



**“Scale-Free Communication?” An
investigation of
the communication metaphor in life
sciences**

Wiktor Rorot, PhD project proposal

Agenda

1. Central question of the project
2. Scale-Free Communication hypothesis
3. Project outline
4. Theoretical background of SFC hypothesis
5. Initial predictions

Central question of the project:

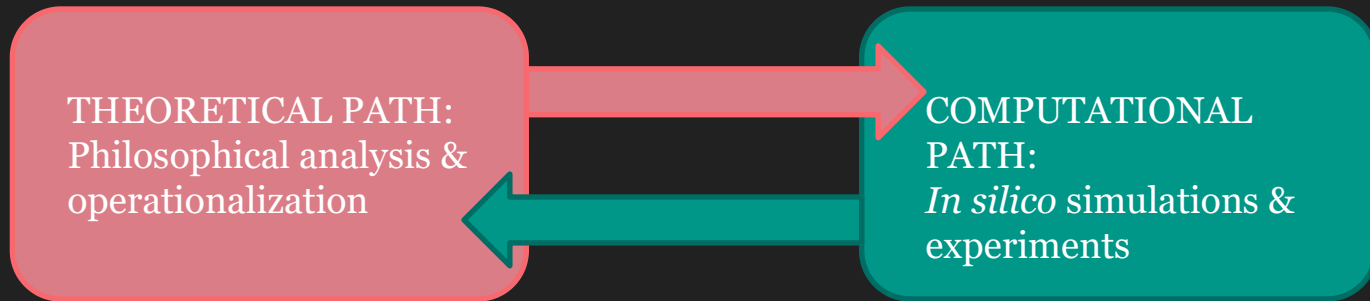
**What is “communication” on
different scales of life?**

Guiding hypothesis:

Communication is scale-free

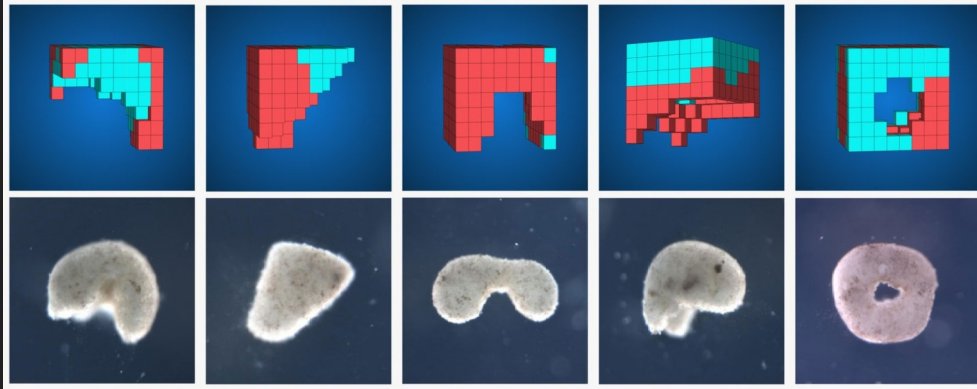
Research questions & project outline

1. How is discrete communication in continuous processes possible?
2. What are the semantics at different scales?
3. How symbolic signification emerges from the non-symbolic?
4. Is Scale-Free Communication computational?

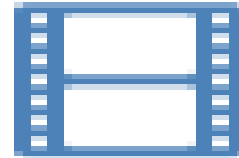


Scale-Free Biology

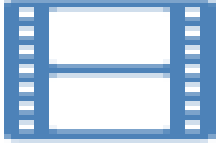
Levin & Fields 2020



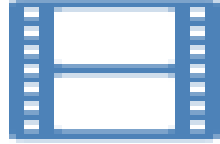
An example:
XENOBOTS

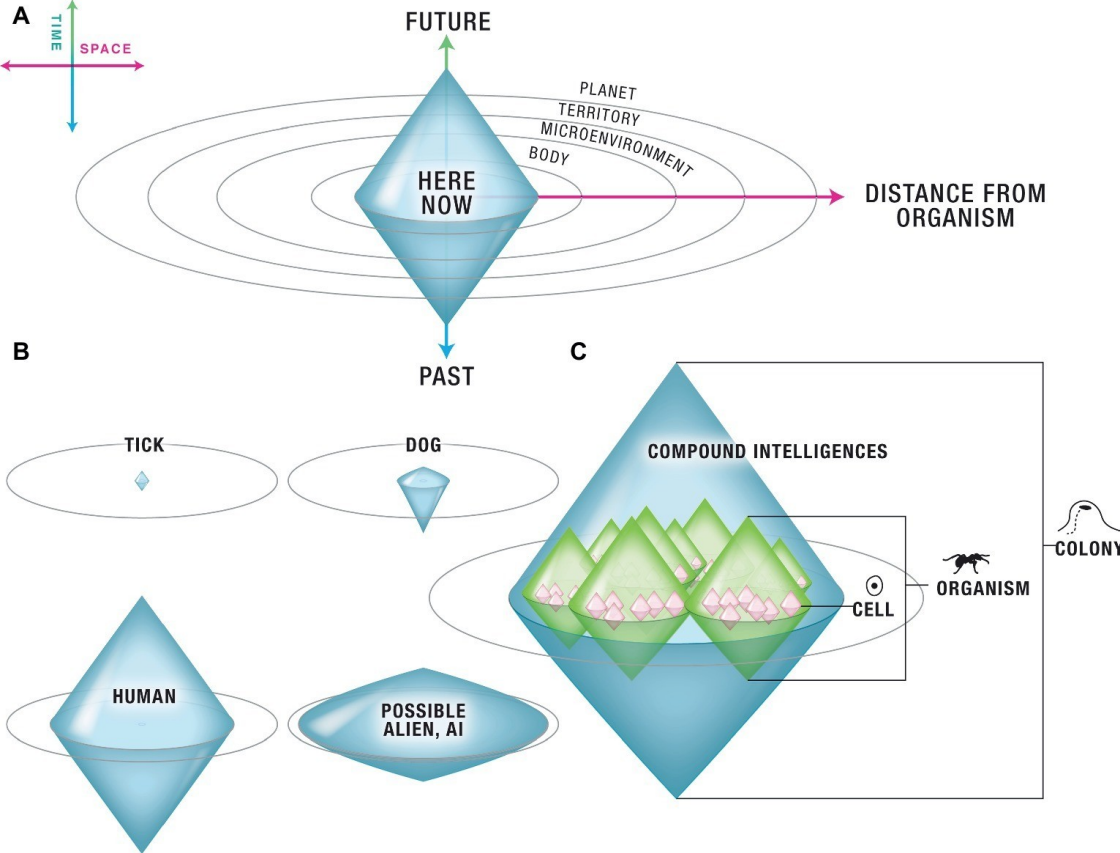


Kriegman et al. 2020



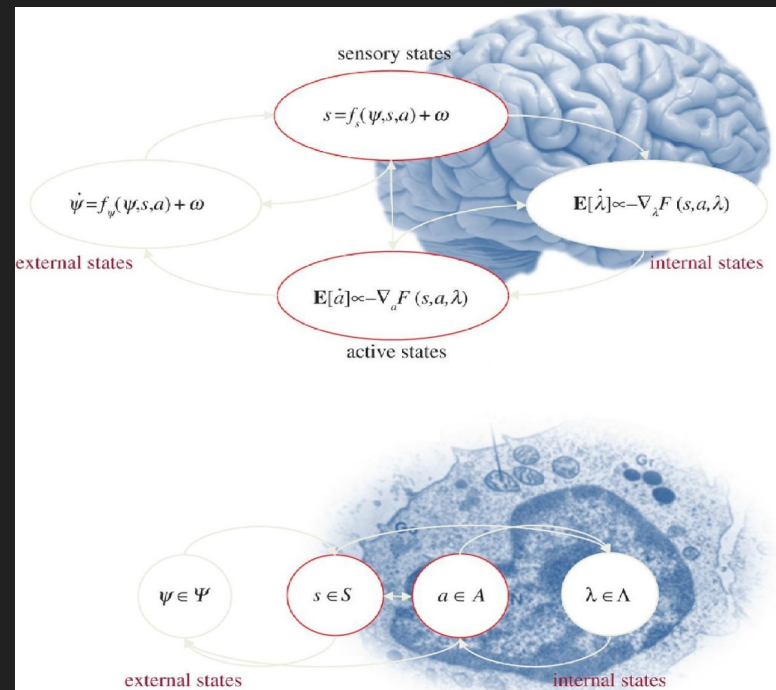
Kriegman et al. 2020





Free-Energy Principle, Active Inference

Friston 2013



Levin 2019

Scale-Free Cognition, computational boundary

1. How is discrete communication in continuous processes possible?

2. What are the semantics at different scales?

4. Is Scale-Free Communication computational?

Information theory & computation

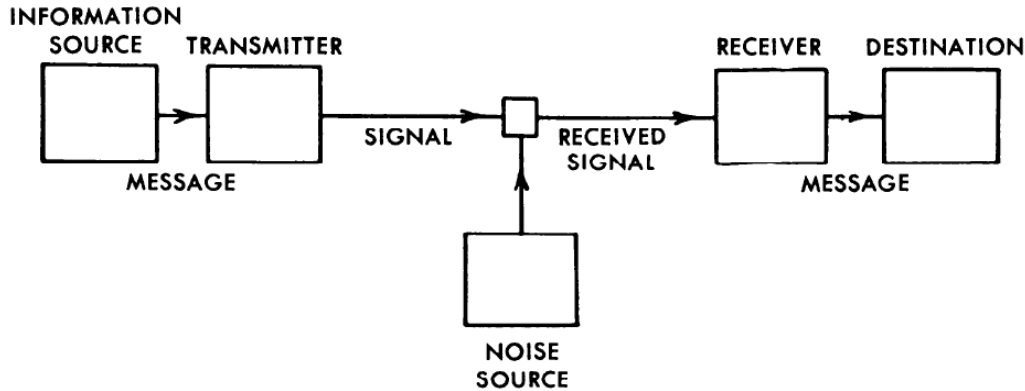


Fig. 1. — Schematic diagram of a general communication system.

Shannon 1948

Isaac 2019:

semantics latent in Shannon information

Kolchinsky & Wolpert 2018:
“the information that a system has that is causally necessary for the system to maintain its own existence”

Dennett 2017:

design worth getting

Information processing & computation: Piccinini vs. Miłkowski

2. What are the semantics at different scales?

3. How symbolic signification emerges from the non-symbolic?

The Symbol (*Un*)Grounding Problem

Harnad 1990: symbol grounding problem

Charles S. Peirce: icons, indexes and symbols



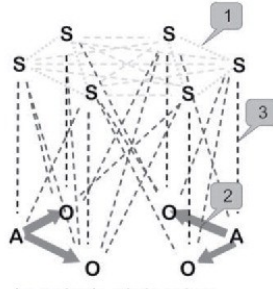
Terrence W. Deacon

H.H. Pattee: symbols as semiotic controls

M. Polanyi

Acquiring symbolic reference stage 1: Sorting possible combinatorial associations

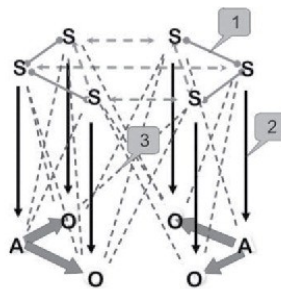
Even for a small set of sign tokens (S), the number of possible sign combinations¹ and their correlations with objects (O) and action A relations² can be immense. Sorting successful from unsuccessful trials taxes working memory but may be aided by training on initially simplified false correlations³



... i.e. reductio ad absurdum

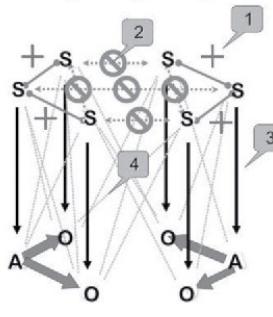
Acquiring symbolic reference stage 2: Discovering associations

Learning to make token-token (S-S) combinations¹ that correlate with successful indication² (and thus acquisition) of an object O via a specific instrumental action A is supported by the memory trace of many past errors.³



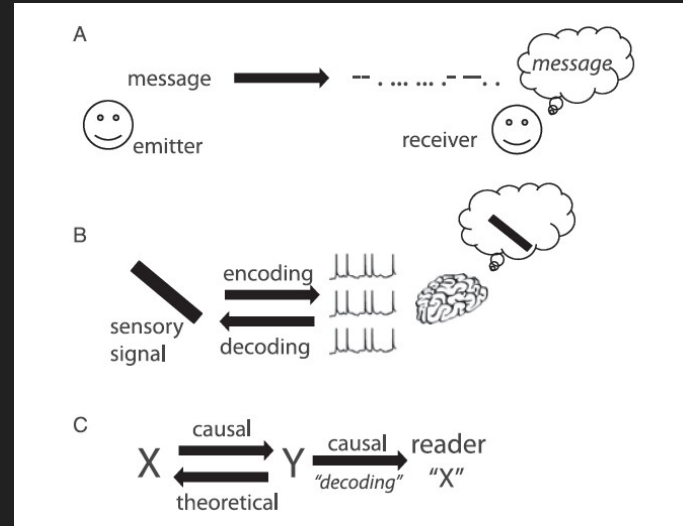
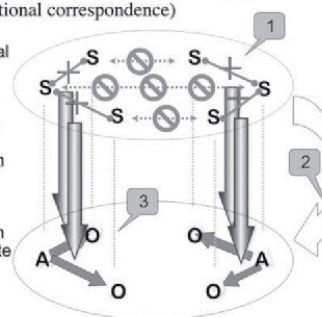
Acquiring symbolic reference stage 3: Regularizing indexical links (correlations)

Learning all patterns of allowed token-token combinations¹ and exclusions² allows the learner to focus on the indexical correlations between tokens and physical consequences³ and allows the non-correlations to be progressively ignored.⁴



Acquiring symbolic reference stage 4: Discovering system-system iconism (relational correspondence)

Full system¹ of logical relationships among symbol tokens becomes the focus. This frees mnemonic load and leads to recognition of iconism² with physical-pragmatic relationships. This enables symbol token relationships to denote objects³ mediated indirectly via this system-system iconism.

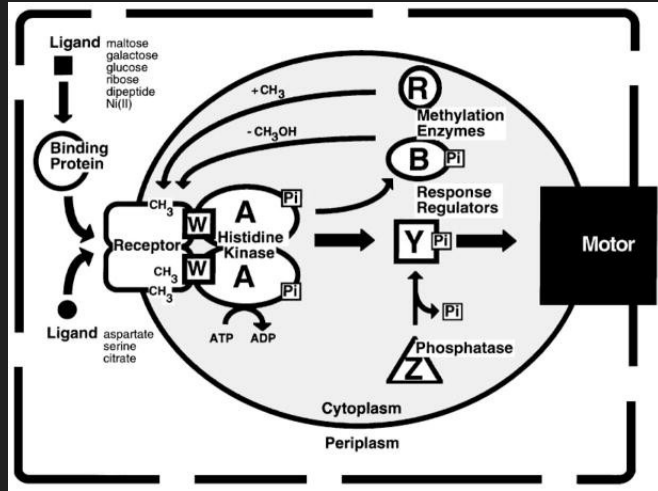


criticism of coding metaphor in neuroscience Brette 2019

Initial predictions

Minimal cognition

(van Duijn et al. 2006; Peter Godfrey-Smith):



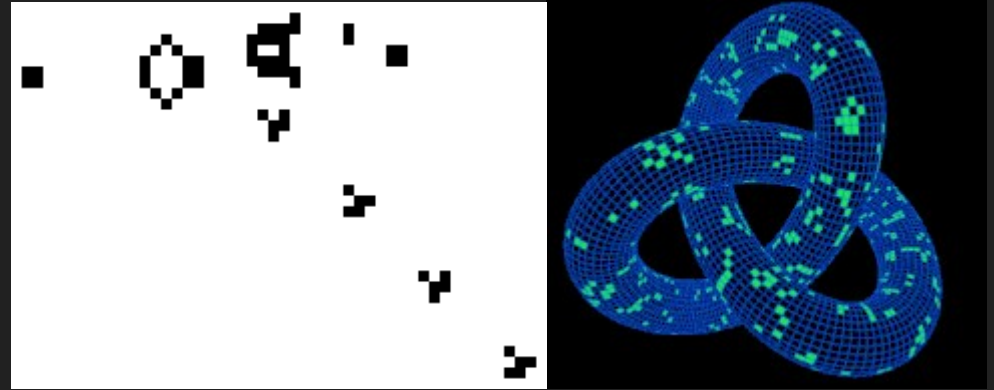
Falke et al. 1997

TCST mechanism of E.Coli bacteria

Information Geometry

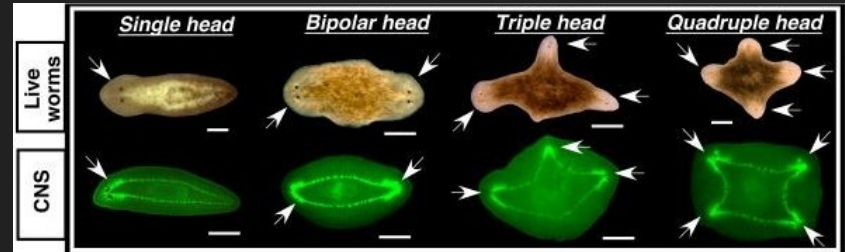
(Amari & Nagaoka 2000; Parr et al. 2020)

Artificial life, cellular automata



Morphogenesis, evolution of multicellularity

(e.g. Levin & Fields 2019; Friston et al. 2015)



Maynard Smith & Szathmary 1995