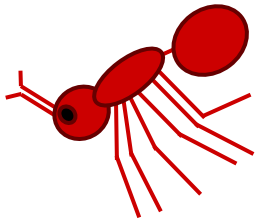
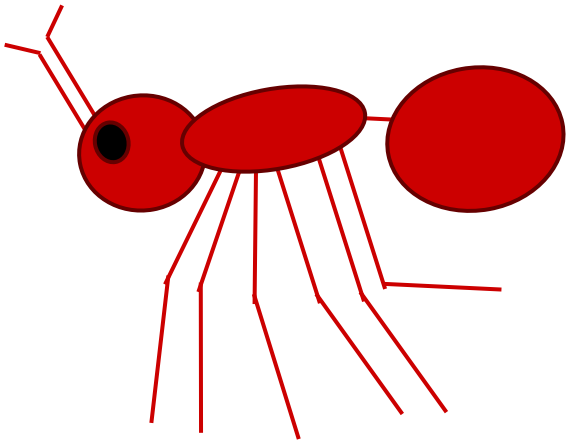
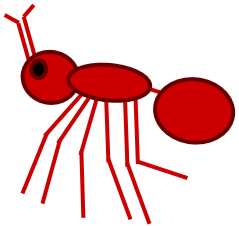
Systems Processes, Active Inference, and Beyond ~







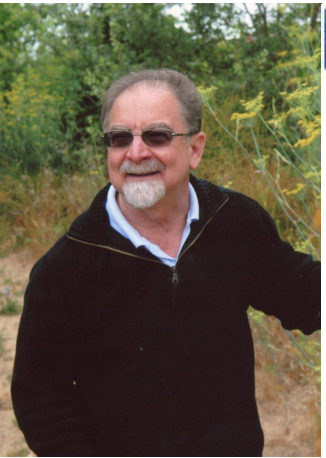
These slides published open source on Zenodo:
10.5281/zenodo.17138224

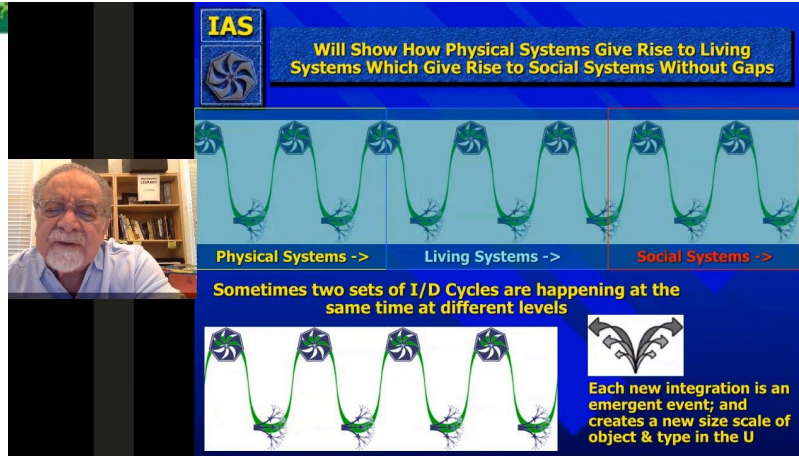
Sept 17, 2025

Daniel Friedman
cognitivesecurity.us/

Outline

- Introduction & Context
- Roads from Systems Processes to Active Inference
- The Warp and Weave of the Meta
- **Discussion**: Towards a fuller Systems Science

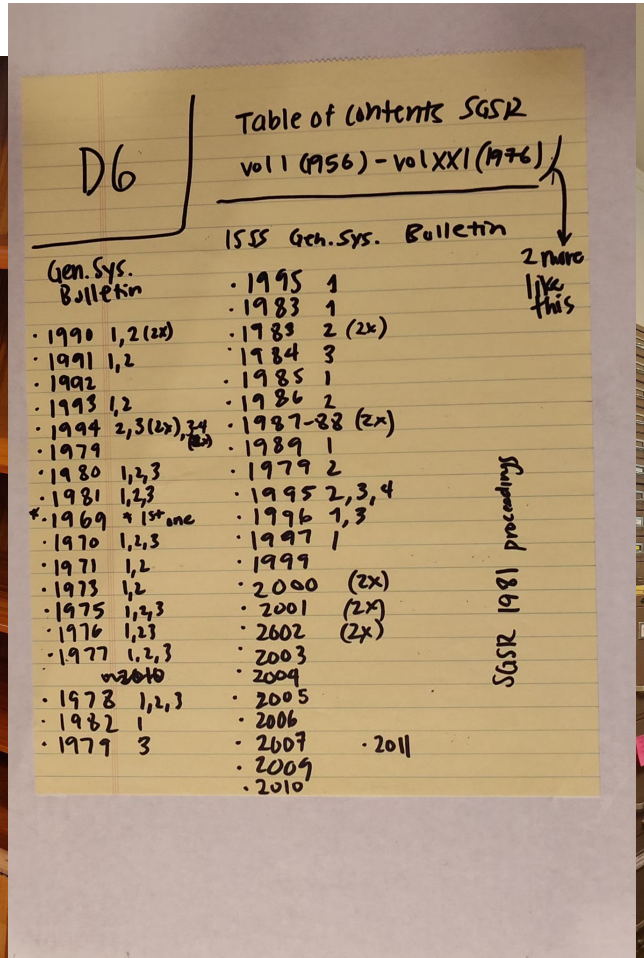




Daniel and Sasha went to Claremont on June 24, 2024, to meet with Luke Friendshuh and pick up some materials from Len Troncale + talk with him.

Currently the 11 boxes (10 boxes of content with lids, 11th box of extra Behavioral journal article are being stored in Crescent City, CA, USA

Link in the ISSS Knowledge Engineering document



Roads to Active Inference

2022 textbook

textbook-group.activeinference.institute

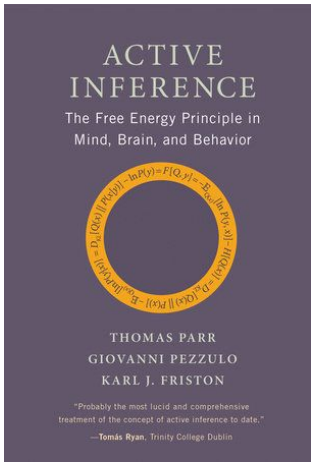
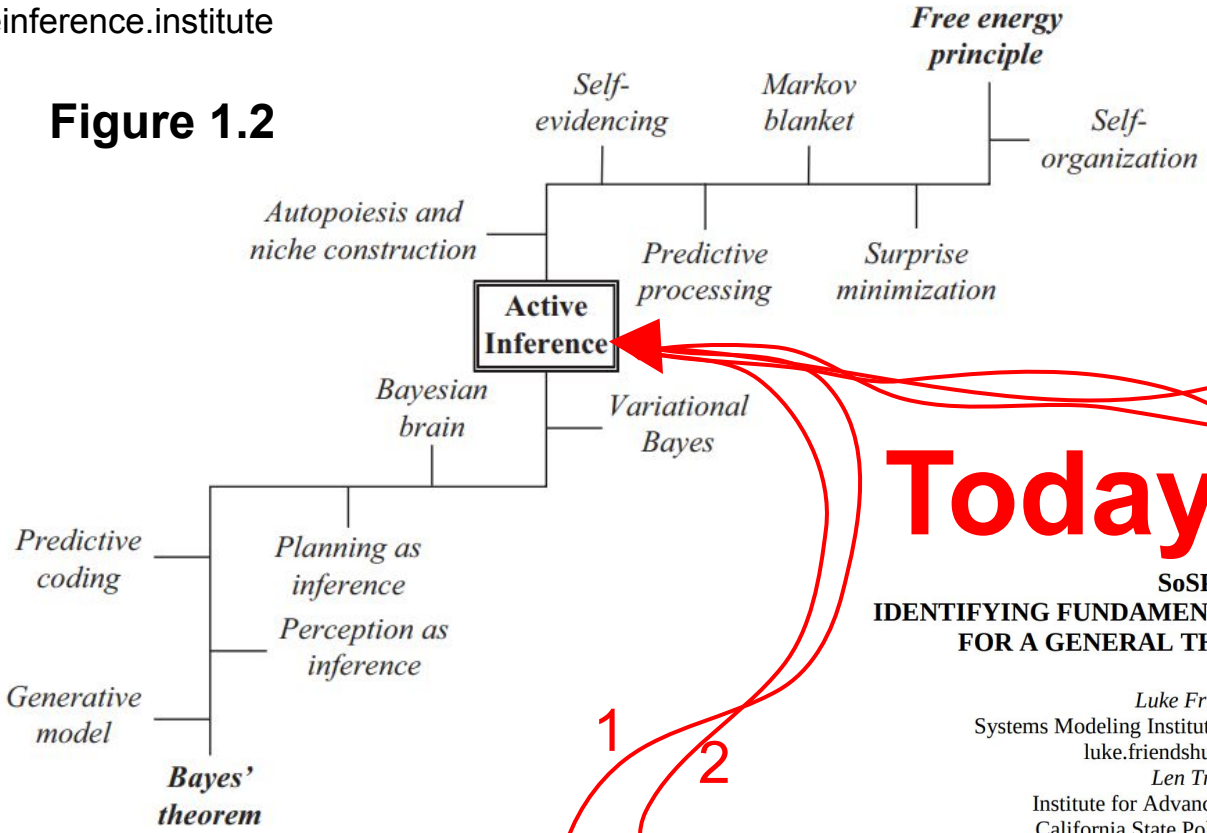


Figure 1.2



Many more resources & get involved!!

welcome.activeinference.institute/

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Today:

SoSPT I.:
IDENTIFYING FUNDAMENTAL SYSTEMS PROCESSES FOR A GENERAL THEORY OF SYSTEMS

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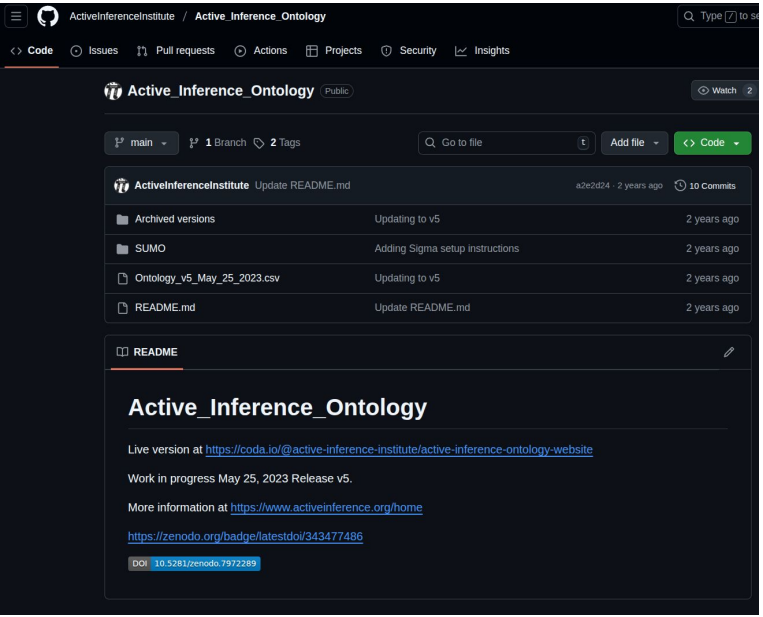
California State Polytechnic University
Pomona, California, lrtroncale@csupomona.edu

Active Inference & Systems Processes



In the SoSPT model, a "systems" process is defined as that series of steps typical of surviving systems that adequately fulfills a needed systems function when considered at the abstract systems level

SoSPT I.:
IDENTIFYING FUNDAMENTAL SYSTEMS PROCESSES FOR A GENERAL THEORY OF SYSTEMS

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What do we get with applied Active Inference? Yes, and…

Computable, Typable, Translations, Open Source education and software, first principles…

Аа	Бб	Вв	Гг	Дд	Ее	Ёё	Жж	Зз	Ии	Йй
a	b	v	g	d	e/ye	ë/yë	ž/zh	z	i	j/ĭ/y
[a]	[b]	[v]	[g]	[d]	[je/e]	[jo/o]	[ʒ]	[z]	[i]	[j]
Кк	**Лл**	**Мм**	**Нн**	**Оо**	**Пп**	**Рр**	**Сс**	**Тт**	**Уу**	**Фф**
k	l	m	n	o	p	r	s	t	u	f
[k]	[l]	[m]	[n]	[o]	[p]	[r]	[s]	[t]	[u]	[f]
Хх	**Цц**	**Чч**	**Шш**	**Щщ**	**Ъъ**	**Ыы**	**ь**	**Ээ**	**Юю**	**Яя**
kh/h/x	c/ts/tc	č/ch	š/sh	šč/shch	''	y	'	é/e/eh	ju/yu/iu	ja/ya/ia
[x]	[ts]	[tʲ]	[ʃ]	[ʃʲtʲ/ʃʲʃʲ]	-	[ɨ]	[ʲ]	[ɛ]	[juᴶu]	[jaᴶa]

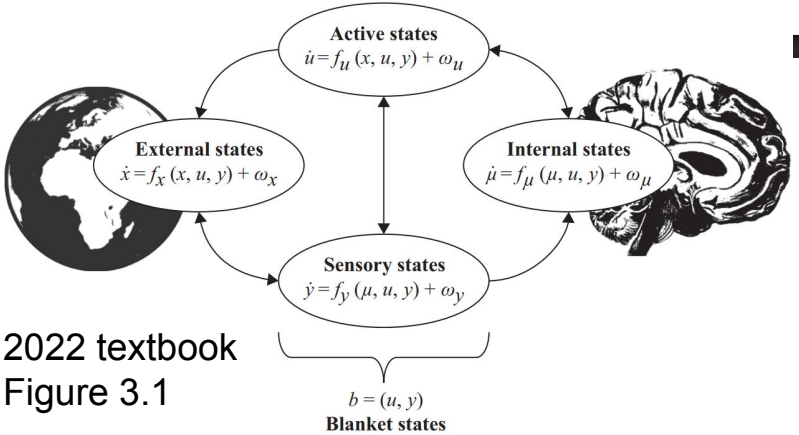
- Same words, same meaning
- Different words, same meaning
- Same words, different meaning

https://github.com/ActiveInferenceInstitute/Active_Inference_Ontology

1 Boundaries ⇆ Markov Blankets

Free Energy Principle formalises the idea of Boundaries through Markov blankets—statistical partitions of internal, sensory and active states that mediate all exchanges with the outside world

- 2024: Structured Active Inference https://arxiv.org/abs/2406.07577
- 2019: A free energy principle for a particular physics https://arxiv.org/abs/1906.10184



2022 textbook Figure 3.1

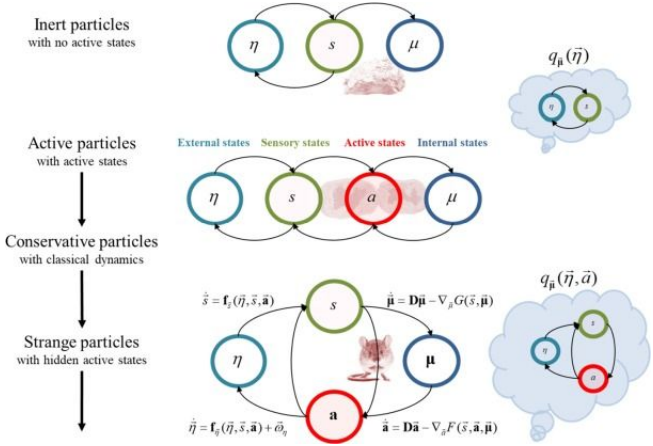
limit, connect, interact, action within/across… formation, change, un-form, sediment….

Boundaries: Boundaries limit the interaction between systems or between a system and it's environment. Boundaries are more like a structure than a process, but in SoSPT, we look to the processes that create the boundaries. Boundaries are found in almost all systems. Examples include cell membranes, atomic structures and corporations. In SoSPT we do not regard boundaries as only "delimiting structures" as we include the farthest extent of intense, local "interactions" or the "limit" of interactions for an entity class

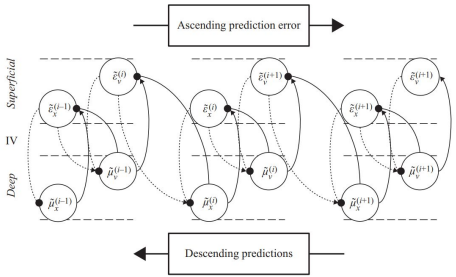
also as "boundaries." In SoSPT the constants and limits found in natural systems are included as "boundaries" as well as the upper limit of size or complexity for each hierarchical scalar level (the Wilson-Troncale Limit). Boundaries serve a variety of functions. They increase stability by "protecting" the system or subsystem from it's environment. It can also encapsulate complexity so the number of possible interactions between systems or subsystems is limited. (Salthe, 1985, p 156) Questions yet to be answered include, "What are the processes that cause boundaries?" and "Are these processes the same across systems?" During our review of the original SoSPT process list, we decided to group transducer processes with boundaries because they are boundary-based and act across boundaries. Limits and constants were included because they are demonstrated and fundamental final extents of sets of entities or processes.

2 Feedback & Cycles ⇆ Predictive Coding Loops

- 2023 Path integrals, particular kinds, and strange things https://www.sciencedirect.com/science/article/pii/S1571064523001094



2022 textbook Figure 5.2



cycle, return, change, loop, open/closed, wheel-within-wheel
Positive/negative, dampen/augment, (de)stabilize….

Feedback: Feedback was probably the first recognized and first widely accepted isomorph by the Founders of the systems movement. Discussions across the disciplines at the NY-ICP Macy Conferences in Mexico resulted in Weiner's legendary text, "Cybernetics" as early as 1948. In feedback some measure or sensing of the output of a system is compared to a "set point" (established by the environment, context, nature, or humans) prompting interventions sent to the relevant processes of the system to change the output relative to the set point. Feedbacks are characterized as "closed loop" processes with the closure prompting to their "feeding back" action. Initially we listed specific types of feedback, such as positive feedback, negative feedback, coupled feedback, feed-forward, 2nd order feedback, etc, as separate processes. We feel each different type of feedback has significantly different effects on systems.. Negative feedback dampens output to accomplish regulation and control. Positive feedback has the opposite effect and results in increase and growth. Coupled combines both tightly, in a non-trivial manner, by impacting the same or linked system mechanisms to achieve alternating increase and decrease in relevant output resulting further in an oscillation around the set point. In the interest of reducing the number of systems processes, we have recently compressed all into one. Further, aspects of feedbacks are prerequisites to, and/or Identifying Features for another systems process we list as cycles and cycling. One function of feedback is increasing sustainability of the system by near-term response to its systems context or environment. So there are many Linkage Propositions already known for the different types of feedback and in Linkage Propositions we retain their different names. We hope reducing the list by compressing feedback types will not lose useful specificity.

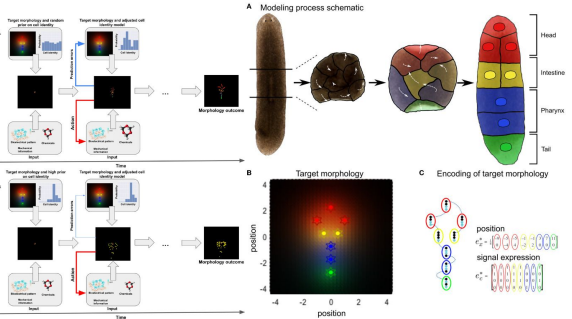
And connection with Min/Max rules!

3 Self-Organization & Autopoiesis

- 2018 Answering Schrödinger's question: A free-energy formulation https://pmc.ncbi.nlm.nih.gov/articles/PMC5857288/
- 2023 Cartography of the multiple formal systems of molecular autopoiesis: from the biology of cognition and enaction to anticipation and active inference
  https://www.sciencedirect.com/science/article/abs/pii/S0303264723001302
  - Framing the multiple formal systems of autopoiesis (FSA) into the Rosen's modeling relation (a process of bringing into equivalence the causality of NS and the inferential rules of FS), allows a classification of FSA into analytical categories, most importantly Turing machine (algorithmic) vs non-Turing machine (non-algorithmic) based, and FSA with a purely reactive mathematical image as cybernetic systems, i.e. feedbacks based, or conversely, as anticipatory systems making active inferences.

Embodied, persistence, reproductive, open-ended, Material organization, sensemaking, mortal, self-recreating, self-reference, Strange Loop…

- 2022 Active inference, morphogenesis, and computational psychiatry
  https://pmc.ncbi.nlm.nih.gov/articles/PMC9731232/



Self-Organization/Autopoiesis/Self-Assembly/Autocatalysis as SysProcesses: As shown in the title, this candidate systems process is a good example of the discinyms cited in SoSPT. Discinyms are "**disci**plinary" syno**nyms,**" that is the naming of the same isomorphic pattern or process by different words because they were discovered in different disciplines in different particular phenomena at different times in history. They are a result of the stovepipe metaphor of investigating reality (reductionism) and the lack of communication between the conventional disciplines. So modern biology uses the term self-organization on the organism level, chemists and biochemists use autocatalysis on the molecular level, physicists generally use self-assembly from the nanoparticle to the chemical levels, and on the philosophical-societal level of humans, general systems theorists coined the term autopoiesis. While proponents of each term might argue for needed discrimination, we choose to group these all together into one "nym" in the minimal list of 55. This teaches us a lesson about the need to recognized, document, and widely publicize discinyms to aid in the cross-field communication that is necessary for any eventual consensus to develop on a science of systems. In one of our papers, we cite several other systems processes that contribute to the process of self-organization and apply it to design of security systems (Troncale, 2011b). This continues as we find not only Linkage Propositions between our candidate systems processes but that several SPs are often the Identifying Features of other SPs. That is why SoSPT considers the whole "System of Systems Processes" to be ITSELF a self-organizing network.

4 Flows and Fields

Fluid, Space-filling, Difference-pursuing, Across, Bridging or Clearing, Downhill, Path of least resistance

- 2022 A Worked Example of the Bayesian Mechanics of Classical Objects
- 2022 Regarding Flows Under the Free Energy Principle https://arxiv.org/abs/2205.07793v2

for ω_t. A quadratic[6] form $\mathcal{L}(\omega_t)$ can naturally be defined on the tangent space to the state space, such that the surprisal is its integral along a given path γ of $\mathcal{L}$:

$$S[\gamma] = \int_0^t \frac{1}{4D}\langle \omega_\tau, \omega_\tau \rangle \, \mathrm{d}\tau \, .$$

The Lagrangian, the integrand of $S[\gamma]$, is a function of noise. The surprisal of a path is then proportional to half its accumulated squared deviation from the expected flow $f(X_t, t)$, normalised by the scaling constant $\sqrt{2D}$. Morally, this is in the same sense as the classical action is proportional to half the square of the accumulated deviation of motion from a potential well [RSH+22, Section 2]. That this action equals[7] the surprisal of a path γ for a given initial condition, $p(x(t) \mid x_0)$, is a simple consequence of the path probability measure being defined as

$$p(x(t) \mid x_0) = \exp\{-\lambda S[\gamma]\} \tag{5}$$

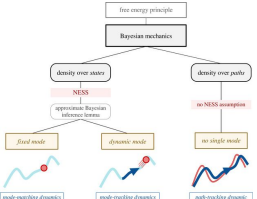
in [Sei12], which is indeed the canonical definition of such an object in any abstract Wiener space

VI. THE TRACKING OF MODES

Mode-tracking can be summarised as the existence of a *target* mode, i.e., a desired mode that systems are tracking towards, either for a finite time or constantly. This allows us to describe the most likely flow of autonomous states as a flow of beliefs [Fri19, PDCF20, AMTB22, RS22], and involves the iteration of approximate Bayesian mechanics [Sak22c]. Within mode-tracking we

Bayesian mechanics leads to various types of approximate Bayesian inference, just like classical mechanics admits different applications of Newton's laws of motion (e.g., the continuum mechanics of fluid flow, or orbital mechanics for satellite motion). As stated, when that parameter is trivial, we have mode-matching; when it is dynamic, this is referred to as mode-tracking [RSH+22]. When

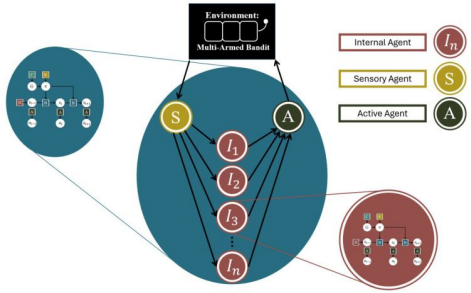
2023 On Bayesian mechanics: a physics of and by beliefs https://royalsocietypublishing.org/doi/10.1098/rsfs.2022.0029



Flow Processes: Flow processes are generally caused by a field or different potentials across a duality. Systems use flow processes for functions such as energy transfer and storage, messaging and movement. (Holland, 1995 p23) Flows are very common processes in many systems. Examples include water flow in ecosystems, plasma flows in stars, data flows in computer systems and cash flow in economic systems. In fact, after some study it appears that flows are essential for many of the other systems processes. Can you have cycles without flows? Can you have feedback at any of its evident scalar levels without flows? Flows as a systems process motivate us to consider placing some of the SP isomorphies as prerequisite for others. This would be a method or ontology that could be used to cluster the 55 SPs to a smaller number of functional clusters as suggested in the original paper.[x]

5 Hierarchies & Networks ⇆ Nested Generative Models

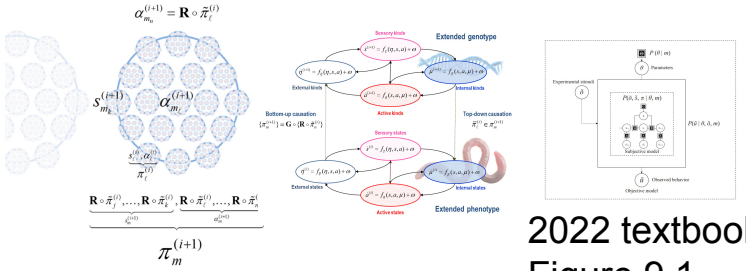
- 2025 As One and Many: Relating Individual and Emergent Group-Level Generative Models in Active Inference https://pubmed.ncbi.nlm.nih.gov/40003140/



Fractals, heterarchy, induction/deduction, abstraction, enclosure, (multi)scale space and time, nested, learning, updating, evolution, structure….

Hierarchy: Many systems are organized into clustered assemblies of subsystems. Often there are several distinct scalar levels of subsystems. Indeed, in SoSPT the entire range of observed natural systems are linked sets of hierarchical levels portrayed in an unbroken series of systems origins. Hierarchies are good examples of SoSPT treatment of what appears to humans as a "structure" found across a wide range of

- 2023 A Variational Synthesis of Evolutionary and Developmental Dynamics https://www.mdpi.com/1099-4300/25/7/964

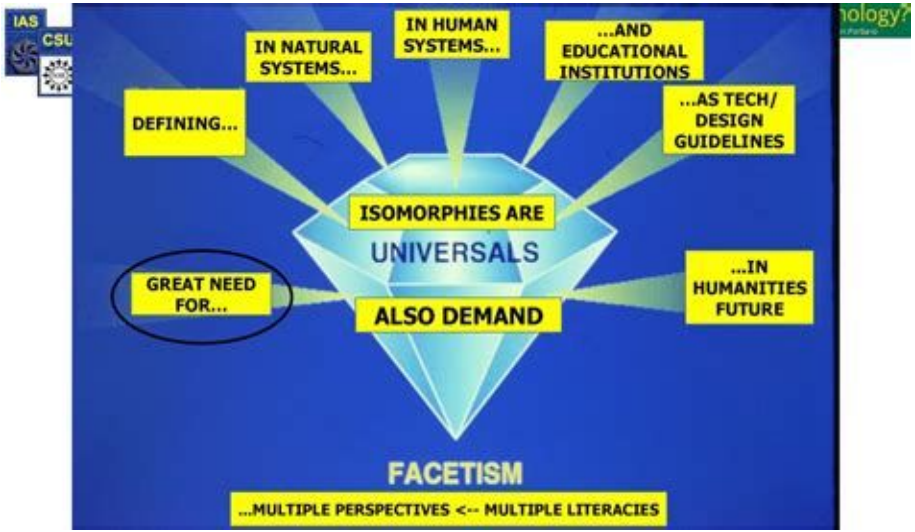


2022 textbook Figure 9.1

systems (structural isomorphies). SoSPT insists that observers go beyond, behind, (or deeper than) the observed structure to "the process that causes the structure." SoSPT regards the process as the key dynamic that interacts through mutual influences with the other systems processes and produces structure. Just as humans find it easiest to first describe rather static structures (in space, in the cell, etc.) and only afterward with much more study do they address dynamics, so also humans recognize systems structure and only later and with greater difficulty, systems processes that cause the structure. In terms of functions, hierarchies enable higher numbers of components and interactions by organizing them in sets of subsystems enabling more complexity than otherwise possible. Also as H.A. Simon pointed out in his famous parable of Hora and Tempus, hierarchies increase stability of assembly of a much more complex entity from sets of simpler assemblies. We have developed many Linkage Propositions of hierarchy with other systems processes.

The Warp and Weave of the Meta

Thank you Len & All



And now, Discussion….