Autonomy: Functional and Organizational Processes in Cognitive Ontogeny

Implications for a cognitive-behavioral bridge in nonhuman cognitive research

Outline

A. Autonomy: From state, agency, to the self-organized
1. Self-organization
   a. self-maintaining, cohesive, informationally open system
   b. attractor state
2. Semiotics: (syntactic, semantic, pragmatic)
3. System Closure
4. Anticipation, Intelligence and Adaptation
5. Environment & Diversity

I. Research:
1. Functionality
2. Parallels
   a. Psychology
   b. Nonhumans

N. Agency
   1. Chimpanzee social context
   2. Finding Autonomy

Autonomy

- Derived from Greek, *autos* (self) and *nomos* (rule)
  - self-control (*Plato's 'courage', acting rational w/o emotion, passion, impulse*) and independence (*Aristotelian autarchia, or self-sufficiency)*
- 'Agency and Autonomy'—as an agent with motive: to get control over environment and to expand control by developing both a specific repertoire of skills and generalized coping ability (Haworth, 1986).
- "Concept of autonomy is designed to capture the general organizational nature of living systems. [Whereas] a living system is defined as a particular kind of cohesive system—one in which there are dynamical bonds amongst the elements of the system which individuate the system from it's environment. (Christensen, W. *et. Al* 1998). "

Autonomy

- Self-maintaining systems are constituted in the complex processes which are sustained by open cycles of interaction (1998).
  - internal and external processes with the environment
  - system integrity arises from self-generating and self-reinforcing processes
    - Rock- features of cohesive bond are passive, rigidity and localization
    - Cell- features of cohesive bond are active, flexible, and holisitc. Vulnerable to disruption.
- Possess global functional organization—constitutive processes are interrelated
  - Process closure
  - Interaction closure
- Cohesive, but not completely independent from environment
  - Nonlinear interactions—cannot be decomposed as linear sum of system plus environment
  - Far-from-equilibrium dissipative system, i.e., require energy input (1998)

Autonomy: Self-organization

~ Autonomous systems are self-organized, dynamical, state determined systems.

- Self-organization is spontaneous formation of well organized structures, patterns, behaviors, from random initial conditions.
  - Emerges when attractor state is reached
    - Attractor state- dependent on the structural operations of the system (Rocha, 1998)

Eigen and the attractor state

- Eigen— Rubber band affect.
  - Eigenvector is persevered direction of the transformation
  - Eigenvalue is the amount stretched
- What!?! Enter Heinz Von Foerster (1965); coins the ability of an organization to classify the environment as *eigenbehavior* (the preserved direction of the 'stretch' due to change in environment) and the *eigenvalue* (measurability of the 'stretch') as the stable structures maintained in self-organizational operations.
- Francisco Varela redefines *eigenbehavior* "as the behavior of autonomous, cognitive systems, which through the closure of the sensory-motor interactions in their nervous systems, give rise to perceptual regularities as objects (as quoted in: Rocha, 1998)."
- The *eigenvalue* are stable observables maintained by the successive cognitive operations.
- *Eigenvalues* are the attractor of self-organizing processes.

More on Self-organization

~ Self-organizational systems are informationally open — in order to classify interactions with environment, it must be able to change its structure, attractor values, explicitly and implicitly (Christensen, *et.al* 1998)

~ Systems are discrete; can only classify those aspects of its environment/ sensory-motor/ cognitive interaction which result in the maintenance of some internally stable state (or the attractor value) (Rocha,1998).

~ The pressures (to classify interactions) are externally **selected** by the environment.

Evolving Semiotics

- **~What distinguishes a naïve self-reproduction and organization (e.g. crystal formation) from a living organism? Eigenvalue?**
- **Answer: Symbol system for construction demands (a description cast on physical structure)**
  - May evaluate states and semantic relations
  - Or may be a sort of random access memory—similar to the discrete representations of observables in eigenvalues

An Example of the symbol system: Semiotics of DNA

- Symbolic DNA encodes for protein synthesis (coding for ‘action’ to be preformed).
- In addition DNA encodes “symbols standing for contextual, environmental, and measurements [so that] a richer semiotics can be created which may have ‘selective’ advantage in rapidly changing environments, or in complicated, context dependent, developmental processes (1998).”

Type 1: symbols stand for actions to be preformed
Type 2: symbols stand for measurements, context

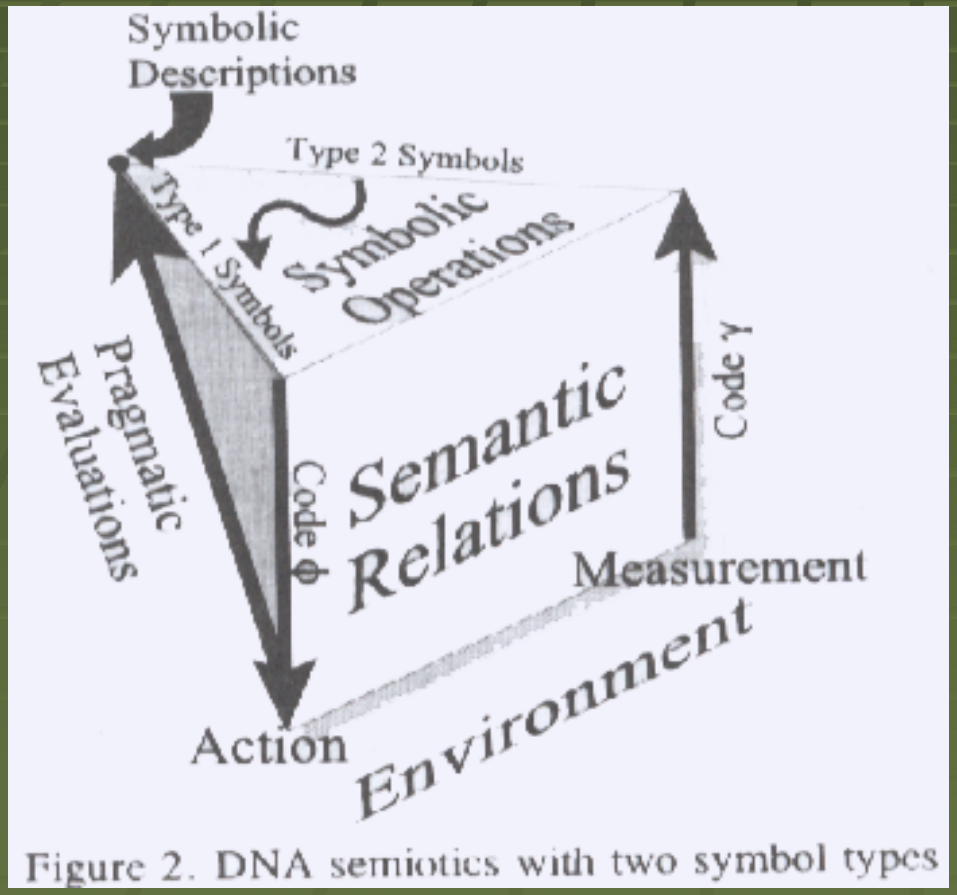

Figure 2. DNA semiotics with two symbol types

- Syntactic- rules based on operations between symbols within the system
- Semantics-relationship between signs and the world external to the sign system
- Pragmatics- evaluation of sign symbol regarding the goals of their user (Rocha, 1998: 340-358)

So…

- **Self-organization** (context specific) and **selection** (action specific) are two indispensable dimensions of an evolutionary system. Pragmatic evaluation, which define an organisms goals and the action (**selection**), is a part of a larger code partially built out of contextual significance. The context significance constrains representational power, defining an organisms ability to construct and discriminate the environment (to **self-organize**) (Rocha, 1998).

The Connection: Autonomy & Self-organization

- Self-organization plays a role in all biological processes (Collier, 1999).
- Self-organization plays an important role in development (more specifically higher-order behavior).
- It increases the individuality of the organism.
- “[Self-organization] may have no necessary affect on autonomy, but if it enhances the capacity for adaptivity, then it is an important part of their autonomy(1999).”

Autonomy: System Closure

- In Varela's *eigenbehavior,* it is through "closure of sensory-motor interactions that perceptual regularities arise."

So, what is closure?

- Closure conditions sustain system autonomy.
  - 1. *Process Closure*–self-generating; state which allows system to retain its cohesion
  - 2. *Interactive Closure*—systems interaction with self and outside
- "The way a process is organized to achieve its closure conditions has an important impact on the systems interaction capacity, affecting its openness, capacity to respond to variation, and capacity to learn (1998)."
- Anticipative closure conditions of autonomous systems play a key role in understanding adaptiveness.

Anticipation as Intelligence

~ Relationship between the present actions and the future action outcome required is the most basic form of anticipation (Christensen & Hook, 1999).

- What distinguishes an intelligent system is the organization enhancement of anticipative modulation, i.e., ability to anticipate.
- If Christensen & Hook (1999) model for intelligence is accurate: "the ability of a system to adaptively direct its interaction processes in complex variable conditions," then anticipation would seem to be the adaptive trait which selects for intelligence.
  - Anticipation: Nonproposition dynamical nature (not necessarily linguistic)
  - May or may not involve memory (instead may be realized through modulatory effects on systems motor/other processes)

Determinants of Anticipation

- Determining anticipation:
  - Width of its anticipatory time window
  - Degree of articulation of the autonomy-related norms which it can use (local context-dependence vs. context-sensitivity)
  - Order of the system and system-environment relationships that it can effectively modulate (Collier & Hook, 1999)

Adaptiveness

- Adaptiveness is bound up with the modes of organization involved in achieving the complex and dynamic global process coherency (Christensen & Hook,1999).
- Meanwhile anticipation may be the mode for which more complex organization and dynamic global coherency is achieved, in turn affecting the overall adaptability of the system.
  - Anticipation modulation builds on the complexity and variation of adaptability
- Autonomy, Anticipation, and Adaptability are integral to understanding complex self-organizing systems. (The Newcastle Group,1999)

Environment: attractor landscape and "task environment"

- Self-organization system must be structurally coupled to some external system.
- The external structure in turn acts on internal structural change.
- The environment supplies constraints on the exercise of autonomy; it fixes opportunity cost to action (Haworth, 1986).
  - Two faces—opportunity and constraints

Environment

- Based on opportunity/constraints, environment may be autonomy-facilitating and or autonomy-inhibiting
- Domain for Autonomy: scale of three paired traits
  - ‘flexibility/inflexibility’
    - The set up, e.g., roles, positions, ranks
  - ‘controllability/uncontrollability’
    - The possibility of changing set up
    - Individual voice in group decision
  - ‘accessibility/inaccessibility’
    - Control and flexibility mean nothing unless there is access
    - Participation as discretionary or forced (e.g., state) (1986; pp.130)

Diversity

- Environmental diversity may be at the genetic, species, or ecological level.
- Environment plays an important role in the regulation of brain, behavior, and physiology.
- Kauffman suggest, “living systems exist in the (ordered) regime near the edge of chaos, and natural selection achieves and sustains such a poised state. (1993, p.232)”
  - Balance between ordered change and effects of single mutation
  - Improvement by natural selection is derived from consuming diversity, and so natural selection is the process of increasing species functionality (Rocha, 1998)

Diversity: various proof

- Returning to the age-old debate, nature vs. nurture, how is it we prove the important impact of diversity?
  - Twin studies (impact on brain-behavior phenotypes; e.g., Sullivan *et al*., 2001)
  - Seclusion studies (Romanian orphanages, e.g., Ellis, B. *et al.,* 2004)
  - Neural changes induced by environmental enrichment (Fahery, C. *et al.,* 2003)
  - Enculturation paradigm in primate research (Bering, J., 2004)

Research: functionality as optimality

- Usually discussion of functionality are based on etiological accounts.
- Etiological account—focus on the external.
- Much of the research on biological organism assumes selective pressures of a trait based on correlations between behavioral observation and environment.
- Optimality of evolution is just assumed, automatically making any selective trait functional (just-so stories).
- “This approach is similar to scientific behaviorism in that it treats the organism as a “black box” and looks only at consequences (Collier,1999).”

But…

"Although selection may ensure the functionality of a trait, it is doubtful that it constitutes the functionality of the trait for at least the reasons that functional traits can be identified accurately without any knowledge of their origins, and secondly, in order to be selected a trait must already be functional, for that is why it is selected (Collier, 1999)."

In the research…

- One strategy is to break down into simpler parts in order to access the complex nature of biologically organized systems.
- Often ‘essential organization’ may be lost in the process.
- E.g. disciplinary psychology

- Furthermore, “not only has disciplinary psychology, through its research practices, consistently put methodological concerns ahead of more substantive concerns about the nature of its subject matter, but it has begun to succeed in replacing subject matter with watered-down, flattened, and highly imperfect clones invented through the practices of psychological research (Martin, J. et al. 2003; pp.32).”

A parallel: nonhuman cognitive research (ToM)

- Inherent complications
  - Nonlinguistic species
    - Reliance on behavioral interpretations
  - Interdisciplinary integration
- Related complications
  - Species-specific and ecologically significance: “consistently put methodological concerns ahead of more substantive concerns about the nature of its subject matter”
    - Theory—adopting a species-specific theory
    - Methodology—applying sound correlations between brain/behavior
    - Task comprehension—inappropriate demands for s-s behavior
  - Research population: “replace subject matter with watered-down, flattened, and highly imperfect clones invented through the practices of psychological research.”
    - Captive
    - Enculturated
    - Wild

“It is possible that when nonhuman primates interact with humans they do not display the abilities that they would show with a conspecific, and thus we are currently underestimating their abilities. It is also possible that the human interaction and training that is required for experimentation creates species-atypical skills in nonhuman primates, and so we are currently overestimating their skills. It is also possible that by focusing on humanlike tasks, we are looking for the wrong thing altogether. (Tomasello & Call, 1997)”

Organization and Function of Autonomy

- Self-organization
  - Mediate relation between environment and organism (via eigenbehavior/value, symbol system)
  - Recursive relationship between external selection and self-organization
- Function
  - Promotes adaptability
  - Anticipatory modulation increases versatility and adaptability
  - Algorithmic function of diversity: a scaffolding of anticipation modulation, adaptation, intelligence, and survival value.

Understanding the Agent: five foundations for understanding strong notion of agency

- Social Ability
- Reactivity
- Pro-activeness
- Emotional core
- Autonomy

  - In behavioral research we define in terms of the interactions between an agent's environment and the motivational qualities of an agent.

Agent 00-chimp: Social context

- A. Social Ability
  - Fusion-Fission nature—the ever-changing (Goodall, 1986)
    - Environmental and demographic factors
    - Monthly and yearly changes (e.g. estrus females)
    - Social factor (role reversals, intrusion, transfers)
  - Surface structure: kind, quality and patterning of relationships (Hinde, 1976)
    - Filial, rank, alliance, agonistic
    - Third party relations
    - Individual histories
  - Dominancy Hierarchy
  - Communication system: calls, gestures, postures, attentional cues, and tactile cues
  - Reciprocity

Agent 00-chimp: Social context

- B. Reactivity
  - Political strategies: coalition, aggression
  - Deception: active concealment, misleading
  - Warning calls
- C. Pro-activeness
  - Intentional communication
  - Deception: intentional misleading, counterdeception (e.g. Rock and Bell; Menzel, 1973)
  - Dominancy displays and agonistic attacks
  - Range patrols and collateral hunting
  - Intentional direction and initiating movement
  - Tool use and tool gathering

Agent 00-chimp: Social context

- D. Emotional Core
  - Facial reactions
  - Social interactions
- E. Autonomy
  - Fusion-fission nature
  - Individual choice in mobility, bonding, coalition, and agonistic behavior

Reduced diversity

- Captive population conditions
  - Reduced group size
  - Reduced range size and conditions
  - Reduced (functional) autonomy
    - Arbitrary group cohesion, relocation, daily transfer
  - Minimal fusion-fission interaction
    - Dynamic third party interactions (recombination)
    - Complex behavior, coalitions, manipulation, deception

Return: Determinants of Anticipation

- Width of anticipatory time window
  - As humans arbitrarily control what would be ‘range behavior’ and group structures, due to extended absences for experimentation, periodic relocation, as well as regimented feeding and repetitious schedules, we may disrupt a natural development of a more dynamic, length oriented time window.
- Local context-dependence vs. context-sensitivity
  - The repetitious schedules and reduction in environmental diversity create for local context-dependence instead of developing more versatile context-sensitivity.
- Order of system and system-environment relationships
  - After removing most natural environmental context for species-specific relationship between system-environment, e.g., threat of survival via food competition, predatory threats, and a normal mate population; individual’s cognitive development may suffer from the less dynamic environment; the relationship between system-environment would suffer as a consequence.

RECAP

- We found that anticipation modulation builds on the complexity and variation of adaptability and self-organization.
- What distinguishes an intelligent system is the organization enhancement of anticipative modulation, i.e., “the ability of a system to adaptively direct its interaction processes in complex variable conditions.”
- Without the ‘complex variability’ there may be no pressure for the enhancement of anticipative modulation, and more specifically the evolvement of higher intelligence.

Impoverished Chimp

- In the domain for autonomy, the captive chimp scale is weighed more towards ‘inflexibility’/ ‘uncontrollability’/ ‘inaccessibility’.
- The natural ecological and contextual diversity is drastically reduced. And thus the material for anticipatory modulation is affected by these environmental constraints.
- How then, shall we perceive the intellectual capacities, species-specific behavioral repertoire, and resultant research on these populations—especially when the focus of research is the very subtle properties which are most affected by a diverse social and ecological environment.