

Epistemic Forms and Epistemic Games: Structures and Strategies to Guide Inquiry

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Epistemic forms are target structures that guide inquiry. Epistemic games are general purpose strategies for analyzing phenomena in order to fill out a particular epistemic form. The article describes in detail the rules and moves for one epistemic game and briefly describes a catalog of epistemic games that are used to analyze phenomena in terms of their structure, function, or processes.

There are recurring forms that are found among theories in science and history. Some of the different forms that occur are stage models, hierarchies, primitive elements, system-dynamics models, and axiom systems. Inquiry in different disciplines involves mastering how to carry out investigations of phenomena guided by one or more of these target structures. We refer to the target structures that guide scientific inquiry as *epistemic forms* and the set of rules and strategies that guide inquiry as *epistemic games*.

The difference between forms and games is like the difference between the squares that are filled out in tic-tac-toe and the game itself. The game consists of rules, strategies, and different moves that players master over a period of time. The squares form a target structure that is filled out as any particular game is played.

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The forms and games we describe are epistemic in that they involve the construction of new knowledge. They are played to make sense of phenomena in the world. If we want to encourage the general skills of explanation seeking, then people need to learn how to play these epistemic games. We call them epistemic games, both because of the allusion to Wittgenstein's (1953) language games and because of the parallel to games such as tic-tac-toe. They are not simply inquiry strategies or methods; rather, they involve a complex of rules, strategies, and moves associated with particular representations (i.e., epistemic forms). As with any complex game, understanding all the subtleties of an epistemic game requires a long period of learning.

It is important to ask whether epistemic forms and games are another name for some well-known concept in science, such as theories, models, or analysis techniques. Theories and models often involve epistemic forms, but they are particular instances; they are not the general forms that guide inquiry. Epistemic games are similar to analysis techniques except that they are more general. There are many analysis techniques in different sciences and they are usually specific to the field and the kind of data analyzed. Epistemic games as we think of them are used across many different fields and apply to many different kinds of data. One possible way to think about epistemic games is as the most general kind of analysis techniques or inquiry approaches.

Currently science and social studies education consists mainly of teaching facts, concepts, and problem-solving methods, along with particular theories and models. We argue that it would also be useful for students to learn some of the more important epistemic forms and games to guide their inquiries. These forms and games have value not only in science and social studies, but in any endeavor to understand the world.

This article is divided into four major sections. The first provides a detailed analysis of one epistemic game. The other three form a catalog of the epistemic games that we have identified so far. The second section describes forms and games that are used for analyzing the structure of systems. The third section examines epistemic forms and games that are used for analyzing causal or functional aspects of systems. The fourth section analyzes epistemic forms and games used for describing the dynamic behavior of systems. We conclude with some hypotheses on the nature and role of epistemic forms and games.

HOW EPISTEMIC GAMES ARE PLAYED

Everyone engages in the most basic epistemic games: making lists, comparing entities, determining the steps in a process, and analyzing trends.

Children apparently learn to use some of these basic inquiry strategies early on. Science has elaborated many of these basic strategies by adding different constraints. By exploiting these constraints systematically, researchers can more productively explore any domain of inquiry.

Any epistemic game can be pursued more or less systematically. For example, if one is comparing two objects or ideas, one simple approach is to list characteristics of each. This is the simplest compare-and-contrast game. A more constrained form of this game involves choosing attributes that apply to both of the items being compared and then filling in the values of these attributes for each item. We explore the different levels of this game in the next section.

One of the simplest epistemic games is list making. People often make lists as part of carrying out their day-to-day activities, but they also make lists in an attempt to understand the world. Every list is implicitly the answer to a question. Some epistemic questions might be: "What are the different kinds of animals?" "What are the basic substances things are made of?" "What are the different forces in the world?" and "What were the causes of the French Revolution?" If the answer to these questions must be discovered, rather than recalled or looked up, then the list-making process is an inquiry process and the resulting list constitutes new knowledge.

Like the game of compare and contrast, list making can be elaborated by adding constraints on the contents of the list. These constraints are the rules of the game and serve two purposes. They cause the resulting list to be more focused, and they facilitate the finding of ideas. This second result might seem counterintuitive at first. After all, more constraints usually make a task harder rather than easier. However, list making is, to a large extent, a memory and inference task, and such tasks are often expedited by the presence of constraints, which serve as probes for retrieval.

The constraints established by the list-making game that we have identified are similarity, coverage, distinctness, multiplicity, and brevity. *Similarity* is the requirement that the items in the list be of the same general form: same size, same kind, same importance, and so on. *Coverage* means that all possible answers to the question are covered by the items on the list. *Distinctness* requires that no two items overlap or are difficult to distinguish. *Multiplicity* means that a list must have more than one element. *Brevity* refers to the fact that short lists are generally better than long ones because they constitute more succinct answers to the inquiry.

Each of these constraints leads to useful list-constructing strategies in the form of auxiliary questions that may help to guide the inquiry. Similarity provokes the question "Is one of these things not like the others?" (a question familiar to viewers of *Sesame Street*). Coverage asks "Has anything been left out?" or "Is every example I can think of covered by one of the items in the list so far?" Distinctness leads to asking "Do any of these

items overlap or mean the same thing?" Multiplicity is a definitional constraint and leads only to the question "Am I really seeking a list?" when only one item can be thought of. Finally, brevity (when a list begins to grow too large) prompts questions like "Should I be using more abstract categories?" or "Can the elements of this list be partitioned in some way?" The questions generated by violations of the brevity constraint often lead to major shifts in the nature of what is being listed. For example, if one begins listing all animal species, the magnitude of the developing list may push one into deciding to use much larger classes or to change games altogether by trying to form a hierarchy or a table.

In addition to constraints, we have identified four other characteristics of epistemic games: entry conditions, moves, transfers, and a target epistemic form.

The *entry conditions* of an epistemic game determine when it is appropriate to play that game. They are concerned with the nature of the question that motivates the inquiry and with the data or knowledge that is available to help in formulating an answer. The list game is appropriate when the question is of the form "What is the nature of x ?" where x is decomposable into subsets or constituents. The list game is also appropriate early in an inquiry process, because it requires little to get it started and because it often provides a basis for playing more powerful games as the inquiry proceeds.

The *moves* in an epistemic game are the actions that can be taken at different points in the game. In the list game, the basic moves are to add a new item, combine two (or more) items, substitute an item, split an item, and remove an item.

Another kind of move is changing the question, for instance, changing the question from "What are the things I can do to prevent pollution?" to "What are the things that anyone can do to prevent pollution?" This sort of question alteration is a basic part of inquiry (Schank, 1986).

As we suggested, sometimes the best move is to *transfer* to a different epistemic game. If an inquiry began as a list-making game, the following transfers are possible: Divide the list into more than one list and specify relations between lists (transfer to the hierarchy game); look for dimensions over which the items vary (transfer to the table game); or identify the basic components that constitute the items (transfer to the primitive-elements game).

The desired result of any epistemic game is the completion of a *target epistemic form* that satisfies the inquiry. Each epistemic game produces a characteristic form. Because of this correspondence, the names of the games and forms are often similar—the list-making game produces lists, the system-dynamics game produces system-dynamics models, and the compare-and-contrast game produces a comparison table. But the same

form may be produced by more than one game. For example, the primitive-elements game also produces lists.

STRUCTURAL ANALYSES

The list game is the simplest structural analysis game, but there are several more. The most similar ones to the list game are spatial and temporal decompositions (i.e., stage models). More complicated structural-analysis games include compare and contrast, cost-benefit analysis, primitive-elements analysis, tables or cross-product analysis, tree structures or hierarchical analysis, and axiom systems. Structural-analysis games answer the question "What is the nature of x ?" by breaking x down into subsets or constituents and describing the relationships among the constituents. The following briefly describes each of these games.

Spatial decomposition is the analysis that takes place in anatomy or circuit diagrams. The goal is to break an entity down into a set of nonoverlapping parts and to specify the topographical relations between the parts. The set of constraints is the same as the list-making game, though each has a spatial aspect. Thus, coverage does not mean including all examples, but rather including the entire entity. Specifying the topographic connections is an additional constraint, and, where applicable, specifying the nature of these connections is another constraint. Topographic connections are sometimes simply points of contact, as in a circuit, or they may be complex entities in themselves, for example, the borders on a map.

Temporal decompositions or *stage models* are common in historical analysis, psychological analysis, and analysis of any process that is characterized by a series of states. The simplest stage model is a list constructed with the constraint that the stages follow each other sequentially without overlap.

Figure 1 shows a more complicated version of a stage model. Each stage might be characterized by multiple characteristics, and, furthermore, these

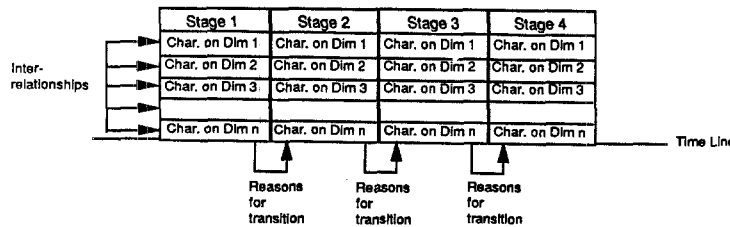


FIGURE 1 Stage models.

characteristics may be arranged on a set of dimensions (e.g., the boy was angry and tired before his nap but happy and energetic afterwards). In a more complicated stage model, the interrelationship between the variables might be specified (e.g., energy state determines mood) and the reason for the change from one stage to the next specified (e.g., a nap leads to an increase in energy). These last four constraints (i.e., multiple characteristics, specified dimensions, specified interrelationships, and reasons for transition) are all optional constraints that a person may or may not use in constructing a stage model.

Compare and contrast is a decomposition game involving comparison of two entities. It is commonly used in beginning analysis in many different fields but is perhaps most prominently seen in history and the social sciences. In order to illustrate further how epistemic forms can be filled out with different degrees of constraint, we present three different versions of a comparison between the Earth and a peach in Figure 2.

The simplest kind of comparison is shown in Figure 2, Example 1, in which the salient features of each are produced by playing the list game for each object. The features may be the same (e.g., round) or different (e.g., hard vs. soft) on some dimensions, but in the simplest version of the game, no dimensional analysis is enforced nor is there a necessary constraint to have the same number of features for each object. In Example 2, a more constrained version of the comparison is shown that employs dimensional analysis. A still more constrained version of this analysis would attempt to cover all the salient similarities and differences between the two objects. Example 3 illustrates how dimensional analysis can be nested to create an even more constrained comparison. As in stage models, further constraints could be introduced by trying to specify the interrelationships between dimensions or the reasons for the similarities and differences on particular dimensions.

Cost-benefit analysis is a special case of compare and contrast that is used in social and economic policy analysis. The things compared in cost-benefit analysis are alternative courses of action, and in playing this game one should first identify all possible courses of action (i.e., the coverage constraint in the list game). Then one tries to identify all the costs and benefits (or pros and cons) of each alternative. This might also involve a set of dimensions on which the alternatives are compared, such as time, effort, and money. Identifying all the costs and benefits (i.e., to obtain coverage) for each alternative is aided by knowing about likely kinds of costs and benefits, such as time, money, and effort; it is also aided by knowing to look for possible side effects, for social as well as individual effects, and for possible countereffects and synergies.

The *primitive-elements* game is a version of the list game that has driven much of the history of the physical sciences and now is playing a large role

EXAMPLE 1		Earth	Peach
		Round Hard Huge	Round Soft Edible Sweet
EXAMPLE 2		Earth	Peach
	Diameter: Shape: Layers:	8000 miles Round 3 layers	2 inches Round 3 layers
EXAMPLE 3		Earth	Peach
Outer Part	Name: Volume: Texture:	Crust Very thin Hard solid	Skin Very thin Moderately hard solid
Middle Part	Name: Volume: Texture:	Mantle Largest Molton rock	Fruit Largest Soft solid
Inner Part	Name: Volume: Texture:	Core Large Part solid iron Part liquid iron	Pit/Stone Large Hard solid

FIGURE 2 Compare and contrast.

in artificial intelligence analyses of the social sciences (e.g., Schank & Abelson, 1977; Waltz, 1975). Ancient Greeks held the view that everything was made of four elements: earth, air, fire, and water. Chemistry later came up with 92 natural elements, and when atoms were discovered, the quest was to determine the basic constituents from which atoms are made. The latest quest is to determine different types of the primitive elements (e.g., quarks) making up protons, neutrons, and other subatomic particles.

Figure 3 shows schematically the epistemic form driving the primitive-elements game. The goal is to characterize a large set of phenomena (e.g., substances, actions) as made up of combinations of a small number of primitive elements. Coverage of all the phenomena by the set of primitive elements is particularly critical in this game. Another constraint is to specify how the elements combine to produce each phenomenon.

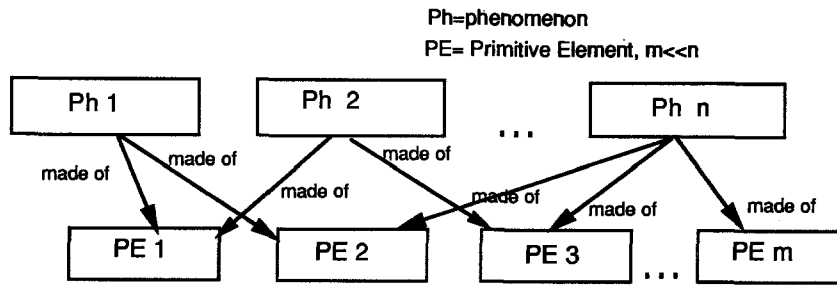


FIGURE 3 Primitive elements.

The *cross-product* or *table game* is a multidimensional version of the list game. The best known example of the cross-product game was the construction by Mendeleev of the periodic table of chemical elements, which led to identifying missing elements and, ultimately, to an understanding of the atomic structure of molecules. One may attempt to decompose any set of elements into an array characterized by a set of dimensions. For example, one could array vehicles by their medium (air, land, ice, etc.) and their form of propulsion (motor, sail, etc.) The dimensions can be continuous or discrete, and cells can be multiply filled or not. These latter constraints have a large effect on how the cross-product game is played. However, just as in the primitive-elements game, coverage of all the elements is a critical constraint in playing the cross-product game.

The *tree-structure* or *hierarchy game* is familiar to everyone from its use in biology. Often the tree-structure game is employed as a transfer from the list game when a list gets too long. Like the table game, the tree-structure game is a way to add more structure to a list, but tree structures are less constrained than tables. The added constraints in a tree structure are that the elements be broken into subsets of similar types (the similarity constraint) and that the relations between the subsets be specified. These kinds of hierarchies pervade the biological and social sciences, because evolutionary processes naturally produce tree structures.

Axiom systems are the most constrained and have the highest status of the structural-analysis techniques. The most famous examples of axiom systems are Euclid's geometry and Peano's axioms for arithmetic. The appeal of this epistemic form is seen in Hull et al.'s (1940) attempt to axiomatize animal behavior and in Whitehead and Russell's (1910-1913) attempt to axiomatize the logical foundations of mathematics. The Hullan example illustrates the power of a high-status epistemic form to drive inquiry in a bizarre direction.

A summary of the main constraints of the axiom-system game appears in Figure 4. Axiom systems are made up of a set of well-formed formulae and

Well-formed formuli (WFF): variables, constants, relations
Rules of Inference (minimal set)
Axioms (Ax) (minimal set, independent)
Theorems (Th)

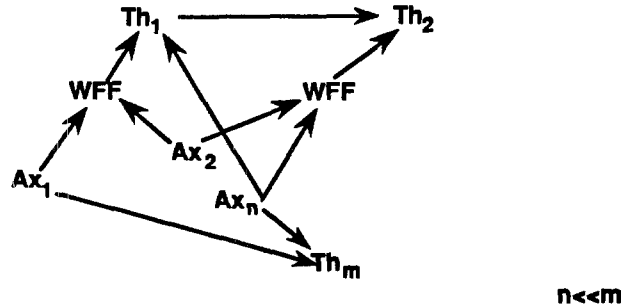


FIGURE 4 Axiom systems.

rules of inference. Well-formed formulae are composed of constants, variables, and relations between them and are formed according to specified rules. Axioms and theorems are special cases of well-formed formulae. Axioms are the assumptions of the theory and ideally should be few in number and independent of each other. Theorems are statements that can be derived by the rules of inference from the axioms. The rules of inference should also be few in number.

The preceding are the most common structural-analysis games. Most employ the constraints described for the list game, but each adds new constraints. They are the basis for understanding the structure of systems, a major form of inquiry carried out in science and history.

FUNCTIONAL ANALYSES

A second major form of analysis that takes place in science and history is functional analysis, in which the goal is to determine the causal or functional structures that relate elements in a system. The following describes some of the most common functional-analysis games that we have identified. These include critical-event analysis, cause-and-effect analysis, problem-centered analysis, multicausal analysis, and form-and-function analysis.

Critical-event analysis occurs in historical analysis (e.g., Eisenstein, 1979) and troubleshooting of various kinds (often called critical-incident analysis). This kind of analysis centers on a particular event (e.g., an airplane

crash, the invention of the printing press). It attempts to identify the events or causes that led to the critical event or the set of consequences that flow from the critical event.

Cause-and-effect analysis is a variation on critical-event analysis that assumes a sequence of events, each one leading to the next. It is frequently used in constructing artificial intelligence models of events. The analysis distinguishes triggering events or causes from preconditions, which are necessary conditions for the effects to occur. Each effect, in turn, can be the triggering event for a new set of effects. This analysis breaks the continuous stream of events in the world into a train (or even lattice) of events that are causally interlinked.

Problem-centered analysis is found throughout the field of history and any subject area in which human goals and actions are paramount. The simplest form of this analysis breaks an event stream into problems and actions taken to solve the problems. These actions lead to main effects and side effects. The side effects are often new problems to be solved. As a philosopher once said, "the main source of problems in the world is solutions."

Problem-centered analysis is embodied in the formal analysis of human-computer interaction by Card, Moran, and Newell (1983) and the analysis of electronic troubleshooting behavior by Hall, Gott, and Pokorny (1992). In a variation on the Card et al. analysis, Hall et al. broke the stream of events into problems, actions, results, and interpretations (called PARI analysis). Each interpretation identifies a new problem to be solved unless the goal state has been reached. Story grammars (e.g., Rumelhart, 1975) are even more elaborate versions of a problem-centered analysis as applied to analyzing stories.

Multicausal analysis or *AND/OR graphs* are another common way to analyze causality in systems. They are particularly pervasive in geography and medicine but are common in many other disciplines in which it is difficult to identify a chain of events that are causally interlinked. In multicausal theories, variables (called factors or independent variables) are linked together in a tree structure. The branches of the tree are ANDed together if a set of factors are all necessary to produce the desired value on the dependent variable. They are ORed together if any of the factors are sufficient to produce the desired value on the dependent variable. Figure 5 shows an AND/OR graph that one respondent produced as his theory of what determines where rice is grown (Collins, Warnock, Aiello, & Miller, 1975). This epistemic form served as a target structure to guide his construction of this theory.

Form-and-function analysis involves different structures, depending on the field of inquiry. The simplest analysis is to distinguish between the forms of objects and their functions or uses. In rhetoric, this is elaborated

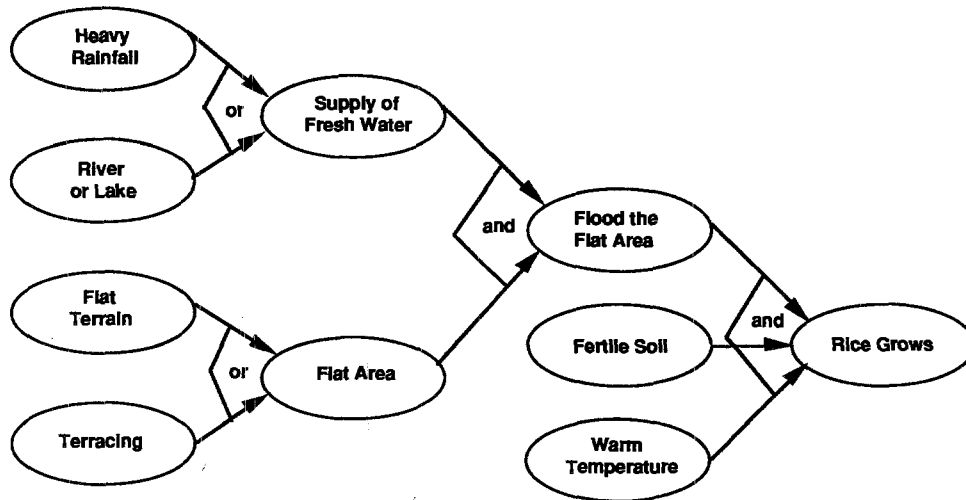


FIGURE 5 A student's analysis of the causal factors affecting rice growing.

into distinctions between the purpose (i.e., function), the form (i.e., structure), and the content of a discourse. Scardamalia, Bereiter, and Steinbach (1984) describe how a dialectic in writing between the content and the form accomplishes the purpose.

Weld (1983) analyzed explanations of the workings of physical devices, such as a car engine, in terms of roles, functions, structures, and mechanisms. The role is the part played by the device in a larger system, the function is the goal that the device accomplishes, the structure is made up of components linked together to accomplish the function, and the mechanism is the process by which the structure accomplishes the function. When explanations describe how different components of a device work, these four aspects of the explanation unfold recursively. This analysis is an example of the way artificial intelligence represents the working of physical systems.

Figure 6 illustrates how another artificial intelligence researcher (D. Edelson, personal communication, August 1992) represented the knowledge extracted from interviewing a biology professor about animal behavior. This is an elaborated form-and-function analysis specialized for biology, with goals at the top and behaviors (akin to mechanisms) that can fulfill goals underneath. In the analysis, properties are environmental characteristics that constrain the behavior, functions, and features of animals. Functions in this analysis consist of abilities, such as flying or stalking, that enable animals to execute their behaviors. Features are the structural forms that enable animals to execute the functions. This analysis might better be

Goals = find food, stay warm, reproduce
Behaviors = flee predator, attract mates, search for food
Properties = habitat, predators, food sources
Functions = locomotion (fly, swim), grasp, senses (hear, see)
Features = fins, scales, wings, teeth

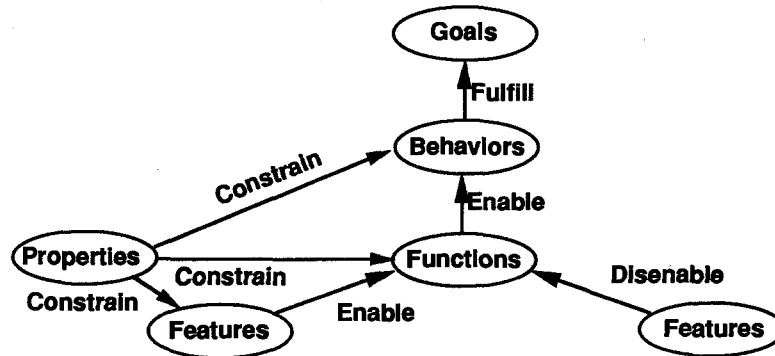


FIGURE 6 Form and function in biology.

structured recursively, as in the Weld (1983) analysis of devices, but it does illustrate how a field such as biology can develop an elaborated form-and-function analysis.

The various functional or causal analysis forms guide inquiry by providing target structures that can be used for analyzing phenomena or events in the world. For example, the form-and-function framework for biology can guide one's analysis of the behavior of a new animal one encounters. Functional analysis pervades humans' attempts to make sense of the world around them (Perkins, 1986).

PROCESS ANALYSES

In addition to analyses in terms of structure and function, there is a third kind of analysis in terms of dynamic behavior of phenomena. We label the various epistemic forms and games designed to make sense of dynamic phenomena as *process analyses*. The major forms and games we discuss are system-dynamics models, aggregate-behavior models, constraint-system analyses, situation-action models, and trend and cyclical analysis.

System-dynamics models are increasingly common, especially in the social and physical sciences. They achieved popular status from Forrester's (1971) work, and there are several computer programs, such as STELLA, that provide tools for constructing system-dynamics models. These pro-

grams in fact provide a generative epistemic form for playing the epistemic game of system-dynamics modeling.

The basic elements in system-dynamics models are variables that can increase or decrease. These are linked together by positive or negative links, usually with feedback loops permeating the system of variables. These models can be either qualitative or quantitative and can have lags built into the system.

A special system-dynamics model that is commonly used is the homeostatic (or negative feedback loop) model. The classic example of this kind of model is the thermostat, which, if the temperature of a place falls below a threshold, turns on a heater until the temperature rises above a second threshold. Homeostatic models have been used in Cannon's (1932) physiology, in the Gaia hypothesis to explain the carbon dioxide/oxygen balance of the earth (Lovelock, 1979), and in rise and fall theories of history (Kennedy, 1987; Olson 1982).

Aggregate-behavior models are constructed frequently to explain behavior in the physical sciences, particularly the behavior of small particles like molecules and electrons. The models assume random, concurrent motion of a large array of particles. When the particles encounter each other, there are a number of possible interactions, such as sticking together, rebounding, or breaking apart, that occur under different conditions. When they encounter a barrier, there also are a set of possible interactions, such as penetrating it, rebounding from it, or sticking to it, under different conditions. These kinds of models are characteristic of diffusion models, chemical mixtures, statistical mechanics, origin-of-life models, and DNA replication.

Constraint systems have permeated our understanding of physical systems since Galileo. They are characterized by a set of equations describing the steady state behavior of a system. Constraint systems are regarded as one of the most precise forms in which to state a theory. The epistemic game most associated with this epistemic form is the controlling-variables game developed by Galileo, in which one tries to manipulate one variable at a time while holding other variables constant in order to determine the effect of each independent variable on the dependent variable.

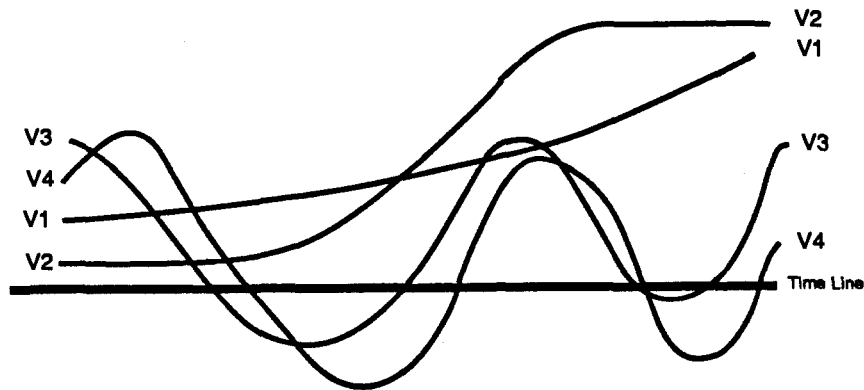
Situation-action models are commonly used to describe behavior in the social sciences (e.g., Newell & Simon, 1972). They are characterized by a set of rules of the form "If in situation x , do y ." The situation can change either because the world changes or because the agent takes an action. Markov models and grammars can be considered as special cases of situation-action models, in which each action takes one into a new state and different actions are possible in each state.

Trend and cyclical analysis is most commonly found in economics and history, but it can be used to analyze any set of variables that change over

time. Figure 7 represents the epistemic form underlying trend and cyclical analysis. A classic example of this kind of analysis is Milankovitch's analysis of how the earth's ice ages depend on cyclic variations of the earth's tilt, the shape of the earth's orbit, and the precession of the orbit (Griffiths & Driscoll, 1982). Looking for gross trends and cycles in events is a fashionable epistemic game in history (e.g., Schlesinger, 1986), but Milankovitch showed how precise predictions can be made from such a model.

In order to illustrate further how epistemic games are played, we developed a set of rules for the trend game and the leading-indicator game, which are associated with trend and cyclical analysis. The rules for the trend game follow:

1. Plot the variable of interest over time.
2. Is it linear, exponential, cyclical, growth, or other?
3. If it is linear, extrapolate it.
4. If it is exponential, plot it on log paper and extrapolate it.
5. If it is cyclical, determine its range and length of cycle(s) and extrapolate it.
6. If it is a growth function, estimate the asymptote on logical grounds and extrapolate the function to approach the asymptote.
7. If some other function appears to be involved, see if there are any regularities that can be used to extrapolate it.
8. Compare the extrapolation with actual values of the parameter over time, and revise the extrapolation if necessary.



- Variable 1 is exponentially increasing (e.g., GNP).
- Variable 2 is a standard growth function (e.g., number of telephones).
- Variables 3 & 4 are cyclical variables (e.g., P/E ratio) and 3 is a leading indicator for 4 (e.g., inflation rate for P/E ratio.)

FIGURE 7 Trend and cyclical analysis.

The goal in the trend game is to be able to predict what will happen to a variable in the future. People who play this game have learned a set of standard functions and what kinds of variables follow what kinds of functions. A common confusion arises between exponential functions, which have no asymptotes, and normal growth functions, which are limited by resources necessary to sustain the growth. There are sometimes inflection points in trends, so that it is necessary to revise the extrapolation if an inflection point occurs.

The rules of the leading-indicator game follow:

1. Identify the dependent variable of interest.
2. Find a candidate indicator (e.g., stock prices \rightarrow production).
3. Is there a correlation with a lag?
4. If the correlation is above threshold, stop. If not, find another candidate indicator.
5. Is there a correlation with a lag for the new indicator?
6. If so, combine the candidate variables. If not, drop the new indicator.
7. Does the combination improve the correlation?
8. If so, keep the combination. If not, keep the best predictor.
9. Recycle to Step 4.

The goal of the leading-indicator game is to find a set of variables that will allow one to predict future changes in a variable of interest. Finding candidate indicators is the most difficult part and usually is based on some hypothesized causal mechanism. It is possible to keep updating the set of leading indicators as circumstances change and other candidate indicators are identified. Milankovitch was playing a version of the leading-indicator game in order to predict future changes in the earth's climate.

Process analyses attempt to characterize the behavior of dynamic systems. The process-analysis games we have identified are diverse and appear to share fewer characteristics than the structural-analysis and functional-analysis games. The groupings of games in this article are advanced as our best hypothesis as to which games share the most constraints.

CONCLUSION

We have briefly described some of the most common epistemic games and the epistemic forms that are associated with them. This is not a complete list, but it does serve to illustrate the potential of the concept of epistemic forms and games. Mastering any of these games gives one a powerful tool for making sense of different phenomena in the world.

By way of summary we list several hypotheses about epistemic forms and games we have formulated in our analysis:

1. Epistemic forms are generative frameworks with slots and constraints on filling those slots. In this respect they are like a grammar that can be expanded to fit the degree of complexity of the phenomena being analyzed. The slots can be cells in a matrix, variables in a model, or types of curves and their parameters.
2. Epistemic forms and games serve to guide inquiry by directing the inquirer as to which slots to fill and which constraints to meet in filling those slots.
3. There are a variety of less complex forms, such as compare and contrast and hierarchical analysis, that are in widespread use.
4. Different disciplines are characterized by the forms and games they use. As disciplines evolve, they develop more complex and more constrained epistemic forms and games. These are sometimes specialized to fit the subject matter being analyzed.
5. Scientific and historical theories often reflect the forms that generated them, but they usually combine a number of different forms in complex interrelationships. For example, chemistry is based in part on a primitive-elements analysis of matter, a cross-product analysis of elements, and an aggregate-behavior model of interaction between elements.

If epistemic forms and games are as powerful as we suggest, it would make sense to teach them to students along with the facts, concepts, methods, and theories we now teach. Like any complex game, however, they cannot be learned in rote fashion. They can only be learned from trying to make sense of different phenomena. There are some attempts to teach basic forms like compare and contrast, cost-benefit analysis, and hierarchical analysis, but they are usually taught in a rather rigid fashion. Generally, the relation of epistemic forms and games to the deeper aspects of inquiry are not understood, and the most powerful forms are only taught at the university level through tacit apprenticeships into different sciences.

This article outlines a prospectus for a theory of epistemic forms and games. We view it as a primitive-elements theory, in which we are trying to identify the primitive forms and games out of which theories in science and history are constructed. Systematic analyses of theories and inquiry strategies in the different disciplines are needed to build a detailed theory of the different epistemic forms and games cited here and to identify other forms and games that sophisticated inquirers use.

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