Towards a Biosemiotic Theory of Development

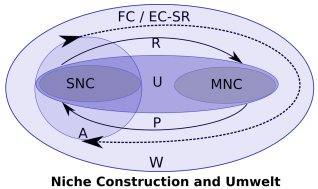
Tiago Rama - Autonomous University of Barcelona - trama.folco@gmail.com

Abstract: My aims are twofold. i) To argue for the integration of Eco-Devo and Biosemiotics on the grounds of signaling systems. ii) To understand on these grounds the musical metaphors proposed by the forerunner of each discipline, K. E. von Baer and J. von Uexküll, respectively. I conclude that this historical link may help us understand core theoretical terms from a signaling viewpoint, such as adaptivity and teleology.

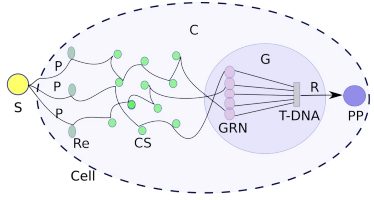
The crossover of Eco-Devo and Biosemiotics

- Both represent a challenge to mainstream neo-Darwinian views of Biology..Eco-Devo [1-2] belongs to a renewed tradition grounded on the idea of "the primacy of development". A proper understanding of evolution must start by addressing inheritance and change in developmental systems. Similarly, biosemioticians [3] understand semiosis as the qualitative difference between living and nonliving beings, a neglected factor in evolution.
- The main criticism concerns the role, functioning, and ontology of genes. Both disciplines reject gene-centrism and advocate a holistic and distributed account of developmental control..
- Both disciplines exploit the notion of *signaling system.*Their core experimental aim is to understand how organic systems respond to signals at different levels of the organism during ontogeny, in order to transcend a reductive viewpoint.
- The core biological processes are the mechanism of *perception and responses* mediated by signals. These constitute functional cycles, as biosemioticians say, or environmental-cue / response-systems, in Eco-Devo idiom [2].

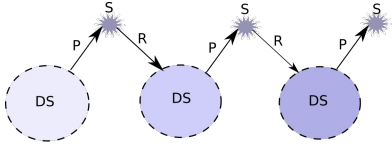
Core developmental phenomena involving signals



Niche Construction and Umwelt
Perceptual processes (P) of certain aspects of the world (W) construct the semantic niche (SNC) of the agent (A), while its responses (R) construct the material niche (MNC). The P-R loops constitute a sensorimotor functional cycle (FC) or an environmental-cue / system response (EC-SR). The functional cycle builds the Umwelt (U) of the organism as a "bubble" compounding the subjective experience and those things experienced.



Epigenetic regulation of gene expression
Extracellular signals (S) perceived (P) in the cell by receptor (Re) initiate a cascade of signaling (CS) through the cytoplasm (C) activating the gene regulatory network (GRN) within the genome (G). The expression of the target DNA (T-DNA) is regulated by the GRN responding (R) by producing a specific protein product (PP).

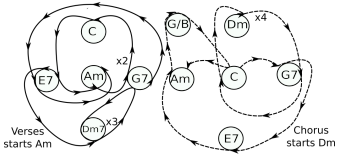


Semtiotic Scaffoldig
Development is scaffolded by signals. The Developmental system (Ds) perceives (P) a signal (S) and responds (R) to it.

Musical metaphors as signaling: a link with the founders

Von Baer, one of the founders of contemporary developmental biology, and von Uexküll, a central reference for biosemiotics have common propensity: musical metaphors. My **thesis** is that musical metaphors aim to describe those biological phenomena that nowadays are understood by involving signaling systems. This idea comes from:

1. The presence of musical metaphors serves the purpose of speaking about the complex coordinations of parts within an organism and with the environment, and the *time*-dependence of this process.In both cases, the temporal and spatial dimensions have harmony: the suitable and admirable connections of living beings with their conditions of life. Such harmony is achieved by signaling systems: they build the organic structure in a holistic way and throughout each step in development -not all specificity is initially latent in the germ cell.
2. There are plenty of connections between the current view on developing organisms and music. Some of them are described in the picture on the right. As in the other drawings (following [4]), I represent the web of relations using vectors.
3. The main theoretical targets behind musical metaphors are the adaptiveness and directedness of development (cf. next).



***Volver a los 17* -Violeta Parra, by Mercedes Sosa**

Some connections with Biology

-Functional cycles - cycles of harmonic sequences ending in tone chord (Am). verses and chorus.

-Scaffolding chords -chords playing the function of moving on the harmony: Am-*G7*-C, Am-*G/B*-C.

-Harmony "at the edge of chaos"
(i) harmonic resolutions: G7-E7-Am
(ii) The song suggests a movement from the tone in Am to C. This is reinforced in the chorus by starting in a mayor mode (C at the center) and ending in a minor mode (Am).

-Structural relationships -the song defined by its internal relationships: I-VII-III-V-IV-VII-V-I -verses; IV-VII-III-V-I-VII-III-I -chorus.

Biosemiotics and development: adaptivity, and teleology

Adaptivity, as an emergent property of the organism, elicits responses according to the needs and conditions of the organism through to its perceptual capacities. Contrary to the blindness of genetic change, developmental systems have sightedness: phenotypes are responses to perceived signals. Moreover, signs endow development with directedness: organismal responses are sensitive to its conditions of life and aimed at maintaining its viability conditions. Teleology lies in current context-sensitive organismal responses mediated by signs and informational processes: similar to representationalism in cognitive science's strategy to explain goal-directed behavior. A open issue for further research is to connect a representational-semantic approach to teleology with the von Baerian teleo-mechanistic program: *The highest law of life, which connects all plan in time, has been named 'directedness' by K. E. v. Baer.* [5]

References

[1] Gilbert, S., & Epel, D. (2015). *Ecological Developmental Biology*. Sinauer.

[2] Sultan, S.(2015). *Organism and environment.* OUP.

[3] Emmeche, C., & Kull, K. (2011). *Towards a semiotic biology: Life is the action of signs.* World Scientific

[4] Gilbert, S. & Bard, J. (2014). Formalizing theories of development: A fugue on the orderliness of change. In Minelli, A., & Pradeu, T. (Eds.) *Towards a theory of development*. OUP. 129-143.

[5] von Uexküll, J. (1938) Das Werden der Organismen und die Wunder der Gene. In: Dennert, E. (ed.) *Die Natur-das Wunder des Gottes. M.Warneck,* 135–144.