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# Across the Scales of Time: Artifacts, Activities, and Meanings in Ecosocial Systems

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## INTRODUCTION AND OVERVIEW

How do *moments* add up to *lives*?

How do our shared moments together add up to *social life* as such?

Every human action, all human activity takes place on one or more characteristic timescales. A heartbeat, a breath, a step, a spoken word takes but a moment; a stroll, a conversation extends over many such moments; and an education or a relationship may be a lifetime project. The great cathedrals of Europe were built over many human lifetimes, and the languages and discourse patterns of our communities have developed over still longer times. And yet a conversation consists of many momentary utterances; a relationship may be built of many strolls and conversations together; a building or a social institution is erected by the sum of many individual actions in a community.

*How?* How do actions or events on one timescale come to add up to more than just a series of isolated happenings? How does a *language* emerge from many utterances? How does a *community* emerge from many people-in-action? On how many different timescales is our social life organized? How does persistent organization on longer timescales constrain the likelihood of events on shorter timescales? How do organizational units and processes on shorter timescales make possible the emergent patternings we recognize on longer timescales?

*Why time?* Our material world is organized on many scales: space, time, matter, energy, and information transfer. In many natural systems there is a strong correlation among these scales: the quick is also small and light and weak and simple; however, in more complex systems, especially those in which *signs* and *meaning* play a role in behavior and system dynamics, these simple correlations break down.

Classical systems theory is rooted in spatial metaphors and the reductionist project: large systems are to be understood by analyzing them in terms of interactions among smaller component

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subsystems. Molecules are understood in terms of interactions of atoms, atoms through interactions of smaller particles. Organisms are analyzed by a hierarchy of interactions among units at progressively smaller spatial scales: organ systems, tissues, cells, organelles, and macromolecules. Ecosystems are modeled as interactions among species and abiotic elements; galaxies as interactions among star clusters or individual suns. In all these cases there is a fundamental assumption: units nearer in space are more likely to interact and to interact more strongly (i.e., with greater effect on one another). This assumption imposes a "spherical" topology on the system: relative to any center, items at the same distance scale (i.e., in the same spherical shell) are equally likely to be interaction partners, with the closer ones interacting more often or more strongly and the further ones less.

In many complex systems, however, this assumption fails. Two distant points along the same stream may interact more than two nearer points not linked by the stream. Two distant cells may communicate chemically via the bloodstream; two distant neurons may interact more than closer ones not in the same neural network of pathways, sensitized to the same neurotransmitters or neuromodulators. In a pond or an ocean, two species in the same layer of water at the same depth may be more likely to interact over wide (horizontal) distances than they are to encounter a species nearer in vertical distance, but separated ecologically by depth-dependent differences of light, temperature, salinity, or pressure. Species roam far in the rainforest canopy without ever venturing a few meters down. In our human ecosocial systems, which are just a specialized kind of ecosystem, people who are linked by the same river, the same railroad, the same phone network, the same chat room on the internet may interact far more than they do with spatially nearer neighbors who are off these social transport and communication networks. In a modern city, spatial proximity may have little relevance to probability or intensity of interaction (see Lemke, 2000a, for more discussion).

In addition to the "spherical" topology for strength of interaction, there are clearly at least these two others: a laminar topology (horizontal layers) and a network topology (lines of connectivity). All three of these principles are at work in the spatial organization of human ecosocial systems, but I generally agree with Bruno Latour that "sociotechnical networks" are critically important for answering the questions with which I began this article (cf. Latour, 1994, 1996; Lemke, 1995b, 1997). Many people interpret Latour's arguments, or the somewhat similar arguments proposed by ethnomethodologists (e.g., Garfinkel & Sacks, 1970, Schegloff, 1991), as leading us to a "flat" view of social systems: that there are only local interactions of people and things, and all the rest (i.e., families, institutions, languages, social communities, class conflicts) are contingent and epiphenomenal, essentially unreal figments of our overly fervid sociological imagination. The "flat" view sees only the human scale, indeed only the scale of the moment and the event, privileging that scale in relation to all others. It does not ask how and why events widely separated in time and space seem to re-enact the same patterns; it does not recognize that there are emergent phenomena unique to every level of organization in a complex dynamical system: recurring and typical patterns of interaction that cannot be explained or predicted from analysis of the interacting units (Campbell, 1974a; Bickhard with Campbell, 2000).

Neither of these essentially "spatial" views of complex ecosocial systems is satisfactory. The spatial hierarchy model ignores the important role of network topologies of interaction. The "flat" interpretation of network models cannot account for regularities at higher-scale levels. The "spatial" view is incomplete, and indeed is not, I believe, the fundamental view needed to understand complex systems, especially human ecosocial systems. I argue here for the usefulness of an alternative, more dynamical view.

In dynamical theories of complex systems, the fundamental unit of analysis is a process (e.g., Andersen, Emmeche, & Finnemann-Nielsen, 2000; Bar-Yam, 1997). It is in relation to the process that its participants are defined, as filling roles in that process. *Things*, or *organisms*, or *persons*, or *institutions*, as usually defined, are not dynamical notions: they are ordinarily defined in terms of their stable and persistent, or invariant, properties. They are not about dynamics, not about change and doing, but about being what they are. Every process, action, social practice, or activity occurs on some timescale (in complex cases on more than one timescale). In a dynamical theory, an ecosocial system is a system of interdependent processes; an ecosocial or sociotechnical network is described by saying what's going on, what's participating and how, and how one going-on is interdependent with another. (This emphasis on a process ontology is not meant to deny the reality of substance; a material process requires either some material medium or some material participants, although these may be as immaterial as quantum fields; cf. Bickhard with Campbell, 2000. It does claim, however, that the properties of substance have meaning only in and through participation in processes, and those of artifacts through participation in networks of interdependent ecosocial processes, including human cultural practices. The apparent stability of material structures is only relative to the timescales of both the processes of observation and the constitutive-disintegrative processes that self-organize or impinge upon the structure. For a compatible process-centered view of meaning as arising from interactional processes where timing is crucial, see Bickhard & Terveen, 1995.)

Each scale of organization in an ecosocial system is an integration of faster, more local processes (i.e., activities, practices, doings, happenings) into longer-timescale, more global or extended networks. It is *relative timescale* that determines the probability and intensity of interdependence (according to what I later call *the adiabatic principle*), and it is the circulation through the network of *semiotic artifacts* (i.e., books, buildings, bodies) that enables coordination between processes on radically different timescales.

In this view the two fundamental questions for analyzing the dynamics of ecosocial systems—and human activities within them—are: What processes, what kinds of change or doing, are characteristic of each relevant timescale of organization of the system/network? and, How are processes integrated across different timescales? In the sections that follow I develop in more detail the implications of multiple-timescale analysis for the study of meaningful human activity and raise a host of research questions generated by this perspective. My principal example is schooling in relation to identity development and cultural continuity. I move from a brief consideration of the basic dynamics of complex systems in general to the case of ecosystems in which meanings matter, and finally to the conclusion that "it takes a village" to study a village.

## ACTIVITY IN TIME

Imagine a school classroom at work. What's happening? What are the characteristic timescales of the processes and events that make it "a classroom" for us? Almost certainly people are talking, and their actions, whether producing an utterance or writing at the chalkboard or handing someone a scissors, cannot be understood either as a selection from the available repertory of human actions or in terms of timing and sequence (i.e., what next? what, when?) apart from the meanings being made in talk and other forms of action (for detailed descriptions and analyses of the particular

classroom scenes I have in mind as I write, see Kamen et al., 1997; Lemke, 1995b, 1996, 1999; Roth, 1998).

What are the characteristic timescales of the actions, processes, and events we observe? Our immediate human interactional timescale ranges from the glance and the word, said or done in a second or less, to the complex sentence spoken or heard and the complex action performed over a few tens of seconds. Evolution has tuned us to this narrow range of timescales; our survival has depended for hundreds of millennia on noticing brief events (a glimpse of a predator through the brush) and sustaining short-term cooperative action. But in the classroom, if we watch and listen long enough, we begin to find repeating patterns (e.g., Lemke, 1990; Mehan, 1979): individual utterances of certain semantic types (i.e., questions, answers, evaluations of answers) predictably follow one another to constitute an exchange. There are identifiable types of exchanges. These recur, recognizably for us and for the participants, not just for awhile or among the same participants, but on different days, in different situations, and even in different classrooms in different schools. They constitute a cultural pattern or social semiotic *formation* (cf. Lemke, 1995b). Exchanges also enter into patterns on a still longer timescale; the ebb and flow of talk, the shifts of topic and activity, divide the lesson into episodes. Some types of episodes also recur. Episodes get integrated somehow into lessons, and there are also lesson types and even sequences of lesson types (cf. Christie, 1997 on "curriculum genres") that recur across wide geographical areas and that may take days or weeks to complete. At these longer timescales there are curriculum units and months- to years-long integrated curricula.

What about shorter timescales? Even an utterance of a single word consists of recognizable and repeated sound patterns, the articulation of the distinctive phonemes of a language, recognizable and repeatable, although perhaps at the edge of our normal awareness. A typical English vowel or short syllable takes about one-tenth of a second to articulate. These articulations represent coordinations of fine muscle control by neuron impulses acting at the few to tens of milliseconds scale, and they in turn sum over neuron membrane depolarizations and ion and neurotransmitter flows that occur on the millisecond timescale. Below that are still faster biochemical reactions, but the scale of the fastest human actions is basically set by the millisecond scale of neuron processes. No coordinated human action, not even autonomic reflexes, can happen faster.

Table 1 shows the approximate timescales for each order of magnitude above and below the 1-sec focal scale of human action. At each timescale we can recognize characteristic processes and social practices. For adjacent timescales it is also quite clear that the processes at the next lower timescale make possible the repeatable patternings of the next longer scale, in accord with the reductionist model of systems hierarchies. What is equally important, however, is that there is always also a higher level process already in place, already running on its own longer timescale, and this sets the context that constrains what is likely and what is socially appropriate at the next scale below. A student's answer to a teacher's question is also meaningful for the participants as part of an exchange, not just as an utterance in its own right, and is judged as appropriate or not to the ongoing exchange and to the episode, the lesson, the unit, the curriculum … and many higher-level contexts. These contexts, however, are not static; they are themselves processes unfolding in time. Very slow processes function like constant, static backgrounds on the timescale of much faster processes.

It is useful to analyze scale hierarchies in groups of three levels at once (cf. Lemke, 1995b, 2000b; Salthe, 1985, 1993). Call the middle level of any such group the *focal level*, or level N, the focus of our interest for now. Dynamical systems theory basically says that processes (and partici-

TABLE 1
Representative Timescales for Education and Related Processes

| *Typical Process* | *Timescale (sec)* | *Duration* | *Reference Events* |
|---|---|---|---|
| Chemical synthesis | $10^{-5}$ | | Neurotransmitter synthesis. |
| Membrane process | $10^{-4}$ | | Ligand binding. |
| Neural firings | $10^{-3}$ | | Neuron process. |
| Neuronal patterns | $10^{-2}$ | | Multi-neuron process. |
| Vocal articulation | $10^{-1}$ | | Edge of awareness. |
| Utterance | 1–10 | | Word, holophrase, short monologue; in context. |
| Exchange | $2–10^{2}$ | Seconds to minutes | Dialogue; interpersonal relations; developing situation. |
| Episode | $10^{3}$ | o(15 min) | Thematic, functional unit; speech genre, educative. |
| Lesson | $10^{3}–10^{4}$ | Hour | Curriculum genre. |
| Lesson sequence | $10^{4}$ | o(2.75 hr) | Macro curriculum genre. |
| School day | $10^{5}$ | Day | ["seamless day"]. |
| Unit | $10^{6}$ | 11.5 days | Thematic, functional unit. |
| Unit sequence | | | [rare]. |
| Semester/year curriculum | $10^{7}$ | 4 Months | Organizational level; unit in next scale. |
| Multi-year curriculum | $10^{8}$ | o(3.2 years) | Organizational level; limit of institutional planning. |
| Lifespan educational development | $10^{9}$ | o(32 years) | Biographical timescale; identity change. |
| Educational system change | $10^{10}$ | o(320 years) | Historical timescale; new institutions. |
| Worldsystem change | $10^{11}$ | 3200 years | New cultures, languages; limit of historical records. |
| Ecosystem, climate change | $10^{12}$ | 32,000 years | |
| | $10^{13}$ | 320,000 years | Last ice age. |
| Evolutionary change | $10^{14}$ | 3.2 million years | Scale of human evolution. |
| | $10^{15}$ | 32 million years | Dinosaurs. |
| | $10^{16}$ | 317 million years | Pangaea. |
| Planetary change | $10^{17}$ | 3.2 billion years | Origin of life, of planet. |
| Universal change | $10^{18}$ | 32 billion years | Cosmological processes. |

pants in those processes) can interact directly and exchange significant amounts of energy or information only if they are on the same scale. Technically, this is only exactly true if we mean on the same time scale (see the following discussion of the adiabatic principle). What is possible on the focal scale, the kinds of interactions that can happen, depends on the kinds of processes and participants at the level immediately below, level N – 1. Processes at level N – 1 are constitutive of processes at level N; they provide the affordances for activity at level N. But level N is never the top level (certainly for human social processes); interactions on the focal level are not free to range over all the possibilities afforded them: they are also constrained by being themselves part of longer timescale processes at level N + 1. The longer-scale processes determine what is probable at the focal level. There are always many ways in which the interactions at level N can satisfy

the constraints of level N + 1, but the probability of each path depends in part on whether it is consistent with the emerging patterns at level N + 1. (For more discussion of emergence and "downward causation" in biological systems consistent with this view, see Campbell, 1974a, 1974b, 1990; Lemke, 2000b; and the articles by C. Emmeche et al., H. H. Pattee, and M. Bickhard in Andersen, Emmeche, & Finnemann-Nielsen, 2000.)

It helps in understanding these inter-level relationships to think of their history and origin. As interactions on some timescale become linked, or coupled, and thus more interdependent, as they do in complex systems of the kind we are interested in here, there are fewer and fewer possible self-consistent patterns (cf. Kaufman, 1993). In the origin of life, for example, there were originally a lot of protein or RNA-like molecules mutually catalyzing one another's synthesis. As more new molecules were produced that could function as potential catalysts for still more chemical reactions, eventually a condition was reached in which a few sequences of reactions formed a self-sustaining cycle that then rapidly outpaced other reactions and entrained most of the available nutrients into its own ongoing patterns. The new patterns were *emergent*, essentially allowed by the previous chemistry but not required by it, and thus unpredictable. The new cycles take more time, complete on a longer timescale than the individual constituent reactions. They form a new level of organization. From now on, any fluctuations in the concentrations of chemicals in the pool are buffered by the existence of the new cycles, and information that takes this form only reaches some still longer-scale (N + 1) process after being filtered or buffered by the new cycles. Once in place the new cycles also alter the probability of reactions occurring on the level below them, providing downwards constraints. And of course the new level itself now becomes a potential unit of organization for something (like us) at a still higher level to be built out of.

All new levels of organization emerge as intermediates between pre-existing levels, and profoundly change the relations among the formerly adjacent levels as well as making possible still newer emergent forms (see discussion in Lemke, 2000b).

Are there emergent processes and patterns in classrooms? I think every teacher and student knows that there are. There are new routines that emerge, new social groupings and the typical interactions that sustain them, class in-jokes, informal rituals, typical sayings and phrasings, favorite word usages with special meanings, and so forth. These in turn can become the raw material for more complex new patterns unique to the classroom, and they certainly constrain the probabilities of actions and utterances that would invoke these special meanings or contribute positively or negatively to social relationships. A classroom, and indeed every human community, is an individual at its own scale of organization. It has a unique historical trajectory, a unique development through time. But like every such individual on every scale, it is also in some respects typical of its kind. That typicality reflects its participation in still larger-scale, longer-term, more slowly changing processes that shape not only its development but also that of others of its type.

A classroom community can be taken as a whole on its longest timescale of activity, typically a few months to a year. We can ask how it develops as an individual and as a typical instance of its kind. Subject to what constraints from which still larger-scale processes? Made possible by which characteristics of which shorter timescale processes? We can look at its component processes and constitutive units as well, each on their own timescales. And here things begin to get rather complex because we can easily see that, for example, a social grouping may form that lasts longer than the classroom community. Is it a unit within the classroom community or a unit at a higher scale? What about a textbook? It is surely the product of a larger-scale, longer-term process (of writing, editing, publishing, etc.) and so a participant in processes on those scales, but it also seems to be a

small-scale participant in short-term events within the classroom (e.g., reading aloud a homework problem at the end of a chapter). To understand such phenomena we need to understand the two different principles that seem to govern relationships across scales: the adiabatic principle and the principle of semiotically mediated heterochrony.

## THE ADIABATIC PRINCIPLE

There is a fundamental principle in physics, found in slightly different forms in mechanics, thermodynamics, and quantum theory, generally known as the *adiabatic principle*. Its basic use in physics is to simplify complex analyses by justifying the neglect of certain possible (but hard to calculate) interactions as being almost certainly too small to make a noticeable difference in the final answer (the adiabatic approximation). *Adiabatic* basically means "it doesn't get through," referring to energy, fields, or information. In its most basic form it is a statement about energy transfer, and it says that it takes time for energy to be transferred from one system to another; therefore, the faster something happens, the less energy is transferred. Conversely, very slowly varying processes appear as a stable background on the timescale of faster ones. This means, in effect, that a very fast and a relatively much slower material process cannot efficiently communicate with one another, cannot efficiently transfer energy. This is the basic warrant for the buffering or filtering effect between non-adjacent levels in the timescale hierarchy and therefore for the usefulness of defining timescales as being distinct from one another in the first place.

A process that produces change only very slowly seems to us not to be a process at all, but a constant fact of life. Very slow changes do not produce "differences that make a difference" (Bateson, 1972) to us; they do not matter to human life. Weather change processes make a big difference to us, but climate change processes are so slow as to be irrelevant (normally, but that may be changing). The continents are moving, the earth's magnetic poles are shifting, the equinoxes are precessing, the rotation of the earth is slowing, the energy output of the sun is changing—but not fast enough to matter to our sense of geography or day and night.

Or consider very fast processes, much faster than those at our nominal 1-sec focal level. If you run fast enough across the hot beach sand, your feet get less burned because less total energy is transferred to you in the shorter time (for hot coals you may need additional help). The extreme case was graphically illustrated in a recent film of H. G. Wells's (1935) classic *The Time Machine,* in which the protagonist survives a nuclear blast in London by accelerating through time at the maximum rate, thus spending too little time in the actual moments of blast energy for very much of it to transfer to him and the machine. Closer to home, fast molecular and atomic processes within the human body do not play a role in our much slower biochemistry, nor can we decipher speech presented to us more rapidly than the maximum rate at which our neurons can respond and process the signals. Moreover, and this goes beyond and adds to the separability of timescales guaranteed by the adiabatic principle, we are buffered from fast, small-scale events, like ionization of individual atoms in our bodies or even errors in gene transcription, by longer-term regulatory and self-correcting processes typical of the intermediate scales of autopoietic or self-organizing systems.

Of course our small degree of autonomy from the environment, within and without, at smaller scales and larger ones, has its distinct limits. One molecular error in one cell can sometimes lead to a cancer that kills the organism. Someday we may cross a threshold in long-term climate change

processes and find sudden droughts and famines on a very human timescale. The adiabatic principle has exceptions, and one of these is fundamental to human social organization.

## HETEROCHRONY AND SEMIOTIC MEDIATION

According to the adiabatic principle, events in the remote past or processes with much longer characteristic timescales should have little impact on normal human activity. There are exceptions, of course. A fast, microscopic event can trigger a cascade, an amplifying avalanche of consequences that grows to a much larger, longer-term scale. A little more or less neurotransmitter or ion concentration in one small part of a neuron or a single ligand molecule binding to a membrane in a millisecond can trigger an action potential spike that propagates itself down a long axon and triggers other neurons to fire, stimulating a large section of the cortex. No doubt there are many intermediate levels of feedback loops designed to buffer accidental events of this kind from disrupting normal brain patterns, but the basic phenomenon is fundamental to the human nervous system. A single brief event at some time in history may have consequences that ramify down the ages and affect us today on a short timescale. Such phenomena as dynamical thresholds and bifurcations are a normal part of our current picture of complex dynamical systems. Normally their effects are filtered out by the self-organizing meta-stability of various intermediate-scale level processes.

But there is another kind of exception to the relative insulation between non-adjacent timescales. Rather than a short timescale event having long-term consequences, as above, we can have the case of *heterochrony*, in which a long timescale process produces an effect in a much shorter timescale activity. This is a very common phenomenon in human social activity. I believe it is the basis for human social organization across timescales. (Note that this usage of the term differs from that in developmental biology, where it refers to either the joint effect of a slowing down and a speeding up of the rates of different developmental processes in the same species, or an evolutionary difference in rates between species; e.g., McKinney, 1988. I use the term here to refer to temporal heterarchy, the interdependence of processes at very different timescale or rate-scale levels of an organizational hierarchy in a complex self-organizing system. See Lemke, 2000a, 2000b.)

Before illustrating this point in the significant case of the classroom, let's enjoy a more colorful initial example. In feudal Japan, members of the samurai warrior class had the right, even the duty, of avenging slights to their and their clan's honor by beheading, on the spot, an offending commoner. Ready to hand in such a situation is the storied and sacred family sword, passed down from father to son for centuries, lovingly polished and razor sharp. But the samurai reaches instead for a much less ready-to-hand, common and ordinary battle sword, not nearly so well-balanced or well-kept, to decapitate the offender. A years-long historical process of cumulating meaning and value envelops the heirloom sword, but this long-term process intersects with and determines action in a very short-term event. The material object itself, the sword, functions in these processes, both long-term and short-term, not simply through its material affordances—the heirloom sword will do just as well or better to cut off a head and is already in hand—but also through the meanings and value it bears. The samurai acts in the situation, not just in relation to present events and material relations, but also in relation to his interpretation of the appropriateness of using the sword and to his own education in the traditions of his family and culture—a process on a timescale intermediate between that of the sword's history and the present event.

Everywhere in human culture we find this type of heterochrony: longer-term processes and shorter-term events linked by a material object that functions in both cases semiotically as well as materially. The material characteristics of the object also function as *signs* for an interpreting system of meanings that belong to processes on a very different timescale than that of the event in which the interpreting process is taking place (Lemke, 1995b, 2000a; Peirce, 1998). Leigh Star & Griesemer (1989) identified such phenomena for sociotechnical networks as ones in which "boundary objects" circulate through the network, playing different roles in different situations. Typical in these cases are *records* (e.g., census forms, zoology field notes, ships' logs) that are created in many short-term events, but are then collated in some "center of calculation" (Latour, 1987) to create a summary table or a map (which in turn circulates still further in the network), linking these times, places, and events both as a material object and as a *sign* or *text*. Considered as a whole, the circulation in the network, the completion of a functional cycle of activities (collecting, summarizing, and publishing data), constitutes a longer timescale process and one that takes place within a more extensive network than does each constituent event.

In the classroom, we will find student notebooks and class textbooks, but also many other meaning-inscribed material objects that afford heterochrony. In two analyses of science classrooms in recent years I have been impressed by the role of these material-semiotic artifacts. In one (Kamen et al., 1997; Lemke,1995a, 1996; see also Roth, 1998), students are designing and building, in part improvising, towers and bridges built of soda straws, cut with scissors and welded with a glue-gun, while they talk, and their activity spawns emergent practices and goals on several timescales. In the other (Lemke, 1999), a student in his chemistry and physics classes juggles multiple meaning systems: speech, writing, diagrams, graphs, gestures, mime, numbers, and algebraic forms, as well as their associated artifacts: textbook, notebook, chalkboard, overhead projections, talking and moving bodies, and a calculator.

In this lesson, when a teacher asks a question, several students begin looking through their notebooks. The notes they look at now were written days or weeks ago. The answers they give are influenced in part by what they read and how they interpret it in relation to the question just asked. The notebook, as a material object with semiotic affordances, as a thing that can also be a sign, materially links two events across time and space and so participates in a process on a much longer timescale than either the event of writing or the event of reading that particular note. And in this case so also does the student. At another juncture, the teacher reads aloud from the textbook, writes on the board, and asks a question that would not have been written or asked as it was without the influence of the textbook's words. Those words, the generic discourse pattern or discourse formation inscribed in the material object of the textbook, have an even longer (cultural) history than does the particular material book or the unique wording of its text. Not only the processes and activities that produced the textbook, but also the processes and activities that produced that standard discourse pattern about chemical reactions and circulated it long ago to the textbook's authors and editors, are now intersecting through the mediation of the book as a material-semiotic object with the much shorter-term events in the classroom episode.

But it is not just obviously textual records of past events that can function semiotically to mediate heterochrony and the integration of social activities over very different timescales. What about the architecture of the room? The layout of the seats? The size, weight, shape, color, and heft of the scissors? We know that these also influence events in the classroom on smaller timescales. To the extent that they are simply material constraints or provide material affordances, they represent a slowly changing constant in accordance with the adiabatic principle. But as "texts," as signs of

the values and habits of a culture, as indexical signs of the work of those who built and designed them, they also afford information about the culture of schooling. And there is more.

What about the student? The student is also a material object, a body on and in which can be inscribed—as clothing, tattoos, neuromuscular habit patterns, verbal memories—meaningful signs. Surely this body is also a material-semiotic artifact, a participant in and a product of longer-term social processes, practices, and activities, and one which circulates as a "boundary object" linking one event and time and place with another? Semiotic mediation and heterochrony as the ground of social integration across time and space did not begin with literate texts or even most likely with specialized record-keeping. Although it may remain a just-so story, it is useful I think to imagine a basic dilemma of our remote ancestors. In small bands they roamed a complex environment. Individuals and smaller groups over time traveled different paths, gained knowledge of dangers and opportunities along their personal trajectories. But what was of value to the band as a whole was the accumulating knowledge that came from integrating individual experiences over geographical journeys, but also over time. The "oral tradition" was not just about myth and legend. It was cumulative knowledge on a timescale and spatial scale that no individual could match; it was maintained and enhanced by integrating short-term processes of discovering, telling, and re-telling across time. And the mediating artifact was the human organism, circulating in its ecosocial networks.

## IDENTITIES AND TRAJECTORIES

What's happening to a student in that classroom? What kinds of changes are taking place, and on what timescales?

Schooling is supposed to facilitate certain changes in the behavior patterns of students. Both educators and their critics wonder how lasting these changes are. How far do they carry beyond the walls of the school? On what timescales do we imagine that personal identities change significantly? Or students' habits of critical reasoning? Their ways of reading, coping with quantitative problems, or interpreting the natural world? Their attitudes toward potential careers or value choices?

Do such changes occur in the course of a 40-min lesson? Even if we imagined that such a change did take place in some "breakthrough" moment, would we still count it as a change of the kind I've just described if it disappeared the next day? Or the next week? The formation of identity, or even fundamental change in attitudes or habits of reasoning, cannot take place on short timescales. Even if short-term events contribute toward such changes, it is only the fact that they are *not* soon erased, do not quickly fade—that subsequent events do not reverse the change—that makes it count. It is the longer-term process, including the effects of subsequent events, that determines for us the reality of basic human social development.

So how could events on the timescale of a conversation or an experiment or reading a story even contribute to identity development? What is the system, or network, within which a notion of "identity" can be defined? It is surely not that of an isolated organism taken at a single moment of time. At the very least, identity must express itself, and that expression in action takes time. An organism as such is not even alive in a single instant of time; its constitutive processes require finite time to occur, and taken as a whole, from its molecular level to its organismic level of integration, it is a multi-timescale dynamical system. From the viewpoint of physics, an organism is alive only across a time interval that necessarily extends somewhat into the future. It can only be observed to

be alive across some finite interval of time, and each of its characteristic dynamical properties has some minimum timescale for possible observation. In fact, the self-organization processes that constitute the living organism as being more than the sum of its non-living parts have a minimum timescale, biologically, of something not much less than a second or two.

Moreover, beyond that second or two the organism only stays alive by interacting with its environment. It has to release heat constantly and waste chemicals eventually; it has to take in oxygen steadily and nutrients periodically. It would never have come to exist in the first place without having developed in a supportive environment that supplied exactly the conditions that evolution had led its development to depend on. If we think about the organism as such a dynamical system, we need to revise our ideas of it in at least two fundamental ways. First, it is not definable or viable apart from its operating as an element in a larger system, some minimal ecosystem. Secondly, it is not definable at a single instant in time, but only over finite time-intervals, and in fact ultimately only as a trajectory-entity developing and individuating through its interactions with its environment over the whole lifespan course from conception to decay.

An organism is a biological unit of organization. Its definition says nothing about semiosis, about how it responds to a material environment in ways that depend on its interpretation of things as signs as well as on its direct interactions with their material properties. What is the minimum timescale on which we can observe a dynamical system to be a person? What is the minimum time, and the typical time, for actions that indicate both that sign-interpretation is playing a role and that the sign-interpretation is recognizably that of a social persona? A system with a self-conscious identity?

Just as in the case of our revision of the notion of an organism both to situate it always within a larger-scale system and to look at it over all its relevant timescales (i.e., as a developing trajectory through time), we must do the same thing, for the same reasons, in the case of the definition of a person. A human is not a person apart from social interactions within a community, nor on timescales less than those on which a sense of identity or habits of sign-interpretation develop and are used. Meanings are not made by organisms but by persons, and they are not made within organisms but within an ecosocial system that minimally includes other persons and the things they make meaning about and that minimally operates over timescales sufficient for a developing person to come to engage in socially meaningful interactions with others and with the non-human surround.

So what then is a self-conscious personal identity? We might say that it is a semiotic articulation of a person's evaluative stance toward interactions. It is what we are inclined to believe or doubt, desire or dislike, expect or find surprising, and so on (cf. Lemke, 1998 for the semantic dimensions of evaluative stances in language), cast in the romantic folk-language of "who we are," what social types or categories we identify with on the basis of shared values. It is a very complex construct, not usually explicitly articulated; in fact, it would be reasonable to say that people do not have stable, unitary identities, but rather that we all learn to interpret certain persistent evaluative stances toward action in these terms and articulate the relevant pieces *ad hoc* from situation to situation and not necessarily consistently. We can also construct some *ad hoc* consistency if we have to, but we don't usually bother.

Thus "personal identity" may not be as long term a phenomenon as we imagine. Like most everything else, it too requires integration across timescales: across who we are in this event and that, at this moment or the other, with this person or another, in one role and situation or another. Nevertheless, evaluative stances or dispositions do develop and change on timescales much lon-

ger than that of a classroom lesson. In his extensive research on evaluative dispositions, Bourdieu (1979) found that they are created by our participation in the typical activities of a local social community over timescales of a decade or two, and they change more slowly as we grow older. He found significant social class differences, tied specifically to education and to economic life-prospects, and comes close to proposing that social class itself be redefined in terms of the differences in "habitus" or dispositions to action produced by different trajectories of socialization.

Every developing biological system develops partly uniquely (individuation of the trajectory) and partly as a typical member of its kind (type-specific, equifinal trajectory). The latter effect is due not just to common genetic heritage, obviously, but to similar epigenetic circumstances eliciting gene expression. In fact, it is easy to imagine the effect of much of that epigenetic information as just an internalization of the landscape we write with our lives. Each of us leaves some imprint on the world, if only in the bodies and memories of those we interact with, and those imprints, as semiotic mediating artifacts, provide informational input to the development of others of our kind. It is the larger-scale social system, obviously, that persists from generation to generation and tends to make one person in a community grow up to act somewhat like others of his or her time and place and class and gender and age.

The classroom then is no different from anywhere else in our world of social artifacts. Its developmental input is there not only in the walls but in the very fact that there are walls; not just in the words in the textbook, but in the existence and use of textbooks. But it is first and foremost in those respects in which the classroom is exactly like the rest of the social world that it contributes to the formation of identities and habits of action that are formed across the longer timescales we also spend in other places. It is not what is unique about classrooms that contributes to our identity development, but what is the same about them compared to many other sites in our culture. Identities develop over long timescales, during which the trajectory of the developing social person takes him or her from classroom to classroom, from school to schoolyard, to street corner, to home, to the shopping mall, to TV worlds. The timescale for sampling all these worlds that is relevant to identity development is the long timescale, one that sees the sameness of patterning across all these venues. The little differences between them are blips in this long, slow process. Of course we also learn those differences, and the appropriate roles for classrooms and other places, but our more general dispositions are necessarily a function of their commonalities.

The most amazing feature of developmental processes is that each step along a developmental trajectory changes the way the system interacts with its environment at the next step. There are no "shortcuts" in development; you must pass through each step in order to be prepared to take the next one because at each step you become a dynamically different system. Different dynamical possibilities are open to you. You have also extended your trajectory to a new timescale on which there are emergent phenomena, both in you and in your interactions with a larger-scale environment. In biological organisms like ourselves, the developmental pathway is extremely long and complex, and each critical turn could easily go down some other path; the message from our genes is a road map for the paths followed by our most successful ancestors. Our ontogeny recapitulates their phylogeny, up to a point. But only up to a point, and less so as developmental pathways come to be guided more by social interaction and culture-specific semiotic information supplied after birth.

Everyone in that classroom was experiencing a different lesson, was interacting with the teacher and the semiotic artifacts of the room and with each other in ways that depended on his or her trajectory up to now (and now-in-progress). No matter how much we homogenize classroom

groups—by age, by social class, by gender, by culture, race, or dominant language—for the classroom processes at each timescale there will be considerable differences in affective engagement, in evaluative dispositions, in relevant knowledge and skills, and in resources for integrating the events of the moment into patterns that will persist on longer timescales. The very act of homogenizing defeats the goal of long-term results: the world outside the classroom is not homogenous in any of these ways, and every difference between the meaning organization of the classroom and that of the rest of life means that much less long-term and wide-ranging persistence of what happens in the classroom. (For similar arguments about identity issues and the role of real-life apprenticeship in learning, see Lave & Wenger, 1991).

Nonetheless, *some* contribution toward identity development is taking place all the time, including during classroom lessons. What's happening?

Again it is useful to analyze on multiple timescales. On each timescale each student is participating in some ecosocial processes and taking on relevant roles. Students interact with one another and with the other available semiotic objects in various intersecting activities, and these activities are recognizable and repeatable and usually repeated. In this participation we learn to do differently and to be different. We engage with a person or an artifact in a particular way, typical of that activity, and now the system in which our *persona* exists and functions changes. Dynamically, we are what we do, and we are now creating ourselves as personae in interaction with new others and artifacts, which means that the current, and perhaps temporary, "I" is the one that exists in the "loop" of efference and afference, of "differences that make a difference" in a kind of complex feedback circuit (in the terms of Bateson's 1972 cybernetic version). There are longer-term Selves already engaged in ongoing longer-term projects and activities and the shorter-term Selves of current activities, some of which contribute to longer-term projects and some of which may not. As we interact socially at the human event scale, we "identify," if not with the Other as such (cf. Van de Vijver, in press), at least with our agency and participation in each emergent new activity whole, always taking place in a larger-scale system than our former, or more isolated Self. In fact, we can even take a reflective perspective in the activity and see our own role in it; that is, we can frame a separated "me" from the viewpoint of this new dynamical "I." Reflexivity is itself an instance of heterochrony.

But all such activities come to an end. What then of the dynamical "I"? Is there a longer-term residual effect of our participation? Perhaps only a weak one, for now we are asking about quantitative matters of degree. Will we re-engage in the same activity with the same persons or artifacts? *How soon*? *How often*? Will we reconstitute some features of the former activity: the same person in a different but similar activity? Or the same artifact in a new activity? Or the same type of activity but with other participants? And in each case *how much* of an "impression" will be made on the organism and in the larger system that enables the organism to reconstitute its emerging identities by getting these activities going again or by interacting again with the same persons or artifacts, or ones it considers similar for this purpose? How strong will the affective engagement be? How positive will the identification be, evaluatively? And above all, how long will the sequence of activities last across which the same identity features are being reinforced?

The person we become for a moment with a new stranger for whom we have no strong feelings and whom we never see or remember again may be transient indeed. The person we feel ourselves to be when interacting with someone we feel strongly about, again and again over the course of a lifetime, is an essential part of who we are. The Self I am when I am writing or teaching or doing those things that mean something fundamental to me and that I can do over many years is basic to

my identity. Even the Self I am when I read a particular book, hear a particular kind of music, play or sing or dance to that music, if I feel strongly enough about it, can become basic to my identity. When I teach or write or have conversations with colleagues, I am often working to recreate activities and senses of Self that are basic to my identity. I am seeking to keep an identity-constituting process going on a longer timescale and across a wider range of settings and participants. If my identity's dispositions value aggressiveness, I may seek activities and roles in which aggression is socially acceptable, or I may make use of other activities in ways that support this identity need. It is likely in our society that gender identity needs are very strong in many people, particularly among men, and that the conduct of many life activities, from driving a car to writing a scientific paper, may be entrained in the service of these needs and so be a very different experience for men and for women, or generally for those constructing different kinds of gender identities with different degrees of intensity. (What I say here of gender identities will also be true in general of age, class, and more broadly of all subculture- and culture-specific identity patterns.)

It is somewhat ironic that classroom education and the formal curricula that are supposed to create more long-term continuity from lesson to lesson and unit to unit (though not, after the earliest years, from hour to hour in the same day or from year to year in the same subject) are narrowly focused on informational content that is more or less unique to school experience, when the major developmental processes of these years appear to be about the formation of identities that fit large-scale social models for gender-, class-, age-, and culture-specific patterns. Students are mainly going about the business of learning to be six-year-olds or twelve-year-olds, masculine or feminine, gay or heterosexual, middle-class or working-class, Jewish or Catholic, Irish-American or Jamaican-American, or any of the many dozens of sociotypical identities for which there are identity-kits available in a particular community (cf. Gee, 1992). Whatever we offer in the classroom becomes an opportunity to pursue this longer-term agenda of identity building; our primary affective engagement is with this agenda, with becoming who we want to be, not with learning this or that bit of curriculum, except insofar as it fits our particular agenda or insofar as "being a good student" or "not falling for that bullshit" fits it. Perhaps late in schooling a few of us are also working to form, within these larger identity projects, specific partial identities as "future scientists" or "future teachers." (How many? How intensely? On how long a timescale? How integrated with the more general identifications like gender?)

Nor, of course, does this picture change very much "after school" (in either sense). In our paid employment, as in our family and leisure life, we are often still involved in the long-term project of maintaining and enhancing, and perhaps occasionally revising, who we are. We integrate each event into this longer timescale project in many ways: in our body hexis, in our habitual ways of talking, in our retrospective narratives about ourselves, in written diaries, in titles on bookshelves or inscriptions on trophy walls, in photographs of children and friends, in collections of videotapes and knickknacks.

But it is not easy to study lives over the timescale of decades and lifetimes.

## "IT TAKES A VILLAGE…"

I want to conclude with some observations about the research process itself.

I began with two key questions: How do moments add up to lives? How do our shared moments together add up to social life as such? I've said a fair bit about the first one now, but the focus on

identity development, although clearly situating it in larger-scale social activity and process, has left less said about the timescales relevant to the formation and maintenance of community as such.

Just as we have mainly studied social development over relatively short timescales (generally the first few years or first decade or two of life), and so know far too little about what human projects are sustained over many decades or a lifetime, so also we know a great deal more about short-term social processes: conversation, negotiation, "service encounters," classroom lessons—events that last on the order of the time you can record on a videotape—than we do about activities and processes that last days or months or years, much less multiple lifetimes. The classic model of Activity Theory (Leontiev, 1978) distinguishes three timescales: operations, actions, and activities, rather similar to the levels exemplified in Table 1 by vocal articulations, utterances, and lessons. But can we lump together all the timescales of "activities" that last from minutes to lifetimes? Are the principles of integration across events just the same whether we are taking out the garbage or building a business empire? At some very high level of abstraction perhaps they are, but we should now become more interested in the potential differences. Following in this intellectual tradition, cultural psychologist Michael Cole (1996) proposed including a much wider range of scales of analysis, from the microgenetic (event scale), meso-genetic (extended activity or project scale), and ontogenetic (developmental-biographical scale) to the historical and evolutionary scales. He has a particular interest in the emergence of sustainable institutions that persist over times longer than the participation of any one individual in them.

But how do we study ecosocial processes on timescales longer than a few hours? Although educational researchers have done extended videotaping of the same classroom over a whole term or year (e.g., Christie, 1997) or even followed the same student through all classes for a few days (e.g., Wyatt-Smith & Cumming, in press), we do not follow students home through all 24 hr of their days for extended periods, nor do we follow even classroom communities over their whole (short) lifespans by looking not just at what happens in the classroom, but what happens among the same participants outside it as well. When the timescale expands, either with its focus on an individual (cf. the social science fantasy depicted in the film *The Truman Show;* Weir, 1998) or on a group or small community, so usually does the spatial scale as well. People move around. How many settings do the members of a community collectively inhabit in the course of a day, much less a year? How many additional, peripheral participants become involved? Even if we had the resources and the persuasive powers to record data on these scales, how could we ever analyze it all? Or even view it all? Imagine the task for detailed records of daily life for even fifteen people over just a year!

Ethnographic studies of small village societies of a few to several dozen members normally collect data over a yearly seasonal cycle. It is highly selective data and is supplemented by the ethnographer's direct participation with a subset of the members—and some response to the inevitable identity shift as the ethnographer begins to become another social person in a very different social system, even on a one-year timescale.

Biographers take the human lifetime as their timescale unit, and otherwise historians and archivists are about the only scholars who concern themselves with social projects or activities that occur on timescales from decades to longer than a single human lifetime.

We can no doubt learn a great deal from each of these fields about the kinds of projects and activities that occupy the longer timescale spaces on our chart, from those that extend through significant portions of the life of an individual to those that are undertaken by the members of an institution or of a smaller or larger community. What are the longest timescale projects ever sus-

tained by a human community? How should we define the continuity of such projects? What are the means by which integration across timescales is defined in long-range institutional and community projects?

The original logic of Leontiev's Activity Theory defined the continuity or unity of extended activity by the maintenance of a goal or object of activity. One can argue that in many forms of social activity, goals are emergent; they change during the development of the project (cf. Lemke, 1996). They are also, in collective activity, not necessarily common or shared among participants; different goals are just successfully enough articulated to permit collective activity to proceed for the most part coherently. When the timescale of a project or activity exceeds a single human lifetime, we clearly should be seeking for alternative principles to define their unity and continuity. Indeed we also have to recognize that many social processes are simply emergent in communities on these timescales: they just happen without anyone or any group intending them. This, too, is characteristic of self-organizing systems on all scales.

How, finally, do we study society? Or more properly, a whole ecosocial system? And study it moreover from the inside, which is contrary to the externalist tradition of modern science (cf. Matsuno & Salthe, 1995), which looks at all systems from a "God's eye" view. Traditional macrosociology has resorted, after the manner of Latour's "centers of calculation," to assembling statistical data and to recognizing that it does so in a positioned way. The kinds of data we seek to collect are usually the ones that seem important from where we sit within the system. It is highly unlikely that any social system looks the same from the viewpoint of all the component groups or roles within it. Ethnographers long ago recognized that men's and women's views of even small "homogeneous" societies are very different. We can say the same in many cases for the views from different age groups, social classes, or minority cultures.

There is still a strong individualist bias in our modernist traditions of research. Whether we favor individualist or communitarian politics, agent-centered or collective-process models, we still tend to define our objects of study in such a way that a single researcher could in principle come to understand them. This appears to be a contradiction in the case of ecosocial systems. The longest timescale processes that characterize such systems are almost certainly longer than a human lifetime. We cannot study such a system from more than a few of the many viewpoints within it, and we honestly do not expect all these views to fit consistently together. We need at least a team to conduct such a study, one as diverse or nearly so as the system under study, and along the same dimensions of difference. And we need a self-sustaining institution that will last long enough to observe major historical change in the system. "It takes a village" to study a village.

Is this possible? There is perhaps some hope insofar as distributed communities of researchers, linked by new communication networks and technologies, may grow to become such "villages" and continue their work over the timescales needed. If we are really optimistic, we might even imagine that before too long all the various viewpoints in our increasingly global society might come to be represented in one way or another in such a research community. But that will mean that the nature of the research project itself will have to change quite radically from how we conceive it today. Our views of social research—its goals, methods, and objects of study—are inevitably still masculinized, still middle-class, still Eurocultural, still specific to the interests of a particular age range within our own social system, in ways we can just barely begin to perceive. And what of the additional viewpoints of the "nonhumans," as Latour calls them—the other participants without which there would be no system? What new roles should they play in an ecosocial community that is able to understand itself across the scales of time?

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