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Vern S. Poythress

An information-based semiotic analysis of theories concerning theories

Abstract: A model of semiotic theory informed by information theory can be adapted to provide a simple theory concerning theories, and to model changes in theories over time. The model appropriates from tagmemic theory the fundamental features of contrast, variation, and distribution that characterize emic units. It then applies these features to second-order theories about theories. The specification of behavior of emic units at this second-order level puts constraints on the expected form of first-order theories and changes in time to first-order theories. A key feature in the constraint on first-order theories is the feature of symmetry. Second-order theory leads to an expectation that shifts in perspective in first-order theories can take three forms: (1) contrastive shifts, due to adding or subtracting emic units; (2) variational shifts, due to changes in probability estimates for co-occurrence; and (3) distributional shifts, due to global change in the system of units. The model for second-order theory is applied specifically to phonology, music, and Newton's laws of motion (treated as a semiotic system).

Keywords: semiotics; information theory; theories concerning theories; tagmemics; second-order theory; symmetry

Vern S. Poythress: Westminster Theological Seminary. E-mail: vpoythress@wts.edu

Theories concerning theories can receive a semiotic analysis.

Human beings have the remarkable ability to transcend the immediacy of a situation. They can stand back and consider what they have done. If they have produced a theory, they can stand back and theorize about the theory. It gets complicated. But without denying the complexity, we can propose simple models that capture at least some elementary aspects of multilevel theorizing.

1 A simple theoretical model of a semiotic system

To do so, we will use the information-theoretic model of semiotics developed in an earlier article (Poythress 2013). According to this model, a simple semiotic system involving two communicators A and B can be expected to maximize the mutual information I(A;B) involving communicative elements A_1, A_2, A_3, . . . , A_n, and B_1, B_2, . . . , B_m. To be precise, the symbols A_i and B_j are theoretical symbols within the semiotic theory for designating the vocabulary a_1, a_2, . . . , b_1, b_2, . . . , which is actually used by the communicators A and B, respectively. The "vocabulary" may be words, letters, phonemes or other signs, depending on the system under study. (Technically, I(A;B) is represented mathematically using the probabilities associated with random variables Q(A_i) and Q(B_j), where Q(A_i) = 1 if the unit a_i [designated by A_i] occurs at the time in question and Q(A_i) = 0 if it does not occur. For simplicity in notation, the probability p(Q(A_i) = 1) that the unit a_i occurs will be abbreviated p(A_i).) Because of the mathematical properties of I(A;B), the requirements that I(A;B) be maximized implies that the elements A_i and B_j will show contrast, variation, and distribution, which are classic features of emic elements in a semiotic system, according to Kenneth Pike's tagmemic analysis (Pike 1967: 86–91; Pike and Pike 1977: 2–3; Pike 1982: 42–65; Poythress 1982a: 289–290; Poythress 1982b).

The key term I(A;B) is defined in information theory (Yeung 2002: 14) as

$$\mathrm{I}(A;B) = \Sigma_\mathrm{i}\, \Sigma_\mathrm{j}\, \mathrm{p}(A_i,B_j) \log \mathrm{p}(A_i,B_j)/[\mathrm{p}(A_i)\mathrm{p}(B_j)]$$

where p(A_i) is the probability of vocabulary a_i occurring (at a particular point in transmission) and p(A_i,B_j) is the probability of the joint occurrence of a_i and b_j.

2 A theory of a theory

Suppose now that this model is used as a first-order theory T for describing some fragment of the communication between persons A and B. As human beings who can transcend our environment, we can analyze this first-order theory with a second-order theory. In fact, in the second-order theory we can use the same theoretical apparatus, and the same constraint on maximizing mutual information I(X;Y). But the communicators are now X and Y, who are talking about the first-order theory, which is about communicators A and B. The communicators A and B belong to a kind of zero-order situation. They are communicating, but they are not propounding a theory about their communication. The emic units a_1, a_2, a_3, . . . , b_1, b_2, . . . are used by A and B, and are *analyzed* by X and Y. Communicators X and Y have their own vocabulary x_1, x_2, . . . , x_n, and y_1, y_2, . . . , y_m, a vocabulary that is used emically by X and Y . This vocabulary includes the theoretical symbols A_1, A_2, . . . , B_1, B_2, . . . , for designating the vocabulary a_1, a_2, . . . , b_1, b_2, . . . , which is the one actually used by A and B. It also includes other terms, such as symbols for various probabilities.

In fact, the situation with X and Y is more complicated than a simple one-way communication channel, because X and Y may engage in extended conversation. In practice, their "vocabularies" will overlap. We may simplify and postulate one common vocabulary $x_1, x_2, \ldots, x_n$. This is the part of X's and Y's vocabulary used in the key description of their theory about A and B. This vocabulary must, of course, include the symbols $A_1, A_2, \ldots$, and $B_1, B_2, \ldots$.

Now we apply a second-order theory to the communication between X and Y. According to this theory, their shared vocabulary will have constraints. The second-order theory will summarize the constraints using its own symbols $X_1, X_2, \ldots$, referring to the symbols $x_1, x_2, \ldots$ used by the first-order theory. So the second-order theory implies that all the emic items x_i (when mentioned and analyzed in the second-order theory) will show contrast, variation, and distribution.

The presence of contrast, variation, and distribution can be used to make guesses about probable constraints on the first-order theory T, even if we start out with no knowledge of its exact shape. For instance, the constraint of contrast, obtained from the second-order theory, makes us expect that the first-order theory will have distinguishable elements enabling it to refer to the zero-order communicative situation. These distinguishable elements are $A_1, A_2, \ldots, A_n, B_1, B_2, \ldots$ (as part of the vocabulary used by X and Y). Note that these are names within the theory T, for the emic units within the communicative situation involving A and B. In addition, since T is a theory, it will have within it notation for the probabilities $p(A_i)$, which (from the standpoint of the second-order theory) are contrastive features belonging to the elements A_i.

Next, the distributional properties of emic units X_i imply that they enjoy relations to one another in multidimensional arrays. The simplest relations are binary relations of co-occurrence and non-co-occurrence, which in the first-order theory take the form of joint probabilities $p(A_i, B_j)$.

One possible property of a first-order theory as a whole is that it displays symmetry. The definition of mutual information $I(A;B)$ shows symmetry between A and B. That is, if A and B are interchanged, the formula for $I(B;A)$ is mathematically the same as for $I(A;B)$ (because $p(A_i, B_j) = p(B_j, A_i)$ and the multiplication of $p(A_i)$ and $p(B_j)$ is commutative: $p(A_i)p(B_j) = p(B_j)p(A_i)$). Moreover, $I(A;B)$ is symmetric under any interchange between two elements A_i and A_j. In the second-order theory, the symmetry of the first-order theory is a distributional property. If a distributional property occurs in the second-order theory, we are saying that one dimension of the second-order theory, namely the resulting theoretic constraint $I(A;B)$ within the first-order theory, stays the same when another dimension, namely the dimension of interchanging elements, is varied. The two dimensions are independent, which is a property typical of distributional constraints.

Thus, the distributional property in the second-order theory leads to expect symmetries in the first-order theory.

Second, a first-order theory might be expected to distinguish its model from alternatives that are less well matched. This gradation in possibilities for models is essentially a *variational* property. The ideal model is one of several, but is superior in some respect to the others that are similar to it. This variational property becomes visible in the requirement that I(A;B) should be maximized. Every situation with communicative elements A_i and B_j will show some value or other for I(A_i;B_j). The theory specifies which situation has a variational maximum, among the many theoretically possible similar situations.

Thus, the application of a second-order theoretical analysis to the first-order theory T suggests important constraints on the structure of the theory. These constraints by themselves do not determine the theory completely. But in a situation where a theorist is searching, they help to guide the search.

3 Changing theories

Now suppose we consider how a first-order theory might change over time. At time $t = 1$, the theory has the form of theory #1, which we symbolize as T_1. At a slightly later time $t = 2$, the theory has the form T_2. In our second-order theory, we now analyze these two theories side by side. Theoretically, there might be no change in their content. But from the standpoint of the second-order theory, they are nevertheless distinguishable, because they exist at two distinct times. From the standpoint of the second-order theory, they are *contrastive* to one another.

It is also possible that the two theories might have no relation to one another. But let us suppose that we are studying the evolution of a theory over time. The same person X who held theory T_1 at time $t = 1$ holds theory T_2 at time $t = 2$. The person in question may have completely abandoned theory T_1 in between the two times. But typically we will expect a gradual change. So now, can we produce a second-order theory about the change of first-order theories in time?

We can do so using our information-theoretic semiotic model, which we now apply as a second-order theory to the whole situation including the theory T_1, the theory T_2, and the first-order theorist X who changes from holding one theory at time $t = 1$ to holding the other at time $t = 2$.

In discussing theorist X, we must be careful to distinguish the various levels. Person X is a first-order theorist who is analyzing a zero-level communicative situation involving persons A and B. Persons A and B use communicative units a_1, a_2, . . . , b_1, b_2, ... The communicative units x_1, x_2, . . . are theorist X's emic terms, with which he expounds the theory T_1, which in turn describes in theoretic terms the behavior of the units a_1, a_2, . . . belonging to the zero-level communicative situation. At time $t = 2$, theorist X has a possibly *different* set of emic terms y_1, y_2, . . . for representing the theory T_2.

The second-order theorist, observing X's situation, infers that person X at time $t = 1$ should be able to communicate efficiently (via memory, notes, etc.) with person X at time $t = 2$. After all, he is the same person! Hence, the second-order theorist suggests that we maximize $I(X;Y)$, the mutual information relating the person X at time $t = 1$ to the same person at time $t = 2$. The earlier theory T_1 communicates its content to the other, later theory. By maximizing the value $I(X;Y)$, the second-order theorist induces contrastive, variational, and distributional constraints on the relation of theory T_1 to theory T_2. The simplest solution to this problem – given some third-order constraints on what we deem to be "simple" – is to have $Y_i = X_i$, which implies also the virtual identity in the terms $y_i = x_i$ used by X at the two times. That is, there is no change in the theory.

But theories do change! Why? Between times $t = 1$ and $t = 2$, person X may have received more information about the situation that he is studying. Or he has received a suggestion from a colleague about a better way of conceptualizing his analysis. Or he has got a bright idea from a dream. It does not matter, because all these sources, good or bad, can be treated as extra information. Symbolically speaking, in the second-order theory about X we should think of maximizing not $I(X;Y)$ but $I(X,R;Y)$, where R represents the extra information that person X has received.

The actual situations that we are discussing can be complicated. R can represent all kinds of input, including surprising input. It would be impossible, in most cases, to specify beforehand in the second-order theory all the probabilities $p(X_i,R_j)$ for occurrences of X's and R's together, or Y's and R's together. But we can still infer that there will be contrastive, variational, and distributional constraints on the changes in a theory T_1. Contrastive constraints imply that the Y's in a later theory will capture almost all the contrasts captured by the X's, though perhaps in a reorganized way. (This phenomenon is illustrated by the fact that proponents of a new scientific theory attempt to capture the phenomena already explained by the old theory.) Variational constraints imply that most of the time the new elements Y will represent small variations on the old elements X. Distributional constraints imply that independent subgroupings within the X's will carry over to independent subgroupings in the Y's.

But what about the effect of the key information represented by R? If R is *empirical* information about the communicative situation between A and B, it will usually affect person X's judgment about the values of the probabilities $p(A_i,B_j)$. That is, person X reevaluates his estimate of the probabilities, based on the new information. This reevaluation in many cases leads to only gradational changes in his theory. But it can produce "seismic" shifts, where he adds or drops some emic elements, or when he globally reorganizes them (in which case the elements y_i are not related in a one-to-one fashion to the previous elements x_i). A revolution in science represents one form of a global shift (Kuhn 1970: 111–135).

So at least three forms of change in a theory are possible: (1) gradational change (small adjustments in the probability values $p(A_i,B_j)$), (2) change by adding or subtracting emic units, and (3) change by global reorganization. The three forms of change correlate in an interesting fashion with the three forms of emic constraint: contrastive, variational, and distributional. From the standpoint of second-order theoretical analysis of person X, a gradational change takes the form of a primarily variational shift. The addition or subtraction of an emic unit is primarily a contrastive shift. The global reorganization of emic units is primarily a distributional shift.

(We may be more explicit. (1) In a gradational change, elements x_i from theory T_1 are closely related to new elements y_i from theory T_2. So we will usually have $p(Y_i \mid X_j) \approx 1$, which is the mathematical representation of the variational constraint. (2) When an emic element x_{n+1} is added or subtracted from the total list of emic elements x_i, the difference between having and not having the extra element is clearly contrastive. One or the other is true. The probability of joint occurrence and non-occurrence of the key extra emic units is nearly zero. So $p(Y_{n+1},X_{n+1}) \approx 0$, which represents the contrastive constraint. (3) When the new emic analysis with y's is a "reorganization" of the old analysis with x's, the probabilities of occurrences for Y's and X's will "cut across" one another, so to speak. Many of the values $p(Y_i,X_j)$ will be nonzero, and in some cases there will be nearly a probabilistic independence, $p(Y_i,X_j)/p(X_j) \approx p(Y_i,X_k)/p(X_k) \approx p(Y_i)$. This constraint is a distributional constraint.)

If input from a colleague induces person X to change his theory, this input is not empirical input from the zero-level situation, but input from another theorist. Nevertheless, the effects on theory change may still be categorized in the same three ways.

Thus it has proved useful to distinguish between the first-order theory of person X and the second-order theory that describes semiotic constraints or information-theoretic constraints on the form of X's theory. Moreover, we can consider a theory that describes changes in the views of person X as a second-order theory that describes relationships between X's theories T_1 and T_2. at distinct times $t = 1$ and $t = 2$. The theory T_1 is what we might call a "static" theory. It describes the static form of a semiotic system. By contrast, the second-order theory describing changes in X's viewpoint is a *dynamic* theory. It encompasses not only a static description of the first-order theories T_1 and T_2, but a description of the expected movement leading from one to the other. This second-order theory

U, held by person P, may itself undergo changes in time. It will itself have semiotic constraints, which will then be described in a third-order theory. It is clear that in principle we may repeat the operation any number of times.

4 A semiotic analysis of elementary Newtonian mechanics

Our theory of theory change was developed in the context of ordinary semiotic systems. But it can be applied to scientific theories, since such theories can be viewed as subsystems of language. As an illustration, let us consider elementary Newtonian mechanics, as expressed in Newton's three laws of motion. The central and most significant law is the second law: $F = ma$, which means that force F is mass m times acceleration a.

Newton's laws have features that combine what we have earlier separated out, namely the first-order theory T_1 (and T_2) and the second-order theory U describing the movement in time. Let us see how.

The complete viewpoint that Newton offered includes the capability of giving a static description of the mechanical state of the physical system at a fixed time (say $t = 1$). This static description can be considered as the analog of the first-order semiotic theory T_1. When analyzed semiotically, the static description includes theoretical terms like *force* and *mass*. It also includes specifications of the positions and velocities of each particle at time $t = 1$. *Force* and *mass* and *position* are emic terms. We also have emic relations between them, such as $F = ma$. Together these terms and relations constitute emic units within the Newtonian first-order theory N_1. They refer to physically measurable features in the world at time $t = 1$.

Newton's approach also provides a way for talking about physical *dynamics*, that is, processes that lead from one state to another. The static specifications within a static theory N_1 at time $t = 1$ lead to a different series of specifications N_2 at time $t = 2$. The dynamics are in fact specified by the value of the term a for acceleration, which is a first-order emic unit, but which in the dynamic viewpoint also indicates the change in velocity (another first-order emic unit) per unit of time. Thus a has a key role in the second-order dynamics. The Newtonian theory as a whole is a second-order dynamical theory that specifies the relationships between a whole series of first-order static pictures, N_1, N_2, N_3, ... In fact, since Newtonian mechanics treats time as a continuum, rather than a discrete series 1, 2, 3, . . . , the static pictures form a continuum of first-order theories, integrated by second-order dynamics.

The physical data to which Newton's theory applies are not relations of personal communication, but when they are referred to within the theory, they become emic elements. So a semiotic viewpoint is legitimate.

Now let us observe that a third-order theory about Newton's second-order dynamical theory constrains the form that Newton's theory will take. The constraints, as usual, include contrastive, variational, and distributional constraints. Let us see what the effect is.

Each Newtonian particle contrasts with every other particle. It has contrastive features, which make up its observable properties. In Newtonian mechanics, the contrastive features of point masses are three: mass, position, and velocity. Technically, there are seven values rather than three, because position and velocity must be measured in three directions each. Each particle therefore has associated with it a cluster of emic units. This information about particles is a contrastive constraint that applies to the first-order static theories N_i. But the same constraint also applies to the second-order dynamic theory, which continues to talk about positions and velocities.

Second, there are symmetries to Newtonian mechanics. To the naive observer (ignoring the high velocities explored by the theory of relativity), particle interactions (the dynamics) are independent of rotations in space and translations in space. (A "translation" consists in the adoption of a new origin for the coordinate system; the origin is the starting place from which positions are measured.) The dynamic properties of particle interactions are also independent of translations in time and (for basic mechanics only) changes in the velocity of the origin point for the coordinate system. That is, as Einstein later observed, the mechanics of motion look the same within a moving train as in a stationary train. These symmetries are distributional constraints.

Finally, the positions and velocities of the particles change continuously rather than abruptly over time. That means that the description of emic features of particles at a time $t = 1$ will be close to the emic features at a closely neighboring time $t = 2$. This property of gradual change is similar to a variational constraint. A particle with an emic measurable feature w within the range $c \leq w \leq d$ at time $t = 1$ will probably continue to have the same property at time $t = 2$, provided the difference in times is not too big and the difference between the values c and d is not too small.

Together, these constraints do not determine everything about the nature of Newtonian mechanics, but they restrict the form that it can take. The symmetry constraints on rotation, position, and velocity lead automatically to Newton's first law of motion: a particle will continue to move at constant velocity in a straight line unless it interacts with another particle. To see why, choose a coordinate system (a "train") that is moving with the same velocity as the particle. Then from the vantage point of that coordinate system, the particle is stationary. If there is no interaction with other particles at other locations, any tendency for the particle to start moving in one direction is a preference for that direction. Such a preference violates rotational symmetry. It follows that the particle will remain where it is. So, returning to the coordinate system in which the particle is moving, we see that it will continue to move with the same velocity.

If there is to be any significant interest to the "dynamics" of a particle system at all, it must mean that the velocities of some of the particles change as they interact. Within a small amount of time, the changes are small, according to the variational constraint. Rather than label the times $t = 1$ and $t = 2$, we may introduce a standard unit of measurement like the second. Suppose, then, that the two times are t_1 and t_2. The difference, $t_2 - t_1$, may be a fraction of a second. Let us suppose that particle A, at time t_1, has positions x, y, and z as measured in the three directions of a three-dimensional coordinate system. At time t_2, according to the variational principle, it will have new positions differing only slightly from the original positions. So the new position in the x direction may be written $x + \Delta x$, where Δx is small. The velocity v_x in the x-direction is the quotient of change in distance divided by change in time:

$$v_x = \Delta x/(t_2 - t_1)$$

Write $\Delta t = t_2 - t_1$ to represent the small time difference. Then

$$v_x = \Delta x/\Delta t$$

Students familiar with calculus will recognize that, in the limit of smaller and smaller time intervals, this equation becomes

$$v_x = dx/dt,$$

which is the standard definition of velocity.

We have already observed that the velocity stays constant unless there is particle interaction. So changes in velocity must be correlated with some quantity representing the interaction of particles. By definition, the change in velocity per unit of time is acceleration a:

$$a_x = dv_x/dt$$

If we denote the quantity that is supposed to represent particle interaction by F, and F_x is the pertinent quantity relevant to the x-direction,

F_x is correlated with a_x

It remains to ask, "What *kind* of correlation can we expect?" Suppose that the specific quantity a of acceleration is correlated with a specific quantity F of interaction in the x-direction. Suppose that we multiply the quantity F by two. We have twice the amount of interaction. Instead of having a quantity $2F$ of interaction over a time period of Δt, we can speculate that the symmetry under translations in time might allow us to have F amount of interaction during one time period Δt, and the same amount F again in a *second*, successive time period Δt, for a total of $2F$. The interaction during the two successive time periods may produce effects nearly equivalent to $2F$ worth of interaction during a single time period Δt. If so, the total change in velocity v_x during the two periods will be an amount $a \times \Delta t$ during the first period of Δt and the same amount during the second period, for a total of $2a \times \Delta t$. If, now, the sum of these effects actually takes place during a single time period Δt, the rate of acceleration is $2a$ instead of a. That is to say, the amount of interaction $2F$ is correlated with $2a$. By similar reasoning, kF is correlated with ka, for any multiplicative factor k. Hence F is proportional to a. A constant of proportionality m is necessary in order to adjust from units measuring acceleration a to units measuring interaction F. So

$$F = ma.$$

We can also observe that this result expresses a relation between F and a akin to a distributional constraint. Interchanging the roles of F and a produces a symmetry, in which the only difference is the proportionality constant.

Because particles have contrastive features in three dimensions, x, y, and z, we actually need three equations:

$$F_x = m_x a_x;\ F_y = m_y a_y;\ F_z = m_z a_z,$$

where m_x, m_y, and m_z are the appropriate proportionality constants in the three directions. But by rotational symmetry, the constants must be the same for all three coordinate directions. So

$$m_x = m_y = m_z = m$$

The distinct particles need not be identical in behavior. So the quantity m should be understood as the definition of the *mass* of particle A, the particle whose motion is in focus. The quantity signified by F is defined to be *force* (in the x-, y-, or z-direction).

Arguments about symmetry under translation in time will show that forces F arising from different sources are additive.

So we have covered Newton's first and second laws of motion. The third law of motion says that for every action there is an equal and opposite reaction. That is, the force exerted by particle 1 on particle 2 has the same quantity and opposite direction from the force exerted by particle 2 on particle 1. This condition is obviously a symmetry condition.

We can treat it as an additional symmetry condition if we like. But we can also treat it as closely related to a shift between an embedded theory and a more comprehensive theory, as discussed below. We can look at particle 1 by itself, together with the forces exerted on it. Or we can look at particle 2 by itself, together with the forces exerted on it. Or, in a more comprehensive theory, we can include both particles in the same theory. In this more comprehensive theory, we still examine forces acting on particle 1 alone, or on particle 2 alone. But we can also consider the joint forces acting on particle 1 and particle 2, considered as a larger system. The total force acting on the system will include the force exerted by particle 2 on particle 1 and the force exerted by particle 1 on particle 2. If these two forces are not exactly balanced, the larger system consisting of particle 1 and particle 2 together will experience a net force in one direction. Left alone, the two-particle system will continually accelerate in this direction, which is not what we see in experience and which contradicts our intuitions about rotational symmetry.

5 Addition of masses

We can also infer that if we combine two particles with masses m_1 and m_2, their joint mass, when treated as if it were a single complex particle, should be additive:

$$m_{total} = m_1 + m_2$$

To see this, suppose we adjust the forces on the two particles so that their acceleration is the same:

$$F_1 = m_1 a \text{ and } F_2 = m_2 a$$

If the forces are additive, the total force exerted on the two masses, taken jointly, is $F_1 + F_2$. The mass of the two particles together is then given by

$$F_1 + F_2 = m_{total}\, a.$$

Solving for m_{total} then gives

$$m_{total} = m_1 + m_2,$$

as desired.

Thus, we have been able to account for many of the features of Newton's laws of motion using semiotic constraints. The constraints apply to Newton's theory, which is a second-order theory. The constraints are visible when we analyze Newton's theory from the standpoint of a third-order semiotic theory, which treats physical symmetries as distributional constraints.

6 Perspectives

What is the role of perspectives in theory-making? When we considered the relation of theories at different times, theory T_1 at time 1 and theory T_2 at time 2, in a sense the two theories were two perspectives on data. But the two can clearly be included within a single larger theory, the second-order theory about the evolution of theories over time. In the second-order theory, we use two distinct perspectives, namely a perspective that focuses on time 1 and a second that focuses on time 2. The distinction between the two perspectives arises because of the contrast between time 1 and time 2, which in turn produces a contrast between the theories T_1 and T_2 that reside at those times.

In treating Newton's theory, we appropriately assumed that the difference between two static theories N_1 and N_2 was small, if the static theories belong to neighboring times. Evolution is gradual. But in our general theory of theories, we had to allow for changes of other kinds. Gradual change is predominantly variational change. But there can also be predominantly contrastive changes, by adding or subtracting emic units. And there can be predominantly distributional changes, where a theorist reconfigures the structure of his theory.

In all the cases that we contemplated, the changes in theory were changes in time, in which the theorist lays down one theory and takes up another. But Newton's theory shows that a higher-order theorist can wrap together two lower-order theories. Newton's theory of *dynamics* does not itself change, but accounts for changes in time between the static descriptions N_1 and N_2.

Could we then contemplate a static account of first-order theory differences of a contrastive type? The most obvious instance of this sort of difference occurs when we include a smaller or larger amount of a situation within the scope of our theoretical description. For example, Newtonian mechanics applied to a single particle #1 has emic units that include a mass m_1, coordinates x_1, y_1, and z_1, velocities v_{x1}, v_{y1}, and v_{z1}, and possible external forces F_{x1}, F_{y1}, and F_{z1} acting in the directions of the coordinate axes. Suppose we add a second particle #2. Then we have new emic units: mass m_2, coordinates x_2, y_2, and z_2, velocities v_{x2}, v_{y2}, and v_{z2}, and possible external forces F_{x2}, F_{y2}, and F_{z2}. We may also have a force F_{12} acting between the two particles.

A theory describing the interactions of several particles can be viewed as a composite of the elementary theories dealing with each particle individually. Structurally speaking, this multi-particle theory could be described as a third-order theory that includes all the second order theories dealing with the individual particles one by one. But it is just as easy, for the sake of not unnecessarily multiplying levels of theory, to treat it as a more expansive theory of the second-order. This expansive theory includes not only theoretical emic terms for the coordinates and velocities of particle 1, and emic terms for the coordinates and velocities of particle 2, but a repertory of terms for describing both of these particles at a continuum of distinct times *t*.

This second-order theory contains within it – unavoidably – an ability to use of perspectives. It can have a distinct perspective for each time, focusing on the static information pertaining to that time. It can also have a distinct perspective for each particle, focusing on the static and/or dynamic description of that particle. It can combine perspectives in time and space, by focusing on particle 2 at time $t = 2$. While the relation between two emic units in two static theories $N_{t=1}$, $N_{t=2}$ at distinct times is *variational*, the relation between the emic units in a smaller theory and those in a more encompassing theory (with more emic units) is *contrastive*, because distinct (contrastive) new emic units are added.

Looked at another way, however, the labeled can be exactly reversed. The two static theories $N_{t=1}$ and $N_{t=2}$ belong to two contrastively distinct times, and the theories as wholes have to be contrastively distinguished from one another, even though the individual emic units *within* the two theories show only small variations when we compare them one by one between the two theories. Now consider the relation of a smaller theory to a more encompassing one. The one theory is simultaneous with the other, and if the more encompassing theory is in focus, the smaller, included theory must necessarily be included. The relationship between the theories is variational.

The third kind of theory change, as we observed, is predominantly distributional. Does this distributional relationship have an analog in simultaneously realizable theories? It does. Within Newtonian mechanics, the most obvious form of distributional predominance arises from the fact that a third-order theorist can consider the symmetries related to changes in the basis for measurement.

We have assumed that Newton's laws of motion should not depend on the choice of coordinate system. That is, they should be invariant under translation, according to which any measurement of position x_{new} in the new coordinate system is related to a measurement x_{old} in the old coordinate system by

$$x_{new} = x_{old} + c$$

for some constant *c*.

Each choice of coordinate system offers an alternative *perspective*. All the measurements look different when we shift perspective. However, this multiplicity of perspectives does not produce any change in the actual particles being studied. The change is in the mind of the theorist. And in fact it is customary to include within sophisticated discussions of Newtonian mechanics the possibility of changing coordinate systems. Rather than considering the changes in perspective as part of a third-order theory looking down on Newtonian mechanics, it is convenient simply to include them in Newtonian mechanics as a second-order theory.

With this understanding, we have incorporated into Newtonian mechanics three types of perspectival change: (2) gradational or "variational" changes in perspective, consisting in small changes in the values of emic units; (3) contrastive changes in perspective from smaller to more encompassing theories, by adding more emic units; (4) distributional changes in perspective generated by adopting a new system of coordinates.

7 Perspectives on semiotic theories

Newtonian mechanics is a well-organized, "clean" theory of specific physical systems. Its clean organization helps us to think through cleanly what it means to shift perspectives in various ways. We can now generalize our analysis to perspectives in semiotic systems in general.

We can contemplate changes in perspective on a first-order semiotic theory that would (1) make small changes in the probabilities associated with emic units; (2) make a contrastive change to a more encompassing theory, dealing with a broader range of semiotic phenomena; or (3) make a distributional change by shifting to a new suite of pertinent emic units. The shift between particle, wave, and field views of a semiotic system can be viewed as an instance of this third kind (Pike and Pike 1977: 4–5; Pike 1982: 19–39; Poythress submitted).

8 An illustration of perspectival shifts in analyzing language

We can illustrate the three types of shift by considering a first-order semiotic theory that analyzes English communication between persons *A* and *B* with a focus on the phonological system. In effect, the first-order theory is an analysis of the phonemes of English, which includes a specification of the contrastive, variational, and distributional probability relations between occurrences of any two phonemes.

A perspectival shift in this theory can take three forms. In a variational shift, the probabilities of co-occurrence are adjusted. This adjustment on the part of the theorist could take place because he has received more information about the communication process. Or it could take place because he applies the same theory to a new communication situation: communicators *A* and *B* at some other time; or communicators *C* and *D* at the same or another time. We can contemplate under this heading dialect differences in pronunciation, which would affect the phonetic realization of phonemes. Or dialect differences could produce a fusion of two phonemes in one dialect into a single phoneme in a second dialect.

We can also contemplate a perspectival shift where we include a broader sweep of information in our analysis. For example, we may contemplate an analysis of words used in communication, words displaying not only phonological features but also grammatical and semantic features. Our suite of emic units for the analysis would have to be expanded. This expansion would be a case of a variational kind of shift of perspective.

Finally, we can contemplate a perspectival shift where we choose a different basis system of units. Instead of looking at phonemes as static units in a particle perspective, we look at communication as wave processes, where transitions and not merely endpoints are in focus. Or we look at the system of English phonemes not as distinct units but as points in a multi-dimensional array of phonological features composing a phonological chart (voicing, point of articulation, manner of articulation).

The shift from emic to etic analysis of a phonological system can be viewed as another instance of predominantly distributional change in perspective. Emic units of phonology constitute a suite of units, used by cultural participants. They are *used* by participants, but rigorously labeled, classified, and analyzed by the first-order semiotician. Etic units, by contrast, are units developed by the first-order theorist, from outside the experience of native participants. These etic units, however, are emic from the standpoint of a second-order analysis of the first-order theory: the units function as integral elements of the theory. Hence, from the standpoint of second-order theory, the switch from first-order emic to first-order etic units is a perspectival switch between two emic sets.

9 Perspectival shifts in analyzing music

We can find analogous shifts in perspective when we consider the semiotic analysis of music. Variational shifts take place when there are small adjustments in probability estimates. These can take place when the analyst obtains more information, or when he shifts from analyzing one piece of music to another.

Contrastive shifts involve broadening or narrowing the perspective, to encompass more emic units or less. For example, an emic analysis of a piece of music may shift from analyzing an arrangement prepared for solo piano and an arrangement (of the "same" music) for orchestra. The arrangement for orchestra clearly has to include emic units distinguishing the instruments in the orchestra. The suite of emic units being used is enlarged in comparison with the suite needed for analyzing piano.

What about distributional shifts? Such shifts take place if, for example, the analyst shifts from analyzing individual notes to analyzing melodic sequences. In the latter case transitions between neighboring notes are in focus, and a different (wave-oriented) suite of emic units may become appropriate.

10 Conclusion

As usual, the general formulation of an information-oriented theory of theories allows smooth application of our model to a number of diverse semiotic situations. We could extend the applications to still more fields – dance, film, sculpture, architecture. The diversity of applications confirms the universal character of the theory.

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Bionote

Vern S. Poythress (b. 1946) is a professor at Westminster Theological Seminary ⟨vpoythress@wts.edu⟩. His research interests include hermeneutics, mathematical linguistics, and theology. His publications include *The gender-neutral Bible controversy* (2000); *Redeeming science* (2006); *In the beginning was the word: Language – a God-centered approach* (2009); and *Redeeming sociology* (2011).