On Semantic Filters

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I- Preliminary Remarks

• All observable systems are material

• All material systems are the direct products of interactions, energy being the ultimate substrate of all that is observable

• Physical interactions can be taxonomized energetically, resulting in a series of largely autonomous and quasi-independent energetic layers or strata wherein nearly all of the constitutive interactions are confined (Anderson 1972, Schweber 1993)

• However, most systems observed in nature are made up of hierarchies of such strata, evidence of interactions that are not confined to any one stratum, but bridge the gaps between adjacent ones.

Hierarchies therefore are the outcome of two distinct types of interactions: those confined within a given stratum (intralevel), and those binding adjacent strata together (interlevel)

• The principal objective of the scientific enterprise is to understand, and therefore to represent, the interactions by which energy transforms itself to generate the world that we observe.

• The representation of intralevel interactions raises no insurmountable difficulties; they are reasonably well understood and amenable to treatment. Each stratum is normally represented by a symmetry group characteristic of the laws that are specific to the interactions confin-ed within it (Cao & Schweber 1993)

• The representation of interlevel interactions, on the other hand, presents enormous difficulties, and this for two reasons: one is that most interpretations of the language of quantum interactions are not useful; the second is that the languages used to represent intralevel interactions, i.e. the various mechanics previously developed, are totally inadequate for this purpose and lead to paradoxes when extended beyond their energetic domain.

There are several reasons for this, which may be grouped for the present purpose under two chief headings: the bridging of the symmetry breaking gap between adjacent energetic strata, and the observational constraints to which scientific discourse is astrained.

• *Observation* is the outcome of a type of interlevel interaction that is characteristic of cognitive systems. More specifically, an observation is the outcome of a complex set of gap bridging interactions linking the physical substrate of cognitive systems to the mental or conscious one: science is a mental, i.e. conceptual, construct elaborated within constraints grounded in the material substrate.

These preliminary remarks being out of the way, I shall now turn to a brief examination of the structure of the gap bridging interactions, and extend it to a brief outline of the functional structure of cognitive systems in observation. Their significance for the whole scientific enterprise will then be adumbrated.

II- On Interactions

In scientific discourse, interactions are what observations are about. But observations are themselves interactions of a complex and hybrid type. It is therefore desirable to sort these out and to indicate, however briefly, how they combine to yield observations.

II-1 Taxonomy of Interactions

Two well supported propositions are of particular import here: The first is that not all interactions marshall the same energetic resources, so they may be taxonomized energetically. The second is that natural systems are complex hierarchies of progressively less energetic strata, a characteristic related to the nature of the interactions involved in their formation.

These two propositions lead to the conclusion that natural systems result from the cooperative effect of two distinct types of interactions, some of which, called *intralevel*, are confined within a single energetic stratum, while the others, the *interlevel* ones, bind adjacent strata together to form energetically stable hierarchies.

(a) The energetically homogeneous interactions were the first to be observed, and so are the most familiar and the best understood. These include the gravitational and the electromagnetic interactions which account for the concentrations of matter in nature, as well as for much of what follows from it.

One of the most significant characteristics of intralevel interactions is their compliance with the first principle of thermodynamics on the conservation of energy. Consequently, they may be simulated computationally, either digitally or analogically, as may be the case with some neural networks and eventually with quantum computers. The reason being that computational simulation exploits the properties of recursive functions, which can only be projected onto homogeneous energetic contexts, i.e. onto an homogeneous observation space.

There are two ways of representing these interactions: either in terms of events or in terms of their energy structures.

When expressed in terms of events, these interactions yield patterns whose representations are known as *laws of nature*. For example Keppler's laws of planetary motion or Galileo's law of free fall, both of which were originally expressed in terms of data points, (e.g. times, positions[1]). These laws are *specific to* the interactions they represent, meaning that they are independent of those occuring in different energetic milieux.

The laws of nature may in turn be expressed in terms of the energy exchanged in the interactions they represent. If, following the example set by Lorentz, they are represented by some appropriate group, that group will exhibit symmetry properties, some of which are specific to them[2] (Weyl 1931). By way of consequence, it also characterises the energetic stratum in which these interactions are confined.

These *symmetry groups* bear a relation to the laws of nature analogous to that borne to the events by the laws of nature correlating them (Wigner 1967). In what follows, the laws of nature should be thought of as expressed by their respective symmetry groups rather than in terms of events. In this guise, the specific symmetry groups provide any energy stratum with an explicit theoretical criterion of identity, the pendant of the laws of nature that identify it observationally.

(b) However, the energetic autonomy of the strata is far from absolute, as is shown by the existence of natural systems. For example, it should be clear that the laws that represent the various modalities of thought, e.g. the laws of grammar or those that depict the processes of conceptualisation, are largely independent of the laws that govern the neurological events in the brain. But it would be ludicrous to argue that mental processes could occur in the absence of some suitable energetic substrate, a dependence which bespeaks of interactions between the conceptual stratum and the neurological one. So, in addition to the *intralevel* interactions referred to above, there are *interlevel* ones to bind, in however loose a fashion, energetically different strata into a single, energetically stable, natural system.

These interactions exhibit characteristics that differ radically from those discussed earlier. By bridging the energetically inhomogeneous gap between adjacent strata, they violate the principle of conservation of energy, thereby breaking a fundamental geometrical symmetry displayed by all intralevel interactions. One of its implications is that these interactions cannot be simulated computationally, either digitally or analogically. In particular, anticipation, in any computationally related sense, cannot be modelled across the energy gap: emergence is really news!

For related reasons, interlevel interactions cannot be represented by laws of nature, for no observable set of events can span the energy gap between adjacent strata, the observer being, per

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[1] Laws of nature so defined are distinguishable from the laws of science. While the latter are not directly expressible in terms of events, the former remain invariant under theoretical change. For example, the Newtonian law of gravitation has been supplanted by Einstein's, a change that has left Galileo's law of free fall unaffected, it not being a force law, therefore not theory dependent. The same can be said of Keppler's laws of planetary motion (Schempp 1994).

[2] Geometrical symmetries, such as those which characterise conservation principles, are common to the laws that govern intralevel interactions in all energy strata.

force, on the external or emergent stratum. An observation is always internal to the system {observer, observed}; it is an intralevel interaction, and as such is energetically homogeneous.

However, and this is important given the ideological tenor of much of naturalists' talk about evolution, interlevel interactions are not chance events: they are governed by laws that are just as deterministic as any law of nature (the fertilisation of an egg leads to a well determined pattern of changes, ending in the emergence of a living organism of a specified type). Furthermore, these interactions are ubiquitous in our evolutionary universe which began with an explosive birthing event, leaving a historical trace punctuated by the successive emergence of more complex energetic hierarchies.

At the stage in the unfolding of the scientific enterprise where we find ourselves, it should be apparent that the representation of these interactions has become the single most important problem in the search for an understanding of our evolutionary universe.

II-2 Representing Gap-Bridging Interactions

(A) GROUP TRANSFORMS

Since gap bridging laws do not represent patterns of either energetically heterogeneous events or of interstitial ones, for the reason that neither exists, they can only relate the patterns formed by energetically homogeneous events in individual strata. More specifically, they will correlate the laws, energetically expressed, that are causally involved in the patterning of events in each stratum.

This is reasonable in view of the fact that energy is the physical substrate common to all strata, since it is energy which is being transformed, not the events which are the traces left by these transformations[3] (Schempp 1997). Therefore, the laws that govern the interactions between adjacent energy strata can be represented by a group transform which links the symmetry group to both sides of the energy gap. More specifically, the group transform can only be performed on the group representing the more energetic level, i.e. the substrate of the natural system, the energetic hierarchisation of nature proceeding from the bottom up. Given the energy asymmetry inherent in this type of interaction, we may call the substrate of the natural system its *causal stratum*, the externally observable one being the *emergent* one.

[3] No one really knows what energy actually is, we only observe its transformations, which are represented by the laws of science, and marked by the eventual traces they leave, which are represented by the laws of nature. Whatever energy is, it is at the very least the dynamical principle of the observable universe.

(B) ENERGETIC STRATIFICATION[4]

This, then, is the natural order in the evolution of the observable universe. It is governed by the progressive extension of the gradient of energy densities that accompanies its expansion, making possible the relative stability of the less energetic emergent levels, such as those which characterise living and cognitive organisms[5]. Energetically speaking, all systems' boundaries, symbolised in what follows as $(\sigma \mid \Sigma)$, are intrinsically asymmetrical in this way. To help visualise this situation, which is fundamental to an understanding of the hierarchisation of natural systems, the energy schema of the causal interactions can be sketched as follows:

The emergence of a system $\mathbf{\Sigma}$ may represented by the following schema (Jantsch 1980):

$$\mathbf{S}(\sigma) \rightarrow (\sigma \mid \Sigma) \begin{array}{l} \nearrow \{\pi_\xi(\Sigma)\} \equiv \Pi(\Sigma) \\ \searrow \{\mathscr{F}_\xi(\Sigma)\} \equiv \mathbf{E}(\Sigma) \end{array}$$

in which:

(a) $\mathbf{S}(\sigma)$ is the dynamical *cycle* internal to $\mathbf{\Sigma}$, with the following properties:

(i) $\mathbf{S}(\sigma)$ is an internally localized cyclical energetic process with a characteristic short time signature relative to its environment $\mathbf{E}(\sigma)$. It consists of relatively strong interactions binding the constituents σ_i of $\mathbf{\Sigma}$, effectively separating the original substrate into two distinct energetic milieux $\mathbf{E}(\sigma)$ and $\mathbf{E}(\Sigma)$. The basic schema of intralevel interactions between the elements σ_i of $\mathbf{\Sigma}$ may be represented thus:

$$\sum_{\substack{\xi \\ j\neq k}} (\pi_\xi(\sigma_j) \otimes \mathscr{F}_\xi(\sigma_k)) \equiv \mathbf{S}(\sigma)$$

as a set of field-charge interactions, though there are alternatives, e.g. field-field interactions.

(ii) The resulting containment of $\mathbf{S}(\sigma)$ is marked by the emergence of a boundary $(\sigma \mid \Sigma)$ separating it from its less energetic surround $\mathbf{E}(\Sigma)$.

(iii) In this sense, $\mathbf{S}(\sigma)$ may be said to be ontologically prior to whatever objectual characteristics $\mathbf{\Sigma}$ sports externally in its environment. It is functionally, i.e. causally, related to their appearance in $\mathbf{E}(\Sigma)$.

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[4] Much of the material in this section is to be found in (Farre 1996).

[5] The expression *system* used here always denotes *energetically complex hierarchies*, not branching hierarchies which are energetically homogeneous and result from the same types of interactions. The former are sometimes referred to as "vertical hierarchies", the others as "horizontal" ones. Whatever the label, it is important to keep this distinction in mind here.

(b) **($\sigma | \Sigma$)**, the *boundary* of **Σ**, exhibits two sets of *endogeneous characteristics*, functional and observational

(i) Functional characteristics:

Energetically asymmetric, **($\sigma | \Sigma$)** differentiates **S(σ)** from **E(Σ)** as two distinct energetic milieux: (α) Qualitatively: energy is transformed as it flows across the boundary and is diffused in the milieu in which it emerges; (β) Quantitatively: energy is not conserved across the boundary. The quantitative difference between the inflow and the outflow of energy is invested internally in the structure of **S(σ)**, and externally in **Σ**'s endogeneous characteristics [Ho 1993].

(ii) Observational characteristics:

(α) **Π(Σ)**: The set of intrinsic properties **{π_ξ(Σ)}** are observationally definable (e.g. charges). They determine the *energetic identity* of **Σ** in **E(Σ)**. These properties are said to be *emergent in E* whenever they are attributable to **Σ** alone: i.e. they are colocalized in **Σ**, and are not distributed over its constituents (e.g. rest mass is an emergent characteristic of electrons, but not of atoms).

(β) **E(Σ)**: A corresponding set of extrinsic saliences that define the environment of **E(Σ)**. Its constituents or fibrations, (e.g. the endogeneous fields), effectively energize the surround of **Σ**: **{$\mathscr{F}_\xi$(Σ)}**.

(γ) **π_ξ(Σ)** and $\mathscr{F}_\xi$**(Σ)** are *conjugate characteristics* for each value of **ξ**: jointly, they are the *observables* that give point to the notion of the emergence of **Σ**. However, until **Σ** interacts with similarly endowed systems, e.g. until it is observed, its conjugate characteristics remain virtual.

Given that (i) all observable systems are material, (ii) the properties of matter are what physics is about, (iii) all known laws of physics are quantal, and (iv) most types of natural systems interact electro-magnetically in processes of observation[6], the causal groupoid characteristic of natural systems is the Heisenberg Nilpotent Lie Group G. The architecture of its transformation is what is to be understood. A paradigmatic case, that of quantum holography, has been detailed by Walter Schempp in a series of remarkable papers and books (Schempp 1986, 1992, 1997).

(C) A PARADIGMATIC CASE OF GROUP TRANSFORM: QUANTUM HOLOGRAPHY

In order to bring out some of the intuitions inherent in the language of physics, let us consider briefly the use of quantum holography in NMRI. In the causal stratum, a complex magnetic stimulation of protonic spins creates a series of concentrically differentiated energetic regions. At the emergent level, bundles of fibers project a picture of various contiguous regions of organs. The patterns they form correspond to those, entirely different, generated in the causal level. The task is

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[6] For an alternative view which I shan't deploy in this paper, cf. for example John Bell (1989): *Against `measurement'* in: 62 Years of Uncertainty (New York: Plenum Press), and the accompanying bibliography.

to represent the process whereby the causal pattern becomes the emergent one in the less energetic stratum.

In general, the task of representing gap bridging interactions rests on a number of facts and assumptions previously mentioned. The following play a significant role:

The model of intralevel interactions exhibit geometric and specific symmetries that characterise a single observation space (Farre 1997). In particular, they satisfy the principle of the conservation of energy. By contrast, the energy gap spanned by interlevel interactions is accompanied by the breaking of specific symmetries, such as some conservation principles, of which that of energy is the most telling (Ho, 1992).

Since energy strata are characterised by their symmetry groups, it is natural to seek to represent the interlevel interactions that bind them together into a hierarchy by the transformation of the causal groupoid. The general schema for these interactions is therefore of the following type:

[Symmetry group of the causal stratum] ------> [Symmetry group of the emergent stratum]
or more simply:

$$[S(CS)] \text{--------}> [S(ES)]$$

Each of the two groups represents the laws characteristic of the intralevel interactions specific to that energetic level, while the arrow symbolises the bridging of the energy gap denoted earlier by $(\sigma \mid \Sigma)$.

The group transform needs to be firmly anchored in each stratum, given that the laws that govern the gap bridging process are deterministic. Further, it must relate the causal patterns to the emergent ones in a way that is theoretically unambiguous.

The satisfaction of these desiderata in a manner that is consistent with the applicable energy constraints is examplified by the phenomenon of *quantum holography*, a part of quantum optics (photonics). More specifically, quantum holography denotes a mathematical procedure, the Kirillov quantisation which, in the neurological context of NMRI, unfolds in three main steps (Schempp 1992, p 282):

(i) The identification of the hologram plane with the three dimensional Heisenberg nilpotent Lie Group G, i,e. divided by its one dimensional center G;

(ii) The holographic transformation, which includes the wave functions before and after the transformation:

$$\psi(t')dt' \otimes \phi(t)dt \vdash H.(\psi,\phi;x,y).dx \wedge dy$$

constrained to the holographic lattices that form the two dimensional arrays of pixels inside the hologram plane. This is the key step in effecting the transform, and its details are to be found in the works of Schempp, especially (Schempp 1992, 1997)

(iii) The identification of the plane of the hologram with a neural plane of local neural networks.

In conclusion, the interactions that bind the different energy levels in a natural hierarchy bridge the gap that separates them. Because different symmetries are specific to each stratum, they are inevitably accompanied by symmetry breaks, a condition which rules out their expression in terms of the events which can only occur within individual strata. Furthermore, as strata are observationally defined in terms of the interactions that take place within their domain, we should expect the gap-bridging causal interactions to show traces in the emergent stratum of the patterns of events in the causal stratum. These traces must be accounted for in terms of the transformation of the causal groupoid (Schempp 1997).

Observation is, as pointed out earlier, an interaction between an observer and what is observed, one that is internal to the system {observer, observed}. Scientific observations, among others, require an intelligent observer, i.e. one endowed with consciousness, though what is observed often dwells in a far more energetic milieu. The apparent lack of energetic homogeneity between the knowing mind and what is observed seems to belie the claim that all observations are intralevel, a situation that demands an explication. What follows is a brief sketch of the functional anatomy of what will be called a *semantic filter*, a natural system within the meaning of the act, whose task is to transform the events resulting from its interaction with the domain it probes into intelligence.

III- The Functional Anatomy of the Semantic Filter[7]

The expression *semantic filter* denotes one aspect of the functional architecture of a specific type of energetically complex natural hierarchies, the *cognitive systems*. Its heart is the *semantic matrix*, i.e. the process by which a context independent conceptual structure is brought to bear on inherently local observations. The difference in scope between the two is mediated by a *syntax* which is, in the case of science, explicitly mathematical [Bochner 1966, Truesdell 1992]. The mediating syntax provides the relational structure which is characteristic of any descriptive language (Wittgenstein 1961). The manner in which theory and observations are thus interfaced is constitutive of the semantic matrix.

More specifically, a *semantic filter* results from the projection of a *semantic matrix* onto some corresponding type of *observation space*, a process which unfolds in two stages:

(1) The semantic matrix includes, on one side the conceptual load which is encoded in the syntactical expression, constitutes its *grammatical dimension*. On the other side, it includes the *semantic dimensions* of the space within which the grammatical structure is to be semantically deployed; these are represented by, for example, phase variables.

Its function is to define a class of possible phenomena, the syntactical expression of which, the *phenomenology*, displays their identifying structure. The phenomenology may thus be regarded as

[7] Part of the material of this section is to be found in Farre 1997

the functional expression of the semantic matrix: the conceptual structure articulated by means of a structure specific instrument, the mathematical syntax.

(2) The second step in the actuation of the semantic filter is the *projection* of the phenomenology onto a corresponding *observation space* wherein the semantic variables find their local values. In the favorable case, the existence of the phenomenon is revealed when the energetic substrate is viewed from the perspective built in the conceptual structure of the phenomenology. The matrix may then be regarded as a specific *information channel discriminator*.

This process can be quite complex, for it requires an observed value s_o to be within the scope of the *measure set* $m_c(s)$ corresponding to a computed value of a semantic variable s_c. The protocol for the determination of the observed values s_o is governed by a number of factors, which include the strategy of observation, itself based on the conceptual perspective specific to the theory, as well as the theory which governs the means of observation themselves[8], etc. A distinctive feature of the filtering process is the embedment of the *discrete data* of observation into the *continuous pattern* represented by the phenomenology, which is conceptual.

Thus construed, the semantic filter effectively defines the *universe of discourse* U_ of the language, which is the domain of *what* the language *is about*, what it describes and what the operational end of the semantic filter is designed to probe. The observations are thus theory laden.

So defined, a semantic filter is a complex hierarchy of different energy strata. At one end, we find *a conceptual or emergent stratum*, and at the operational end, a more energetic *physical or causal stratum*. It is there that intralevel interactions between the operational end of the filter and the energetic substrate of the observational space take place. This is the level where the significant data (the events), are revealed as such against the background of the ambient noise inherent in the *probing* of the energetic substrate.

Alternatively, the function of the semantic filter may be viewed as the extraction of *intelligence* from the probing of the stratum by its operational end, whence the earlier reference to an information channel discriminator. *Information* may then be defined as intelligence plus noise, the noise being the sum of all the intelligence channels effectively blocked out by the structural specificity of the phenomenology inherent in the filter. The semantic filter acts as a selective information channel opened to the flow of raw empirical data originating in the probed energetic substrate of the local context of observation.

Representations being structure specific, the structural characteristics of the phenomenology can be deployed in the structure of the representational expression, provided it is done perspicuously. *Perspicuity* in this context is to be taken both semantically and grammatically. *Semantically*, because of the referential role the phenomenology plays in the language, where its structural characteristics function as the *criterion of identity* for the phenomena it denotes; and

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[8] The theory of the apparatus cannot be at stake in the actual observation. Whether s_o falls within the scope of $m_c(s)$ or not does not call into question the theory of the instrument(s) used, though it may well do so to the *protocol of observation* which guides the implementation of that strategy, and of course it may call into question the theory which yielded s_c in the first place.

grammatically, because its inferential role depends in an essential way on its being woven out of the same conceptual cloth as that of the theoretical model [Duhem 1954, Wittgenstein 1961].

So defined, a case can be made for viewing the semantic filter as the natural, archetypal *interlevel instrument* for the detection of complex energetic hierarchies. It differs from interlevel transactions found in other natural hierarchies in that its emergent stratum is conceptual.

The symbolisation of its operational function is traditionally expressed by a two-level functional relation encompassing the dimensions of the semantic space and their conceptual linkage, e.g.

$$f(x_i)$$

In it, the independent variables x_i denote the events observable in each of the dimensions of the semantic space, and the dependent variable *f(-)* symbolises the conceptual link between them. This link is what makes possible the expression of scientific laws in terms of events [Wigner 1967].

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