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# Distributed cognitions

## Psychological and educational considerations

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# Contents

# 1 A cultural-historical approach to distributed cognition

*Michael Cole and Yrjö Engeström*

It was supposedly Goethe who observed that everything has been thought of before; the task is to think of it again in ways that are appropriate to one's current circumstances. Whoever made the remark, we have thought of it often in relation to the current wave of discovery that both the content and process of thinking (however those slippery terms are interpreted) are distributed as much among individuals as they are packed within them.

Our own rediscovery of the distributed nature of mind has grown from our acquaintance with the cultural-historical school of psychology. Consequently, we have decided to explore approaches to distributed cognition by tracing this line of thinking back to the origins of psychology as a distinct discipline, by relating how it was developed by the cultural-historical school of psychology earlier in this century, and by suggesting the advantages of working within the cultural-historical framework (informed by modern cognitive psychology, anthropology, and sociology) when studying cognition as a distributed phenomenon.

## Wundt's version of distributed cognition

Around the time that psychology was celebrating its centennial as a scientific discipline, there was a good deal of discussion about the work of Wilhelm Wundt – according to the discipline's folklore, the "father" of scientific psychology (Blumenthal, 1980; Farr, 1987; Toulmin, 1981). Among the many issues raised in this reevaluation was the failure of modern psychologists to realize that virtually half of Wundt's writings were devoted not to the study of elementary sensations using brass instruments and the method

of trained introspection, but to the study of historically accumulated, culturally organized knowledge as revealed in the written accounts of explorers and early anthropologists as well as the analyses provided by philologists and historians (Wundt, 1921).

The better known half of Wundt's dual system was called "physiological psychology," the study of immediate experience based on the experimental method. The goal of this half of the discipline was to determine how elementary sensations arise in consciousness and the universal laws by which the elements of consciousness combine. The label "physiological" for this half of Wundt's enterprise is somewhat misleading, because experiments carried out in its name rarely involved physiological measurement. Rather, it was believed that the verbal reports of subjects who were presented carefully controlled stimuli would yield results that could eventually be traced to physiological processes. Experiments conducted with this goal in mind concentrated on the qualities of sensory experience and the decomposition of simple reactions into their components. The psychological processes corresponding to external stimulation were presumed to take place inside of individual people's heads.

The other half of Wundt's system involved the study of "higher psychological functions," including processes of reasoning and the products of human language. Wundt claimed that this second branch of psychology, which he called *Völkerpsychologie*, could not be studied using laboratory methods focused on the contents of consciousness, because the phenomena being studied extend beyond individual human consciousness. He argued, for example:

> A language can never be created by an individual. True, individuals have invented Esperanto and other artificial languages. Unless, however, language had already existed, these inventions would have been impossible. Moreover, none of these has been able to maintain itself, and most of them owe their existence solely to elements borrowed from natural languages. (Wundt, 1921, p. 3)

According to Wundt's view, higher psychological functions had to be studied by the methods of the descriptive sciences, such as ethnography, folklore, and linguistics. The results were to be formulated in terms of historically contingent phenomena that could be described but not explained according to the canons of experimental science. Wundt believed that the two enterprises must supplement each other; only through a synthesis of their respective insights could a full psychology be achieved. To those who would claim that *Völkerpsychologie* could be entirely subsumed under experimental psychology, Wundt replied that "individual consciousness is wholly incapable of giving us a history of the development of human thought, for it is conditioned by an earlier history concerning which it cannot of itself give us any knowledge" (Wundt, 1921, p. 3). In modern terms, Wundt was arguing that while elementary psychological functions may be considered to occur "in the head," higher psychological functions require additional cognitive resources that are to be found in the sociocultural milieu.



The same folklore that tells us that Wundt was the founding father of the discipline also holds that within a few decades Wundt's influence dwindled to insignificance; his methodology was rejected and his distinction between physiological/experimental and cultural/descriptive approaches was ignored. However, there is no mistaking the fact that those currently interested in distributed cognition have rediscovered some of Wundt's ideas, especially his ideas about *Völkerpsychologie*, the methods for its study, and the difficulty of reconciling data obtained from the two ways of knowing about minds.

## Hugo Münsterberg

In view of the fact that many of the people who study distributed cognition gather their data from socially valued, practical activities, such as those that occur in schools, hospitals, and the workplace, it is interesting that Hugo Münsterberg, the "father of applied psychology," fully adhered to Wundt's dual-psychology distinction and provided one of the earliest systematic statements of the distributed nature of cognition. Münsterberg (1914, p. 16) referred to the experimental half of Wundt's program as "causal" psychology and the descriptive half as "purposive" psychology, warning that it was "extremely important to keep them cleanly separated and to recognize distinctly the principles which control them."

In connection with his discussion of the purposive half of psychology, Münsterberg (1914) argued that cognition occurs not only "in the head," where millions of brain cells interact outside the range of consciousness to "remember for us," "to think for us," "to will for us," but in the objective elements of communication among individuals:

> A letter, a newspaper, a book, exists outside of the individuals themselves, and yet it intermediates between two or between millions of persons in the social group. . . . The book remembers for the social group, and the experiences of the group, objectively recorded in it, shape the social action and the social thought. The letter can connect any distant social neurons; the paper may distribute the excitement from one point of a social group to millions of others. Every objectified expression becomes a social short cut. (pp. 267–8)

Although there is a renewed interest in the ideas of these pioneer psychologists (see, e.g., Cahan & White, 1992; Farr, 1987; Toulmin, 1981), the overall programs they espoused did not give rise to any recognizable, modern approach to human cognition.[1] History (thus far) has been kinder to the originators of the cultural-historical approach associated with the names of Alexei Leont'ev, Alexander Luria, and Lev Vygotsky.

## The cultural-historical approach

The basic ideas of cultural-historical psychology are contained in a series of articles and monographs written in the late 1920s and early 1930s (Leont'ev, 1932; Luria, 1928, 1932; Vygotsky, 1929, 1960). While remaining firmly committed to a Darwinian theory of human phylogeny, one of the central tenets of the cultural-historical school is that "the process of the historical development of human behavior and the process of biological evolution do not coincide; one is not a continuation of the other. Rather, each of these processes is governed by its own laws" (Vygotsky, 1960, p. 71).

The presumed qualitative discontinuity between human and animal development is characterized in a variety of interlocking ways by the initiators of the cultural-historical school. In the first article about

[1] A possible exception to this generalization is John Dewey. Although Dewey cannot be considered a major influence in contemporary cognitive psychology, his ideas about education and development continue to be influential among social scientists. In a small book summarizing his ideas about education and experience, Dewey (1938/1963) wrote the following: "Experience does not go on simply inside a person. . . . In a word, we live from birth to death in a world of persons and things which is in large measure what it is because of what has been done and transmitted from previous human activities. When this fact is ignored, experience is treated as if it were something which goes on exclusively inside an individual's body and mind. It ought not to be necessary to say that experience does not occur in a vacuum. There are sources outside an individual which give rise to experience" (p. 39).

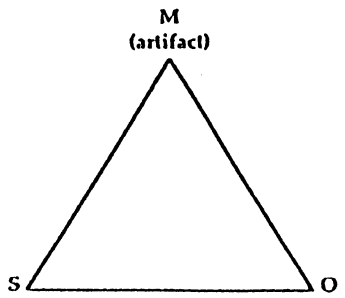


Figure 1.1. The basic mediational triangle with subject (S), object (O), and medium (M) at its vertices indicating the basic constraints on mind.

the school's ideas to appear in English, Alexander Luria opens with the well-known assertion that "man differs from animals in that he can make and use tools." These tools, he writes, "not only radically change his conditions of existence, they even react on him in that they effect a change in him and his psychic condition" (Luria, 1928, p. 493).

The structural change that arises pari passu with tool mediation is that "instead of applying directly its natural function to the solution of a particular task, the child puts between that function and the task a certain auxiliary means . . . by the medium of which the child manages to perform the task" (Luria, 1928, p. 495). The basic structure of human cognition that results from tool mediation has traditionally been pictured as a triangle, as in Figure 1.1.

Simplifying for purposes of explication, "natural" ("unmediated") functions are those along the base of the triangle; "cultural" ("mediated") functions are those where interactions between subject and object are mediated by an auxiliary means, at the vertex of the triangle. While Luria's initial statement seems to imply that the cultural route totally replaces the natural route, in many places in his writings and those of his colleagues it is made clear that both routes exist simultaneously. Such a conclusion is necessary because human beings do not cease being phylogenetically evolved creatures by virtue of their ability to create, transmit, and acquire culture.

The way in which Luria writes about tool mediation may incline one to think that he had in mind such tools as hoes and plates. However, he and his colleagues considered language to be an integral part

of the overall process of cultural mediation, the "tool of tools," and they had a decidedly two-sided notion of tool mediation. As Vygotsky explains in his monograph "Tool and Symbol" (1978), what we conventionally call tools and what we conventionally call symbols are two aspects of the same phenomenon: Mediation through tools was said to be more outwardly oriented, mediation through signs was more inwardly oriented, toward "the self," but both aspects adhered in every cultural artifact.

Many years later, Luria (1981) summarized the psychological consequences of culturally mediated behavior, referring in particular to human language, as follows:

> The enormous advantage is that their world doubles. In the absence of words, human beings would have to deal only with those things which they could perceive and manipulate directly. With the help of language, they can deal with things that they have not perceived even indirectly and with things which were part of the experience of earlier generations. Thus, the world adds another dimension to the world of humans. . . . Animals have only one world, the world of objects and situations. Humans have a double world. (p. 35)

Here we see clearly that the classical mediational triangle is a description of the basic structural constraints on individual human cognition. But such a static description leaves out the dynamic, double world of which Luria writes. Consequently, we have to add another dimension to this structural picture – time – in the course of which the two worlds (the directly given and the culturally mediated) are constantly synthesized to provide the mental foundations of people's real-time actions in the world. This expanded version of the basic mediational triangle is shown in Figure 1.2, which emphasizes the fact that cognition requires analysis and synthesis of (at least) two sources of information in real time.

An important implication of these remarks is the assumption that other human beings, both those present to the senses and those of prior generations, play a crucial role in the formation of human cognitive capacities. This point is summed up in what Vygotsky (1934/1987) called the "general law of cultural development":

> The history of the development of signs brings us, however, to a far more general law that directs the development of behavior. Janet calls it the fundamental law in psychology. The essence of the law is that the child in the process of development begins to apply to himself the very same forms of behavior which others applied to him prior to that. The child himself acquires social forms of behavior and transposes those on to himself. . . . The sign originally is always a means of social contact, a means of influence upon others, and only subsequently does it find itself in the role of a means for influencing oneself. (Vygotsky, 1960, p. 192)



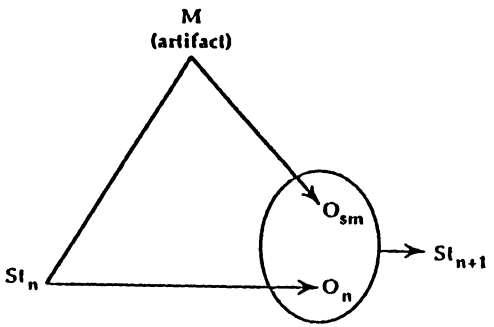


Figure 1.2. The basic mediational triangle with time included in the unit of analysis. This figure symbolizes the fact that new states of the subject arise from coordination of information from both the mediated (cultural) and direct (phylogentic) connections between subject and object. M, Medium; $St_n$, subject's state of knowledge at time $n$; $O_{sm}$, object as represented via the medium; $O_n$, object at time $n$; $St_{n+1}$, emergent new state of subject's knowledge at time $n + 1$.

Although useful as schematic "minimal structures" of human cognitive functions, the mediational triangles in Figures 1.1 and 1.2 fail to account for the collective nature of human activities, or activity systems as Leont'ev (1978, 1981) called them. In Figure 1.3 we have added certain crucial elements to the abstract, individual model depicted in Figures 1.1 and 1.2. First, the fact that individuals ("subject") are constituted in communities is indicated by the point labeled "community." As indicated in Figure 1.3, the relations between subject and community are mediated, on the one hand, by the group's full collection of "mediating artifacts" and, on the other hand, by "rules" (the norms and sanctions that specify and regulate the expected correct procedures and acceptable interactions among the participants). Communities, in turn, imply a "division of labor," the continuously negotiated distribution of tasks, powers, and responsibilities among the participants of the activity system.

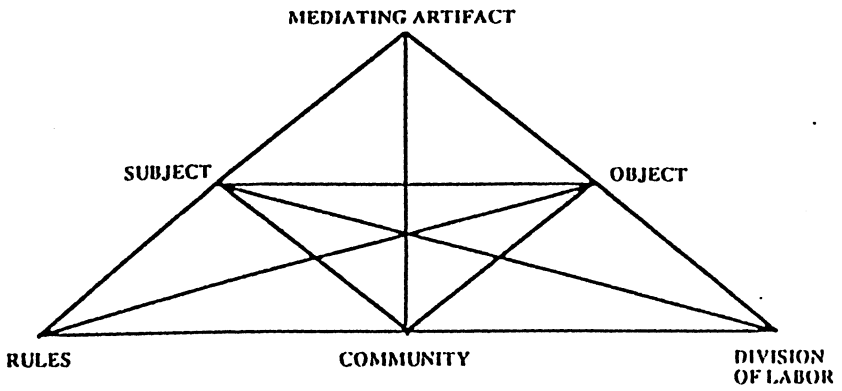


Figure 1.3. The basic mediational triangle expanded (after Engeström, 1987) to include other people (community), social rules (rules), and the division of labor between the subject and others.

Using Figure 1.3 to represent the idea that activity systems are a basic unit of analysis leads to certain important insights. First, it provides a conceptual map to the major loci among which human cognition is distributed. Second, it includes other people who must somehow be taken into account simultaneously with the subject as constituents of human activity systems.

Another important feature of activity as a basic unit of analysis of human behavior is that when activities become institutionalized, they are rather robust and enduring. Once they gain the status of cultural practices, they often have radically longer half-lives than an individual goal-directed action. In fact, activity systems such as those that take place in schools and doctors' offices, for example, appear to reproduce similar actions and outcomes over and over again in a seemingly monotonous and repetitive manner that gives cultural constraints on action a seemingly overpowering quality. However, closer analysis of apparently unchanging activity systems reveals that transitions and reorganizations are constantly going on within and between activity systems as a fundamental part of the dynamics of human evolution.

Consequently, activity systems are best viewed as complex formations in which equilibrium is an exception and tensions, disturbances, and local innovations are the rule and the engine of change. When an



activity system is followed through time, qualitative overall transformations may also be found. Institutionalized activity systems seem to move through developmental cycles that typically last years (Engeström, 1987).

We can summarize the cultural-historical conception of the basic structure of human activity as follows:

1. The psychological functions shared with our prehuman cousins, so-called natural functions, develop according to principles that are different from psychological functions that are mediated through tools and rules – for example, "cultural" functions.
2. Cultural mediation creates a species-specific, universal structure of human mind and associated morphology of action.
3. Cultural mediation has a recursive, bidirectional effect; mediated activity simultaneously modifies both the environment and the subject.
4. Cultural artifacts are both material and symbolic; they regulate interaction with one's environment and oneself. In this respect, they are "tools" broadly conceived, and the master tool is language.
5. The cultural environment into which children are born contains the accumulated knowledge of prior generations. In mediating their behavior through these objects, human beings benefit not only from their own experience, but from that of their forebears.
6. Cultural mediation implies a species-specific mode of developmental change in which the accomplishments of prior generations are cumulated in the present as the specifically human part of the environment; culture is, in this sense, history in the present.
7. Cultural mediation implies a special importance of the social world in human development since only other human beings can create the special conditions needed for that development to occur.
8. A natural unit of analysis for the study of human behavior is activity systems, historically conditioned systems of relations among individuals and their proximal, culturally organized environments.

Although accepting activity systems as a unit of analysis in principle, Russian cultural-historical research based on the ideas summarized here was restricted primarily to the level of individual actions using the "method of dual stimulation." The basic idea of this method (see Valsiner, 1988, for an excellent, extended discussion) is to put a person in a problem-solving situation where direct action proves ineffective, so that the individual must find or create auxiliary means to

reach the goal. In the hands of Vygotsky, Luria, and Leont'ev, experiments using this method were also considered a specific version of a microgenetic experiment, which provoked the process of psychological change under controlled laboratory conditions.[2]

A wide variety of studies carried out by Russian cultural-historical psychologists made use of this method. For example, in studies of the development of voluntary behavior in young children, Alexander Luria demonstrated that the acquisition of self-control in simple situations where children were asked to squeeze a rubber bulb or refrain from squeezing was intimately related to the children's ability to mediate their activity through language. Such results substantiated his belief that "voluntary behavior is the ability to create stimuli and to subordinate [oneself] to them; or in other words, to bring into being stimuli of a special order, directed at the organization of behavior (Luria, 1932, p. 401).

Just as studies with children could lay bare the way in which the acquisition of mediational means was crucial to the ontogeny of behavior, so such studies of the mediational means crucial to the remediation of behavior in cases of injury or disease could permit analysis of the microgenetic processes of everyday thinking. In a well-known early example of this principle, Luria and Vygotsky carried out pilot work with a patient suffering from Parkinsonism. So severe was this condition that the patient could not walk across the floor. Paradoxically, however, the patient could climb stairs. Vygotsky and Luria (reported in Luria, 1979) hypothesized that, when the patient was climbing stairs, each stair represented a signal to which the patient had to respond in a conscious way. When Vygotsky placed pieces of paper on a level floor and asked the patient to walk across the room stepping over them, the formerly immobile patient was able to walk across the room unaided. In a series of studies, Luria and Vygotsky showed that a variety of techniques that induced subjects to regulate

[2] Vygotsky (1978, p. 61) referred to this form of experimentation as "experimental-developmental," an idea taken from Kurt Lewin. Borrowing from Heinz Werner, he declared: "Any psychological process, whether the development of thought or voluntary behavior, is a process undergoing changes right before one's eyes. The development in question can be limited to only a few seconds, or even fractions of seconds (as in the case of normal perception). It can also (as in the case of complex mental processes) last many days or even weeks. Under certain conditions, it becomes possible to trace this development.



their behavior indirectly through language and artificial signs produced the same kinds of remedial effects.

Subsequently this "remediation" strategy was used in a wide variety of studies of the development of higher psychological functions both in children and in adults who were injured in some way. For example, Luria (1929/1978)studied the development of writing as a way of overcoming heavy demands on memory, Leont'ev (1981) studied the development of the use of mnemonic devices in normal and retarded children, Maniulenko (1948/1975) studied the way in which play can reorganize memory and motor functions, while many investigators including Leont'ev, Luria, and Zaporozhets developed remediational techniques to deal with injury cases in which speech, memory, and motor functions had been destroyed.

Summing up this early theorizing, we can see that the Russians took seriously Wundt's distinction between two kinds of psychology and accepted the notion that the study of higher psychological functions must be approached by a distinct methodology. However, unlike Wundt, who claimed that the two psychologies were necessarily distinct, they aspired to create a unified psychology with cultural mediation, and hence the assumption that cognition is a distributed phenomenon, at its core.

## Using cultural-historical psychology to think about distribution of mind

After the 1950s, a number of publications of the cultural-historical school began to appear in English, German, and other languages. There were, naturally enough, varied, selective interpretations of these ideas when they were taken out of the Russian context (for better or for worse – see Valsiner, 1988, for both an accessible summary of main lines of research and a trenchant critique of U.S. versions of cultural-historical scholarship). Consequently, all we can offer is "a" cultural-historical approach to the problem at hand.

Our own view is that several productive expansions of cultural-historical psychology have grown out of the U.S. and European hybrids of Russian approaches. We will explore these expansion in two ways. First, using the representation of mediated activity in Figures 1.1 through 1.3 as a heuristic device, we will sketch various ways in

which cognition can be said to be distributed in different fundamental loci of an activity system. Then we will provide two examples from our own research that exploit these ideas.

### *Distribution of cognition "in" the person*

One must keep in mind that knowledge and forms of thought are not uniformly distributed in the brain, as Luria never tired of saying. Luria's remediational procedures were based on methods that deliberately redistributed cognition depending on the particular brain deficit afflicting a patient (Luria, 1973).

In a passage that clearly indicates his acceptance of Wundt's dual psychology, Luria makes explicit his belief in an extrasomatic distribution of cognition:

> The chasm between natural scientific explanations of elementary processes and mentalist descriptions of complex processes could not be bridged until we could discover the way natural processes such as physical maturation and sensory mechanisms become intertwined with culturally determined processes to produce the psychological functions of adults. We needed, as it were, to step outside the organism to discover the specifically human forms of psychological activity. (Luria, 1979, p. 43)

His point has been made quite markedly by contemporary neuroscientists (e.g., Edelman, 1987) who urge on us the recognition that which parts of the brain are engaged in what way in getting through a particular event depends critically on the cultural constitution of that event. Experiencing a Chopin scherzo and experiencing a Chagall painting give rise to very different patterns of brain activity, and both differ crucially from an experience like giving birth to a child. The heterogeneity of activity within the brain is conditioned in part by the structure of the events, in both their sensual and symbolic aspects, in which the person is participating.

### *Distribution "in" the medium culture*

Not surprisingly, since culture is their foundational concept, anthropologists have made a major contribution to our understanding of both the universal process of culturally mediated cognition and the various ways in which the heterogeneity of culture supports and requires the distribution of cognition.



The basic sense in which cultural mediation implies the distribution of cognition was emphasized by Gregory Bateson, who proposed the following thought experiment:

> Suppose I am a blind man, and I use a stick. I go tap, tap, tap. Where do I start? Is my mental system bounded at the hand of the stick? Is it bounded by my skin? Does it start halfway up the stick? Does it start at the tip of the stick? (1972, p. 459)

Bateson goes on to argue that the answer to the question changes depending on how the event is conceived. Analysis of mind's focus must include not only the man and his stick, but his purposes and the environment in which he finds himself. When the man sits down to eat his lunch, the stick's relation to mind totally changes, and it is forks and knives, not sticks, that become relevant. In short, the ways in which mind is distributed depend crucially on the tools through which one interacts with the world, and these in turn depend on one's goals. The combination of goals, tools, and setting (or perhaps "arena," in Lave's, 1988, terminology) constitutes simultaneously the context of behavior and the ways in which cognition can be said to be distributed in that context.

The notion that mediation of activity through artifacts implies a distribution of cognition among individual, mediator, and environment, as well as the fundamental change wrought by artifact-mediated activity, is eloquently expressed by two otherwise very different anthropologists, Leslie White and Clifford Geertz. Writing about the nature of the discontinuity between *Homo sapiens* and its near phylogenetic neighbors, White (1942) wrote:

> Man differs from the apes, and indeed all other living creatures so far as we know, in that he is capable of symbolic behavior. With words man creates a new world, a world of ideas and philosophies. In this world man lives just as truly as in the physical world of his senses. . . . This world comes to have a continuity and a permanence that the external world of the senses can never have. It is not made up of present only but of a past and a future as well. Temporally, it is not a succession of disconnected episodes, but a continuum extending to infinity in both directions, from eternity to eternity. (p. 372)

Among other properties White here attributes to culture, his emphasis on the way it creates an (artificial) continuity between past and future merits special attention, as we will attempt to show a little later. It is also significant that both White and the Russian

cultural-historical psychologists (e.g., Vygotsky, 1934/1987) emphasize that, as mediators of human action, all artifacts can be considered tools and symbols. As White (1959) expressed the relationship:

> An axe has a subjective component; it would be meaningless without a concept and an attitude. On the other hand, a concept or attitude would be meaningless without overt expression, in behavior or speech (which is a form of behavior). Every cultural element, every cultural trait, therefore, has a subjective and an objective aspect. (p. 236)

What White refers to as the "subjective aspect" of artifacts should be thought of in the context of this discussion as the cognitive residue of prior actions crystallized in the object.

It is to Clifford Geertz that we owe some of the most explicit statements of both the distributed nature of mind and the interpenetration of the cultural-historical and phylogenetic aspects of human cognition. He argued, on the basis of the archaeological and paleolithic evidence, that "culture, rather than being added on, so to speak, to a finished or virtually finished animal, was ingredient, and centrally ingredient, in the production of that animal itself" (Geertz, 1973, p. 47). In words that echo strongly the ideas of the founders of the cultural-historical school in Russia, Geertz went on to write:

> By submitting himself to governance by symbolically mediated programs for producing artifacts, organizing social life, or expressing emotions, man determined, if unwittingly, the culminating states of his own biological destiny. Quite literally, although quite inadvertently, he created himself. (p. 48)

> Such symbols are thus not mere expressions, instrumentalities, or correlates of our biological, psychological, and social existence; they are prerequisites of it. Without men, no culture, certainly; but equally, and more significantly, without culture, no men. (p. 49)

### *Patterning of culturally distributed cognition*

There is a tendency in some anthropological circles to think of culture as a uniform, patterned ensemble of beliefs, values, symbols, tools, and so on that people share. This "configurational" approach is greatly influenced by the work of Franz Boas and his students in anthropology (see Bock, 1988, or Stocking, 1968, for an excellent summary of Boas's work) as well as by the cross-cultural psychologists who study "cognitive style" (Berry, 1976).

There is no doubt that culture is patterned, but there is also no doubt that it is far from uniform, because it is experienced in local, face-to-face interactions that are locally constrained and, hence, heterogeneous with respect to both "culture as a whole" and the parts of the entire cultural toolkit experienced by any given individual. This point has been emphasized by Ted Schwartz (1978, 1990), who explores the way in which knowledge is distributed differentially across persons, generations, occupations, classes, religions, institutions, and so on. Schwartz argues that culture is necessarily a distributed phenomenon insofar as it is brought to bear, and acquired, in everyday interactions among people, no two of whom share all of the culture of the group to which they belong. (Note that even the notion of group must be left underspecified, because it could refer to a group of children who have gone to the same summer camp, or to all of the people living in a particular place at a particular time speaking the same language, or to all of the residents of a large, modern, multiethnic, national state.)

This distributed view of culture, like the distributed view of brain processing espoused by the early Russian cultural-historical psychologists, also requires us to "step outside" a category boundary (in this case, culture rather than the brain) in order to specify how culture/cognition is distributed. For example, some of the commonality to be found in the schema/word meanings of a culture arises because of shared phylogenetic structure of human brains evolved under common environmental circumstances, while some of it arises from joint activity subordinated to phylogenetically underspecified, but historically accumulated cultural constraints (Boster, 1991). A distributed notion of culture also requires one to think about how cognition is distributed among people by virtue of their social roles (which, again, are both phylogenetically and culturally constrained). As Fussell and Krauss (1989) clearly demonstrate, part of one's cultural knowledge is knowledge about the extent to which others are likely to share one's knowledge and cognitive perspective. Hence, the social distribution of cognition both adds to, and subtracts from, the degree of common culture mediating any particular interaction.

While it may readily be agreed that culture is not a seamless configuration and that knowledge is distributed among people within a cultural group, it is still important to specify the units in terms of

which cultural structuration operates. In one well-known formulation, Geertz (1973) proposed that "culture is best seen not as complexes of concrete behavior patterns – customs, usages, traditions, habit clusters – . . . but as a set of control mechanisms – plans, recipes, rules, instructions (what computer engineers call 'programs') – for governing behavior" (p. 44). Significantly (since these mechanisms might seem to be located entirely inside people's heads and therefore entirely ideal) Geertz goes on to write in a manner that links up neatly with the notion of artifact mediation central to the cultural-historical approach:

> The "control mechanism" view of culture begins with the assumption that human thought is basically both social and public – that its natural habitat is the house yard, the marketplace, and the town square. Thinking consists not of "happenings in the head" (though happenings there and elsewhere are necessary for it to occur) but of traffic in what have been called, by G. H. Mead and others, significant symbols – words for the most part but also gestures, drawings, musical sounds, mechanical devices like clocks. (p. 45)

A complementary notion of structured ensembles within the overall medium of culture is offered by Roy D'Andrade, another anthropologist, who suggests the term "cultural schemas" to refer to units that organize entire sets of conceptual/material artifacts. In D'Andrade's (1984) terms:

> Typically such schemas portray simplified worlds, making the appropriateness of the terms that are based on them dependent on the degree to which these schemas fit the actual worlds of the objects being categorized. Such schemas portray not only the world of physical objects and events, but also more abstract worlds of social interaction, discourse, and even word meaning. (p. 93, original in italics)

D'Andrade's approach, like Geertz's, might be read as locating culture (and cognition) inside the head. However, D'Andrade (1986, p. 22), like Geertz, makes it quite clear that objects should be considered "reified ideas in a solid medium"; that is, objects are suffused with conceptual content.

D'Andrade refers to physically realized cultural models as mediating structures, using as an example Hutchins's (1986) discussion of checklists as tools to accomplish complex cognitive tasks involving people who work together. His points out that when using such mediator-cum-cultural models



> the user does not coordinate his or her behavior directly with the task environment, but rather coordinates with a mediating object that has a structure that is like the task environment in some important way. (p. 107)

After describing in detail all of the subroutines that must be mastered and executed in order for the checklist/script/model to be effective, D'Andrade concludes that "what might at first look like a simple device in fact turns out to be a complex of mediations – that is, of coordinations between structures" (p. 107). In the case of the checklist it is essential that the model and the reality it represents be identical. A highly experienced expert, on the other hand, may directly recall the actions and operations to be taken and their effects on the environment.

### *The distribution of cognition in the social world*

These descriptions of the units of organization of human activity within a cultural medium, like Bateson's example of the blind man with a stick, help us to think about the distribution of cognition between an individual, a mediating artifact, and the environment. At the same time, they invite us to locate those actions in a wider system of activity. For example, we might assume that Batesons' blind man is just stopping off at a café to have a beer and chat with friends before going down the block to participate in a local dramatic circle. This larger perspective makes us attend to the fact that short-lived actions of walking and sitting down are actually embedded in something collective and relatively enduring. Not only are the blind man's thoughts focused on the technical procedure of moving from place to place. When he sits down at the table he is part of one activity system with its standing rules, community, and division of labor. Should his companions at the café also be actors, they may be inhabiting one setting physically, but their mental activity may be organized (collectively) around a quite different one that they will participate in shortly. In short, constituents of the blind man's cognitive processing are to be located both in the immediate setting (distributed to each of the nodes in the expanded triangle in Figure 1.3) and in the upcoming activity, which is presupposed in all of his actions. Within each local setting, such "cognitive actions" as remembering and decision making are distributed not only among the artifacts (the menu, the

arrangement of chairs and tables, the sign pointing to the restrooms) but among the rules (one pays before leaving the premises; sitting down at a table with strangers requires one to ask permission) and among people according to the division of labor (waiters fulfill different parts of the activity at the café than the customers or the dishwasher; the janitor must remember to put away the mop and bucket; the owner is responsible for paying the janitor and waiter). It is such considerations that motivated Douglas (1987) to write a book about "how institutions think" and Connerton (1989) a book about "how societies remember."

### *The distribution of mind in time*

The final way in which we suggest that cognition is distributed is in time. We can best illustrate the properties of temporal distribution that we have in mind with an example drawn from a real-life event, the birth of a baby. Our example comes from the work of pediatrician Aiden Macfarlane (1977), who published several transcripts of the reactions of parents when they first caught sight of their newborn child and discovered its sex. Typical comments include "We shall be worried to death when she's eighteen" and "It can't play rugby" (said of another girl). Aside from their interest as indicators of sexism in Anglo-Saxon cultures in the 1960s, these remarks and the phenomena associated with them illustrate the kinds of distribution of cognition in time that are highlighted by a cultural-historical theory of mind.

In each of these examples, the adults interpret the biological characteristics of the child in terms of their own past (cultural) experience. In the experience of English men and women living in the mid-twentieth century, it could be considered "common knowledge" that girls do not play rugby and that when they enter adolescence they will be the object of boys' sexual attention, putting them at various kinds of risk. Using this information derived from their cultural past and assuming that the world will be very much for their daughter as it has been for them, the parents project a probable future for the child. (She will be sought after by males as a sexual partner, causing the parents anxiety. She will not participate in a form of activity [rugby] requiring strength and agility that is the special preserve of males.)

The different ways in which temporality enters into the distribution of cognition in time illustrated by Macfarlane's example are represented in Figure 1.4. Figure 1.4a presents five time lines, the bottom four of which correspond to the four "developmental domains" (Wertsch, 1985) that, according to the cultural-historical framework espoused here, simultaneously serve as major constraints on, and resources for, human development. At the top of Figure 1.4a is what might be called "physical time," or the history of the physical universe that long precedes the appearance of life on earth. The second line represents phylogenetic time, the history of life on earth. The third represents cultural-historical time, which has co-evolved with phylogenetic time. The fourth line represents ontogeny, the history of a single human being, and the fifth line represents microgenesis, the moment-to-moment time of lived human experience. The ellipse running vertically through the figure is the event under analysis, the birth of a baby girl. The four horizontal lines correspond to four kinds of genesis, four temporal scales: phylogenesis, culturogenesis, ontogenesis, and microgenesis, each "lower" level embedded in the level "above it."

To begin with, Macfarlane's example forces on us the need to keep in mind that not one but *two* ontogenic time scales are interacting here. This added time dimension is included in Figure 1.4b. That is at a minimum one needs a mother and a child in a single social context for the process of birth to occur and for human development to continue. These two ontogenies are coordinated in time by the simultaneous structuration provided by phylogeny, culture, and microgenetic processes of interaction. Following the arrow from the "thought" of the mother, one can see that it traces this thought process from the present into the cultural-historical past and then into the imagined future of the child, and finally back to the present in the form of patterned interactions with the child. In short, cognition is distributed both "vertically" in the different time dimensions occupied by each of the participants and "horizontally" with respect to past, present, and future.

This example also helps us to illustrate another feature attributed to culturally mediated thought: the process by which the "ideational" side of all cultural artifacts is transformed into its "material" side. One traces the temporal course of the mother's thought from

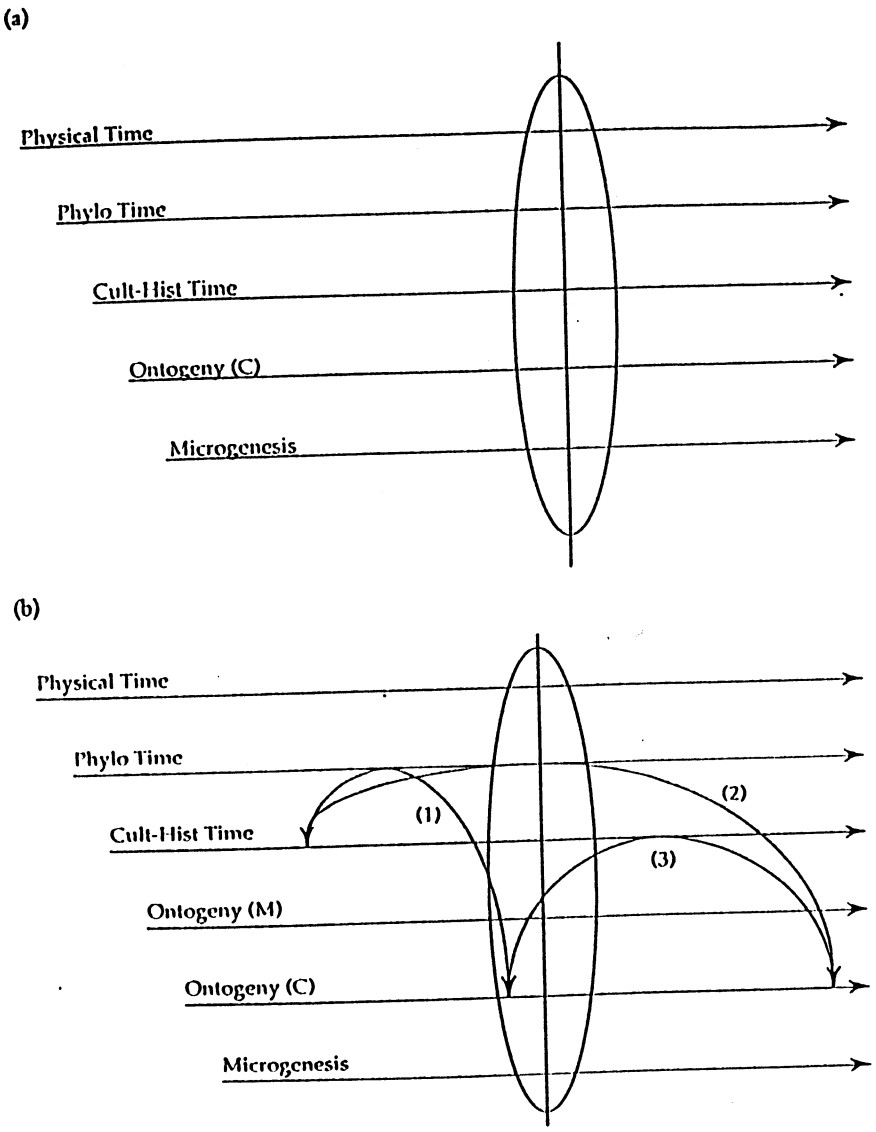


Figure 1.4. (a) The successive horizontal lines represent separate time scales corresponding to the history of the physical universe, the history of life on earth (phylogeny), the history of human beings on earth (cultural-historical time), the life of the individual (ontogeny), and the history of



present into the cultural past (taking note of the phylogenetic structure of the child), one sees that the parents' (purely ideal/cultural) projection of their child's future becomes a fundamentally important (material/cultural) constraint organizing the child's life experiences in the present. As copious research has demonstrated, even adults totally ignorant of the real gender of a newborn will treat the baby quite differently depending on its symbolic/cultural "gender." Adults literally create different material forms of interaction based on conceptions of the world provided by their cultural experience when, for example, they bounce "boy" infants (those wearing blue diapers) and attribute "manly" virtues to them, while they treat "girl" infants (those wearing pink diapers) in a gentle manner and attribute beauty and sweet temperaments to them (Rubin, Provezano, & Luria, 1974). Macfarlane's example also motivates the special emphasis placed on the social origins of higher psychological functions by cultural-historical psychologists. As his transcripts clearly demonstrate, human nature is social in a sense that is different from the sociability of other species because only a culture-using human being can "reach into" the cultural past, project it into the future, and then "carry" that (purely conceptual) future "back" into the present in the shape of beliefs that then constrain and organize the present sociocultural environment of the newcomer. It is worth recalling in this context White's telling image, that temporally the culturally constituted mind "is not a succession of disconnected episodes, but a continuum extending to infinity in both directions, from eternity to eternity." The assumption that the cultural future will be more or less like the cultural past, or (which may amount to the same thing) that we can only project a future based on past, culturally mediated experience, provides one essential basis of continuity in human mental life.

Figure 1.4. (*cont.*) moment-to-moment lived experience (microgenesis). The vertical ellipse represents the event of a child being born. (b) Another line, the ontogeny of the child, has been added to that of the individual. The distribution of cognition in time is traced sequentially into (1) the past of the mother, (2) the mother's imagination of the future of the child, and (3) the subsequent behavior of the mother. In this same sequence, the ideal aspect of culture is transformed into its material form as the mother and other adults structure the child's experience consistent with their (imagined) future identity.

## Two research programs: applying cultural-historical ideas in practice

Having laid out in a general way how a cultural-historical, activity-based approach to cognition leads one to think about the distribution of cognition among people, cultural artifacts, and time, we now provide two examples drawn from our own research that employ these ideas in addressing research issues of general interest to students of human cognition. Each example highlights a somewhat different mix of the distributive properties we have summarized.

### *Reading acquisition*

There is broad agreement that reading is a "complex skill requiring the coordination of a number of interrelated sources of information" (Anderson, Hiebert, Scott, & Wilkinson, 1985), and a great deal is known about how those who have acquired some degree of skill behave. But despite intensive research efforts throughout this century, and especially over the past two decades, the process of acquisition remains disputed (see Foorman & Siegel, 1986, for a juxtaposition of conflicting views). Especially troublesome has been the problem of accounting for "reading with comprehension" and the sequence of interactions through which this process develops. We believe that part of the problem in contemporary research on reading is that the psychological models of reading acquisition fail to take account of the distributed properties of cognition. In particular, they are especially weak in their conception of learning to read as joint, mediated, meaning-making activity between teachers and students in which the distribution of cognitive work must be systematically transformed.

Despite important differences among them, modern cognitive science approaches to reading share certain properties. First, they distinguish a series of "levels" in the constitution of written language that begin at the lowest level with features and proceed "upward" to letters, which make up words, which make up sentences, and so on. In principle, theories of reading posit the existence of both "bottom-up" decoding processes that assemble larger and larger units of text and "top-down," comprehension-driven processes that constrain the bottom-up processes to permit interpretation of the decoded texts.

When cognitive scientists present such models, the "bottom-up" parts of the process tend to be well specified up to the level of a word and, perhaps, to the level of a sentence or even a paragraph. But the "ultimate" top-down constraint appears only as an arrow descending from the top of the diagram, descending, as it were, from the bow of Zeus (McClelland & Rumelhart, 1981). Implicitly, this sort of model assumes reading to be a solitary activity occurring inside the head of the learner; the fact that learning is part of a larger, joint activity, called instruction, is not acknowledged. In reality, with very few exceptions, acquiring the ability to read is most decidedly *not* an individual process, and we have a pretty good idea of where Zeus's arrow is coming from – the teacher, the bearer of the cultural past, the bearer of authority concerning the correct interpretation of the text, the organizer of the teaching/learning process.

When we apply ideas about the distribution of cognition that flow from a cultural-historical, activity approach to the problem of reading acquisition, two principles present themselves as relevant:

1. The cognitive processing involved in learning to read is not an individual matter; the requisite cognitive processes are distributed among teacher, pupil, other students, and the cultural artifacts around which they coordinate in the activity called "teaching/learning" to read.
2. The expected future state, mature reading, must somehow be present at the beginning of instruction as constraints enabling the development of the to-be-acquired new system of mediation, mature reading.

*Bringing the endpoint "forward" to the beginning.* We begin by examining, in terms of the basic mediational triangle, the necessary structural properties of the interactions that should organize the activity setting we create at the "student–teacher" level of description. Figure 1.5 displays in graphic form the fact that at the beginning of instruction there are two preexisting mediational systems that can create the constraints necessary to permit the development of reading in the child. At the far left of the figure we represent the commonsense fact that children enter reading instruction with years

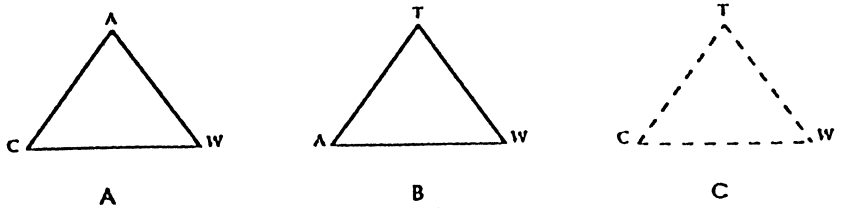


Figure 1.5. The to-be-coordinated systems of mediation that exist when a novice begins to learn to read from an expert. (A) The child C can mediate interactions with the world W via an adult A. (B) The adult can mediate interactions with the world via text. (C) The child–text–adult relationship is the goal of instruction.

of experience at mediating their interactions with the world via adults. In the center we represent the equally commonsense fact that literate adults routinely mediate their interactions through text. Finally, on the far right we represent the to-be-developed system of mediation that is our target.

Figure 1.6 shows the next stage in the analytic/instructional strategy: The given and to-be-developed systems of child mediations must be juxtaposed and the preexisting adult system superimposed on them, to create the skeletal structure of an "interpsychological" system of reading. As depicted in Figure 1.6, this mediational system establishes a dual system of mediation for the child, which permits the coordination of text-based and prior-world-knowledge-based information of the kind involved in the whole act of reading. The instructional/developmental task is now better specified: We must somehow create a system of interpersonal interaction such that the combined child–adult system at the right of Figure 1.6 can coordinate the child's act of reading before the child can accomplish this activity for him- or herself.

*Creating the activity.* Having identified the skeletal structural relations that must be coordinated at the level of teacher–student–text relations, we now need to figure out the system of activity that will achieve the needed coordinations. Our strategy for accomplishing this goal was to create an artificial activity system including a script, props, and roles. This system, understood as a distinctive form of ac-



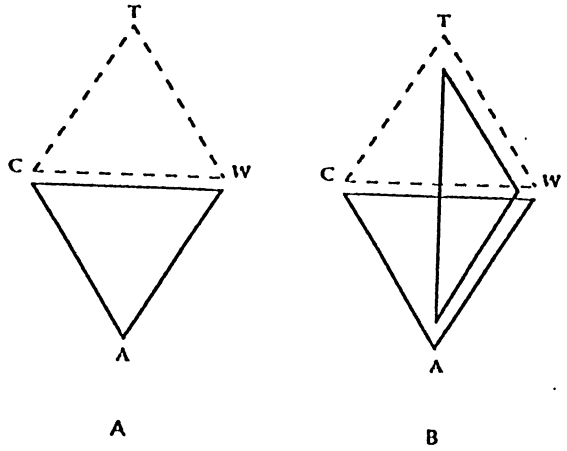


Figure 1.6. The juxtaposition of existing and to-be-formed systems of mediation that have to be coordinated. (A) The two existing systems. (B) The two existing systems plus the to-be-formed system.

tivity, deliberately distributes cognition through a system of artifacts so as to maximize both the teacher's ability to diagnose the state of the child's understanding and the chances that the child will learn to read. The specific procedure is a modification of the reciprocal teaching procedure of Palincsar and Brown (1984), in which teacher and student silently read a passage of text and then engage in a dialogue about it that includes summarizing the text, clarifying comprehension problems that arise, asking a question about the main idea, and predicting the next part of the text. For a number of reasons (see King, 1988; Laboratory of Comparative Human Cognition, 1982, for additional details), our modification of reciprocal teaching was instantiated as a small-group reading activity with third- to sixth-grade children identified by their teachers as experiencing extraordinary difficulties learning to read.

The key mediational tools of the procedure are a text, a publicly visible script for the joint activity written on a blackboard, a set of roles (each corresponding to a different hypothetical part of the whole act of reading reified in a set of role cards printed on 3-in. × 5-in. index cards), and rules for conducting the activity we called "Question-Asking-Reading."

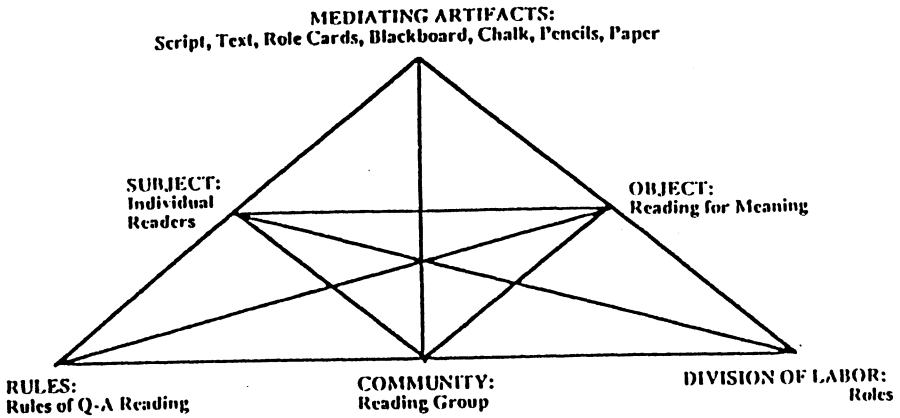


Figure 1.7. Question-Asking-Reading represented in terms of the expanded activity system model.

To connect the resulting procedure to the preceding and following discussion, Figure 1.7 represents the triangular structure of activity presented earlier in Figure 1.3 with the specific tools, object, community, division of labor, and social rules appropriate to the activity under construction. Figure 1.7 also specifies how we conceive of the distribution of cognition in the Question-Asking-Reading activity.

Question-Asking-Reading activity unfolded as shown in Figure 1.8. Each session began with "goal talk" about the children's reasons for wanting to learn to read. These included such poorly understood reasons (from the children's point of view) as the need to obtain an attractive job (e.g., as an astronaut), intermediate-level goals (graduating from Question-Asking-Reading to assist adults with computer-based instruction), and quite proximate goals (the desirability of getting correct answers on the quiz that came at the end of each reading session).

Next the group leader produced the text to be read and various paraphernalia important to the activity – role cards, pencils, paper, and a timer – and then turned attention from the script outline of the activity on the board to the text, simultaneously passing around the paraphernalia used in Question-Asking-Reading. This preparatory sequence ended with the choice of role cards. These cards specified the following roles:

1. The person who asks about words that are hard to say
2. The person who asks about the words that are hard to understand
3. The person who asks a question about the main idea
4. The person who picks the person to answer questions asked by others
5. The person who asks about what is going to happen next

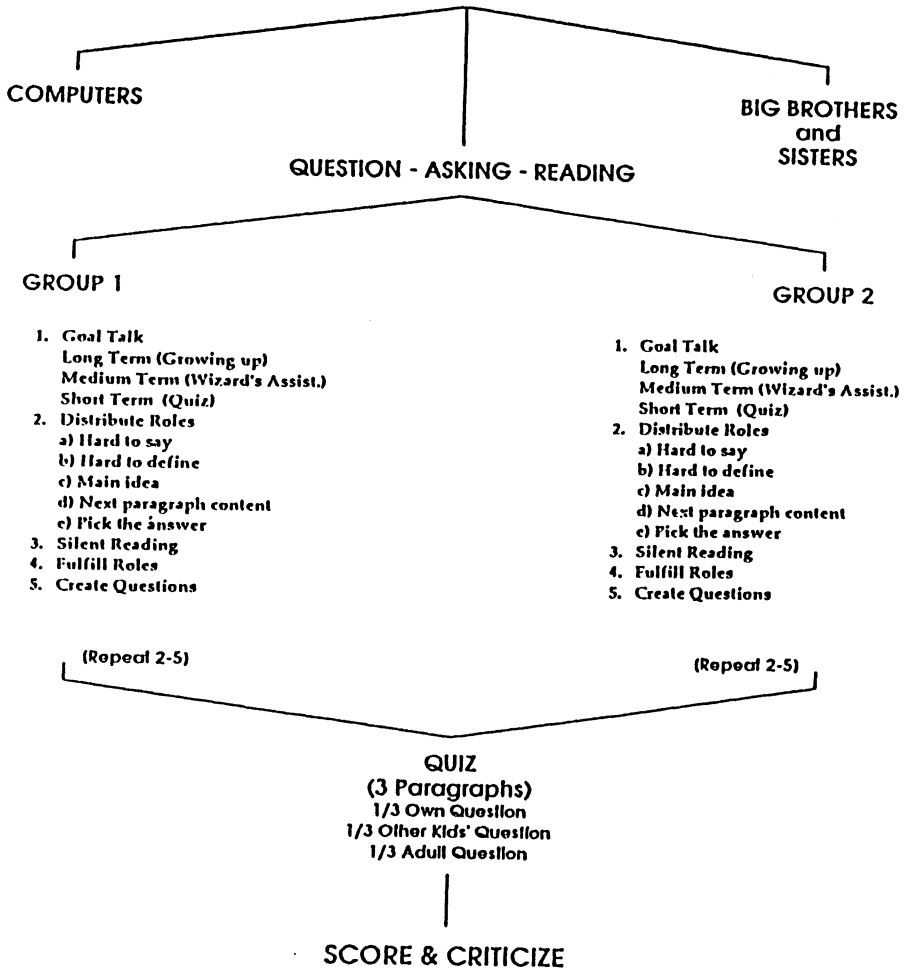


Figure 1.8. Overall structure of Question-Asking-Reading.

A good deal of discussion usually ensued about who had gotten what roles; picking the answerer was an obvious favorite, while the card implicating the main idea was avoided like the plague.

Once the role cards were distributed, the text for the day (usually taken from local newspapers with content of potential interest to the children) was distributed, one paragraph at a time. The participants (including the instructor and one competent reader, usually an undergraduate at the University of California, San Diego, and the children), then bent over their passages to engage in silent reading.

These and other procedural arrangements constituted our attempt to create a medium that would repeatedly create moments when the three mediational triangles depicted in Figure 1.5 would be coordinated to create the conditions for children to experience, and then perhaps acquire, the full act of reading.

Our evidence for the way in which this procedure worked is derived from several sources: videotaped recordings of the instructional sessions, the children's written work on the quizzes that completed each session, and various test results (see Griffin, King, Diaz, & Cole, 1989, for more details). Of greatest interest in the present context is the way in which this system allowed us to trace the microgenesis of reading acquisition.

For the first few sessions, the children were uncertain of the rules, roles, and tools for this strange form of reading. But the two competent readers present kept the activity going, and mutual help was encouraged. Within a few sessions, Question-Asking-Reading was a well-known routine. The children began to develop strategies for getting their favorite role cards. Various aspects of the procedure that provoked discoordination and repairs in the early sessions began to be presumed, not even acted out, by the children and the adults.

Once a relatively steady state of coordination around the artifacts and goals of Question-Asking-Reading was achieved, it became apparent that different children discoordinated with the routine in systematically different patterns. For example, one child experienced great difficulty in coming "unglued" from the letter–sound correspondences when he attempted to arrive at the main idea. When asked about the main idea, he repeatedly returned to the text and sought a "copy match" in which some word from the question appeared in the text, read the relevant sentence aloud, and then puzzled



over it. A second child's problem was of a quite different order: he continually lost track of the relevant context, importing information from his classroom activities that day or previous reading passages, although they had no relevance to the text being read.

Over the course of the sessions, the ability of all of the children to carry out parts of Question-Asking-Reading increased; that is, they could fulfill more roles more often without engendering any discoordination in the joint activity of reading with comprehension. Many of them displayed improved performance in their classrooms, and some showed improvement on state-mandated reading tests.

With respect to the in situ data, our ability to detect selective discoordinations in a joint, mediated activity served as powerful testimony to the efficacy of our approach to reading acquisition. But with respect to criteria external to the activity, such as grades and test scores, we had nothing principled to say because we had no proper control group. Having focused on the *process* of our system of reading instruction, we failed to address adequately the relative quality of the *product*. In order to address the issue of relative efficacy, King (1988) replicated the small-group reading procedures in a follow-up experiment that included appropriate control conditions and more stringently quantified pre- and posttest measures.

In addition to testing the effectiveness of Question-Asking-Reading against a no-treatment control group, King included a group of children who were provided the kind of structured intervention that Scardamalia and Bereiter (1985) call "procedural facilitation" to assess whether the dynamic, dialogic characteristics of Question-Asking-Reading were any more effective than workbook exercises that required children to complete each of the tasks corresponding to the role cards individually in written form. Once again children with difficulties in learning to read were selected from the upper elementary grades.

King found that both Question-Asking-Reading and her version of the procedural facilitation technique boosted the children's reading performance. However, children in the Question-Asking-Reading group retained significantly more material from the training passages than did the students in the procedural facilitation group. The students in the Question-Asking-Reading group also spent more total time actively engaged with the task and demonstrated a greater

interest in the content of the readings, indicating an intimate link between the motivational, social-interactional, and cognitive aspects of activity-in-context.

### *Expertise in transition*

Although education has traditionally been a primary area of human practice studied by cultural-historical researchers, a number of interesting studies illustrating the dynamics of cognition as a distributed phenomenon have been carried out in the domain of work. Our second example is taken from a longitudinal research project studying the reorganization of medical work in a Finnish health center that provides primary health-care services to the population of a middle-sized city (see Engeström, 1990, in press).

Work activity in a complex organization is an obvious case of distributed, artifact-mediated cognition. As an object of study it differs from reading acquisition in some important ways. The organization of an ongoing work activity cannot be designed from scratch by the researcher. Experimentation through design and implementation of a new model system of activity can nonetheless be built into the study of work. In what is called "developmental work research," researchers provide data and conceptual tools for the practitioners, who analyze the contradictions of their own work and design a new model for it in order to master and solve those contradictions. Such transformation is essentially an expansive learning process (Engeström, 1987) in which the practitioners acquire a new way of working while designing and implementing the new practices themselves.

A workplace is not a homogeneous activity system. Jay Katz (1984) points this out with regard to physicians:

> The public, and professionals as well, need to become more aware of the fact that many disparate groups now live under medicine's tent. Contemporary medicine is not a unitary profession but a federation of professions with differing ideologies and senses of mission. This diversification has changed medical practices. (p. 189)

There is also a historical dimension to be observed. Competing schools of thought and practice originate in different historical periods and conditions. Old traditions persist and are modified. In this



sense, alternative frames of reference may be analyzed as if they are historical layers of expertise, to be identified by an "archaeology of expert knowledge." Competing and contradictory historical layers of expertise can regularly be discovered within one and the same organization, and often within the actions and thoughts of one and the same practitioner.

To begin with, we conducted an extensive interview with each of the 16 physicians of two health stations in a single health center. The interview contained, among other themes, a cluster of questions concerning the physician's conception of the object of his or her work. These questions required the physicians to describe and justify their reactions in hypothetical difficult situations (e.g., a patient visit the physician considers medically unnecessary; a patient with unclear or incomprehensible symptoms; a patient with mental symptoms; a patient with a self-made diagnosis; a patient with multiple problems).

The analysis of the interview protocols resulted in a classification of the physicians' frames of reference concerning the object of their work (Table 1.1). The five frames of reference found among the physicians of this organization correspond to five historically distinct and culturally deep-seated theoretical patterns of thinking about illness (see, e.g., Arney & Bergen, 1984; Shorter, 1985). These frames of reference cannot be conceived of in terms of stages along a one-dimensional path from novice to expert: The 16 subjects were a quite homogeneous group in terms of age and years of professional experience.

In addition to conducting interviews, we videotaped five or six randomly chosen patient consultations with each of the doctors. Analyses of the videotapes support the conclusion that these distinct frames of reference are in fact connected to different practical procedures or "scripts" for dealing with patients in practice (Engeström, 1989).

This kind of diversity or multivoicedness is an important feature of the distribution of cognition in expert work. Potentially it is a rich source of resources, making the activity system capable of combining different viewpoints and skills in the handling of complex problems.

However, in this particular organization, as in so many modern organizations, the potential advantages of multivoicedness were all but impossible to tap. The health centers in Finland provide primary-care services free of charge. In the center we studied, there were a

Table 1.1. *Physicians' conceptions of the object of their work*

| Object of work | Number of subjects | Corresponding theory of illness | Key expressions in the transcripts |
|---|---|---|---|
| Somatic diseases | 4 | Ontological-biomedical | Old-fashioned diseases; small problems medically unnecessary; clear-cut causes; psychic problems difficult; self-made diagnosis aggravating; care is under control; patient is honest and compliant |
| Consumers of health-care services | 4 | Administrative-economic | Types of visits and patients; misuse; referrals; self-made diagnosis aggravating; relationship between patient and institution; patient should observe the agreed-upon appointment |
| Patient as a psychosomatic whole | 1 | Psychiatric | Mental health problems; no unnecessary visits; deepest psychic reasons revealed through interviewing; patient must be made to talk; give patient time |
| Patient's social life situation | 2 | Sociomedical | Social problems and multiple illnesses; no unnecessary visits; psychic problems have social origins; patient's own diagnosis important |
| Patient as collaborator | 5 | Systemic-interactive | Active thinking patients; unnecessary visits caused by lack of knowledge and bureaucracy; make patient reflect on his or her own situation and alternative action; make patient take health into his or her own hands; patients more critical and informed than they used to be; equal collaboration |



large number of patients who used the services excessively and changed doctors constantly (either willingly or unwillingly). These patients usually seemed to have multiple problems, often with psychosocial implications. These were important features of the substantial complexity of physicians' work in the health center. The physicians were compartmentalized in their work, both organizationally and in terms of their approaches. Organizationally, any patient could see any doctor, depending on who happened to be on duty or have available time slots. A doctor was not assigned any population list or geographic area for which he or she would be permanently responsible. Doctor–patient relationships were dominated by anonymity and discontinuity. These facts, together with strong production pressures, created an atmosphere of deepening crisis in the activity system.

The physicians had little time or incentive to stop and reflect on the problem of complex patients, let alone to discuss them jointly. The immediately available communicative tool, the computerized medical records system, in no efficient way helped or prompted the physicians to analyze and plan the care of these patients collaboratively. Health center assistants, trained as assistant nurses, were effectively reduced to gatekeepers allotting appointment times to patients.

The compartmentalized organization of expertise led to recurrent open and latent disturbances and discoordinations in the functioning of the activity system. The following is a rather commonplace example of such occurrences (for more details, see Engeström, Engeström, & Saarelma, 1988).

A male patient in his early 20s comes as an acute case to see a female doctor whom he has not seen before. The patient complains of a cold and cough. The doctor examines the patient and gives him a sick leave for two days. She then suggests that the current symptoms might have something to do with the patient's previous chest pains and hyperventilation problems, of which she learned from the patient's computerized medical record. The patient denies the connection. In a postconsultation interview the doctor explains that from the patient's multiple previously recorded visits she got an impression of a "young man who may react sensitively with his body."

This doctor is unusual in that she takes a very careful look at the past record of a patient with a common cold, even if the patient makes it clear that the symptoms have only emerged the previous day. The doctor hypothesizes a link between the cold and the patient's frequent visits and his history of frequent colds, chest pains, and hyperventilation, for which he has been treated in a hospital. Considering the fact that the doctor has never seen the patient before and that she hasn't had a chance to discuss the patient with her colleagues, the computerized record functions here in a remarkable manner as a diagnostic aid, providing a bridge between the past recorded by others and the present faced by the first-timer.

The same patient returns to the health center about three months later. He comes to another female doctor whom he has not seen before, again as an acute case without an appointment. Again, the complaint is rather commonplace: "When I breathe out or cough or laugh, it hurts here kind of like in the lung." The doctor examines the patient. She then asks whether the patient has ever before had "anything in his lungs." The patient says no. The doctor gives the patient a two-day sick leave. She then sends the patient to the X-ray department to make sure that there is no organic abnormality in the lungs. She enters the referral to that department into the computer.

All in all, this doctor takes an approach that is very different from the previous one. Instead of studying the record to make a hypothesis based on the patient's history, the doctor acts on the basis of the patient's explicit statements and physical examination. In the postconsultation interview, she justifies her approach by referring to the acute nature of the case. She states that had the patient had a similar problem previously, she would have suspected anxiety or related mental reasons. But since the patient denied having similar lung or chest problems before, she went ahead on a purely biomedical basis.

In other words, the first doctor's hypothesis about a connection between the patient's repeated colds, previous chest pains, hyperventilation, and possible underlying psychic problems was not followed up by the second doctor. The two consultations happened as if with two different patients. Ostensibly this break occurred because the second doctor did not check the patient's previous records.

In his postconsultation interview, the patient expressed no dissatisfaction with such discontinuity and compartmentalization. Rather, it



seemed to fit and reinforce his own way of drifting through the events of life – and from one doctor to another.

It might be tempting to dismiss this patient's case as too vague and confused to be taken seriously. However, the patient used many health-care services by drifting from one doctor to another and from one variation of symptoms to another. He thus contributed to the production pressure felt by practitioners in the activity system.

The communicative rupture between the two consultations remained latent and unnoticed. It did not surface as an open disturbance – although such situations often do. It would be easy to blame the second doctor for the rupture. But that would in no way help us understand the recurrent features of the activity system that make such ruptures commonplace. Actually the second doctor acted according to the rules of the system. It was the first doctor who violated the rule requiring that in acute cases attention to be paid only to the current, acute symptoms.

In this activity system, deep-seated contradictions were a better explanation for such breaks than were mere technical shortcomings of the medical record system or so-called psychological resistance of the doctors to computers and communication. The first contradiction was that between the complexity of the patient's problems and the arbitrary distribution of patients to physicians, each compartmentalized and effectively separated from the others. The second contradiction was that between the demand for quality care for complex problems and the rule requiring speedy consultations, especially in the category of acute consultations without an appointment. The ensuing production pressure reinforced a compartmentalized approach on the doctor's part. The third contradiction was that between complex patient problems and rather traditional tools of biomedical diagnosis. In such conditions, the medical record easily served as only a minimal administrative device.

In Figure 1.9, the three contradictions are placed in appropriate locations within our general model of an activity system. The compartmentalized and alienated approach to health care, reinforced by drifting on the patients' part, eventually contributed to increased production pressure. A vicious circle was thus established.

The researcher's task was to provide data (such as the videotapes and interview transcripts of the case discussed earlier) and conceptual

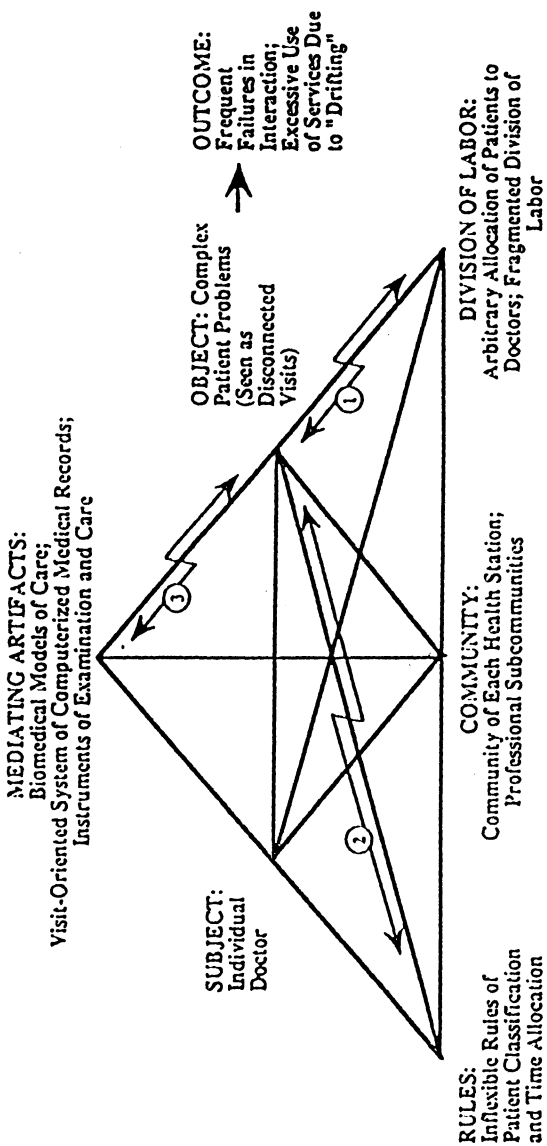


Figure 1.9. A representation of the health-care workers' activity system with major contradictions indicated.



tools (such as the models in Figures 1.3 and 1.9) that enabled the practitioners to break the vicious circle by realizing how their division of labor reinforced and perpetuated the production pressure and alienation they felt. The identification and conceptualization of such contradictions by the practitioners were a crucial precondition for their focused effort to design a new model for their work.

The key feature of this new model is a new division of labor that radically alters the conditions for exploiting the distributed cognitive resources of the system. Each physician is assigned a geographic area with a population of 2,000 to 2,500 inhabitants for whose primary health services the physician is responsible. Four physicians and two health center assistants responsible for adjoining areas constitute a team. Team members help one another; for example if a doctor is ill, others in the team make sure that an excessive patient backlog will not be generated for that doctor. Each team has its own designated physical space and reception within a health station. In that way, the large health stations are effectively decentralized. The inhabitants receive a letter telling them who their designated physician and team are to be. The teams meet regularly to organize, plan, and evaluate their work. Teams are responsible for analyzing the health-related needs of their target populations (community diagnosis). Health center assistants are drawn into direct interaction with patients, giving guidance and participating in actual care. As full-fledged team members, they also take responsibility for the overall functioning of the team. The key features of the new model are summarized in Figure 1.10.

The implementation of the new model produced some dramatic outcomes. In 1987 and 1988, the crisis of the health center began to manifest itself in the form of an increasing number of vacant positions for physicians. Several doctors left the activity system, often moving to the private health care sector. It was extremely difficult to recruit new doctors.

The new model required that for each carefully composed population area there was a designated doctor. In the fall of 1988, the two health stations where the project was carried out were anxious to start implementing the new model, but the lack of doctors threatened to postpone the implementation. It was feared that the postponement

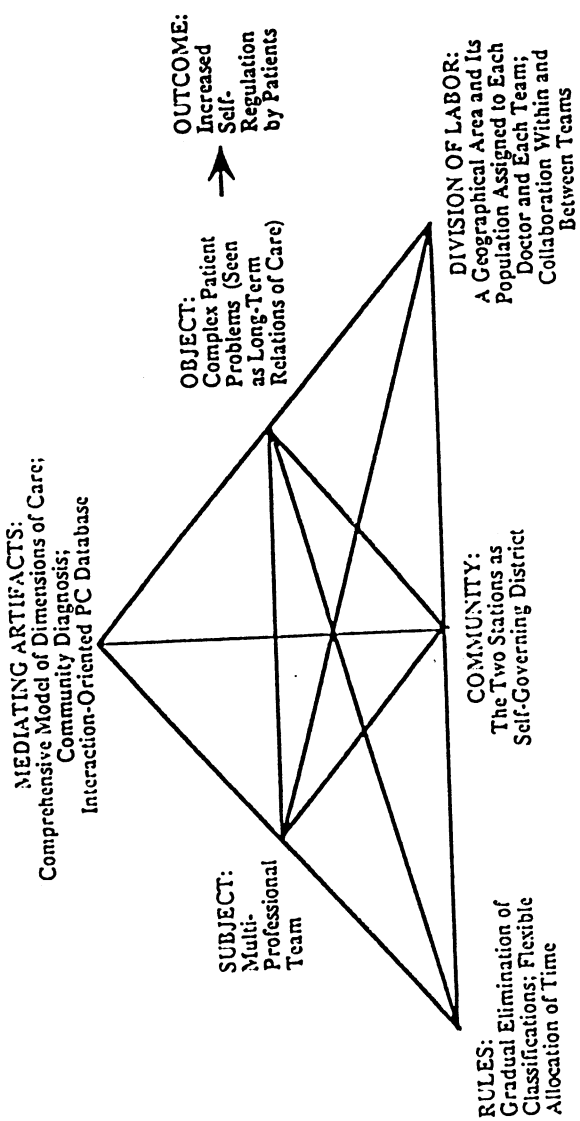


Figure 1.10. A representation of the created system of activity following resolution of the crisis of change.



would allow the crisis to deepen, thus making the implementation even more improbable. In other words, an aggravated form of a vicious circle was emerging. After an initial two-month postponement, a series of crisis meetings were held among the personnel of the stations. The personnel of the smaller station came up with a solution. They proposed lending some of their doctors temporarily to the bigger station, so that the implementation could proceed in the population areas of that station. The smaller station would operate with minimal personnel resources, as if on an emergency basis, until the new model's beneficial impact in the bigger station could attract a sufficient number of new physicians to the system. This proposal was accepted.

The implementation was in fact so successful that, by the summer of 1989, all the vacancies were filled and the two stations started to operate jointly on the basis of the new model. The new model dramatically changed the availability and accessibility of care. Long waiting times and queues have all but disappeared, and there is no longer a shortage of physicians willing to work in the stations. For example, in October 1988 (the last month before the implementation of the new model), the average waiting time for patients coming to the walk-in urgent care unit was 103 minutes; a year later it was 27.5 minutes. In 1988, a patient had to wait three to four weeks for an appointment. In 1990, all doctors had appointments available within one to three days. These changes are clearly reflected in the distribution of different types of visits to the doctors (Table 1.2). The excessive use of walk-in urgent care services was dramatically reduced as the accessibility and availability of regular daytime appointments and telephone consultations were improved.

Cognitively, this transformation demands that the practitioners reconceptualize the object of their work. Instead of occasional visitors, patients and their problems are to be seen as being in potential or ongoing long-term care relationships with the doctors. After the implementation of the new model, one of the physicians characterized this reconceptualization as follows:

> In this new model of work, it makes sense to treat patients who have a prolonged problem actively from the beginning. You can't deal with the problem shortsightedly, like here is medicine and come back if it continues – because the patient comes back to you. It's better to spend a bit more time the first time, you'll get the benefit when

Table 1.2. *Distribution of visits to doctors before and after the implementation of the new model*

| Type of visit | Jan. 1 to June 30, 1988 | Jan. 1 to June 30, 1990 | Percent change |
|---|---|---|---|
| With appointment | 14,724 | 20,192 | +37 |
| Without appointment during daytime | 8,023 | 4,973 | −38 |
| Walk-in urgent care in the evenings | 4,946 | 3,895 | −21 |
| Telephone contacts | 3,600 | 5,277 | +47 |

it continues. I mean, do it properly right away. Previously we were tempted to do it more superficially and we hoped that the patient would go to someone else if the problem continues.

If the daily functioning of the activity system in crisis took the form of a vicious circle, the transition just described might be characterized as an expansive cycle (Engeström, 1987, 1991). An expansive cycle is a developmental process that involves both the internalization of a given culture of practice and the creation of novel artifacts and patterns of interaction. The new activity structure does not emerge out of the blue. It requires reflective analysis of the existing activity structure – participants must learn to know and understand what they want to transcend. And the creation of a new activity system requires the reflective appropriation of advanced models and tools that offer ways out of the internal contradictions. However, these forms of internalization are not enough for the emergence of a new structure. As the cycle advances, the actual design and implementation of a new model for the activity gain momentum: Externalization begins to dominate. This is schematically depicted in Figure 1.11. The expansive cycle of an activity system begins with almost exclusive emphasis on internalization, on socializing and training novices to become competent members of the activity as it is routinely carried out. Creative externalization occurs first in the form of discrete individual violations and innovations. As the disruptions and contradictions in the activity become more demanding, internalization increasingly takes



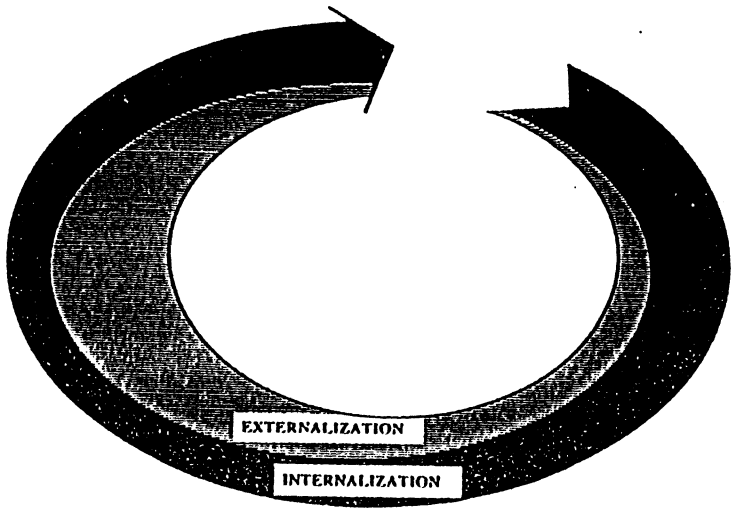


Figure 1.11. A representation of the cyclical relationship between internalization and externalization at different points in an expansive cycle of changing activity.

the form of critical self-reflection – and externalization, the search for novel solutions, increases. Externalization reaches it peak when a new model for the activity is designed and implemented. As the new model stabilizes itself, internalization of its inherent ways and means again becomes the dominant form of learning and development.

At the level of collective activity systems, such an expansive cycle can be seen as the equivalent of traveling through the zone of proximal development discussed by Vygotsky (1978) at the level of individual and small-group learning. A key feature of expansive cycles is that they are definitely not predetermined courses of one-dimensional development. What is more advanced, "which way is up," cannot be decided using externally given, fixed yardsticks. Decisions of that kind are made locally, within the activity system itself, under conditions of uncertainty and intensive search. Yet they are not arbitrary decisions. The internal contradictions of the activity system in a given phase of its evolution can be more or less adequately identified, and any model for the future that does not address and solve those contradictions will eventually turn out to be nonexpansive.

Expertise can be understood as a system of cognition, distributed as an activity system. The type of distribution observed in the health center at the beginning of the project was one of compartmentalization. The type of distribution achieved through the expansive cycle was one of teamwork. The transition from compartmentalized expertise to team-based expertise was essentially a process of redistribution of cognition based on design from below. It can be assumed that such a design will be incorporated into the new team-based type of expert practice as a novel cognitive resource. The verification of this assumption will be a task of further analysis.

## By way of a summary

We have not been able to provide examples of all the ways in which cognition manifests itself as distributed activity. However, we hope that our brief treatment of two examples selected to represent different forms of activity and different parts of the life cycle are sufficient to make clear the affinity between cultural-historical psychology and the notion of distributed cognition. In essence, when one takes mediation through artifacts as the central distinctive characteristic of human beings, one is declaring one's adoption of the view that human cognition is distributed. Precisely how cognition is distributed must be worked out for different kinds of activity, with their different forms of mediation, division of labor, social rules, and so on. The underlying principles, however, are universal. In aggregate they constitute a cultural theory of mind.

After reading an earlier draft of this chapter, a commentator asked what seems to us to be two reasonable and interesting questions. First, why is all of this rediscovery of the idea of distributed cognition going on right now? Second, have we learned anything from this rediscovery that would allow us to say we had made scientific progress?

Why the current burst of interest in distributed cognition? In the most general terms, it is because of the widespread belief that the positivistically oriented social sciences, with their notion of cognition firmly located inside the individual, are inadequate for the task of



grasping the essential nature of human experience and behavior. That psychologists are *re*discovering these ideas stems from the same source: We are replaying in new terms precisely the same debate in which Wundt, Münsterberg, Dewey, and the Russian cultural-historical psychologists formulated competing versions of a psychology that unites the natural and cultural sciences. Such attempts at unification, we believe, will come up with some way of conceptualizing cognition as a distributed phenomenon.

Have we made any progress? We are not so sure, save for the fact that we are attacking the problem having learned from the experiences of our predecessors. An additional advantage is that we have a far more sophisticated technology for representing complex, temporally extended behavior than did researchers at the end of the century. Audio and video tape recording, films, and computers have all, in their own way, enabled us to interact with the phenomena of mind in a more sophisticated way. We can now not only talk about the mutual constitution of human activities, but display it in scientifically produced artifacts. Whether these advantages will prove any greater relative to the complexities of the tasks we are asked to deal with is another matter. We believe we *can* create cognitively and socially useful forms of activity in a variety of institutional settings. But so could Dewey, Luria, and Münsterberg. Our inclination is to conclude that our progress, if any, has been slight. Goethe could be nodding his head.

We should note in closing that the joint activity of producing this chapter was distributed in a manner that is recent historically but that is increasing rapidly in frequency. During the first round of writing, one author was in northern California, the other in southern California. During the second round of writing, one author was in southern California, the other in northern Europe. One writes on an MS/DOS machine, one on a Macintosh. Three Unix systems and an electronic mail network mediated between the different text editors and linked the co-authors to each other and to support staff (including the U.S. and Finnish postal systems). It may be in no small measure owing to such new forms of joint-activity-at-a-distance that we have made the current rediscovery that thinking occurs as much among as within individuals.

## References


Anderson, R. C., Hiebert, E. H., Scott, J. A., & Wilkinson, I. A. G. (1985). *Becoming a nation of readers.* Washington, DC: National Institute of Education.

Arney, W. R., & Bergen, B. J. (1984). *Medicine and the management of living: Taming the last great beast.* Chicago: University of Chicago Press.

Bateson, G. (1972). Form, substance, and difference. In *Steps to an ecology of mind* (2d ed.). New York: Ballantine Books.

Berry, J. (1976). *Ecology and cultural style.* New York: Sage-Halstead.

Blumenthal, A. L. (1980). Wilhelm Wundt: Problems of interpretation. In W. G. Bringmann & R. D. Tweney (Eds.), *Wundt studies: A centennial collection* (pp. 435–45). Toronto: Hogrefe.

Bock, P. (1988). *Rethinking psychological anthropology.* New York: Freeman.

Boster, J. (1991). The information economy model applied to biological similarity judgement. In L. B. Resnick, J. Levine, & S. D. Behrend (Eds.), *Perspectives on socially shared cognition* (pp. 203–25). Washington, DC: APA Press.

Cahan, E. D., & White, S. (1992). Proposal for a second psychology. *American Psychologist, 47,* 224–35.

Connerton, P. (1989). *How societies remember.* Cambridge University Press.

D'Andrade, R. (1984). Cultural meaning systems. In R. A. Shweder & R. A. LeVine (Eds.), *Culture theory: Essays on mind, self, and emotion* (pp. 88–119). Cambridge University Press.

(1986). Three scientific world views and the covering law model. In D. Fiske & R. Shweder (Eds.), *Meta-theory in the social sciences* (pp. 19–41). Chicago: University of Chicago Press.

(1990). Culture and human cognition. In J.W. Stigler, R.A. Shweder, & G. Herdt (Ed.), *Cultural psychology: Essays on comparative human development.* Cambridge University Press.

Dewey, J. (1963). *Experience and education.* New York: McMillan. (Originally published 1938.)

Douglas, M. (1987). *How institutions think.* London: Routledge & Kegan Paul.

Edelman, G. (1987). *Neural Darwinism.* New York: Basic Books.

Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research.* Helsinki: Orienta-Konsultit.

(1989). *Developing thinking at the changing workplace: Toward a redefinition of expertise* (Technical Rep. 130). University of California, San Diego: Center for Human Information Processing.

(1990). *Learning, working and imagining: Twelve studies in activity theory.* Helsinki: Orienta-Konsultit.

(1991). Activity theory and individual and social transformation. *Multidisciplinary Newsletter for Activity Theory, 7–8,* 6–17.

(in press). Developmental studies on work as a testbench of activity theory. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context.* Cambridge University Press.





Engeström, Y., Engeström, R., & Saarelma, O. (1988, September). Computerized medical records, production pressure and compartmentalization in the work activity of health center physicians. In *Proceedings of the Conference on Computer-Supported Cooperative Work* (pp. 65–84). New York: Association for Computing Machinery.

Farr, R. (1987). The science of mental life: A social psychological perspective. *Bulletin of the British Psychological Society, 40,* 1–17.

Foorman, B., & Siegel, A. W. (Eds.). (1986). *The acquisition of reading skills.* Hillsdale, NJ: Erlbaum.

Fussell, S. R. & Krauss, R. M. (1989). The effects of intended audience on message production and comprehension: Reference in a common ground framework. *Journal of Experimental Social Psychology, 25,* 203–19.

Geertz, C. (1973). *The interpretation of culture.* New York: Basic Books.

Griffin, P., King, C., Diaz, E., & Cole, M. (1989). *A socio-historical approach to learning and instruction* (in Russian). Moscow: Pedagogika.

Hutchins, E. (1986). Mediation and automatization, *Quarterly Newsletter of the Laboratory of Comparative Human Cognition, 8,* 47–57.

Katz, J. (1984). *The silent world of doctor and patient.* New York: Free Press.

King, C. (1988). *The social facilitation of reading comprehension.* Unpublished doctoral dissertation, University of California, San Diego.

Laboratory of Comparative Human Cognition (1982). A model system for the remediation of learning disabilities. *Quarterly Newsletter of the Laboratory of Comparative Human Cognition, 4*(3), 39–66.

Lave, J. (1988). *Cognition in practice.* Cambridge University Press.

Leont'ev, A. N. (1932). Studies in the cultural development of the child, 3: The development of voluntary attention in the child. *Journal of Genetic Psychology, 37,* 52–81.

(1978). *Activity, consciousness, and personality.* Englewood Cliffs, NJ: Prentice-Hall.

(1981). *Problems in the development of mind.* Moscow: Progress Publishers.

Luria, A. R. (1928). The problem of the cultural development of the child. *Journal of Genetic Psychology, 35,* 506.

(1932). *The nature of human conflicts.* New York: Liveright.

(1973). *Traumatic aphasia.* New York: Basic Books.

(1978). The development of writing in the child. In M. Cole (Ed.), *The selected writings of A. R. Luria.* White Plains, NY: Sharpe. (Originally published 1929.)

(1979). *The making of mind.* Cambridge, MA: Harvard University Press.

(1981). *Language and cognition.* Washington, DC: Winston.

Macfarlane, A. (1977). *The psychology of childbirth.* Cambridge, MA: Harvard University Press.

Maniulenko, Z. V. (1975). The development of voluntary behavior in pre-school-age children. *Soviet Psychology, 13,* 65–116. (Originally published 1948.)

McClelland, J. L. & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception, Part 1: An account of basic findings. *Psychological Review, 88*(5), 375–407.

Münsterberg, H. (1914). *Psychology: General and applied.* New York: Appleton.
Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and monitoring activities. *Cognition and Instruction, 1,* 117–75.
Rubin, J. Z., Provezano, F. J., & Luria, Z. (1974). The eye of the beholder: Parents' view on sex of newborns. *American Journal of Orthopsychiatry, 44,* 512–19.
Scardamalia, M., & Bereiter, C. (1985). Fostering the development of self-regulation in children's knowledge processing. In S. F. Shipman, J. W. Segal, & R. Glaser (Eds.), *Thinking and learning skills: Research and open questions* (pp. 65–80). Hillsdale, NJ: Erlbaum.
Schwartz, T. (1978). The size and shape of culture. In F. Barth (Ed.), *Scale and social organization* (pp. 215–52). Oslo: Universitetsforlaget.
(1990). The structure of national cultures. In P. Funke (Ed.), *Understanding the USA* (pp. 110–49). Tübingen: Gunter Narr.
Shorter, E. (1985). *Bedside manners: The troubled history of doctors and patients.* New York: Simon & Schuster.
Stocking, G. (1968). *Race, culture, and evolution.* New York: Free Press.
Toulmin, S. (1981). Toward reintegration: An agenda for psychology's second century. In R. A. Kasschau & C. N. Coter (Eds.), *Psychology's second century: enduring issues* (pp. 264–86). New York: Praeger.
Valsiner, J. (1988). *Developmental psychology in the Soviet Union.* Bloomington: Indiana University Press.
Vygotsky, L. S. (1929). The problem of the cultural development of the child, II. *Journal of Genetic Psychology, 36,* 415–34.
(1960). *The development of higher psychological functions (in Russian).* Moscow: Izdael'stov Akademii Pedagogicheskikh Nauk.
(1978). *Mind in society.* Cambridge, MA: Harvard University Press.
(1987). *Thinking and speech.* New York: Plenum. (Originally published 1934.)
Wertsch, J. (1985). *The social formation of mind.* Cambridge, MA: Harvard University Press.
White, L. (1942). On the use of tools by primates. *Journal of Comparative Psychology, 34,* 369–74.
(1959). The concept of culture. *American Anthropologist, 61,* 227–51.
Wundt, W. (1921). *Elements of folk psychology.* London: Allen & Unwin.



# 2 Practices of distributed intelligence and designs for education

*Roy D. Pea*

## Introduction

Widespread conceptions of learning and reasoning invoke "intelligence" largely as a property of the minds of individuals. This belief is prevalent in educational settings, which are concerned largely with solitary intelligence. Intelligence, they say, is what testing firms test and, increasingly commonly, what schools need to be held more accountable to measuring and improving.

Problems lurk in these assumptions. Anyone who has closely observed the practices of cognition is struck by the fact that the "mind" rarely works alone. The intelligences revealed through these practices are distributed – across minds, persons, and the symbolic and physical environments, both natural and artificial. Gregory Bateson remarked that memory is half in the head and half in the world. In this chapter, I will first lay out the central ideas of the distributed-intelligence framework and then provide a background to its development, before closing with considerations of some implications for education. How we think about these relations may change what we

Portions of this chapter were originally slated to appear in a book edited by David Perkins and Becky Simmons of Harvard University's Educational Technology Center. Plans for that book subsequently foundered, and portions of my essay (Pea, 1988) appear here as a necessary pretext to subsequent work. Previous papers on this theme were first presented in April 1988 to the First Annual Cognition and Education Workshop, Bolt, Beranek and Newman, Inc., Cambridge, Massachusetts, and at the 1988 Cognitive Science Society Meetings. Related work was described at the 1989 Social Science Research Council Conference on Social Aspects of Computing (in which Gavriel Salomon and David Perkins participated) and in the 1990 American Educational Research Association Symposium on Distributed Intelligence, which led to the plan for this book. I am indebted to Christina Allen for provocative discussions of distributed intelligence, especially concerning design and the roles of human desires.