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Emergence

The Contravariancy of Anticipatory Systems

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Where does anticipation come from? By definition strong anticipation resides in the anticipatory system itself. If this is so, anticipation is of the nature of the system and forms part of the Universe. Anticipation must therefore reside in nature and arise from relationships in nature. Likewise from no more than its definition, the Universe consists of entities related one to the other. Thus each entity affects every other. Existence is not therefore just a first order effect but needs an inherent higher order formalism to represent such multi-body interdependence. The relationship between any pair of entities depends on every possible path between them. In category theory this is the property of cartesian closure found in the highest structure possible-- the identity natural transformation designated as the '*topos*'. However if every entity is related to every other it follows that the relationship is both ways but not just a simple inverse relationship as appears from the laws of physics. A category C of objects and arrows between the objects will have a dual C^{op} with arrows reversed. The whole universal structure of both-ways relationships will then be represented by the product $C^{op} \times C$. This gives rise to the principle of duality throughout the Universe.

Duality is a common enough concept in mathematics, philosophy and most of the sciences with some renowned examples like the mind-body duality. It also appears in other versions of contrast as between the dynamic and the static and between global and local. To capture the full effect and subtleties of opposing views and relationships a single view of the duality is needed as a process. Duality is not a closed Boolean view. Rather it encapsulates opposite orderings within a single (functorial) concept of variancy. These may be conveniently labelled covariant and contravariant but only relative one to the other and not as absolute descriptions. Systems theory is a case in point where these different views need to be integrated. Thus for anticipatory systems, anticipation is an instantaneous, local static instantiation of a dynamic global feature that looks either forward or back. The natural categories of process as advanced by Whitehead encompass this contravariancy found in reality.

A three-level structure is sufficient to provide complete closure with internal contravariant logic providing a generalisation of negation. Contravariancy across levels provides more sophisticated reversals such as reverse engineering. The ultimate contravariancy is to be found in the universal adjointness between any pair of functors contravariant one to the other to provide both the quantitative and qualitative semantics of intension-extension logic. A topical example may be found in quantum information processing where the simple 'qubit' is now recognised to be a dual package (described as 'discord') containing both covariancy and contravariancy. This Heyting negation sacrifices the principle of *tertium non datur* but recovers associativity in quantum mechanics.

An anticipatory system is but the structured ordering of adjointness between the systems as a whole and every locality within it. Thus in the special case of time, the present is the particular locality of interest as a reductionist self-duality. The past and the present is a contravariant view of the past

from the present while the present access to future states is also a contravariant arrow from the future to the present.