LEARNING TO MANAGE GLOBAL ENVIRONMENTAL CHANGE: A REVIEW OF RELEVANT THEORY

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Executive Summary

This paper forms part of a research program on long-run changes in social response to global environmental risks -- how they are perceived, named, studied, and managed. The scope of the program is international, its time scale decadal. This paper reviews relevant theory and case studies, seeking hypotheses, animating questions, and methodological guidance for the empirical research program. We employ "social learning" as the theme to cut across several diverse areas of social theory.

"Social learning" means different things to different disciplines. For some, it means learning by individuals that takes place in social settings, or is socially conditioned; for others it means learning by social aggregates. The focus of a body of theory is defined by its answers to the following questions, which are largely (but not entirely) definitional and methodological: Who (or what) learns? What kinds of things are learned? What counts as learning? And why bother asking? With such a focus defined, research programs aspire to answer a second set of questions: What specific things did they learn? How did they learn them? Under what conditions, and why? Did it matter? And how could the learning's effectiveness have been increased?

We first review theories of individual learning, including those that focus on social mediation and determination of individual learning. In subsequent sections we consider learning by groups and organizations, and studies of the advance of scientific knowledge and long-term change in policy-making as instances of learning in particular communities.

Evolution is another metaphor frequently employed to describe change in social systems. We discuss the conditions under which evolutionary explanations can be useful in accounting for social change, and to what extent learning and evolutionary approaches are consistent. Learning and evolution can be equivalent descriptions of a social process only at different levels of analysis; learning may occur at an aggregate level through selection among ideas, routines, or technologies at a lower level.

While available evidence suggests that some form of meaningful learning can occur at all levels of society, from the individual to the international, the best developed theories of learning are at the level of individuals and small, face-to-face groups. Such theory can be usefully applied to studies of small policy-making communities, but is of limited value in examine change in larger aggregates.

Introduction*

A central challenge for human society over the coming decades is to learn how long- term, large-scale environmental risks can be better managed. The broad goal of such management has been captured in the term "sustainable development -- development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[1] But agreement on such general objectives, while welcome, has so far provided little practical guidance on how to improve management capacity in the face of

the tremendous complexity and uncertainty that now characterize our understanding of global environmental risks.

In searching for such guidance, it is important to realize that the risks associated with possible changes in the global environment have been debated, funds spent on their analysis, and management policies considered since at least the International Geophysical Year of 1957. We might expect this historical experience in addressing global environmental risks to produce a record of increasing intelligence and effectiveness -- in short, of learning. Moreover, whatever the past record on such questions, we will certainly need effective learning in the future. For no matter what science we conduct or policies we adopt, the debate over what these risks are and what should be done about them will be with us long into the future. No single scientific report, no single decision, and no single nation will have the last word, or even a very important word, to say on how humanity ultimately comes to terms with these risks. More important than whether any given assessment or policy is right, is therefore whether it is in some sense better than what went before. More important than whether some past research conclusion or international convention was wrong is therefore what we have learned from living with it. The central questions are whether we are learning to manage the risks of global change as quickly as possible, and what we can do to improve our performance.

This paper forms part of a larger research program on long-run changes in social response to global environmental risks -- how they are perceived, named, studied, and managed. The scope of that program is international, examining the flow of ideas, skills, and influence within and among nations, and between national and international organizations. The time-scale is decadal, seeking crucial linkages between the evolution of scientific knowledge, institutional structures, and long-term bio-physical processes, that would be invisible at shorter time-scales.

This long view makes a conventional policy-analytic approach inappropriate. We cannot just examine whether particular environmental decisions or policies were effectively informed by the best available scientific and technical advice. Nor can we even focus on particular, well-defined practical problems; over several decades, the very identity and definition of issues are plastic. Indeed, over this period the most interesting and important question to ask about an environmental issue may be how its definition and conception evolve.

This paper reviews relevant theory and case studies, seeking hypotheses, animating questions, and methodological guidance for our empirical research program. Because the study is essentially concerned with change, the theory we need is dynamic. But most social theory is static, treating change (if at all) as an exogenous shock to the system and confining study to the constant factors that maintain, and subsequently restore, equilibrium.

The most striking common feature of that social theory which is dynamic is its reference to learning. Learning, as a manifestly dynamic process, provides a theoretical counterpoise to social theory based on power and interest, which characteristically yield a static formulation.[2] The tension between theories of learning and power, and their

interpenetration in explanations of social change and stability, permeate the great social and political theories from the classics, through the enlightenment and the present century. Consequently, we have chosen "social learning" as the organizing metaphor for these studies.

The term "social learning" conceals great diversity. That many researchers describe the phenomena they are examining as "social learning" does not necessarily indicate a common theoretical perspective, disciplinary heritage, or even language. Rather, the contributions employ the language, concepts, and research methods of a half dozen major disciplines; they focus on individuals, groups, formal organizations, professional communities, or entire societies; they use different definitions of learning, of what it means for learning to be "social," and of theory. The deepest difference is that for some, "social learning" means learning by individuals that takes place in social settings, and/or is socially conditioned; for others it means learning by social aggregates.

The next two Sections elaborate on some of the questions implicit in this diversity of views of social learning. Section 2 discusses some philosophical tensions that run through the concepts of learning and of social learning, while Section 3 presents a set of simple categorizing questions to provide an ordering scheme for the literatures reviewed.

Section 4 reviews literature of social learning in five different areas, and draws out some connections and cross-cutting themes. Because all work on social learning is grounded in views of or analogies to individual learning, we begin with a discussion of theories of individual learning. Some of these are less "social" in their orientation, some more. One line of theory, in which social determination is so strong that the focus of enquiry is shifted away from the individual, is treated separately in Section 4.2. The remainder of Section 4 treats learning in particular collections of people -- formal organizations, the scientific community, and policy communities. Section 5 discusses evolutionary theories in social science and their relationship to learning theories. Section 6 presents tentative conclusions and assessments of how this literature can help guide our empirical research program.

Though our main focus is on theory, we have included in the review some applied and empirical work that uses the social learning concept and that shows parallels to this project. The overall approach is inclusive: a work's ostensible concern with social learning was a sufficient, but not a necessary, condition for its inclusion. Consequently we have cast a broad net and the treatment of many bodies of literature is highly schematic.

The decadal time scale introduces one tension that we state but do not resolve: on such a time scale, longer than many careers and many lives, substantial influence over the development of an issue may be beyond the capacity of any individual agent. Yet this study shares with conventional policy analysis an agenda that is at least partly normative. Our interest in these questions reflects the assumption that it makes sense to apply evaluative criteria to decadal-scale social response; some societies may do better than others in identifying significant environmental risks, marshalling research and information bearing on the question, and managing the hazard -- whether through centralized or decentralized, formal or informal means. It is our hope that learning about long-term social learning processes may help some agents better understand how to play a constructive role, or

suggest ways of structuring institutions, organizations, or negotiations to make effective learning more likely.

2. Philosophical Roots

Some of the conceptual differences between different students of social learning reflect deeper philosophical tensions that lie within the concept of learning itself, and in social learning in particular. On the confusing nature of learning in general, Polanyi[3] cites the paradox first raised in the Meno -- that to seek new knowledge and recognize that you have found it, you must have somehow already known it. Polanyi's resolution is that all knowledge, in addition to its explicit, conscious part, has a second part that is implicit or "tacit", and that learning involves attending to different parts, different levels of a question or task in way that moves bits of knowledge back and forth between the conscious and tacit realms. In anything that we really know, we know more than we can tell. Polanyi wrote only about individual knowledge, drawing on examples of language, complex skills such as music and chess, and scientific discovery; others have used his conscious-tacit dichotomy to refer to knowledge and learning of groups as well.

On social learning in particular, Friedmann[4] argues that the term embodies tensions that were first articulated in John Dewey's epistemology and politics. Dewey argued that all knowledge comes from the interaction of people with the material environment, and that collective learning from such practical experience, guided by the principles of scientific enquiry, could lead society progressively toward a Golden Age[5] Public decisions are viewed as a series of experiments with the world, which will yield progressive social improvement.

Dewey advanced several views on the difficult question of the validation of such learning, and of knowledge in general. In The Quest for Certainty he proposed the pragmatic condition that knowledge is validated when it helps an actor settle a problem, granting that its "settled-ness" may be provisional or temporary. This condition, while reasonable for individual learning and consonant with the "learning-by-doing" approach of Dewey and modern students of innovation, poses problems for public decisions. It presumes that the settled-ness of an issue is not persistently opaque, as may be the case with certain issues of risk management. And it does not address the question, "settled for whom?," or the possibility that whether a public issue is settled may be deeply contested.

Dewey later moved to the consensual theory that knowledge is validated by people's opinions. [6] He thus regarded the validation of knowledge, although not its production, as a social enterprise. But whose opinion validates? This view still presumes that no concepts are "essentially contested", and that there is no fundamental conflict between the primacy of public opinion and a scientific, experimental approach to public decision-making.

This last tension, between democracy and reason, appears most sharply in The Public and its Problems. Here, Dewey espoused an idealistic vision of neighborly discourse as the foundation of all political decision, but also argued that most of the concerns of the modern state are technical matters, best left to the experts to resolve on the basis of the facts. He thus bequeathed to the modern debate on social learning its two most enduring

tensions, one positive and one normative: the roles of the individual and of society in the creation and validation of knowledge; and the appropriate relationship between a learning, conversing public and political or expert authority in public decision-making. We will see that these run through all the streams of literature surveyed here.

3. Organizing Questions

Who (or what) learns? What kinds of things are learned? What counts as learning? Why bother asking? These simple questions can be used in categorizing works in social learning. These are largely, but not entirely, definitional and methodological; they concern what each body of work defines learning to be, what level of analysis they focus on, and how they decide whether or not learning has occurred. These questions are locators; they provide four dimensions on which to map the territory of social learning theory.

Answers to these questions, perhaps tentative ones, define a research program. Once a focus is defined, a second class of empirical questions arises, that the research program aspires to answer. What specific things did they learn? How did they learn them? Under what conditions and why? Did it make a difference? And how could the effectiveness of learning have been increased?

Who or what learns? Societies, governments, and organizations, or just individuals? Our basic conceptions of learning are formed from observing individuals, but collections of people large and small also exhibit changes in task performance, coordination, complexity of communication, and goals that look very like individual learning. Any writer who uses the term "learning" to apply to a collection speaks to this common perception, implying some form of relationship between what the collection is doing and individual learning. This implied relationship is typically of one of two kinds, which we call "Decomposition" and "Analogy", and which we discuss in Section 4.3 prior to reviewing the literature of organizational learning.

What kinds of things are learned? Individuals learn a vast array of different classes of things: behaviors, facts, concepts, words, skills, desires, opinions, attitudes, and values. There may also be a logical hierarchy of categories of things learned, analogous to the difference between improvement in one task and improvement in the rate of learning new, "similar" tasks, which depends on the second-order task of recognizing a context of "similarity."[7]

Collections of people learn all the same sets of things, and in addition such essentially collective things as languages, technologies, slogans, images, forms of social organization, and norms. It is reasonable to presume that different classes of things are learned in different ways. A useful learning theory must be clear about its breadth of application.

Useful theory will also treat carefully the relation between "who learns" and "what is learned". Particular things learned will move differently through different communities. Some things are only intelligible to particular sub-populations, while

others may rely on a prior favorable disposition. When taking a macro view of whole societies, particular learners (whether individuals or organizations) may become too fine to resolve, and the appropriate methodological focus may be strictly on the things learned -- the ideas, facts, behaviors, and norms -- and on their origination, propagation, and growth or decay.

What counts as learning? Any change in the phenomena studied, or only certain changes? If only certain changes, then what criteria distinguish learning change from nonlearning change? Short of admitting any change as learning, one might say that only change in response to identifiable stimuli or information is learning; or more restrictively still, that the change must follow rationally (defined somehow) from the stimulus. Some researchers propose narrower definitions still: increasing cognitive complexity, or increased effectiveness at attaining given ends. Others argue that definitionally, any cognitive change should be treated as learning, and questions of effectiveness or progress should emerge from the subsequent research.[8] We follow the latter advice in this review, since it is the more inclusive approach.

Why bother asking? Most students of social learning would answer, in order to understand and explain the societal phenomena we observe. In this view a social learning theory, like any theory, would be a set of general, causal statements whose purpose is to guide enquiry and explain observed phenomena. Others, working in the tradition of critical theory, take a more activist view of social theory. They would answer that we ask about social learning in order to bring about personal liberation and social transformation. In this view, a theory is a set of propositions to guide communication between people, whose purpose is to bring about these transformations and which is validated by a) its acceptance by the agent addressed in a non-coercive situation, and b) its efficacy in bringing about the desired transformations.[9] While critical theory does not address itself to learning as such, there are obvious points of contact with some of the strains of literature surveyed here -- to individual social learning theory as employed in therapeutic practice, [10] and to some strains of the organization development literature.[11]

It is difficult to incorporate the critical perspective into a generally naturalistic enquiry into the characteristics and determinants of social learning, but this view cannot be ignored.[12] An enquiry directed to social intervention, as arguably any project in "policy research" is, may lie closer to the agenda of critical theorists than to that of positive theorists. In policy research, as in clinical practice, "what works" may be the appropriate validation criterion.

4. Literatures of Social Learning

This section reviews five broad categories of literature on social learning. Section 4.1 reviews theories of individual learning and its social determinants, while Section 4.2 discusses related work in which the perspective is shifted more strongly to the social level. The remaining sections, 4.3 through 4.5, discuss learning in various social aggregates. Section 4.3, after a general discussion of relationships between learning in collections and individual learning, surveys the literature on learning in formal organizations. Section 4.4considers the possibly unique situation of learning in

science, and Section 4.5 reviews theoretical and empirical studies of learning in politics, policy-making, and international relations.

4.1. Individual Learning

The process of learning is so central to what it is to be human that any model of the person will address it. Theories of learning are consequently just as diverse as models of the person. Two extreme points for models of learning are marked by the rational-actor, and the radical behaviorist models. In their pure forms these two share the characteristics of great cogency and parsimony, and strongly mixed empirical success; they differ in almost every other conceivable way. They embody venerable philosophical disputes on the nature of the mind, and pose strongly differing methodological agendas. As general models of the person they are so well-known as not to need summaries here, except to note that each in its way admits an extremely limited conception of learning.

Rational-actor theory, rooted in economics, political science, and philosophy, is a normative theory that also makes descriptive claims. It is first a theory of choice, but also implies a theory of rational belief because, in order to choose, individuals must predict the results of their choices. It is in forming and revising estimates of the consequences of choice that the rational actor can learn. [13]

The rational actor's learning is limited, though, because the actor already knows so much. Only two kinds of learning can occur: Bayesian updating of probability distributions of world-states, and in interactive decision situations, re-assessments of other agents' interests, available choices, and rationality. More substantial revision of cognitive structures, decision algorithms, or world-views is excluded by the presumption of optimality. As for changes in interests or values, the theory does not exclude them but it has nothing to say about them; it is purely instrumental. [14] The social context of choice and learning is reduced to its informational content -- evidence to be used in rational re-assessment of the decision situation.

The behaviorist actor's learning is also limited, because the actor knows so little. The methodological focus is strictly on behavior, viewed as a set of Stimulus-Response connections determined by the past reinforcement regime. The general principle is that behaviors that have been reinforced (rewarded) will occur more frequently in the future. While the behavior exhibited can be versatile, complexly contingent on environmental conditions, even seemingly creative, "learning" is deemed identical to the observed changes in behavior. Concepts of retained information or image, or internal cognitive structures, are deemed unobservable and superfluous.[15] The social context of choice and learning is reduced to its reinforcement content -- a set of socially delivered rewards and punishments.

If the rational actor has a perfect internal model of the world while the behaviorist actor has none, any theory that can accommodate meaningful learning will lie between; actors will hold incomplete, imperfect models of the world, subject to revision in the light of experience. There have been many branches of such theory over the last couple of decades, some growing from the behaviorist root and some from the rational-actor root.

All these branches are informed by the empirical results of an increasingly powerful experimental technique. The discussion here briefly reviews a few of the major branches. At the same time, more theorists have looked at the social context of learning. In a somewhat arbitrary division reflecting historical lineages, one body of work stressing social factors in particular learning tasks is discussed here, another that stresses social determinants of broader cognitive development in Section 4.2.

One influential body of learning theory is known as Social Learning Theory (SLT).[16] SLT is strongly rooted in behaviorism, but broadens the range of phenomena that are taken to affect individual behavior. In particular, it grants more standing to social determinants of individual learning.

SLT introduces three factors that determine behavior in addition to directly experienced reinforcement: observation and imitation of the behavior of others; symbolic representation of events and experience through language and other media; and self-generated rewards and punishments. Together, these enable people to transform the stimuli impinging on them, and thereby partially to control their own behavior. This intermediate degree of individual autonomy, in Bandura's words, "...neither casts people into the role of powerless objects controlled by environmental forces, nor free agents who can become whatever they choose. "[17]

The emphases on symbolic systems as reinforcement intermediaries, and on self-generated reinforcements, both suggest a role for internal representations that puts SLT at some distance from its behaviorist heritage. Different strains of SLT are more or less "representationalist", but recent movement has been toward more."

A second major line of psychological theory, Cognitive Dissonance Theory, focuses on changes in attitude and belief.[19] This theory views belief systems as highly interconnected and people as seeking to maintain the coherence of these systems. Inconsistencies among cognitions, or between cognitions and behaviors, cause comfortable tension ("dissonance") that people seek to reduce by resolving the

inconsistency. The standard experimental demonstration involves inducing people to act contrary to their beliefs, and demonstrates that their beliefs then adjust. The adjustment is greater the smaller the externally-imposed pressure or justification for behaving as they did. The fundamental, highly counter-intuitive result, is that attitudes can adjust to behavior rather than the reverse, or in Bruner's words, "people act themselves into a way of believing as readily as they believe themselves into a way of acting." [20]

There has also been development of new theory from the rational-actor pole. The rational-actor model has been softened by economists and students of artificial intelligence who realized that rational actors faced impossible computational and observational burdens. The goal is to relax assumptions of omniscience and reflect people's real perceptual and cognitive limitations, while still retaining an evaluative framework.

Evidence of the need for such movement has been of two kinds: empirical evidence of how people choose, learn, and solve problems; and attempts to simulate these processes on computers. Researchers in Artificial Intelligence have found that heuristic structures to filter and interpret information, and to short-cut lengthy optimizing procedures, are essential for computers to address decision problems of complexity that people handle routinely. [21] Studies of people's decision-making, learning, and problem-solving, on the other hand, show the working of strong ordering principles that are not describable as rational optimization. There are strong, systematic biases in the attribution of causes to other people's behavior, [22] in the estimation of probabilities, and in inferences of causality. [23] Choices in uncertain situations depend strongly and systematically on the way the situation is described, or "framed."[24]

Early theoretical models moving away from the strict rational-actor approach were called "bounded rationality" models, stressing human computational limits that prevented optimization. The simplest such models originate in cybernetics, and use a model of control (and learning to the extent that it occurs) based on negative-feedback loops along a few simple information channels. [25] More sophisticated versions explicitly substitute for optimization the search for an acceptable alternative, subject to information, calculation, and other constraints. [26]

A more recent approach focuses on information and its processing, particularly on the need to select, filter, and impose structure on the vast excess of information coming in through the senses. People are viewed not as passive recipients of information, but as active shapers of their experience even at unconscious levels in the process of perception. [27] They construct powerful but fallible knowledge structures to make inferences about the environment, and update them like "naive scientists."[28] These structures act to reduce information needs and reduce ambiguity in the environment, in order to make it stable enough to allow people to choose and act.

Modem approaches largely share a focus on the internal cognitive structures used to represent the world. The convergence of these disparate bodies of research is called cognitive science. Gardner (1987), in a history of the Cognitive Science movement, summarized its distinguishing characteristics as follows: a focus on information-processing, downplaying the influence of context, affect, culture, and history; explanation using representations and internal cognitive structures; the use of computers as analogies and research tools; and rootedness in old philosophical questions about the nature of mind. [29]

Different kinds of mental representations are posited by researchers studying different mental phenomena -- perception, categorization, imagery, problem-solving, and memory. In one influential body of work, the constructs are called Schemas. [30] These are generic concepts stored in memory, collections of usual, representative

knowledge. Schemas are not attitudes; they have no affective significance or evaluative component, and are purely cognitive. They serve several functions: the selection of what is important from sense-data; economical storage of information in memory (which they achieve by reducing redundancy); facilitating "reasonable" inferences that go beyond the information available; and promoting the envisioning and carrying out of sequences of actions. Understanding is viewed as a process of matching new information to existing schemas, with some analogic reasoning required since every new stimulus has some unique features.

There are three types of schema: scripts, metaphors, and personae. [31] Scripts are characteristic sequences of events generalized from experience, such as "going to a restaurant."[32] Scripts mediate behavior in two ways: by the selection of a particular script as the best representation of a situation, and by the choice of a role in the script. Metaphors are schemas selected as analogic models when there is no close-enough literal fit to the present situation. A common example is the representation of complex situations in terms of sports or games. [33] Personae are stock characters that permit inferences of someone's likely personality or behavior from their superficial resemblance to a persona. [34]

The three characteristic inferential biases observed by Tversky and Kahneman (1974), availability, representativeness, and anchoring, fit well with a schema approach. Availability and representativeness describe efficient but fallible procedures for the selection of a particular schema to apply to a situation; the schema chosen tends to be a vivid, recent, or memorable one (availability), and tends to show certain stereotypical, superficial similarities to the case at hand (representativeness). Anchoring describes the persistence of schemas once chosen, and their resistance to change in the face of contrary information.

The economic storage of information that schemas offer, though, comes at the cost of a loss of flexibility in accommodating new situations or novel combinations. Holland et al argue that a more general representation of human inference and decision-making should be based on systems of mental rules, clustered in hierarchical structures. [35] In their model rules can be synchronic or diachronic, and specific or general in their application. Several rules can be triggered simultaneously by any particular state of the environment; if simultaneously- triggered rules conflict, other rules define precedence relations and rules can gain or lose strength through competition over time. Induction processes include both parameter revision, such as changing rule-strengths, and mechanisms to generate plausible new rules.

The list of characteristics that Gardner cited to define Cognitive Science did not relate explicitly to learning, and different cognitive theories address learning to different degrees. But a simple elaboration of Gardner's list would give the following characterization of cognitive theories of learning: learning is an experience-driven change in the internal cognitive structures used to represent information. People respond to disparity between their cognitive structures and feedback from their behavior by revising their cognitions.

This description still subsumes much variation. The changing representations can be of very different kinds. Change can be incremental, quantized, or some combination of the two. And change may be principally mediated by motivational factors ("hot control", more connected to behavioral models) or informational ones ("cold control", more connected to rational-actor models). [36]

4.2 Co-Determined Individual and Social Learning

Other streams of theory are substantially more social and less individualistic in their orientation than those reviewed above. They either view social factors as completely dominant, or individual learning and the social environment as interacting so strongly that they are jointly determined. Either view calls for a less individualistic methodological approach.

One line of theory is descended from the Sociology and Anthropology of the early to mid-Twentieth Century, which argued that social constructs effectively constrain individual action and thought, and that these constraints are not themselves coherently reducible to individual phenomena. [37] In its strongest form, as for example in the "thought-style" shared by members of Fleck's (1979 tr.) "thought community", such a construct "...sets the preconditions of any cognition, and it determines what can be counted as a reasonable question and a true or false answer." [38] The most fundamental organizing principles of thought -- similarity and difference, classification, and causality -- are seen as conditioned by the thought-style. And the thought-style is invisible to the individuals who participate in it. "The individual within the collective is never, or hardly ever, conscious of the prevailing thought style which almost always exerts an absolutely compulsive force upon his thinking, and with which it is not possible to be at variance." [39]

For these theorists, the focus of enquiry is the role rather than the person, and the norms or rules that constitute a role. The characteristic form of explanation is "functional", in which social forms are explained by the social benefits they bring about. [40] There has been substantial theoretical controversy over the possibility of sustaining coherent, autonomous functional explanations that do not collapse into either individual human intention or evolutionary selection.[41]Moreover, functional explanations are static, and hence of limited value as theories of learning. [42] Granovetter (1985) calls such explanations "oversocialized", arguing that to assume rigid social determination of individual behavior is as limiting as "undersocialized" rational-actor explanations. He advocates a focus on ongoing, changing networks of social relations. Giddens (1984) presents a comprehensive theoretical attempt to reconcile networks of social control and individual human agency.

A more dynamic system of theory that put social factors as dominant causes appeared in the Soviet Union in the 1920s and 30s, in the work of L.S. Vygotsky and his students.[43] The primary focus was on cognitive development and its interaction with cultural factors, particularly with tools and systems of signs. Vygotsky contended that culture affects not just the contents of thought, but the structure of its processes.

Wertsch states that three themes form the core of Vygotsky's theory -- "A reliance on a genetic or developmental method; the claim that higher processes in the individual have their origin in social processes; and the claim that mental processes can be understood only if we understand the tools and signs that mediate them"[44] -- and that the focus on tools and signs is primary, for these are the socially-determined elements that play an essential mediating role in all thought and action, and in the development of thought through instruction.

Vygotsky argued that the development of tools of thought depends on the child's entering into, and subsequently internalizing, a dialogue. The dialogue takes the form of guided participation in tasks slightly beyond their present ability, led by adults or more skilled children.[45] Vygotsky defined the Zone of Proximal Development as that set of tasks that a child cannot complete unguided, but can when guided or prompted with hints, questions, or examples. Vygotsky's contention that all learning takes place in the zone of proximal development has obvious parallels to Polanyi's "tacit knowledge", but on a social plane. Indeed, Rogoff (1990) broadens the view of the dialogue that guides learning to include tacit and non-verbal communication; she also stresses that the learning child is not passive in this process, but actively contributes to the interactive processes that in turn shape her own development.

In this view, social causes and active individuals reach a dynamic equilibrium in which social/cultural forms and the cognitions of individuals are co-determined. Cole (1985) has argued that culture and cognition create each other in the zone of proximal development. Wertsch[46] argues that individual and collective factors are so tightly inter-woven that efforts to separate them and look at reciprocal effects in a research program are bound to be fruitless; he argues for a different level of analysis, in which "mediated action" is the primary unit of investigation. Such a research program would pose daunting methodological problems, and would likely be cross-cultural. [47]

4.3 Organizational Learning

The next three sections discuss learning in various social aggregates: task-oriented groups, formal organizations, and professional communities. As we stated above, using the term "learning" to apply to a collection implies one of two forms of relationship between individual learning and changes taking place in the aggregate, which we call "Decomposition" and "Analogy".

Decomposition treats group learning as the sum of learning by the group's constituent individuals. [48] It is not restricted to the obviously trivial case in which the individuals' group membership does not affect what they learn or how they learn it. What each individual learns may be complexly contingent on the choices and learning of other group members, for example in the pursuit of high-level coordinated performance by a group such as a basketball team or a string quartet. Or the means of individual learning might be through activities that depend on the participation of other group members, such as discourse, imitation, or shared activity. [49]

Analogy treats group learning as autonomous, determined by group-level causal processes that correspond to the processes shaping individual learning. This view may simply represent a methodological convenience; even if all learning is reducible in principle to

individuals, the most fruitful way to study groups may involve observations and theoretical constructs at the group level. The value of studying chemistry is not diminished by its being in principle reducible to Physics. One may apply analogies between individual concepts such as perception, reinforcement, memory, cognitive dissonance, or schematic change, and changes in group routines, stones, or behavior, without actually believing that the group sees, thinks, or remembers.

Alternatively, one may reason by analogy to individual phenomena and believe that the collective phenomena are autonomous, truly irreducible to individuals. This position originates in Durkheim's insistence that social facts be explained by social facts, and his denunciation of dipping into the Psychological level for explanations. [50]

Studies of learning in formal organizations include some instances of both decomposition and analogy, and some studies that combine the two approaches. [51] While one body of theory, the neoclassical theory of the firm, analyzes organizations by analogy to the individual rational-actor model, the more frequent approach is to study organization-level variables such as routines and procedures with analogies to individual reinforcement or cognitive structures.

March and Olson (1976) presented a general model of interaction between an organization and its environment, based on a four-element feedback loop. The cognitions and preferences of individuals within the organization determine individual behavior, which determines organizational choices, which determine environmental consequences, which determine the preferences and cognitions of individuals in the organization. They describe this pattern as a complete learning cycle.

Each of these four causal connections can be broken, though, yielding a particular kind of incomplete learning cycle in each case. When individuals in an organization are not able to act out their preferences, the resultant incomplete learning is called "role-constrained learning". When individual actions are not translated into organizational actions, the result is "audience learning". When the causal relations between organizational choice and outcomes are not well understood, the result is "superstitious learning". And when it is not clear to individuals what the consequences of organizational action were, the result is "learning under ambiguity". Hedberg (1981, 12) points out that when learning cycles are incomplete, direct empirical falsification does not occur, and consequently organizations can persist in incorrect belief or ineffective action.

March and Olson's treatment is general, and explicitly decomposes organizational learning into learning by the constituent individuals. A focus on organizational routines is also common. [52] Heiner (1983), for example, argues that simple decision rules or routines are the appropriate response to an uncertain environment whose complexity exceeds the analytic capability of the agent. The larger is the disparity between environmental complexity and the agent's cognitive ability, the simpler and more predictable are the decision rules.

In a recent survey article, Levitt and March (1988) stress reliance on routines in their three basic observations on organizational learning: that behavior in organizations is based on routines, chosen more on a basis of legitimacy or appropriateness for the situation at

hand than of outcome calculation; that organizational actions are determined strongly by interpretations of history and past outcomes and only adjusted incrementally in response to feedback; [53] and that organizations are oriented to targets, with success or failure assessed by the relation between observed outcomes and aspiration values. [54] Learning is more typically a response to shortfall or scarcity than to success, although affluent organizations may search out new opportunities. [55]

Organizations learn by encoding inferences from history into routines that guide their behavior. In the simplest terms, a strict analogy to the behaviorist model of individuals applies; routines that are associated with successful attainment of targets will tend to be repeated. [56] If the organization's environment and tasks are sufficiently stable, such learning will lead to long-term trends of improved performance. The clearest observed example of such learning is the "learning by doing" effect, through which production costs in a wide variety of goods and services decline with cumulative experience.[57.] A recent study has shown, though, that the learning effect of past production decays markedly with time. [58]

Organizations and institutions can also be viewed from a rational-actor perspective as systems of rules and relations that rational agents construct to reduce transactions costs and defend themselves against fraud and exploitation. [59] Organizational change can also be studied as rational response by organization members to a changing environment. In his study of institutional change, North studies the interaction of institutional constraints, organizational routines, and the incentives of individuals within organizations to acquire new skills and information. Drawing on Polanyi (1966), he argues that organizational routines, like individual knowledge, embody both conscious, transmittable knowledge and tacit knowledge reinforced by practice and interaction. [60]

A more "cognitive" approach would recognize that organizations exert some control over what stimuli to notice; that the assessment of success and failure is problematic and related to internal organizational conflict; that the collective memory in which routines are recorded is imperfect; and that organizations share stories, assumptions, beliefs, and myths that guide action and give meaning to experience, but retain important elements of ambiguity.[61]

Modeling organizational learning as a response to outcomes that are finally interpreted as either success or failure implies that learning is limited to means of achieving specified organizational goals. Argyris and Schon (1978) consider the deeper process of articulating and reconceptualizing organizational goals and perceived causal relationships, which they call "double-loop learning". Their model focuses on the difference between espoused theories and the "theories-in-use" that actually guide individuals' behavior in organizational contexts. Like Beer's (1972) "meta-logic", theories-in-use are typically inaccessible to the individuals who are guided by them. Changes in theories-in-use are inhibited by cognitive and behavioral feedback loops which, among other functions, suppress recognition of the present theory. They propose a dialectical process of articulating, and thereby transforming, the unspeakable assumptions that guide organizational action. Though

often treated as such, their theory is more than a simple distinction between learning means and learning ends; its connection to critical theories of social transformation[62] is direct.

Like individuals in Social Learning Theory, organizations do not just learn from direct experience but can learn from observing others. The experience of other organizations can be acquired through the movement or imitation of technologies or procedures, contacts with or movement of personnel or consultants, or via professional associations or public media. Organizations like individuals have some power to select or control their environments, and consequently to control their learning context. The movement of innovations between organizations has been modeled as broadcast and contagion processes, [63] sometimes with different degrees of match between the innovation and the organization being the most significant factor in explaining adoption.[64]

Theories of organizational learning can be mapped onto the behavioral/cognitive/rational distinction presented above for individual learning. But theories of organizational learning also reflect differences in the fundamental metaphors used to characterize organizations. Morgan (1986) delineates different bodies of work that treat organizations as machines, organisms, cultures, political systems, "psychic prisonsm," and instruments of domination. Each of these metaphors implies a different view of the nature and determinants of organizational change, and of what it means for an organization to learn.

Although the goal of organizational learning theory has been to improve organizational performance, Hedberg in 1981 concluded that little progress had been made in the prior twenty years and that current knowledge did not permit much specific guidance. He offered a few general practitioner's suggestions: promote experimentation by reducing penalties for failure; build in regular shocks to routines through such measures as time- -limited management contracts; and don't filter the information reaching senior management too much.[65]

4.4 Learning in Science

Science may represent a special case of collective learning. Many social writers have granted a special place to scientific knowledge, believing that the superior verification of scientific method made the resultant knowledge more reliable and less liable to social explanation than other kinds of knowledge. Mulkay (1979) describes the "classical sociological view of science" as holding that scientific institutions and the social use of scientific knowledge were fair ground for sociological analysis, but that the conceptual content of scientific knowledge was not. The perception that science succeeds uniquely in generating new, reliable social knowledge lies behind the once common call for scientific principles to be applied to the solution of our social problems.[66] Contrary views have focused on the usefulness and legitimacy of transferring scientific thinking to the realm of public decision-making, rather than on the special epistemological status of scientific knowledge.[67]

But this special status has increasingly come under question. It depends upon several presumed characteristics of scientific method: the generation of falsifiable hypotheses and their attempted empirical refutation; observable facts that are unproblematic and uncontaminated by theory; and gradual, cumulative progress. [68] But all of these have increasingly been cast in doubt by new theoretical constructions of science, and by observations of what scientists actually do.

Kuhn (1970) was the first to argue for shifting focus from particular theories to those larger macro-theories that temporarily bound particular scientific specialties, defining promising directions for research questions and criteria for correct answers. Kuhn argued that these macro-theories (which he called paradigms) are determined consensually, and tend to persist even in the face of substantial empirical counter-evidence. Lakatos (1970) refined the characterization of macro-theories (which he called research programs), distinguishing a hard center or "negative heuristic" of fundamental assumptions that are temporarily immune from criticism, from a softer periphery or "positive heuristic" which provided general guidelines for the generation of particular testable hypotheses. Contrary to Kuhn, he argued that more than one research program can be active at one time, and that rejection is not sudden but a gradual decay as other programs show more empirical success. Laudan (1977) proposed that macro-theories (which he called research traditions) can evolve over time, because while a core set of propositions is sacrosanct at any time, that set can change over time. He also argued that theories are tested by the balance between the empirical problems they solve and the conceptual problems and anomalies they generate.

These different views of how science works have increasingly been investigated through detailed historical study. Donovan et al (1988) present sixteen detailed case studies of scientific change, examining hypotheses on the role of guiding assumptions and anomalies, and the character of innovations and revolutions.

Mulkay (1979) argues that the newer view, which regards science's epistemological status as more fallible, makes sociological study of science's conceptual content legitimate. Over the past decade there have been increasingly detailed sociological studies of the collective creation of scientific knowledge. Fleck's 1935 study of syphilis (1979 tr.), which argued the social determination of all cognition, was a remarkable early exception to the former deference. Recently there have been many studies of routine operation of scientific laboratories and of scientific controversies. [69]

Some studies have persuasively demonstrated social factors determining the acceptance of particular scientific theories or evidence, [70] while many others have yielded weak or ambiguous results. Laudan (1977) argues that the pursuit of social explanations of scientific knowledge has been too expansive. He accepts that the territory of scientific ideas can reasonably be partitioned into those parts determined rationally and those socially, but contends that sociologists have too readily accepted the narrow, classical definition of rational explanation and thus have claimed a too-large remainder for themselves. He argues for a "history-of-ideas" approach to the study of science, following a methodological heuristic of first trying to account for scientific ideas on rational grounds of successful problem-solving, coherence, and consistency with other bodies of theory, and only seeking

social explanations when the results of this attempt are weak. The record of social studies of science would seem to support Laudan's agenda. It suggests that social factors play the largest role when a body of work is new, incomplete, and has limited or unclear connections to more mature lines of enquiry; as a field matures, the rational pressures become more tightly constraining and the room for social determination of concepts becomes more limited.

4.5 Learning in Policy-Making

A second special case of collective learning, one of particular relevance to this study, is the learning that goes into policy-making, policy change, and international relations. In contrast to the classical deference accorded to scientific learning, the traditional view of policy change is that it is better explained by power, interests, and coalition alignments than by learning.

The postwar rise of the disciplines of policy analysis and operations research has led to a contrary, and excessive view of the role of technical and scientific knowledge, and learning, in policy-making. The following caricature captures the flavor. Political leaders, in doing their job of making discrete policy decisions among well-defined alternatives," realized that the increasing scientific and technical content of the decisions they were required to make called for outside advice. They turned to a professional cadre of analysts, who presented the relevant scientific and technical information. The decision-makers, now knowing the relevant consequences of whatever decision they might make, then performed the appropriate balancing of values and interests to arrive at a decision. Note that the analysts operated only in a technical arena, and their only audience was the decision-maker.

This caricature is rooted in the reality of some specific policy and operational problems, many concerned with efficient military operations, that were solved in the early days of Operations Research. Were such separation of the technical and the political possible, the tension between democracy and reason described above in the discussion of Dewey would not arise. But for most policy and analysis, it is indeed a caricature. Even when policymakers know what technical or instrumental questions they want to ask, they are often ones whose answers science does not yet (or cannot) know." And in an ambiguous, messy decision environment where goals are multiple or contested, they may well not know what questions they want to ask. In this environment, it is not surprising that so much policy analysis is bad, not listened to, or used for non-substantive purposes."

But even with a more realistic view of the relationship between policy-makers and analysts there is much opportunity for learning in this system. One key result is that policy analyses often serve a longer-term "enlightenment function" (particularly relevant to our decadal time-view) even if they have little immediate effect on particular government decisions." Clark and Majone (1985) point out that evaluating policy analysis using standards drawn from either pure science or pure democracy is liable to convict too frequently, and suggest a set of standards that mixes output, input, and procedural criteria. Increasing recognition of the role of deliberation, and of the similarity of deliberative processes in policy and in the sciences, has led several authors to call on analysts to acknowledge their role as debaters, persuaders, and rhetoricians and

jump into the fray." As Rouse (1987) argues, even in the natural sciences there is a substantial collective, procedural element in determining who is right; the rightness of your view is determined by your ability, using the tools and results at your disposal, to persuade others of it. Majone (1980) extends the analogy between policy and science by arguing that policy change follows a process similar to Lakatosian competition among research programs in science.

An increasing number of case-studies in policy change have focused on learning as a key and under-addressed issue. [76] The most common focus is on the learning and cognitive processes of top individual decision-makers. Some studies apply models of learning from psychological research, while others apply their own definitions and models. Jervis (1976) systematically studies the application of theories of individual cognition and perception, and related biases, to international relations. Larson (1985) applies psychological theories of attitude change to the changing views of four senior American officials at the origin of the cold war. Etheredge (1985) examines senior officials' decision-making in recurring similar foreign-policy incidents and concludes that they do learn, but only under conditions of crisis. Ernst Haas (1990) articulates two models of non-learning adaptation and one of learning, and applies them to a series of case-studies of international organizations.

Steinbruner (1974) describes three characteristic biases in cognitive processes in organizational decision-making; grooved thinking, uncommitted thinking, and theoretical thinking. He asserts that these restrict learning and so characterizes organizational learning under a cognitive model as "constrained learning", but provides no details of the structure or dynamics of learning under such a model.

Peter Haas (1990) takes more of a group focus in his study of the influence on Mediterranean pollution control agreements of a so-called "epistemic community". He argues that this international group of like-minded officials, mostly scientists, reached a common understanding of the issue relatively early, and then exploited their monopoly on relevant scientific knowledge and their positions of control in specialized government agencies to push their governments into strong international agreements.

Heclo's 1976 study of social policy-making in Britain and Sweden finds an important element of social learning among officials developing policies. Hall (1990), building on Heclo's work, articulates a model of policy learning in the context of the theory of the state. Three central features of the model are that policy is strongly influenced by recent policy; [77] that a key role in advancing policy learning is played by experts in government or acting as advisers to it; and that states have substantial ability to act autonomously from societal pressures. Bennett (1990), in a study of learning among senior Soviet foreign-policy decision-makers from 1973 to 1983, formulates a series of learning hypotheses on the individual, group, and governmental level.

Two studies of long-term learning by governments are of particular relevance to a study of learning on environmental risk management. Cooper (1989) studied the long-term development of knowledge, cooperation, and institutional capacity for combating international movement of diseases in the 19th and early 20th centuries. Hall (1989) studied

the development and movement of Keynesian ideas and policies in eight countries. He delineates three approaches to studying the political influence of economic ideas: economist-centered approaches, which turn on the ideas' intellectual acceptability to economists and presume the dominance by economists of economic policy-making;[78] state-centered approaches, which emphasize the institutional structure of the state apparatus and its recent experience with similar policies; and coalition-centered, in which a new idea's success turns on politician's ability to construct novel willing coalitions around it. Hirschmann, in his "comment", stresses the intellectual component of even a coalition-centered approach:

> "Prior to Keynes, there was no respectable theoretical position between centralized planning, on the one hand, and, on the other, the traditional laissez-faire policies, with their denial of any governmental responsibility for economic stability and growth."[79]

Hall concludes that ideas do affect policy, but the manner and extent that they do depends on their economic, administrative, and political viability. He finds four central factors in determining the adoption of Keynesianism: orientation of the governing party; permeability of the civil service; concentration of power over macro-economic management; and the power of the central bank over policy-making (central bankers did not like Keynesianism).

In summary, these studies show two distinct approaches: studying learning among a few top political decision-makers, or in the somewhat larger community of policy experts on a particular issue. With the former approach, the focus is clearly on individuals. Consequently, the large body of work on individual learning, attitude formation, and cognitive change applies directly. With the latter approach, the focus is necessarily on a larger and only roughly bounded group. Consequently, as in the discussion of organizational learning above, the relevant learning theory -- theory of how the group learns -- is not well developed. Several authors limit their comments on group learning to the observation that individual learning is necessary but not sufficient for group learning, for routines and conflict can prevent individual learning from being expressed in group activity.[80] The most frequent response is not to look inside the policy community, but instead ask how their learning affects policy change. On this question the theorizing is largely ad hoc, amounting to the assertion that learning by policy elites does affect policy change; change is not all reducible to contending political interests and bureaucratic inertia. The theoretical tools for distinguishing the effects of learning from other forces of change, though, are still at an early stage of development.

5. Evolution and Learning: Complementary Models?

Aside from learning, evolution is the other manifestly dynamic process often employed as a model for change in social systems. An evolutionary approach can cut across the various categories of learning studies we have considered thus far. Evolutionary models have been applied to learning processes at the individual and organizational levels, in science and in policy-making, and to other processes of social change. This section discusses the

biological basis of evolutionary models, their application to learning and other processes of social change, and the relationships between learning and evolution as theoretical models for social dynamics.

The basis of an evolutionary model is the selection among invariant forms leading to differential survival. In biology, evolutionary models are based on stably propagating species defined by reproduction within but not across the species boundary; on variation among the individuals comprising a species, at least some of which is heritable; and on differential reproductive success of individuals leading to shifts over time in the genetic and somatic characteristics of the species.

The differential reproductive success of individuals is mediated by many factors, some of which are fixed (some variations are quickly lethal to the individual carrying them); some of which are contingent on particular characteristics of the environment the species presently occupies; and some of which are socially contingent, depending on the distribution of related characteristics or behaviors among other members of the same population. Overall adaptivity or fitness is not absolute, but contingent on many factors.

The shift in species characteristics over time and in response to changes in environment sometimes brings about the creation of new species. It is widely agreed that speciation must require a population's undergoing substantial change during a period of effective physical reproductive isolation, which proceeds so far as to create effective biological reproductive isolation if and when the separated populations come back into contact.

There is dispute, though, over the primary locus of selection. The standard view is that selection is among individuals, through processes of reproduction and death. One can construct scenarios, though, under which marginal populations diverge quickly enough that internally stable, reproductively separate groups come into competition for the same environmental resources, with selection thereby operating among species through processes of speciation and extinction. [81]

This basic structure of evolutionary thought -- a mechanism of novelty generation and one of selective retention -- has provided a richly provocative analogy, and sometimes formal models, for students of learning at the individual and group level. The richest approach has not been to argue that learning shows particular characteristics because of adaptive advantage,[82] but rather to apply evolutionary arguments to non-biological phenomena that show the same processes of a) generally stable propagation, b) some means of generating innovation and variation within the basic regime of stability, and c) a separate mechanism of selection from among variants, such that some are more likely to survive and propagate than others.

Applying evolutionary thinking to ideas and cognitions themselves, Campbell (1960; 1974) has argued that human learning is at root an evolutionary process. Bateson[83] proposes an ecological approach to broad classes of human cognition and behaviors. Popper's (1972) view of falsification and progress in science is expressed in explicitly evolutionary terms. Toulmin (1972) presented an evolutionary view of concepts in

society at large, not just science, emphasizing that concepts that are dominated are not necessarily eliminated; like marginalized sub-species, they can remain available to exploit future opportunities.

At the organizational level, an evolutionary perspective can be particularly fruitful in view of the competitive relations among economic organizations. Nelson and Winter (1982) argue that competition among firms applies selection pressure to the processes of routine generation and innovation that operate within firms. Since the 1970s, the emerging field of Organizational Ecology has sought to apply ecological and evolutionary principles to broader classes of organizations. Hannan and Freeman (1977; 1984) applied theoretical constructs from population ecology to organizations. They distinguish two forms of organizational change: learning from the environment, and adapting to change in the environment. Organizations with too much inertia to change fast enough relative to change in the environment will be removed by selection pressure. The more recent literature has focused on the levels-of-analysis problem, arguing that the population is not the only or most useful level at which to study organizations, particularly the origin and diversification of organizations. [84] Young (1988) provides a forceful critique of biological analogies in the study of organizational change, arguing that fundamental concepts such as species, niche, and death are defined ambiguously or circularly.

In their work on mathematical modeling of cultural evolution, Cavalli-Sforza and Feldman (1981) argue that cultural artifacts or "memes"[85] can be modeled by the same processes as biological evolution, with two possible exceptions. First, innovations, unlike biological mutations, are typically created with a purpose or in response to a perceived problem, so the determinants of their adaptiveness may be structured differently, and the probability higher than for biological mutations. [86] Second, cultural selection may have complex interactions of either direction with Darwinian selection. While most cultural patterns likely have minimal direct Darwinian effects, some clearly have negative effects (they cite ritual mutilations, particularly female circumcision, and risky sports) and some clearly positive (the adoption of agriculture, with resultant increases in local carrying capacity).[87] Boyd and Richerson (1985) develop a "dual inheritance" model, in which formal Darwinian selection is applied independently to genetic and cultural inheritance. [88]

In less formal treatments, Adler (1989) applied evolutionary concepts to government learning, explaining two major innovations in American foreign policy through a process of idea-generation, domestic selection, and international diffusion. Schmid (1987) and Eder (1987) take an evolutionary approach to the explanation of social systems, norms, and rules.

An evolutionary model cannot be equivalent to a learning model at the same level of analysis. Evolution is based on selection among invariant forms through birth and death processes, while learning implies that the learning system survives its changes. Moreover, as Elster (1979) argues, evolutionary systems are restricted to changes through "local hillclimbing", selection based on the immediate adaptive advantage of each local increment, while human learners can proceed obliquely, take one step back for two forward, pause to re-frame a problem, or otherwise circumvent the demands of continuous local improvement in pursuit of a superior global goal.

But an evolutionary model may be equivalent to a learning model at a different level of analysis. Selection among organizational routines may represent learning by the organization.[89] Selection among particular organizations by birth and death may represent learning by the system in which the organizations operate. As Campbell (1974) and Popper (1972) have argued in different contexts, individual learning may be an evolutionary process at the level of cognitions, through which "our hypotheses die in our stead".

If evolutionary concepts are to be used in studying social learning, the selection must operate on the things learned -- the concepts, names, slogans, images, acts, technologies, forms of social organization, political movements, opinions, attitudes, norms, and skills that people learn, individually or collectively. The evolutionary concepts of selection, ecological community, and species suggest many provocative analogies, hypotheses, and questions for the study of social learning. To determine how useful they are requires a careful look at the applicability of each of the constituent concepts: origination of variation, propagation, selection, and speciation and species stability.

First we need a description of origination. While most would agree that particular new ideas are generated by individuals, there is more dispute over the relative effects of individual creativity and social ordering on the total set of new ideas generated. Social or cultural factors may interact with individual creativity to determine the range of novel concepts a member of a particular society is capable of inventing. Thereafter, some social factors are likely involved in determining the intelligibility, sense of importance, and ease of communicating a new idea or image, and consequently its initial viability.

Next we need a mechanism of propagation. Different forms of propagation apply to different classes of things learned. Some things can be replicated cheaply and accurately by print or electronic media, others (e.g., behaviors to be learned by modeling) require more detailed information, still others (e.g., skills and craft knowledge, forms of argument, persuasion to a new value) may resist explicit encoding completely and require direct communication from another person, guided participation, or practice. [90]

Models of information propagation alone may not be adequate to capture the full range of learning processes, though. In addition to the issue of tacit knowledge, there may be things learned that, contrary to the cognitive science model, bundle evaluation or affect with information.[91] The particular content of information and affect may change as a word or slogan is propagated and used, through the effects of both the channels of communication through which it passes and the people who hear and use it.

Third, there must be mechanisms to introduce variation in the propagation. Although physical processes of replicating information have low error rates, people's inclination to interpret and modify what they receive in view of their own experience, values, information, and cognitive processes, will create pressure toward variability. One need only to have played the party game in which a story is passed around the room in whispers, finally returning to its originator transformed beyond recognition, to realize how rapidly an idea can be transformed in interpersonal transmission.

Additional variation can also arise from the movement of ideas through various communication channels and to different audiences.[92] Certain kinds of ideas, such as technical concepts of specialized disciplines, may only be intelligible to a few people. When such ideas move through broader circles they may be altered in ways that reflect the characteristics of the new, broader audience or of the channels of communication through which they pass, e.g., new scientific results reported on television or used in Congressional debate. There is also something in the transmission of ideas akin to sexual reproduction in biology, with its mixing of existing genetic material to create new variations. Ideas, norms, and images come together in inter or intra-personal process -- in introspection or in discourse -- and generate new ones.

If there is to be a strong analogy to biological evolution, though, these forces for variability must be countered by forces to stabilize related collections of ideas. If the intrapersonal processes determining what is intelligible or worthy of consideration are not sufficient to effect this stabilization, then it must come from some inter-personal process -from discourse, from comparison to other cognitions and views held, or from argument and evaluation in view of a common shared body of knowledge.

This stabilizing force could operate as selection pressure on individual ideas to reinforce related systems of ideas. Bodies of ideas could be mutually reinforcing by being intelligible in terms of each other, reciprocally confirming, suggesting questions or actions whose results will further reinforce the collection. Disciplinary boundaries perform these functions in science, as do the various forms of macro-theory within disciplines.[93] Inpolitical and social discourse, corresponding bodies of thought might be called ideologies or national characters.[94] The analogy to selection forces preserving the stability of species is evident.

There is abundant anecdotal evidence for the notion of bodies of related ideas defending their integrity and borders through repression of deviance and sniping at those who enter no-man's-land. This would parallel the argument that the relative paucity of smooth large transitions in the fossil record shows the middle ground to be highly unstable. If you must change, you survive by evolving quickly across the boundary to find a new stable niche beyond. The often-lamented difficulty of establishing and maintaining interdisciplinary scholarly careers and academic programs would fit this model. In this case the niches for which groups are competing are university appointments and research grants – the competition will be intense. In the realm of political ideas, Chomsky's work on propaganda argues for the existence of social mechanisms that delimit the range of acceptable political debate in a society. [95]

The adaptation of bodies of ideas, like adaptation of species, is relative. They compete not against objective criteria of value but against each other in view of the opportunities that the environment presently offers. This lends a provisional character to any presently ascendant ideology or thought system. [96]

Moreover, a great breadth of survival opportunities for idea systems will exist in a reasonably pluralistic society. The evolutionary analogy suggests that small populations

of marginal ideas, like Toulmin's temporarily-dominated concepts, may survive through long periods when the mainstream environment is unfavorable, flourishing anew when environmental conditions change in their favor. The persistence of neo-fascist movements among alienated young men in industrial countries and the rapid re-appearance of such movements (and of ancient ethnic hatreds) in eastern Europe and the Soviet Union may be examples of this phenomenon. The analogy also suggests that there may exist many such small marginalized sub-populations of ideas, collectively representing an important reservoir of cognitive variability that can increase society's resilience to extreme environmental change.

6. Conclusions: Guiding an Applied Research Program

The purpose of this endeavor has been to gather together the major strands of theory related to social learning with a view to guiding a research program of empirical case studies in the management of global environmental risks. The case studies will have to include a broad set of learners and things learned, for the project's focus on functions of risk management leaves open the questions of who does or learns what.[97]

At least five different groups of learners are of clear relevance for environmental risk management: senior policy decision-makers; scientific communities; industrial organizations making production and technology decisions; other non-governmental organizations; and, to the extent that consumer market forces and broad political views and images condition the centralized decisions, the citizenry at large. The things they learn may include scientific facts and models, "policy theories", technologies, preferences, behavioral norms, images and names, or broad worldviews and conceptions of society.

The available evidence suggests that some form of meaningful learning almost certainly can occur at all levels of society, from the individual to the international. The best developed theories of learning, however, are at the level of individual learners, and to a lesser extent at the level of small, face-to-face groups. Indeed, some writers limit their definition of social learning to processes that occur in such groups. Friedmann (1987), for example, argued that significant social learning only occurs in small, task-oriented groups whose dynamics are not reducible to individuals' characteristics; that the learning is embodied in group relationships that are lost when the group dissolves; that learning occurs primarily through dialogue; and that such learning groups discover their objectives in the course of action.[98]

Such theory has been usefully applied to studies of small policy-making communities, for example in Hall (1989) and P. Haas (1990). These two could provide models for studies of learning in global environmental risk-management by policy and scientific elites.

Hall's study shows many parallels. The strongest is the focus on an incomplete and contentious body of scientific information, which evolves under the eyes of policy-makers seeking answers to their immediate crises. The major contrasts include the focus on present harms of known character, involving mature and powerful

institutions, and concerning primarily well-entrenched political values such as jobs and incomes.

Haas's study of the Mediterranean involves knowledge and institutions similar to those involved with global environmental risks, and includes both industrial and developing countries. It departs from the present project in focusing on a specific, more short-term, acute environmental phenomenon.

These studies both provide useful beginnings for efforts to understand and manipulate long-term improvements in the management of environmental risks. But to the extent that such improvements depend on the broad spread of images, norms, knowledge, and behavior through society at large, other models are also required. An evolutionary perspective that focuses on the population of things learned may be most suitable, but existing work in this area goes scarcely beyond provocative analogy. The immediate need is to increase the stock of empirically rich case studies informed but not constrained by today's body of social learning theory.

FOOTNOTES

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[1]World Commission on Environment and Development, 1987, p.8.

[2] E. Adler (1989), p.2-5

[3]1966, p.22.

[4]Friedmann (1987), pp.187-202.

[5]Dewey (1920).

[6]Dewey (1939).

[7] Bateson (1942b) calls these classes "proto" and "deucero " -learning. Douglas (1986, p.55) in a related comment, asserts that "Similarity is an institution", at least partly socially constructed.

[8] Nye (1987); Bennett (1990), p.100; Breslauer (1987), p.432.

[9] Geuss (1981); Habermas (1979).

[10] Stuart (1989).

[11] Argyris and Schon (1978); Friedmann (1987), 202-216.

[12] Braybrooke (1987) provides a clear delineation of the naturalistic, interpretative, and critical approaches to social theory.

[13] Elster (1986:1-4).

[14]Concise discussions of this model can be found in Elster (1986), Harsanyi (1986), and Allison (1971). Axelrod (1984), Taylor (1987), Rapoport and Chammah (1965), and Luce and Raiffa (1956) consider interactive decision problems from a rational-actor perspective.

[15]Gardner (1987) provides a brief history of the behaviorist movement. Its furthest imperial expansion was Skinner (1957), the first rationalist counter-attack Chomsky (1959). Skinner (1971) is a clear popular treatment.

[16] We will denote this body of theory as Social Learning Theory (capital letters), to distinguish it from the general topic of social learning.

[17]1977, vii.

[18]Bandura (1973); Bandura (1977); Aronfreed (1976); Mischel (1968); Kanfer (1971); Wren (1983); Rushton (1983).

[19] Festinger (1957); McGuire (1966).

[20]1979, p.132.

[21]Tamashiro (1984); Newell and Simon (1972).

[22]Heider (1958); Schneider et al (1970), 46-73; Jervis (1976).

[23]Tversky and Kahneman (1974, 1981); Hogarth and Reder (1986).

[24]Kahneman and Tversky (1981).

[25]Bateson (1967).

[26]The classic works of bounded rationality are Simon (1955, 1959).

[27]Steinbruner (1974: 92); Hochberg (1964).

[28]Nisbett and Ross (1980).

[29]Hunt (1989) is a recent literature review of cognitive science.

[30]Minsky (1975); Schank and Abelson (1977); Rumelhart(1980).

[31] Abelson (1976: 33-45); Larson (1985: 50-57).

[32] Scripts can be of two kinds: episodic (a sequence of events described as a single experience, e.g. "Chamberlain at Munich"), and categorical (generalization from common features, e.g. "appeasement encourages aggressors to make more extreme demands"). Abelson (1976).

[33] Schon (1979); Miller (1979).

[34] Nisbett and Ross (1980).

[35] p. 12-28.

[36] Nisbett and Ross (1980).

[37] The original statement of these principles is Durkheim (1938).

[38] Douglas (1986), p.13.

[39] Fleck (1979 tr.), p.41.

[40] Douglas (1986) argues that functional explanation requires that the benefits be unintended, indeed unperceived, by the individuals participating in the social form. Elster (1989, pp. 105-6) presents a skeptical view, arguing that even if norms are important determinants of individual behavior, they need not be "supraindividual entities".

[41] Dore (1961); Homans (1964)

[42] There is, though, a recent body of empirical research on norms, based mostly on experimental studies in small groups, that focuses on norm creation and evolution and is consequently not functionalist in orientation. e.g., Bettenhausen and Murnighan (1985); Feldman (1984); Handel (1979); Opp (1982).

[43]discussed in Wertsch 1985a, 1985b, 1991.

[44]Wertsch (1985), p. 14-15.

[45] Rogoff (1990), p. 14; Bruner (1986), p. 73.

[46]1991, p.6-16.

[47] Cole and Scribner (1974) provide a useful historical review of cross-cultural research on cultural determinants of cognition.

[48]Udehn (1987); Elster (1989), p.104-105.

[49] Bandura (1977); Argyris and Schon (1978); Habermas (1979).

[50] Durkheim (1938), p.110-112.

[51] Hedberg (1981, p.6) states that organizational learning studies mostly avoid the question of relationships between group and individual learning, using organization-level theoretical constructs but being based on observations of individuals.

[52] Cyert and March (1963).

[53] Lindblom (1959), Steinbruner (1974)

[54] Simon (1955); Siegel (1957).

[55] Hedberg (1981, 16); Lewin and Wolf (1975).

[56] Cyert and March (1963)

[57] Levitt and March (1988), p.321.

[58] Argote et al (1990).

[59] Williamson (1975, 1985)

[60] North (1990), p.74.

[61] Hedberg (1981), p.11-12; Levitt and March (1988), p.324.

[62] e.g., Habermas (1976).

[63] Kimberley (1981); Rogers and Shoemaker (1971); Heclo (1974) uses a contagion model to explain innovations in social policy. An early literature treating the spread of rumors with epidemic models was summarized by Dietz (1967).

[64] Mansfield (1968); Kay (1979).

[65] Hedberg (1981), p.19-23.

[66] Friedmann (1987), pp.63-82, traces this "social engineering" view from Saint-Simon and Comte, to modem muted strains in Simon and Dunn.

[67] Lindblom (1959); Lindblom and Cohen (1979); Braybrooke and Lindblom (1970).

[68] Popper (1959; 1972)

[69] e.g., Latour and Woolgar (1986); Gilbert and Mulkay (1984).

[70] For example, Wynne's (1976) study of Barka's J-radiation demonstrating a consensus made and kept by highly selective use of evidence; Collins and Pinch's (1978) study of parapsychology demonstrating the force of unquestionable assumptions; and Frankel's (1976) demonstration that individual's acceptance of particular claims can depend on their social position, e.g., that outsiders take more risks.

[71] This view, called "decisionism", is from Shklar (1964).

[72] Weinberg (1972); Haefele (1974).

[73] Clark and Majone (1985); Sabatier and Jenkins-Smith (1988); Dunn (1980); Webber (1983).

[74] Weiss (1977, 1982).

[75] Majone (1989); Sabatier and Jenkins-Smith (1988); McCloskey (1985)

[76] e.g., Keohane and Nye (1987).

[77] Hall's presentation implies that he is distinguishing progressiveness in policy from policy that simply responds to present interest alignments, rather than asserting that policy learning is sluggish.

[78] This approach has strong parallels to Haas's "epistemic community" work on environmental policy.

[79] p.356.

[80] e.g., Nye (1987); E. Haas (1990); Bennett (1990). This view fits neatly into the "incomplete learning cycle" of March and Olson (1976).

[81] This summary draws heavily on Eldredge (1985), and Curtis and Barnes (1989).

[82] This is the approach of Sociobiology, which asserts that some human behavior is genetic in origin. Wilson (1978).

[83] 1972, particularly the essays collected in Part 5.

[84] Astley (1985); Carroll (1984) and Singh and Lumsden (1990) provide surveys of Organizational Ecology, distinguishing three levels of analysis: the organization, the population (of similar organizational forms), and the community.

[85] following Dawkins's usage (1976), for "units subject to imitation".

[86] p.66.

[87] p.362-366.

[88] Boyd and Richerson (1985).

[89] Nelson and Winter (1982)

[90] These forms of propagation have been studied with various contagion models drawn from epidemiology, e.g., Cavalli-Sforza and Feldman (1981), and the studies reviewed by Levitt and March (1988), pp. 329-331.

[91] This applies not just to clearly evaluative phenomena such as attitudes, but also to names, definitions, and facts. For example, the words "racism" or "sustainable development", or the fact that "The United States, with 5 per cent of the world's people, consumes 25 per cent of its energy. " are learnable things in which cognition, evaluation, and affect are tightly bundled.

[92] This argument is an inversion of Fleck's notion of a "thought community", with a core of initiates and a soft periphery of adherents who take the ideas literally and unquestioningly. In Fleck's view, movement originates from the center and ossification occurs on the rim, but the reverse is also possible. (1979)

[93] Lakatos (1970); Kuhn (1970); Laudan (1977).

[94] Geuss (1981); Bateson (1942a).

[95] e.g., Chomsky (1989).

[96] This has been most clearly recognized in the descriptions of science of Lakatos (1970) and Laudan (1977).

[97] Clark (1990).

[98] p.186-187

SOURCES

Adler, Emanuel 1989. "Cognitive Evolution: A Dynamic Approach for the Study of International Relations and Their Progress", CSIA Working Paper 89-4, June 1989.

Alchian, A., 1950. "Uncertainty, Evolution, and Economic Theory," Journal of Political Economy 58:211-222.

Allison, Graham T., 1971. Essence of Decision, Boston: Little, Brown and Co.

Argote, Linda, Sara L. Beckman, and Dennis Epple (1990), "The Persistence and Transfer of Learning in Industrial Settings", Management Science 36:2, 140-154, February 1990.

Argyris, Chris and Donald A. Schon, 1978. Organizational Learning: A Theory of Action Perspective, Reading MA: Addison-Wesley.

Aronfreed, J., 1976. "Moral Development from the Standpoint of a General Psychological Theory", in T. Likona ed., Moral Development and Behavior, New York: Holt Rinehart and Winston.

Astley, W.Graham, 1985. "The Two Ecologies: Population and Community Perspectives on Organizational Evolution", Administrative Science Quarterly 30:224-241.

Axelrod, Robert, 1984. The Evolution of Cooperation, New York: Basic Books.

Bandura, Albert, 1973. Aggression: A Social Learning Analysis. Englewood Cliffs NJ: Prentice-Hall.

_____, 1977. Social Learning Theory. Englewood Cliffs NJ: Prentice-Hall.

Bateson, Gregory, 1942a. "Morale and National Character", from Goodwin Watson, ed., Civilian Morale, Society for the Psychological Study of Social Issues. Reprinted in Bateson 1972.

_____, 1942b. "Social Planning and the Concept of Deutero-Learning", in Science, Philosophy, and Religion: Second Symposium. New York: Harper and Row. Reprinted in Bateson 1972.

_____ , 1967. "Cybernetic Explanation", American Behavioral Scientist 10:8,29-32. Reprinted in Bateson 1972.

_____ , 1972. Steps to an Ecology of Mind, New York: Ballantine.

Beer, Stafford, 1972. Brain of the Firm, New York: Herder and Herder.

Bennett, Andrew O. 1990. Theories of Individual. Organizational, and Governmental Learning and the Rise and Fall of Soviet Military Interventionism. 1973-1983, Doctoral dissertation in Public Policy, Harvard University, February 1990.

Bettenhausen, Kenneth and J.K.Murnighan, 1985. "The Emergence of Norms in Competitive Decision-Making Groups", Administrative Science Quarterly 30:350-372.

Boyd, Robert and Peter J. Richerson, 1985. Culture and the Evolutionary Process, Chicago: University of Chicago Press.

Braybrooke, David, 1987. Philosophy of Social Science. Englewood Cliffs, N.J.: Prentice Hall.

Braybrooke, David and C.E.Lindblom 1970. A Strategy of Decision: Policy Evaluation as Social Process New York: Free Press.

Breslauer, George 1987. "Ideology and Learning in Soviet Third World Policy", World Politics 39:3,432.

Bruner, Jerome 1979. On Knowing: Essays for the Left Hand, 2nd Edition, Cambridge MA: Harvard University Press.

_____, 1986. Actual Minds, Possible Worlds, Cambridge: Harvard University Press.

Campbell, Donald T.. 1960. "Blind Variation and Selective Retention in Creative Thought as in Other Knowledge Processes Psychological Review 67: 380-400. Reprinted in Radnitzky and Bartley, eds., 1987.

_____ , 1974. "Evolutionary Epistemology", in Paul A. Schilpp, ed., The Philosophy of Karl Popper, LaSalle: Open Court.

Carroll, Glenn R. 1984. "Organizational Ecology", Annual Review of Sociology 10: 71-93.

Cavalli-Sforza, L. L. and M. W. Feldman, 1981. Cultural Transmission and Evolution: A Quantitative Approach, Princeton NJ: Princeton University Press.

Chomsky, Noam, 1959. "A Review of B.F.Skinner's Verbal Behavior", Language 35, 2658.

_____, 1989. Necessary Illusions: Thought Control in Democratic Societies, Boston: South End Press.

Clark, William C., 1990. "Social Learning in the Management of Global Environmental Risks", grant proposal to the MacArthur Foundation.

_____, and G. Majone, 1985. "The Critical Appraisal of Scientific Inquiries with Policy Implications", Science, Technology, and Human Values 10:3, 6-19,

Summer 1985. Cole, M., 1985. "The Zone of Proximal Development: Where Culture and Cognition Create
Each Other", in J. V. Wertsch, ed., Culture, Communication, and Cognition: Vygotskian Perspectives, Cambridge: Cambridge University Press.

_____ , and Sylvia Scribner, 1974. Culture and Thought. New York: Wiley.

Cooper, Richard N., 1989. "International Cooperation in Public Health as a Prologue to Macroeconomic Cooperation", in Can Nations Agree? Issues in International Economic Cooperation, Washington: The Brookings Institution.

Collins, H.M. and T.J. Pinch, 1978. "The Construction of the Paranormal: Nothing Unscientific Is Happening", in R. Wallis (ed.), Rejected Knowledge: Sociological Review Monograph, Keele: University of Keele.

Cottam, Martha L., 1986. Foreign Policy Decision-Making: The Influence of Cognition, Boulder: Westview Press.

Curtis, Helena, and N.Sue Barnes, 1989. Biology 5th ed. New York: Worth.

Cyert, Richard and James March 1963. A Behavioral Theory of the Firm, Englewood Cliffs NJ: Prentice-Hall.

Dawkins, Richard, 1976. The Selfish Gene. New York: Oxford University Press.

Dewey, John, 1927. The Public and Its Problems: An Essay in Political Inquiry Chicago: Gateway Books.

_____, 1938. Logic: The Theory of Enquiry New York: Holt.

_____, 1980 (orig. 1929) The Quest for Certainty: A Study of the Relation of Knowledge to Action, New York: Perigee Books.

Dietz, Klaus 1967. “Epidemics and Rumors: A Survey”. Journal of the Royal Statistical Society Series A, 130: 505-528.

DiMaggio, Paul J. and Walter W. Powell, 1983. “The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields”, American Sociological Review 48: 147-160 (April).

Donovan, Arthur, Larry Laudan and Rachel Laudan eds 1988. Scrutinizing Science: Empirical Studies of Scientific Change Dordrecht: Kluwer Academic Publishers.

Dore, R.P. 1961. “Function and Cause”, American Sociological Review 26:843-853.
Douglas, Mary 1986. How Institutions Think, Syracuse NY: Syracuse University Press.

Dunn, Edgar, 1971. Economic and Social Development: A Process of Social Learning, Baltimore: Johns Hopkins University Press.

Dunn, William, 1980. “The Two-Communities Metaphor and Models of Knowledge Use”, Knowledge 1: 515-536, June 1980.

Durkheim, Emile, 1938. The Rules of Sociological Method, (8th ed, translated by S.A.Solovay and J.H.Mueller, edited by G.E.G.Catlin) New York: Free Press.

Eder, Klaus, 1987. “Learning and the Evolution of Social Systems: An Epigenetic Perspective”, in Schmid and Wuketits, eds. (1987).

Eldredge, Niles, 1985. Unfinished Synthesis: Biological Hierarchies and Modern Evolutionary Thought, New York : Oxford University Press.

Elster, Jon 1983. Explaining Technical Change: A Case Study in the Philosophy of Science, Cambridge: Cambridge University Press.

_____, 1986. Rational Choice, New York: New York University Press.

_____, 1989. The Cement of Society: A Study of Social Order, Cambridge: Cambridge University Press.

Etheredge, Lloyd S. 1981. "Government Learning: An Overview", in Samuel L. Long ed., The Handbook of Political Behavior, Vol. 2. New York: Plenum.

_____ , 1985. Can Governments Learn? American Foreign Policy and Central America, Elmsford NY: Pergamon Press.

Feldman, Daniel C., 1984. "The Development and Enforcement of Group Norms", Academy of Management Review 9:47-53.

Festinger, Leon 1957. A Theory of Cognitive Dissonance, Stanford, California: Stanford University Press.

Fleck, Ludwig 1979. The Genesis and Development of a Scientific Fact Translation by F.Bradley and T.J.Trenn of 1935 German edition. Chicago: University of Chicago Press.

Frankel, E., 1976. "Corpuscular Optics and the Wave Theory of Light: The Science and Politics of a Revolution in Physics", Social Studies of Science Vol 6, pp. 141-184.

Friedmann, John 1987. Planning in the Public Domain: From Knowledge to Action Princeton: Princeton University Press.

Geuss, Raymond 1981. The Idea of a Critical Theory: Habermas and the Frankfurt School, Cambridge: Cambridge University Press.

Giddens, Anthony, 1984. The Constitution of Society: Outline of a Theory of Structuration. Berkeley: University of California Press.

Gilbert, G. Nigel and Michael Mulkay 1984. Opening Pandora's Box: A Sociological Analysis of Scientists' Discourse Cambridge: Cambridge University Press.

Granovetter, Mark, 1985. "Economic Action and Social Structure: The Problem of Embeddedness". American Journal of Sociology 91:3, 481-510 (November).

Haas, Ernst 1990. When Knowledge is Power: Three Models of Change in International Organizations, Berkeley: University of California Press.

Haas, Peter 1990. Saving the Mediterranean: The Politics of International Environmental Cooperation New York: Columbia University Press.

Habermas, Jurgen 1979. Communication and the Evolution of Society, Boston: Beacon Press.

Hall, Peter A., ed., 1989. The Political Power of Economic Ideas: Keynesianism Across Nations. Princeton: Princeton University Press.

_____ , 1990. "Policy Paradigms, Social Learning, and the State: The Case of Economic Policy-Making in Britain". mimeo.

Handel, Warren, 1979. "Normative Expectations and the Emergence of Meaning as Solutions to Problems: Convergence of Structuralist and Interactionist Views", American Journal of Sociology 84:855-881.

Hannan, Michael T. and John Freeman, 1977. "The Population Ecology of Organizations", American Journal of Sociology 82: 929-964.

_____ and _____, 1984. "Structural Inertia and Organizational Change", American Sociological Review 49: 149-164 (April).

Harsanyi, John C. 1986. "Advances in Understanding Rational Behavior", in Elster ed., (1986).

Heclo, Hugh, 1974. Modern Social Politics in Britain and Sweden, New Haven: Yale University Press.

Heider, F. 1958. The Psychology of Interpersonal Relations. New York: Wiley.

Heiner, Ronald A., 1983. "The Origin of Predictable Behavior", American Economic Review 73:4, 560-595. September 1983.

Hochberg, J. 1978. Perception Englewood Cliffs NJ: Prentice-Hall.

Hogarth, Robin M. and Melvin W. Reder, Rational Choice: The Contrast Between Economics and Psychology. Chicago: University of Chicago Press.

Holland, John H., K.J. Holyoak, R. E. Nisbett, and P.R.Thagard, 1986. Induction: Processes of Inference, Learning, and Discovery. Cambridge MA: MIT Press.

Homans, George C., 1964. "Bringing Men Back In", American Sociological Review 29:5,809-818.

Hunt, Earl 1989. "Cognitive Science: Definition, Status, and Questions", Annual Review of Psychology 40, 603-630.

Jervis, Robert 1976. Perception and Misperception in International Politics, Princeton: Princeton University Press.

Kahneman, Daniel and Amos Tversky 1979. "Prospect Theory: An Analysis of Decision Under Risk", Econometrica 47, 263-91.

_____ and _____, 1981, "The Framing of Decisions and the Psychology of Choice", Science 211:453-58, January 30, 1981.

Kanfer, F.H., 1971. "The Maintenance of Behavior by Self-Generated Stimuli and Reinforcement", in A.Jacobs and L. Sachs, eds., The Psychology of Private Events, New York: Academic Press.

Kay, N.M. 1979. The Innovating Firm: A Behavioral Theory of Corporate R&D, New York: St. Martin's Press.

Keohane, Robert O. and Joseph Nye 1987. "Power and Interdependence Revisited" International Organization 41(4): 725-753.

Kimberley, J.R. 1981. "Managerial Innovation", in Nystrom and Starbuck, eds., 1981, 1:84 - 101.

Kuhn, Thomas S. 1970. The Structure of Scientific Revolutions, 2nd edition, Chicago: University of Chicago Press.

Lakatos, Imre 1970. "Falsification and the Methodology of Scientific Research Programmes", in Lakatos and Musgrave eds, Criticism and the Growth of Knowledge, Cambridge: Cambridge University Press.

Larson, Deborah Welch 1985. Origins of Containment: A Psychological Explanation, Princeton: Princeton University Press.

Latour, Bruno and Steve Woolgar 1986. Laboratory Life: The Construction of Scientific Facts Princeton: Princeton University Press.

Laudan, Larry 1977. Progress and its Problems: Toward a Theory of Scientific Growth Berkeley: University of California Press.

Levitt, Barbara and James G. March 1988. "Organizational Learning", Annual Review of Sociology 14:319-340.

Lewin, Arie Y. and Carl Wolf, 1975. "The Theory of Organizational Slack: A Critical Review", in E. Shifler, ed., Proceedings of Twentieth International Meeting, The Institute of Management Science, Vol 2:648-654, Jerusalem: Jerusalem Academic Press.

Luce, R. Duncan and Howard Raiffa, 1957. Games and Decisions New York: John Wiley and Sons.

Lindblom, Charles E., 1959. "The "Science" of Muddling Through", Public Administration Review 19:79-88.

_____, and David K. Cohen 1979. Usable Knowledge: Social Science and Social Problem-Solving, New Haven: Yale University Press.

Majone, G., 1980. "Policies as Theories", Omega 8:151-162.

_____ , 1989. Evidence, Argument, and Persuasion in the Policy Process, New Haven CT: Yale University Press.

Mansfield, E., 1968. The Economics of Technical Change, New York: Norton.

March, James G. and Johan P. Olson, 1976. Ambiguity and Choice in Organizations, Bergen: Universitetsforlaget.

McCloskey, D.N., 1985 The Rhetoric of Economics, Madison: University of Wisconsin Press.

McGuire, William J., 1966. "Attitudes and Opinions", Annual Review of Psychology 17.

Miller, George A. 1979. Images and Models, Similes and Metaphors, in Ortony ed. (1979).

Minsky, Marvin 1975. "A Framework for Representing Knowledge", in P. H. Winston, ed., The Psychology of Computer Vision. New York: McGraw-Hill.

Mischel, W. 1968. Personality and Assessment. New York: Wiley.

Modelski, George 1990. "Is World Politics Evolutionary Learning", International Organization 44:1, 1-24.

Morgan, Gareth, 1986. Images of Organization. Beverly Hills: Sage.

Mulkay, Michael 1979. Science and the Sociology of Knowledge, Controversies in Sociology Series #8, London: George Allen and Unwin.

Nelson, Richard R. and Sidney G. Winter 1982. An Evolutionary Theory of Economic Change, Cambridge MA: Harvard University Press.

Newell, A. and H. A. Simon, 1972. Human Problem-Solving. Englewood Cliffs NJ: Prentice-Hall.

Nisbett, Richard and Lee Ross 1980. Human Inference: Strategies and Shortcomings of Social Judgment, Englewood Cliffs NJ: Prentice-Hall.

North, Douglass C., 1990. Institutions, Institutional Change, and Economic Performance. New York: Cambridge University Press.

Nye, Joseph S. (1987). "Nuclear Learning and US-Soviet Security Regimes", International Organization 41:3, 371-402.

Nystrom, N.C. and W.H. Starbuck, eds., 1981. Handbook of Organizational Design, Oxford: Oxford University Press.

Ortony, Andrew ed., 1979. Metaphor and Thought, Cambridge: Cambridge University Press.

Opp, Karl-Dieter, 1982. "The Evolutionary Emergence of Norms", British Journal of Sociology 21:139-149.

Polanyi, Michael, 1958, Personal Knowledge: Toward a Post-Critical Philosophy. Chicago: University of Chicago Press.

_____, 1966, The Tacit Dimension. Garden City, NY: Doubleday.

Popper, Karl R., 1959. The Logic of Scientific Discovery. London: Hutchinson.

_____ , 1963. Conjectures and Refutations: The Growth of Scientific Knowledge. London: Routledge and Kegan Paul.

_____ , 1972. Objective Knowledge: An Evolutionary- Approach, Oxford: Oxford University Press.

Powell, Charles A., Helen E. Dyson, and James W. Purkitt, 1987. "Opening the Black Box: cognitive Processing and Optimal Choice in Foreign Policy Decision Making", in Charles F. Hermann, Charles W. Kegley Jr, and James Rosenau, eds., New Directions in the Study of Foreign Policy. Boston: George Allen and Unwin.

Radnitzky, Gerard and W.W.Bartley, eds., 1987. Evolutionary Epistemology, Rationality. And the Sociology of Knowledge La Salle IL: Open Court.
Rapoport, Anatol and Albert M. Chammah, 1965. Prisoner's Dilemma: A Study in Conflict and Cooperation, Ann Arbor: University of Michigan Press.

Rogers, E.M. and F.F. Shoemaker, 1971. Communication of Innovations. New York. Free Press.

Rogoff, Barbara 1990. Apprenticeship in Thinking: Cognitive Development in Social Context, New York: Oxford University Press.

Rouse, Joseph 1987. Knowledge and Power: Toward a Political Philosophy of Science Ithaca: Cornell University Press.

Rumelhart, D., 1980. "Schemata: The Building Blocks of Cognition", in R. Spiro et al, eds., Theoretical Issues in Reading Comprehension, Hillsdale NJ: Lawrence Erlbaum.

Ruse, Michael 1987. "Evolutionary Models and Social Theory: Prospects and Problems", in Schmid and Wuketits, eds., (1987).

Rushton, J. Philippe 1982. "Altruism and Society: A Social Learning Perspective". Ethics 92:425-446.

Sabatier, Paul A., "An Advocacy Coalition Framework of Policy Change and the Role of Policy-Oriented Learning Therein", 1988, in Sabatier and Jenkins-Smith, eds., 1988.

Sabatier, Paul A. and Hank C. Jenkins-Smith, eds., 1988. "Policy Change and Policy-Oriented Learning: Exploring an Advocacy Coalition Framework", special issue of Policy Sciences, 21:123-127.

Schank, R. and R.P. Abelson, 1977. Scripts. Plans, Goals, and Understanding: An Enquiry into Human Knowledge Structure. Hillsdale NJ: Lawrence Erlbaum.

Schmid, Michael 1987. “Collective Action and the Selection of Rules. Some Notes on the Evolutionary Paradigm in Social Theory”, in Schmid and Wuketits eds. (1987).

Schmid, Michael and Franz M. Wuketits eds. 1987. Evolutionary Theory in Social Science, Dordrecht: D.Reidel.

Schneider, David J., A.H.Hastorf, and P.C.Ellsworth, 1970. Person Perception, 2nd edition, Reading MA: Addison-Wesley.

Schon, Donald A. 1979. “Generative Metaphor: A Perspective on Problem-Setting in Social Policy”, in Ortony ed. (1979)

Siegel, S. 1957. “Level of Aspiration and Decision-Making”, Psychological Review 64: 253262.

Simon, Herbert A. 1955. “A Behavioral Model of Rational Choice”, Quarterly Journal of Economics 69: 99-118.

_____, "The Architecture of Complexity" in The Sciences of the Artificial, MIT Press
1968,

_____, "Theories of Decision-Making in Economics", American Economic Review 49:253-283, 1959;

Singh, Jitendra V. and Charles J. Lumsden, 1990. "Theory and Research in Organizational Ecology", Annual Review of Sociology 16: 161-195.

Skinner, B. F. 1957. Verbal Behavior, New York: Appleton-Century-Crofts.

_____, , 1971. Beyond Freedom and Dignity, New York: Knopf.

Steinbruner, John 1974, The Cybernetic Theory of Decision, Princeton: Princeton University Press.

Stuart, Richard B., 1989. "Social Learning Theory: A Vanishing or Expanding Presence?" Psychology: A Journal of Human Behavior 26:1,35-50.

Tamashiro, Howard, 1984. "Algorithms, Heuristics, and the Artificial Intelligence Modelling of Strategic Statecraft", in Donald A. Sylvan and Steve Chan, eds., Foreign Policy Decision Making, Praeger 1984.

Taylor, Michael, 1987. The Possibility of Cooperation, Cambridge: Cambridge University Press.

Toulmin, Stephen, 1961. Foresight and Understanding: An Enquiry into the Aims of Science, New York: Harper and Row.

_____ , 1972. Human Understanding, Princeton: Princeton University Press.

Tversky, Amos and Daniel Kahneman, 1974. "Judgment Under Uncertainty: Heuristics and Biases", Science 185:1124-1131.

Udehn, Lars, 1987. Methodological Individualism : a Critical Appraisal, Uppsala: Uppsala Universitet.

Vygotsky, L.S. 1978. Mind in Society: The Development of Higher Psychological Processes, Cambridge MA: Harvard University Press.

Waltz, Kenneth 1979. Theory of International Politics, Reading MA: Addison-Wesley.

Webber, David 1983. "Obstacles to the Utilization of Systematic Policy Analysis", Knowledge 4: 534-560, June 1983.

Weiss, Carol H. 1977. "Research for Policy's Sake: The Enlightenment Function of Social Research", Policy Analysis 3: 531-545, Fall 1977.

Weiss, Carol H. 1982. "Policy Research in the Context of Diffuse Decision-Making", policy Studies Review Annual 6:19-36.

Wertsch, James, 1985a. Vygotsky and the Social Formation of Mind. Cambridge MA: Harvard University Press.

_____ , ed., 1985b. Culture, Communication, and Cognition: Vygotskian Perspectives. New York: Cambridge University Press.

_____ , 1991. Voices of the Mind: A Sociocultural Approach to Mediated Action. Cambridge MA: Harvard University Press.

Williamson, Oliver E., 1975. Markets and Hierarchies: Analysis and Antitrust Implications. New York: Free Press.

_____ , 1985. The Economic Institutions of Capitalism. New York: Free Press.
Wilson, E.O. 1978. On Human Nature, Cambridge MA: Harvard University Press.

World Commission on Environment and Development, 1987. Our Common Future, Oxford: Oxford University Press

Wren, Thomas E. 1982. "Social Learning Theory, Self-Regulation, and Morality", Ethics 92:409-424.

Wynne, B., 1976. "C.G.Barkla and the J Phenomenon: A Case Study of the Treatment of Deviance in Physics", Social Studies of Science Vol 6, pp.307-347.

Young, Ruth C., 1988. "Is Population Ecology a Useful Paradigm for the Study of Organizations?", American Journal of Sociology 94:1, pp.1-24. (July)