognitive processes and anthropologists would be responsible for cognitive content. In this view, culture became simply a pool of ideas that are operated on by cognitive processes. Tylor's definition stresses the acquisition of cultural entities and tries to give a catalog of abilities and artifacts that constitute culture. Goodenough's definition was crucial to the birth of cognitive anthropology, but it and D'Andrade's formulation completely ignore the material aspects of culture. I reject both of these definitions.

Culture is not any collection of things, whether tangible or abstract. Rather, it is a process. It is a human cognitive process that takes place both inside and outside the minds of people. It is the process in which our everyday cultural practices are enacted. I am proposing an integrated view of human cognition in which a major component of culture is a cognitive process (it is also an energy process, but I'm not dealing with that) and cognition is a cultural process.

Anthropologists are also guilty of accepting this marginalization of culture, or even enhancing it, by granting a special place to the powers and limitations of the mind, as if these can be established without reference to culture. Anthropological structuralism tries to read the properties of minds from the structure of public representations. Sahlins (1976) criticizes it as follows: "It would seem ... that the main problem of 'reductionism' besetting modern structuralism has consisted in a mode of discourse which, by giving mind all the powers of 'law' and 'limitation,' has rather placed culture in a position of submission and dependence. The whole vocabulary of 'underlying' laws of the mind accords all force of constraint to the mental side, to which the cultural can only respond, as if the first were the active element and the latter only passive."

Marginalizing culture by reducing it to some collection of ideational contents hides the many ways in which cognition is part of the cultural process. Culture is a process, and the "things" that appear on list-like definitions of culture are residua of the process. Culture is an adaptive process that accumulates partial solutions to frequently encountered problems. It is unfortunate that cognitive science left culture, context, and history to be addressed after the understanding of the individual had matured. The understanding of the individual that has developed without consideration of cultural process is fundamentally flawed. The early researchers in cognitive science placed a bet that the modularity of human cognition would be such that culture, context, and history could be safely ignored at the outset, and then integrated in later. The bet did not pay off. These things are fundamental aspects of human cognition and cannot be comfortably integrated into a perspective that privileges abstract properties of isolated individual minds. Some of what has been done in cognitive science must now be undone so that these things can be brought into the cognitive picture.

Mistaking the Properties of the System for Those of the Individual

Another cost of failing to see the cultural nature of cognition is that it leads us to make too much of the inside/outside boundary or to assume the primacy of that boundary over other delimitations of cognitive systems.

CONSTRUCTION OF PRIMITIVE THOUGHT

A surprising side effect of the heavily drawn inside/outside boundary is that it reinforces the idea that individuals in primitive cultures have primitive minds. The firm drawing of the inside/outside boundary creates the impression that individual minds operate in isolation and encourages us to mistake the properties of complex sociocultural systems for the properties of individual minds. If one believes that technology is the consequence of cognitive capabilities, and if one further believes that the only place to look for the sources of cognitive capabilities is inside individual minds, then observed differences in level of technology between a "technologically advanced" and a "technologically primitive" culture will inevitably be seen as evidence of advanced and primitive minds. Differences in mental capacity seem necessary to account for differences in level of technology. I tried to show in chapters 2–6 that moving the boundaries of the unit of cognitive analysis out beyond the skin reveals other sources of cognitive accomplishment. These other sources are not mysterious, they simply arise from explicable effects that are not entirely internal to the individual.

Overattribution

Overlooking the cultural nature of cognition has another cost—one that may be the most interesting and far-reaching for the field of cognitive science itself. When one commits to the notion that all intelligence is inside the inside/outside boundary, one is forced to cram inside everything that is required to produce the observed behaviors. Much of cognitive science is an attribution problem. We wish to make assertions about the nature of cognitive processes that we cannot, in general, observe directly. So we make inferences on the basis of indirect evidence instead, and attribute to intelligent systems a set of structures and processes that could have produced the observed evidence. That is a venerable research strategy, and I have no objection to it in principle. However, failing to recognize the cultural nature of cognitive processes can lead to a misidentification of the boundaries of the system that produced the evidence of intelligence. If we fail to bound the system properly, then we may attribute the right properties to the wrong system or (worse) invent the wrong properties and attribute them to the wrong system. In this attribution game, there has been a tendency to put much more inside than should be there.

How Cognitive Science Put Symbols in the Head

If there are fundamental deficiencies in the dominant conceptions of cognition in cognitive science, how did that come about?

It is sometimes difficult to say things that are quite simple. The words we must say are simple, but sometimes it takes a lot of work to construct the conceptual framework in which those simple words have the right meanings. There are many possible readings for the sentences I want to write. In the previous chapters I tried to construct some of the conceptual background that will allow me now to say some simple things. However, one hurdle remains. Some of what I have done here departs from the mainstream of cognitive science. And some of the unexamined assumptions of the field make my words unruly. What I want to say cannot be said simply in that framework.

In order to construct a new framework, I will have to deconstruct the old one. In what follows I will give a brief "Official" History of Cognitive Science. This is a history as seen by the proponents of the currently dominant paradigm. I will then reread the history of cognitive science from a sociocultural perspective. In doing this I will identify a number of problems in contemporary cognitive science and attempt to give new meanings to some of the familiar events in its history.

The "Official" History of Cognitive Science

I begin the official history of cognitive science with a quote from Herbert Simon and Craig Kaplan (1989): "The computer was made in the image of the human."

The ideas on which cognitive science is based are so deeply ingrained in our culture that we can scarcely see how things could be otherwise. The roots of representationalism go back at least to Descartes.

Dreyfus (1992) summarizes the history of Good Old Fashioned Artificial Intelligence (GOFAI) as follows:

> *GOFAI is based on the Cartesian idea that all understanding consists in forming and using appropriate symbolic representations. For Descartes, these representations were complex descriptions built up out of primitive ideas or elements. Kant added the important idea that all concepts are rules for relating such elements, and Frege showed that the rules could be formalized so that they could be manipulated without intuition or interpretation.*

The entities that are imagined to be inside the mind are modeled on a particular class of entities that are outside the mind: symbolic representations.

Symbolic logic has a special place in the history of cognitive science. The idea that a computer might be in some way like a person goes back to the formalization of logic and mathematics. In the early years of cognitive science, developments in information theory, neuroscience, psychology, and computer science came to have a synergistic interrelationship. In information theory the notion of a binary digit (bit) as the fundamental unit fit with speculations by McCulloch and Pitts that neurons could be characterized as on/off devices. Thus, the brain might be seen as a digital machine (this turned out to be wrong, but at the time that did not interfere with the developing synergy). Both of these ideas fit well with Turing's work showing that any function that could be explicitly specified could be computed by a class of machine called a universal machine and with his demonstration that the imaginary Turing Machine that operated on a binary code was an example of a universal machine.

The symbol-processing model of cognition has something else going for it as well: "A universal machine can be *programmed* to compute any formally specified function. This extreme plasticity in behavior is one of the reasons why computers have from the very beginning been viewed as artifacts that might be capable of exhibiting intelligence." (Pylyshyn 1989: 54) This was an essential component of the history of the field. Referring to the human cognitive architecture, Newell et al. (1989: 103) say that "the central function of the architecture is to support a system capable of universal computation." By choosing a formalism that is capable of any specifiable computation, the early theorists were surely casting a wide enough net to capture human cognition, whatever it might turn out to be. It seemed that the only viable challenge to this view would be a demonstration that human cognition might not be formally specifiable. There are many varieties of systems capable of universal computation. Newell and his colleagues and most others in the classical camp have taken what is called a "physical symbol system" as the primary architecture of human cognition. "A physical symbol system is an instance of a universal machine. Thus the symbol system hypothesis implies that intelligence will be realized by a universal computer." (Newell and Simon 1990) Newell and Simon (ibid.) define a physical symbol system this way:

> *A physical symbol system consists of a set of entities, called symbols, which are physical patterns that can occur as components of another type of entity called an expression (or symbol structure). Thus a symbol structure is composed of a number of instances (or tokens) of symbols related in some physical way (such as one token being next to another). At any instant of time the system will contain a collection of these symbol structures. Beside these structures, the system also contains a collection of processes that operate on expressions to produce other expressions: processes of creation, modification, reproduction, and destruction. A physical symbol system is a machine that produces through time an evolving collection of symbol structures. Such a system exists in a world of objects wider than just these symbolic expressions themselves.*

According to Pylyshyn (1989), the notion of mechanism that underlies the classical concept of cognition is "concerned only with abstractly defined operations such as storing, retrieving, and altering tokens of symbolic codes."

Simon and Kaplan (1989) cite the Logic Theorist of Newell and Simon (1956) as an example of abstract intelligence and note the role of psychological research in its design:

> *The earliest artificial intelligence programs (for example, the Logic Theorist (Newell and Simon 1956)) are perhaps best viewed as models of abstract intelligence; but nonetheless their design was informed by psychological research on memory and problem solving—note, for example, the use of associative structures in list-processing programming languages and subsequently the frequent use of means-ends analysis for inference.*

By embodying the growing knowledge of human information-processing psychology in computer programs, the early researchers were able to express their theories about cognition as working models that, in many cases, were capable of actually reproducing many important aspects of the behavior of human subjects.

Artificial intelligence (AI) and information-processing psychology thus have a synergistic relationship to each other. Information-processing psychology investigates humans as information processors via the computational metaphor of mind, while AI investigates machine implementations of intelligent processes. The operation of machines that are purportedly built in the image of humans is believed to shed light on natural human intelligence. Since the properties of abstract systems of intelligence are not dependent on the implementational details of the machines on which they run, intelligence in general (in addition to specifically human intelligence) can be investigated with this technology. The hope is that these traditions will continue to synergistically feed each other. In the most optimistic versions of the story, AI and information-processing psychology are the principal motors of scientific progress in cognitive science.

An Alternative History of Cognitive Science

Let us back up and examine the history of computers a bit more. The digital computer is a physical device that can support a mechanized version of a formal system. And it is this capacity that makes it a potential model of intelligence. Understanding computers requires an understanding of formal systems. We know that formal systems go back several thousand years in the history of our species. I do not know when the formal aspects of formal systems were first understood. I suspect that real understanding of the formal aspects of formal systems did not come until the revolutionary work on mathematics and logic at the beginning of this century that was critical to the foundation of cognitive science. Formal systems themselves are much older than our explicit understanding of them. The first arithmetic systems are at least 3000 years old, so we may take that as a minimum age of formal systems in the human experience. The idea of a formal system is that there is some world of phenomena, and some way to encode the phenomena as symbols. The symbols are manipulated by reference to their form only. We do not interpret the meanings of the symbols while they are being manipulated. The manipulation of the symbols results in some other symbolic expression. Finally, we may interpret a newly created string of symbols as meaning something about the world of phenomena.

Being able to find sets of syntactic manipulations of symbols that preserve this relationship so that we can reinterpret symbolic expressions into the world is of paramount importance. As Pylyshyn (1989) says: "One might ask how it is possible for symbolic expressions and rules to keep maintaining their semantic interpretation, to keep the semantics of the expressions coherent. It is one of the important discoveries of formal logic that one can specify rules that operate on symbolic expressions in such a way that the sequence of expressions always corresponds to a proof." If we built the right formal system, we could now describe states of affairs in the world that would have been impossible or impractical to observe directly. Such a state of affairs might be something in the future, which we cannot observe directly, but which can be predicted. I consider the mastery of formal systems to be the key to modern civilization. This is a very, very powerful idea.

The system of ship navigation that I have presented in this book is based on formal manipulations of numbers and of the symbols and lines drawn on a chart. It is a system that exploits the powerful idea of formal operations in many ways. But not all the representations that are processed to produce the computational properties of this system are inside the heads of the quartermasters. Many of them are in the culturally constituted material environment that the quartermasters share with and produce for each other.

Now, here is what I think happened. It was discovered that it is possible to build machines that can manipulate symbols. The computer is nothing more than an automated symbol manipulator. And through symbol manipulation one can not only do things we think of as intelligent, like solving logical proofs or playing chess; we know for a fact that through symbol manipulation of a certain type it is possible to compute any function that can be explicitly specified. So, in principle, the computer could be an intelligent system. The mechanical computers conceived by Charles Babbage to solve the problem of unreliability in human compilers of mathematical and navigational tables were seen by his admirers to have replaced the brain: "The wondrous pulp and fibre of the brain had been substituted by brass and iron; [Babbage] had taught wheelwork to think" (H. W. Buxton, cited in Swade 1993). Of course, a century later it would be vacuum tubes that created the "electronic brain."

But something got lost in this move. The origin myths of cognitive science place the seminal insights of Alan Turing in his observations of his own actions. Dennett (1991) describes the context of Turing's discoveries:

> *He was thinking self-consciously and introspectively about just how he, a mathematician, went about solving mathematical problems or performing computations, and he took the important step of trying to break down the sequence of his mental acts into their primitive components. "What do I do," he must have asked himself, "when I perform a computation? Well, first I ask myself which rule applies, and then I apply the rule, and then write down the result, and then I look at the result, and then I ask myself what to do next, and. . . ."*

Originally, the model cognitive system was a person actually doing the manipulation of the symbols with his or her hands and eyes. The mathematician or logician was visually and manually interacting with a material world. A person is interacting with the symbols and that interaction does something computational. This is a case of manual manipulation of symbols.

Notice that when the symbols are in the environment of the human, and the human is manipulating the symbols, the cognitive properties of the human are not the same as the properties of the system that is made up of the human in interaction with these symbols. The properties of the human in interaction with the symbols produce some kind of computation. But that does not mean that that computation is happening inside the person's head.

John Searle's "Chinese room" thought experiment provides a good example of this effect. Imagine a room inside of which sits the philosopher Searle. Chinese people come up to the room and push strings of Chinese characters through a slot in the door. Searle slips back other strings of characters, which the Chinese take to be clever responses to their questions. Now, Searle does not understand Chinese. He doesn't know the meaning of any Chinese character. To him, the characters of written Chinese are just a bunch of elaborate squiggles. However, Searle has with him in the room baskets of Chinese characters, and he has a rulebook which says that if he gets certain sequences of characters he should create certain other sequences of characters and slide them out the slot.

Searle intends his thought experiment as a demonstration that syntax is not sufficient to produce semantics. According to Searle, the room appears to behave as though it understands Chinese; yet neither he nor anything in the room can be said to understand Chinese. There are many arguments for and against Searle's claims, and I will not review them here. Instead, I want to interpret the Chinese room in a completely different way: The Chinese room is a sociocultural cognitive system. The really nice thing about it is that it shows us very clearly that the cognitive properties of the person in the room are not the same as the cognitive properties of the room as a whole. There is John Searle with a basket of Chinese characters and a rulebook. Together he and the characters and rulebook in interaction seem to speak Chinese. But Searle himself speaks not a word of Chinese.

Let us be clear, then, on the distinction between the cognitive properties of the sociocultural system and the cognitive properties of a person who is manipulating the elements of that system.

The heart of Turing's great discovery was that the embodied actions of the mathematician and the world in which the mathematician acted could be idealized and abstracted in such a way that the mathematician could be eliminated. What remained was the essence of the application of rules to strings of symbols. For the purposes of producing the computation, the way the mathematician actually interacted with the material world is no more than an implementational detail. Pylyshyn (1989) claims that while Turing was developing the notion of the mechanically "effective procedure" he was looking "at what a mathematician does in the course of solving mathematical problems and distilling this process to its essentials." The question of what constitutes the essentials here is critical. For Turing, the essentials evidently involve the patterns of manipulations of the symbols, but they expressly do *not* involve the psychological processes which the mathematician uses in order to accomplish the manipulations. The essentials of the abstract manipulation of symbols are precisely not what the person does. What Turing modeled was the computational properties of a sociocultural system.

When the manipulation of symbols is automated, neither the cognitive processes nor the activity of the person who manipulated the symbols is modeled. The symbols themselves are dematerialized and placed inside the machine, or fed to it in a form that permits the straightforward generation of internal representations. What is important about this is that all the problems the mathematician faced when interacting with a world of material symbol tokens are avoided. That is good news, if those things are considered unimportant, because they are a nuisance to model anyway. The rulebook (or the mathematician's scribbled notations of rules) is replaced by abstract rules, also inside the computer. The mathematician who was a person interacting with a material world is neither modeled by this system nor replaced in it by something else. The person is simply absent from the system that performs automatic symbol manipulation. What is modeled is the abstract computation achieved by the manipulation of the symbols.

All that is fine if your goal is to extend the boundaries of human computational accomplishments. But it is not necessarily a model of the processes engaged in by a person doing that task. These programs produce the properties, not of the person, but of the sociocultural system. This is a nontrivial accomplishment. But the culture of cognitive science has forgotten these aspects of its past. Its creation myths do not include this sort of analysis. *The physical-symbol-system architecture is not a model of individual cognition. It is a model of the operation of a sociocultural system from which the human actor has been removed.*

Having failed to notice that the central metaphor of the physical-symbol-system hypothesis captured the properties of a sociocultural system rather than those of an individual mind, AI and information-processing psychology proposed some radical conceptual surgery for the modeled human. The brain was removed and replaced with a computer. The surgery was a success. However, there was an apparently unintended side effect: the hands, the eyes, the ears, the nose, the mouth, and the emotions all fell away when the brain was replaced by a computer.

The computer was not made in the image of the person. *The computer was made in the image of the formal manipulations of abstract symbols. And the last 30 years of cognitive science can be seen as attempts to remake the person in the image of the computer.*

It is no accident that the language of the physical-symbol-system hypothesis captures so much of what is happening in domains like ship navigation. The physical-symbol-system hypothesis is based on the operation of systems of this type. Conversely, there is nothing metaphorical about talking about the bearing record book as a memory, or about viewing the erasure of lines drawn in pencil on a chart as forgetting. Sometimes my colleagues ask me whether I feel safe metaphorically extending the language of what's happening inside people's heads to these worlds. My response is "It's not a metaphorical extension at all." The computer was made in the image of the sociocultural system, and the human was remade in the image of the computer, so the language we use for mental events is the language that we should have used for these kinds of sociocultural systems to begin with. These are not examples of metaphorical extension from the base domain of mental events to the target domain of cultural activity. Rather, the *original* source domain for the language of thought was a particular highly elaborated and culturally specific world of human activity: that of formal symbol systems.

At first, the falling away of the apparatus that connects the person to the world went unnoticed. This may have been because there was a lot of justifiable excitement about what could be done with this technology. All that remained of the person, however, was the boundary between the inside and the outside. And this boundary was not the same as the boundary of the Chinese room. The boundary that remained was assumed to be the boundary of the person—the skin or the skull. In fact, it was the boundary of the formal system. The boundary between inside and outside became the boundary between abstract symbols and the world of phenomena described by symbols. The walls of the Chinese room were mistaken for the skin of the person. And the walls of the room surrounded the symbols, so the symbols were assumed to be inside the head.

This separation between the boundaries of the formal system and the skin shows up in the language of cognitive science. "Symbol systems are an interior milieu, *protected from the external world*, in which information processing in the service of the organism can proceed." (Newell et al. 1989: 107 [my emphasis]). Or:

> *Act*, as is typical of many theories of cognition, focuses on the central architecture. Perception and motor behavior are assumed to take place in additional processing systems off stage. Input arrives in working (memory), which thus acts as a buffer between the unpredictable stream of environmental events and the cognitive system. (ibid.: 117)*

The "off stage" metaphor of Newell et al. expresses the isolation of the cognitive system from even the sensory and motor experiences of an organism. In fact, many cognitive scientists take the word 'cognitive' as an antonym to 'perceptual' or 'motor'. Here is a typical example of this usage: "This is especially true for tasks that are primarily cognitive, in which perceptual and motor operations play only a small role in the total sequence." A strong claim about the modularity of the human cognitive system is implicit in this use of language. It places a large divide between cognition and the world of experience. But the existence of perceptual and motor processes that are distinct and separate from so-called cognitive processes is not an empirical fact: it is simply a hypothesis that was made necessary by having constructed cognition out of a mechanized formal symbol processing system. Proponents of the physical-symbol-system hypothesis point to the existence of various sensory and motor memories that can act as buffers between cognition and the world of experience as evidence of this modularity. In fact, there may be many other uses for such buffers. We are unlikely to discover these other uses, however, as long as we keep cognition isolated from the world. For example, such buffers may be essential in maintaining training signals after the disappearance of stimuli while learning is taking place.

The model of human intelligence as abstract symbol manipulation and the substitution of a mechanized formal symbol-manipulation system for the brain result in the widespread notion in contemporary cognitive science that symbols are inside the head. The alternative history I offer is not really an account of how symbols got inside the head; it is a historical account of how cognitive science put symbols inside the head. And while I believe that people do process symbols (even ones that have internal representations), I believe that it was a mistake to put symbols inside in this particular way. The mistake was to take a virtual machine enacted in the interactions of real persons with a material world and make that the architecture of cognition.

This mistake has consequences. Why did all the sensorimotor apparatus fall off the person when the computer replaced the brain? It fell off because the computer was never a model of the person to begin with. Remember that the symbols were outside, and the apparatus that fell off is exactly the apparatus that supported interaction with those symbols. When the symbols were put inside, there was no need for eyes, ears, or hands. Those are for manipulating objects, and the symbols have ceased to be material and have become entirely abstract and ideational. The notion of abstractness was necessary to bleach the material aspect out of the symbols so that they could become freed from any particular material instantiation. Calling logic and mathematics "abstract" more than misses the point of their concrete nature as human activities; it obscures it in a way that allows them to be imported into a cognitive inner sanctum. The physicality of material symbols in the environment has been replaced by the physicality (causality) of the computer; thus, while the physical is acknowledged in the physical-symbol-system hypothesis, it is rendered irrelevant by the claim that the physical aspect is an implementational detail. This idea may also help to explain the indifference that cognitive science generally shows to attempts to study implementation in real human systems.

Observe how a proponent of the classical view treats the manipulation of a computational artifact. Here Pylyshyn (1989: 56) constructs an example of manipulations of symbols that are codes for numbers:

> *If you can arrange for the computer to transform them systematically in the appropriate way, the transformations can correspond to useful mathematical operations such as addition or multiplication. Consider an abacus. Patterns of beads represent numbers. People learn rules for transforming these patterns of beads in such a way that the semantic interpretation of before-and-after pairs corresponds to a useful mathematical function. But there is nothing intrinsically mathematical about the rules themselves; they are just rules for moving beads around. What makes the rules useful for doing mathematics is that we are assured of a certain continuing correspondence between the formal or syntactic patterns of beads and mathematical objects (such as numbers).*

There are no hands or eyes in this description. There are only the formal properties of the patterns of beads. Pylyshyn is using the example of the abacus to show how the manipulation of symbols produces computations. He provides a very nice illustration of the power of this cultural artifact. He is not interested in what the person does, or in what it means for a person to learn, to "know," or to apply a rule. Rather, he is interested in the properties of the system enacted by the person manipulating the physical beads. That is fine as a description of the computational properties of a sociocultural system, but to take this as being about cognitive processes inside the skin is to recapitulate the error of mistaking the properties of the sociocultural system for the properties of a person. It is easy to do. It is something we do in our folk psychology all the time. But when one is really careful about talking about cognition, one must carefully distinguish between the tasks that the person faces in the manipulation of symbolic tokens and the tasks that are accomplished by the manipulation of the symbolic tokens.

A failure to do this has led to a biased view of the tasks that are properly considered cognitive. Problem solving by heuristic search is taken as a representative cognitive activity. This is tailor-made for the symbol-shuffling apparatus. The definition of cognition has been unhooked from interaction with the world. Research on games and puzzles has produced some interesting insights, but the results may be of limited generality. The tasks typically chosen for laboratory studies are novel ones that are regarded by subjects as challenging or difficult. D'Andrade (1989) has likened the typical laboratory cognitive tasks to feats of athletic prowess. If we want to know about walking, studying people jumping as high as they can may not be the best approach. Such tasks are unrepresentative in another sense as well. The evolution of the material means of thought is an important component of culturally elaborated tasks. It permits a task that would otherwise be difficult to be re-coded and re-represented in a form in which it is easy to see the answer. This sort of development of material means is intentionally prohibited in puzzle tasks because to allow this sort of evolution would destroy the puzzling aspects of the puzzle. Puzzles are tasks that are preserved in the culture because they are challenging. If the performance mattered, we would learn to re-represent them in a way that removed the challenge. That would also remove their value as puzzles, of course. The point is that the tasks that are "typical" in laboratory studies of thought are drawn from a special category of cultural materials that have been isolated from the cognitive processes of the larger cultural system. This makes these tasks especially unrepresentative of human cognition.

Howard Gardner (1985) is very kind to cognitive science when he says that emotion, context, culture and history were deemphasized in early cognitive science because, although everyone believed they were important, everyone also knew that they complicated things enormously. According to Gardner, getting the program started required a simple model of cognition. The field therefore deferred consideration of affect, culture, context, and history until such time as there was a good model of how an individual worked in isolation. It was hoped that these things could be added in later. That is a charitable reading of the history, I think. I can see why there were compelling reasons to see it as it was seen, and not to notice that something is wrong when AI was producing "deaf, dumb, and blind, paraplegic agents" (Bobrow 1991) as models of human cognition.

Newell et al. (1989) seemed genuinely puzzled by the fact that no one had succeeded in integrating emotion into the system of cognition they had built. Yet this failure is completely predictable from the assumptions that underlie the construction of the symbol-manipulation model of cognition. The person was simply omitted from what was taken as the model of the cognitive system. The model of cognition came from exactly that part of the system that was material rather than human. Within this underlying theory of cognition there can be no integration of emotion, because the part of the cultural system that is the basis of the physical symbol system excludes emotion. The integration of cognition with action will remain difficult because the central hypothesis separates cognition and action by definition. History and context and culture will always be seen as add-ons to the system, rather than as integral parts of the cognitive process, because they are by definition outside the boundaries of the cognitive system.

Adherents of the physical-symbol-system hypothesis are obviously aware of the presence of a world in which action takes place, and they have attempted to take it into account. Consider the following passage from Newell and Simon's seminal 1972 book *Human Problem Solving* :

> *For our theory, specification of the external memories available to the problem solver is absolutely essential. These memories must be specified in the same terms as those we have used for the internal memories; symbol capacities, accessing characteristics, and read and write times. The problem solving program adopted by the information-processing system will depend on the nature of its "built in" internal STM and LTM [short-term memory and long-term memory].*
>
> *From a functional viewpoint, the STM should be defined, not as an internal memory, but as the combination of (1) the internal STM and (2) the part of the visual display that is in the subject's foveal view. . . .*
>
> *In short, although we have few independent data suited to defining precisely how external memory can augment STM, the two components do appear to form a single functional unit as far as the*

detailed specification of a problem solving information-processing system is concerned.

This is a good start on the problem, but I think it is fair to say that in the twenty years since the publication of *Human Problem Solving* the use of material structure in the problem-solving environment has not been a central topic in the physical-symbol-system research agenda. Some recent work within this tradition takes the "external world" into account (Larkin 1989; Vera and Simon 1993) but treats the world only as an extra memory on which the same sorts of operations are applied as are applied to internal memories. Structure in the world can be much more than an augment to memory. The use of cultural structures often involves, not just the same process with more memory, but altogether different processes. The overattribution of internal structure results from overlooking the coordination of what is inside with what is outside. The problem remains that the nature of the interaction with the world proposed in these systems is determined by the assumptions of the symbolic architecture that require the bridging of some gap between the inner, cognitive world and an outer world of perception and action.

These criticisms by themselves are not sufficient grounds for rejecting the notion that humans are symbol-processing systems. Newell and Simon (1990) wisely acknowledge that the physical-symbol-system hypothesis is a hypothesis and that the role of symbolic processes in cognition is an empirical question. It has proved possible to interpret much of human problem-solving behavior as if the very architecture of human cognition is symbol processing. It's a hypothesis. A lot of data can be read as failing to reject it. Yet, the hypothesis got there under suspicious circumstances. There are no plausible biological or developmental stories telling how the architecture of cognition became symbolic. We must distinguish between the proposition that the architecture of cognition is symbolic and the proposition that humans are processors of symbolic structures. The latter is indisputable, the former is not. I would like to be able to show how we got to be symbol manipulators in relation to how we work as participants in sociocultural systems, rather than assume it as an act of faith. The origins of symbolic processes have not been explored this way, though, because they were obfuscated by the creation myth that maintains that the computer was made in the image of humans.

Increasingly, the physical-symbol-system hypothesis is a perspective into which things don't fit. It was a bet or a guess, grounded in a nearly religious belief in the Platonic status of mathematics and formal systems as eternal verities rather than as historical products of human activity. This is an old dispute that lies at the heart of the developing split in cognitive science between those who feel there is more to be learned from the physical-symbol-system research and those who feel it has been exhausted. (See the special January-March 1993 issue of *Cognitive Science.*) By advocating this alternative view, I am espousing what might be called a "secular" view of cognition—one that is grounded in a secular perspective on formal systems, in contrast with the quasi-religions "cosmic truth" view put forth by the symbolists.

Why cognition became disembodied is clear from the history of the symbolic movement. An important component of the solution is to re-embody cognition, including the cognition of symbol processing.

I believe that humans actually process internal representations of symbols. But I don't believe that symbol manipulation is the architecture of cognition. Historically, we simply assumed that symbol processing was inside because we took the computer as our model of mentality. Humans (and, I suspect, most other animals) are good at detecting regularities in their environment and at constructing internal processes that can coordinate with those regularities. Humans, more than any other species, spend their time producing symbolic structure for one another. We are very good at coordinating with the regularities in the patterns of symbolic structure that we present to one another. As was described in chapter 7, the internal structures that form as a consequence of interaction with symbolic materials can be treated as symbolic representations. Ontogenetically speaking, it seems that symbols are in the world first, and only later in the head.

Studying Cognition in the Wild

Many of the foundational problems in cognitive science are consequences of our ignorance of the nature of cognition in the wild. Most of what we know about cognition was learned in laboratory experiments. Certainly, there are many things that can be learned only in closely controlled experiments. But little is known about the relationships of cognition in the captivity of the laboratory to cognition in other kinds of culturally constituted settings. The first part of the job is, therefore, a descriptive enterprise. I call this description of the cognitive task world a "cognitive ethnography." One might have assumed that cognitive anthropology would have made this sort of work its centerpiece. It has not. Studying cognition in the wild is difficult, and the outcomes are uncertain.

Cognitive systems like the one documented in this book exist in all facets of our lives. Unfortunately, few truly ethnographic studies of cognition in the wild have been performed. (Beach 1988, Frake 1985, Gladwin 1970, Goodwin 1993, Goodwin and Goodwin 1992 and 1995, Latour 1986, Lave 1988, Lave et al. 1984, Ochs et al. (in press), Scribner 1984, Suchman 1987, and Theureau 1990 are lonely exceptions to this trend.) We trust our lives to systems of this sort every day, yet this class of phenomena has somehow fallen into the crack between the established disciplines of anthropology and psychology and appears to be excluded by foundational assumptions in cognitive science. This book is an attempt to show what a natural history of a cognitive system could be like.

Among the benefits of cognitive ethnography for cognitive science is the refinement of a functional specification for the human cognitive system. What is a mind for? How confident are we that our intuitions about the cognitive nature of tasks we do on a daily basis are correct? It is a common piece of common sense that we know what those tasks are because we are human and because we engage in them daily. But I believe this is not true. In spite of the fact that we engage in cognitive activities every day, our folk and professional models of cognitive performance do not match what appears when cognition in the wild is examined carefully. I have tried to show here that the study of cognition in the wild may reveal a different sort of task world that permits a different conception of what people do with their minds.

Cognitive science was born in a reaction against behaviorism. Behaviorism had made the claim that internal mental structure was either irrelevant or nonexistent—that the study of behavior could be conducted entirely in an objective characterization of behavior itself. Cognitive science's reaction was not simply to argue that the internal mental world was important too; it took as its domain of study the internal mental environment largely separated from the external world. Interaction with the world was reduced to read and write operations conducted at either end of extensive processing

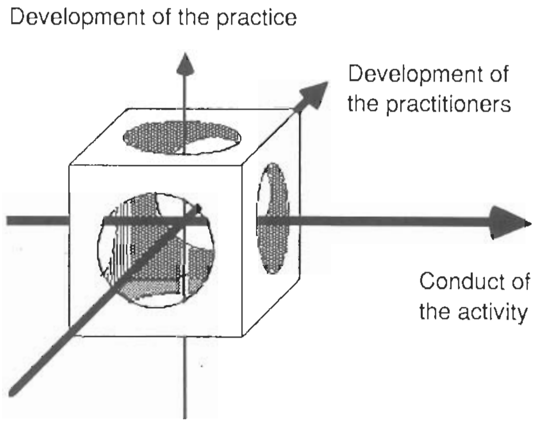

Figure 9.1 A moment of human practice.

activity. This fit the computer metaphor very well, but it made the organization of the environment in which thinking took place seem largely irrelevant. Both behaviorism and cognitivism must be wrong.

Cognition in the Intersection of Cultural Processes

The cube depicted in figure 9.1 represents any moment in navigation practice (or, in fact, any moment in any human practice). The arrows passing through the cube represent three developmental sequences of which every moment of practice is simultaneously a part. I have adopted some simple conventions to capture several aspects of the situation in this single diagram. The thickness of the arrow represents the density of interaction among the elements in that dimension. The length of the shaft of the arrow emerging from the cube represents the rate at which states in that dimension are changing. The length of the tail of the arrow going into the cube represents the duration of the relevant history of the activity in the given dimension.

It is essential to keep in mind that these things are all happening at the same time in the same activity. Having reinstated a whole human being in a culturally constituted activity, I see the following.

The conduct of the activity proceeds by the operation of functional systems that bring representational media into coordination with one another. The representational media may be inside as well as outside the individuals involved. These functional systems propagate representational state across the media. In describing the ongoing conduct of navigation tasks, it is possible to identify a number of cognitive systems, some subsuming others. One may focus on the processes internal to a single individual, on an individual in coordination with a set of tools (chapter 3), or on a group of individuals in interaction with one another and with a set of tools (chapter 4). Each system produces identifiable cognitive properties, and in each case the properties of the system are explained by reference to processes that transform states inside the system (chapter 5). The structured representational media in the system interact in the conduct of the activity. Each medium is put to use in an operational environment constituted by other media. As indicated in figure 9.1, the conduct of the activity itself has a relatively short history. An entry into a harbor, for example, involves a few hours of preparation and takes about an hour to complete. Changes in this dimension happen quickly, and the elements of the task performance are in relatively intense interaction with one another. The conduct of the activity creates elements of representational structure that survive beyond the end of the task. These elements—the logbooks, pencil marks on charts, the quartermasters' memories of the events—are the operational residua of the process.

In this adaptive system, the media may be changed by the very processes that constitute the conduct of the activity. The operations of the navigation team produce a structured experience for the participants that contains opportunities for individual learning (chapter 6). As a consequence of their participation in the task performance, the quartermasters may acquire internal organization that permits them to coordinate with the structure of their surroundings. In this way, learning can be seen as the propagation of organization through an adaptive system (chapter 7). The development of the practitioners themselves takes years. Through a career, a quartermaster gradually acquires the skills that are exercised in the performance of the job. Changes to the organization of the internal media that the quartermasters bring to the job take place more slowly than the changes to the states that the media support. That is, it takes longer to learn how to plot a fix, for example, than it does to plot a fix. But since most learning in this setting happens in the doing, the changes to internal media that permit them to be coordinated with external media happen in the same processes that bring the media into coordination with one another. The changes to the quartermasters' skills and the knowledge produced by this process are the mental residua of the process.

The setting of navigation work evolves over time as partial solutions to frequently encountered problems are crystallized and saved in the material and conceptual tools of the trade and in the the social organization of the work. The development of the practice takes place over centuries (chapter 2). The very same processes that constitute the conduct of the activity and that produce changes in the individual practitioners of navigation also produce changes in the social, material, and conceptual aspects of the setting. The example given in chapter 8 illustrates the creation in interaction of a new concept and a shared lexical label for it (the "total" in the modular form of the true-bearing computation). The microgenesis of the cultural elements that make up the navigation setting is visible in the details of the ongoing practice.

All this happens simultaneously in cognition in the wild. It is in this sense that cognition is a fundamentally cultural process.