Prolegomena: What Speaks in Favor of an Inquiry into Anticipatory Processes?

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An Ode To Robert Rosen … again and again and again and again

- Prolegomena: a critical or discursive introduction to a book.
- Written in 1979,published in 1985,
  - wasn't published for long time due to bad reviews
  - ran out of print ~25 years later…
- Misunderstood
  - "We are getting tired of guessing what Rosen meant."
  - The variety of understandings associated with the concept requires clarification
- Cited and cited by second sources (~15)
- Presents novel ideas at the time
- Mathematics and biology rarely blend
  - Times have changed:
- Later reviews said this book was "interesting"

Why / Where is it useful

- The need to develop predictive procedures for evaluating the outcome increases.
- Perception processes, in particular those related to seeing, allow for an optimum in brain functioning (“energy saving” feature).
- Understanding *anticipatory systems* is crucial not only for biology, but also anywhere decision making based on planning is involved.
  - Systems which contain predictive models of themselves and their environment, and use these models to control their present activities

Inspired by

- Kant “How can the intuition of the object occur before the experience of the object “
- The need to understand fundamental characteristics of living
- Physical structure’s only requirement is to allow the characteristic behaviors themselves to be manifested
- “relational biology,” a concept originating with Rashevsky (1954) *(helped by Rosen)*
  - Questions and challenges the centuries-old *reductionist*-deterministic foundations of biology

Inspired by

- “(M,R)-Systems” (metabolism,repair) defines *relational* cell *models* that describe organisms
  - a new perspective within which anticipation is only one aspect
  - have an inherent anticipatory aspect, built into their organization
  - derived as a dynamic description of the living cell
  - contrasted to the atomic model inspired by physics which is reactive in nature
  - Also, tried to define replication mechanisms inherent in the organizational features

The basic ideas

- Against excessive specialization, encourages holistic view of the world
- Utilizes:
  - Extremely abstract language of Mathematics
  - Especially category theory
- Science is not the collection of facts or the accumulation of data
- Anticipation, is a very large subject;
  - in fact, a whole new way of looking at the world (Rosen)
  - played a major role in developing a concept Rosen called *complexity*
- No implicit definitions are given!

The Social and The Biological

- *Relational biology* contrasts with analytical approach
- (Rosen) focused on functional aspects, on understanding behaviors
- Parallels between biological processes and social structures

"What would it mean if common models of organization could be demonstrated between social and biological structures?"

- Things appear quite differently to an observer than to those involved

- To be a true mathematical biologist one must be familiar with social organization

The Social and The Biological

- social <-> biological organization
  - expanded to predictive models
- stimulus-reaction explanatory concept could not account for situations in which subjects predict consequences of their own actions
- moreover, for situations in which a course of action is changed not as a result of stimuli, but in accordance with a subject's predictive model

The Social and The Biological

- *Switch;*
  - *FROM reactive behavior* (limited descriptions)
  - *TO anticipatory behavior* (much richer descriptions) (Termed by Rosen)
- Defines properties of logical and mathematical structures.
- Every functional aspect of the model is contained within another functional component (*Impredicativity*)
- Major consideration is given to causality
  - In particular to phenomena that involve purpose or a goal

The Social and The Biological

- “How planning could go wrong”
- A system’s perspective is not bulletproof
  - But “the defect of any part of a sensory mechanism in an organism leads to a particular array of symptoms”
- “Principle of Function Change”: the same structure is capable of simultaneously manifesting a variety of functions
- Need to;
  - Focus on what a model is
  - Define the relation between a biological entity and its model
  - Understanding how an open system (the natural system) and its model (always less open) eventually make predictions possible.

Natural and Formal Complexity

- The distinction between simple systems and organisms
- “relational biology” (Rashevsky) redefined:
  - only after abstracting “away the physics and the chemistry”
  - Understand the organizational features common to all living systems
- Rashevsky used graphs where
  - nodes were “biological functions” and
  - directed edges were “relations of temporal or logical procedure”
- Against reductionist modeling

Natural and Formal Complexity

- Formal systems (i.e., logic and mathematics)
- Defined information as “anything that is or can be the answer to a question”
  - formal logic does not account for the interrogative (“including mathematics”)
- Therefore, information cannot be formally characterized
- He instead used the formalism of implications (If A, then B)
  - If (initial conditions), then (meter reading)?”
  - If (I make certain assumptions), then (what follows?)
    - “analogous to prediction”

Natural and Formal Complexity

"When formal systems are used
to construct images of what is going on in the world, then
interrogations and implications become associated with ideas of causality"

- Complexity is not just complication but a whole new theoretical world
  - with a whole new physics associated with it
- Therefore complexity is not just a technical matter to be handled within the Newtonian paradigm
- Against reductionist modeling

Natural and Formal Complexity

- The dynamics of the measured affects the dynamics of the measuring device.
- Every interpretation is the result of interactions

"The essential difference between reactive and anticipatory systems is that reactive control depends on correction of an existing deviation, while anticipatory control depends on preventions of a predicted deviation"

References

- *Fundamentals of Measurement and Representation in Natural Systems* (*FM*, 1978);
- *Anticipatory Systems. Philosophical, Methodological and Mathematical Foundations* (*AS*, 1985);
- and *Life Itself .A Comprehensive Inquiry into the Nature, Origin, and Fabrication of Life* (*LI*,1991).
regarding
- “Adaptive prediction of environmental changes by microorganisms” (Mitchell et al. 2009);
- “Early-warning signals for critical transitions” (Scheffer et al. 2009)
- “Stimulus Predictability Reduces Responses in Primary Visual Cortex” (Alink et al. 2010)

Thank you for listening

- Questions ???