

Understanding by Building:

ALIFE Approaches to Mind, and How We Share Them

Keisuke Suzuki, PhD

Center for Human Nature, Artificial Intelligence, and Neuroscience

Hokkaido University



Keisuke Suzuki, PhD

Biography

1998-2002	Department of Physics, Sophia University, Japan
2002-2007	MSc and PhD in Graduate School of Arts and Sciences, The University of Tokyo, Japan supervised by Prof. Takashi Ikegami
2008-2011	RIKEN Brain Science Institute, Japan
2011-2021	Sackler Centre for Consciousness Science, University of Sussex, UK
2021-	Center for Human Nature, Artificial Intelligence and Neuroscience (CHAIN), Hokkaido University, Japan

Research Area

Artificial Life

Embodied Cognitive Science

Virtual Reality

Computational Phenomenology

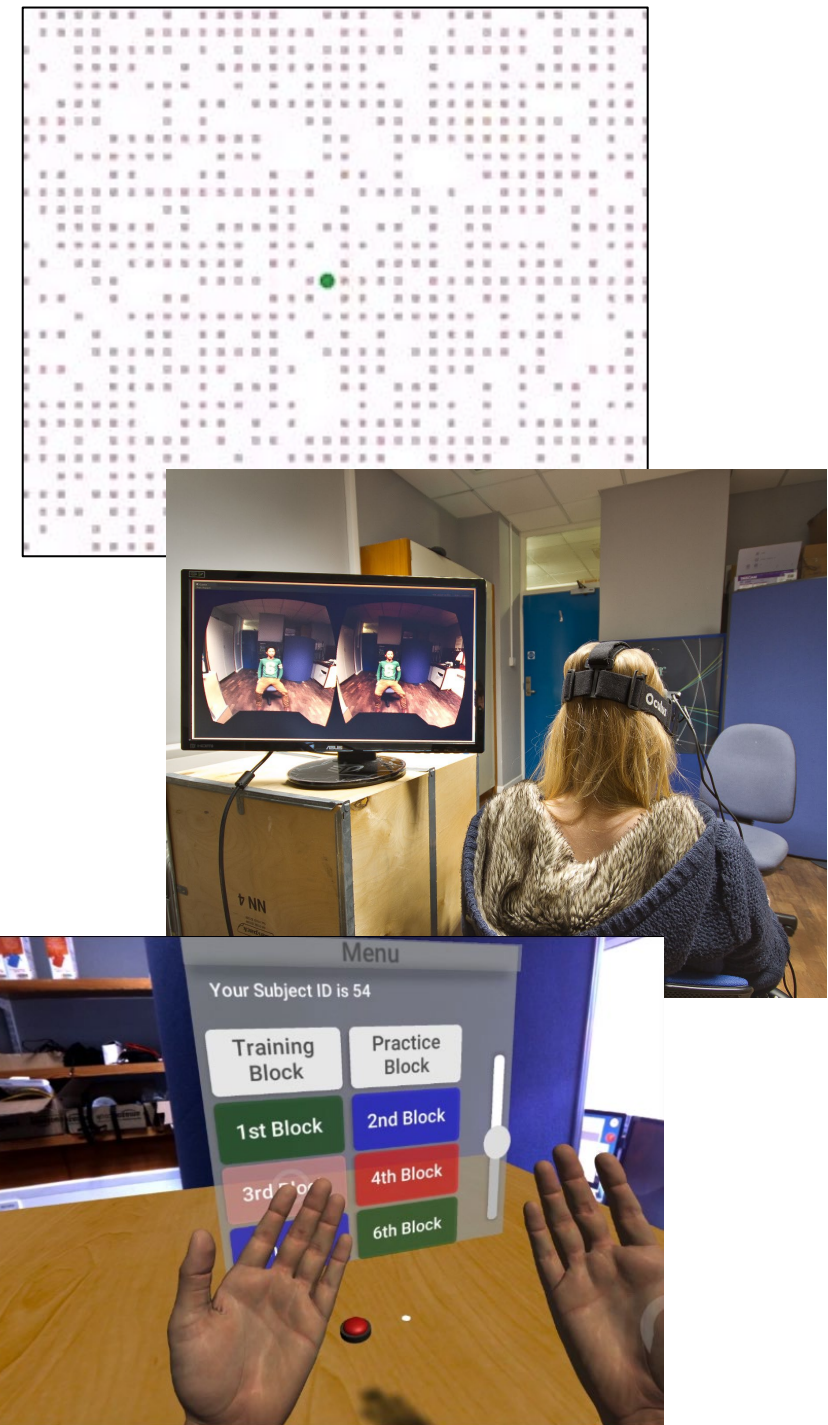
Topics interested

✓ Autopoiesis / Minimal-Agency

✓ Bodily-self / Interoception

✓ Sense of Presence / Reality

✓ Hallucination / Delusion



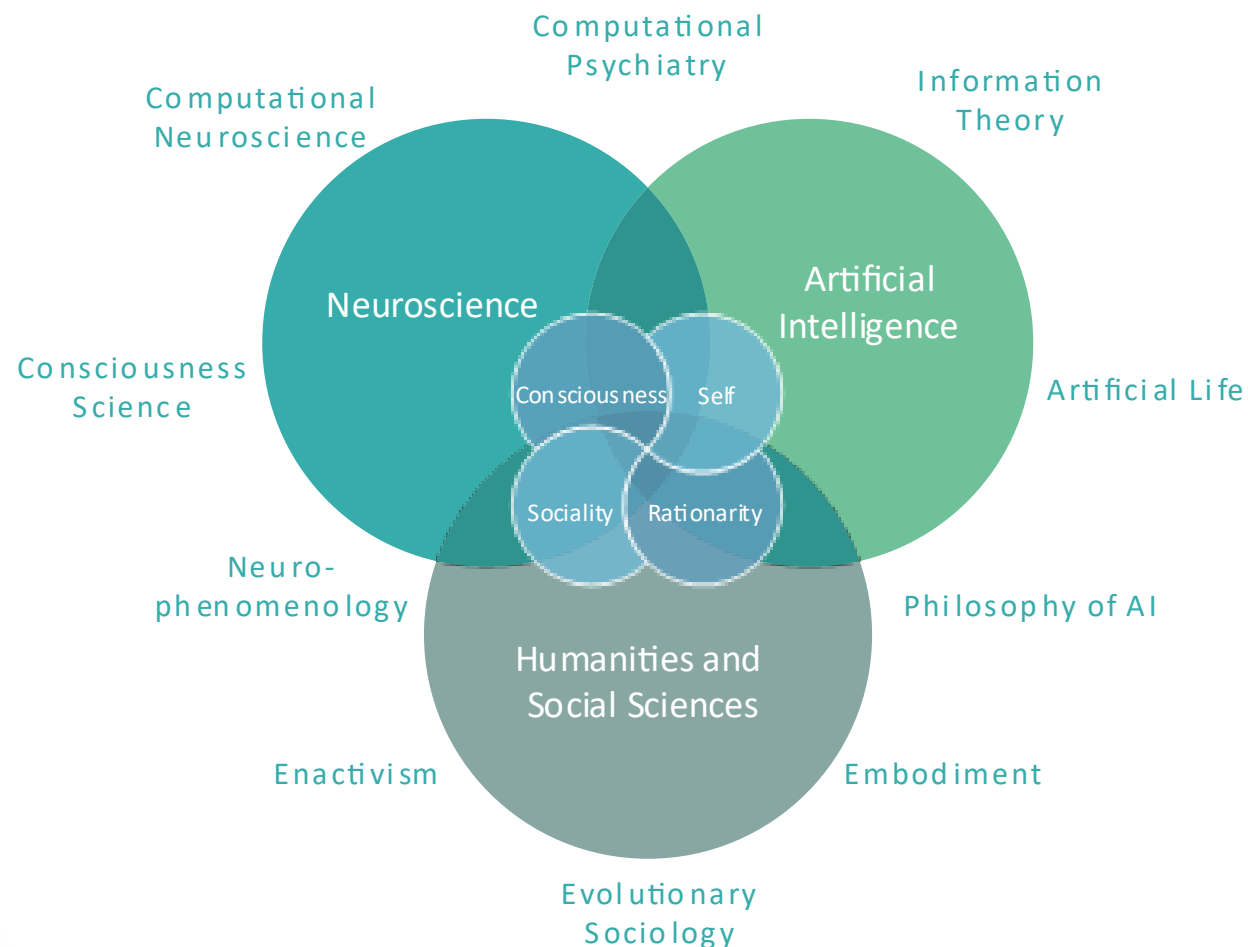
北海道大学

人間知×脳×AI研究教育センター



CHAIN

Hokkaido University
Center for Human Nature,
Artificial Intelligence,
and Neuroscience



Today's Roadmap

1

Constructivist Approach & *Life-as-It-Could-Be*

Understanding life and mind by building them

2

Case 1 — Hallucination Machine

VR + deep convolutional networks as a model of visual hallucinations

3

Case 2 — Allostatic Agent & Mindfulness

A neurophenomenological model of being-mode and meta-attention

4

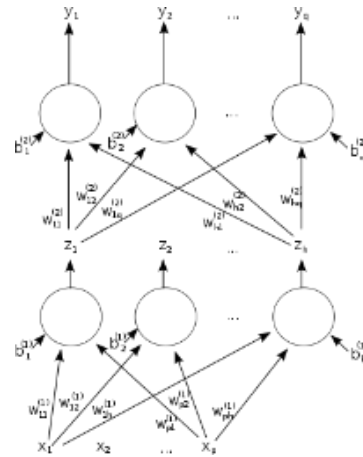
Open Science in ALIFE

Open-source code and pre-registration as the medium of cumulative research

Constructivist Approaches



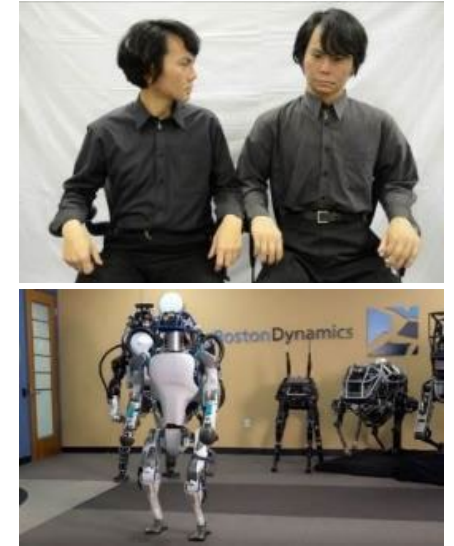
Biological Brain



AI



Human



Humanoid robots

- ✓ The subject you want to understand is first constituted 'artificially'



- ✓ Once a functionally identical artefact is created, the mechanism of the object can be understood by analysing it

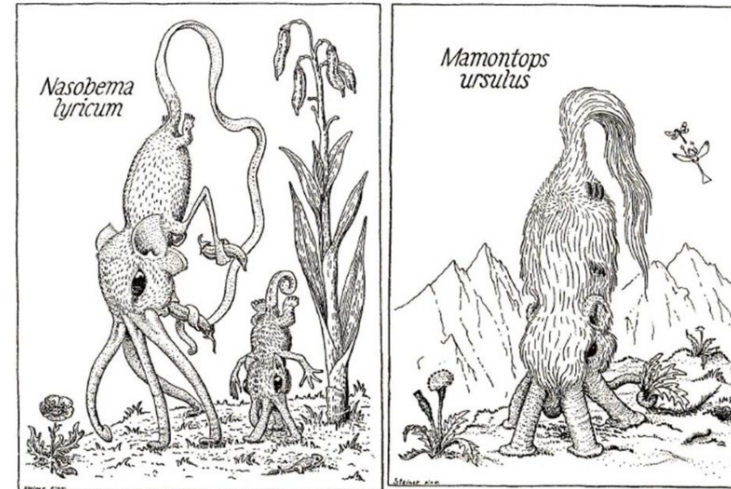
Artificial Life & *Life-As-It-Could-Be*

Interdisciplinary field aiming to understand life and cognition via *a constructivist approach* (understanding by building)

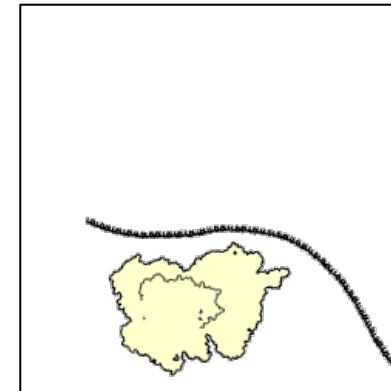
- ✓ Reproduce biological principles in computational simulations and artificial systems
- ✓ Enables study of phenomena like biological evolution, self-replication, adaptation, and emergent behaviors

“Life-as-it-could-be”

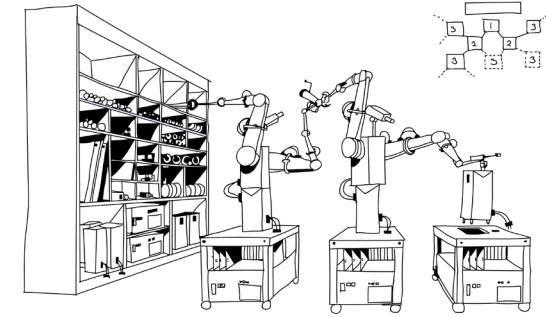
- ✓ Stepping beyond the narrow perspective of life phenomena as they exist on Earth, we seek to uncover the *universal principles* of life that encompass every conceivable form.



Harald Stümpke (1981) The Snouters: Form and Life of the Rhinogrades



Protein Synthesis in Ribosome



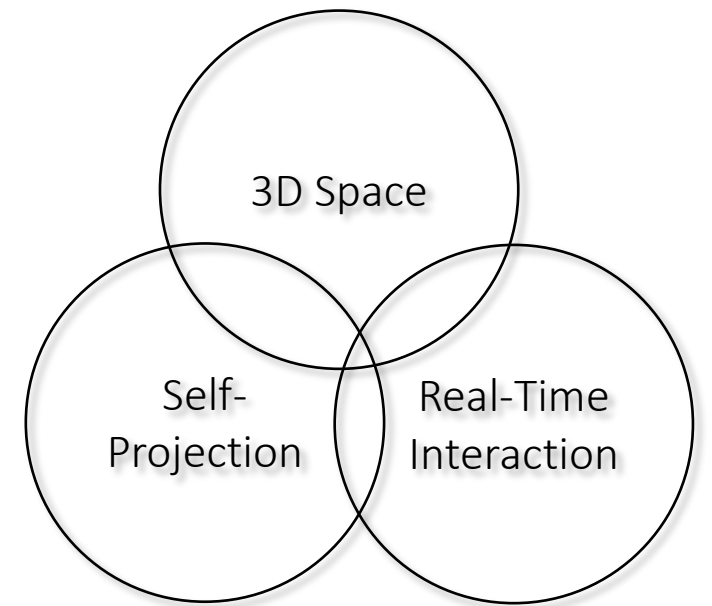
How does one copy oneself while already in the process of replicating?

UNEXCITABLE	U			
ORDINARY TRANSMISSION	→	↑	←	↓
	•→	•↑	•←	•↓
SPECIAL TRANSMISSION	⇒	⇑	⇐	⇓
	•⇒	•⇑	•⇐	•⇓
CONFLUENT	C ₀₀	C ₀₁	C ₁₀	C ₁₁
SENSITIZED	S ₀	S ₀	S ₁	S ₀₀
	S ₀₁	S ₁₀	S ₁₁	S ₀₀₀

Universal Constructor (Neumann, 1966)

Virtual Reality

- ✓ A technology that immerses users in a computer-generated world.
- ✓ By replacing sensory inputs, it strives to match the realism of the physical world.
- ✓ Its ultimate goal is to provide an “as-if” experience—one that feels just like reality.



The Three Key Elements of VR



CAVE(computer assisted virtual environment)



Head mounted display (HMD)



Optical motion tracking systems

Out-of-body Experiences

- ✓ A state where one feels they have left their physical body and can move freely in midair
- ✓ Frequently reported during sleep paralysis, near-death experiences, and under anesthesia
- ✓ Historically viewed as psychic or mystical, often linked to the occult or parapsychology
- ✓ Electrical stimulation of the right temporoparietal junction (TPJ) can induce OBEs (Blanke et al., 2002)

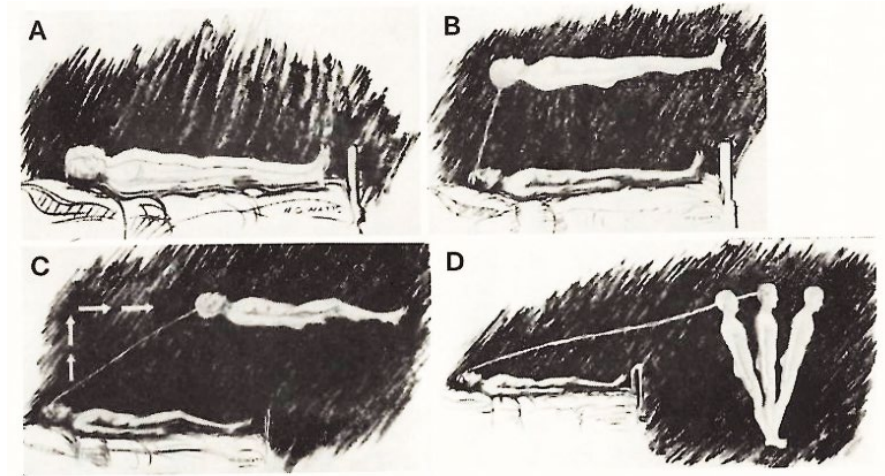
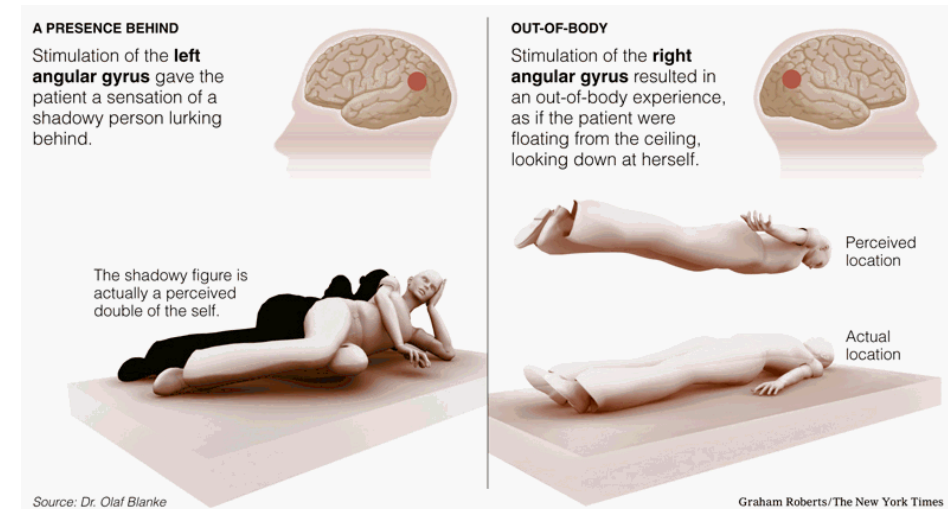


図5 体外離脱現象が開始する際の現象的身体イメージの運動学。マルドゥーンとキャリントンの『霊体の投射』(S. Muldoon and H. Carrington, *The Projection of the Astral Body*, London: Rider & Co., 1929)によれば、これが「古典的な」運動パターンである。



Metzinger (2009) *The Ego Tunnel*, Basic Books.

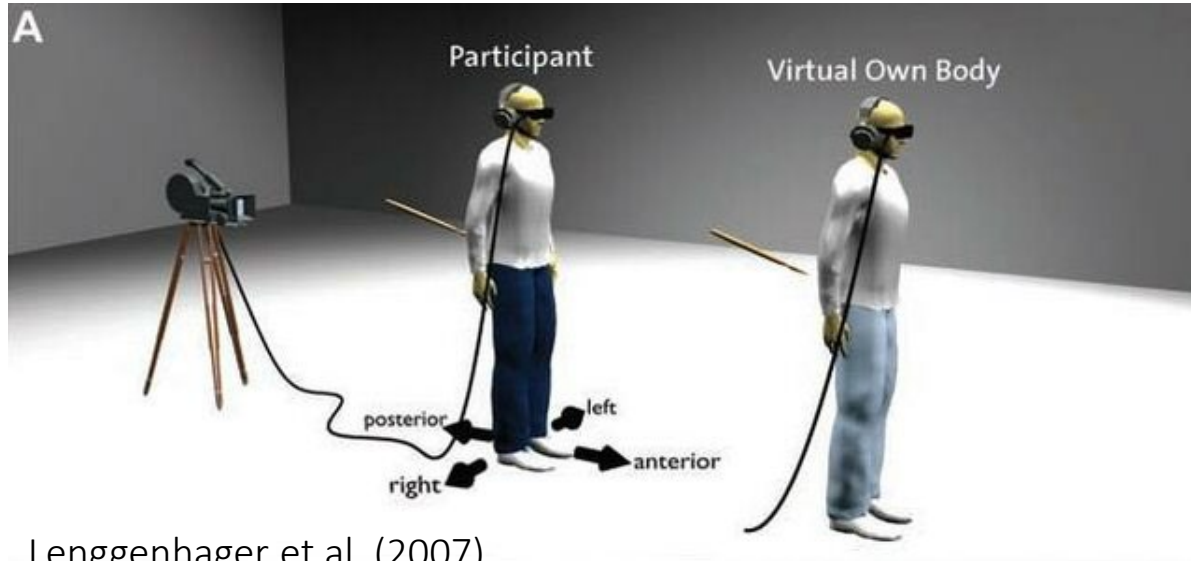
Blanke et al. (2002) Stimulating own-body perceptions. *Nature*, **419**, 269 – 270

Arzy et al. (2006) Induction of an illusory shadow person. *Nature* **443**, 287

VR-induced Out-of-body Experiences

Full-body Illusions (Lenggenhager, et al. 2007; Ehrsson, 2007)

When participants view their own backs from behind through a VR headset and receive synchronized visual and tactile stimulation, they experience the illusion that their body is positioned in front of them.



Lenggenhager et al. (2007)

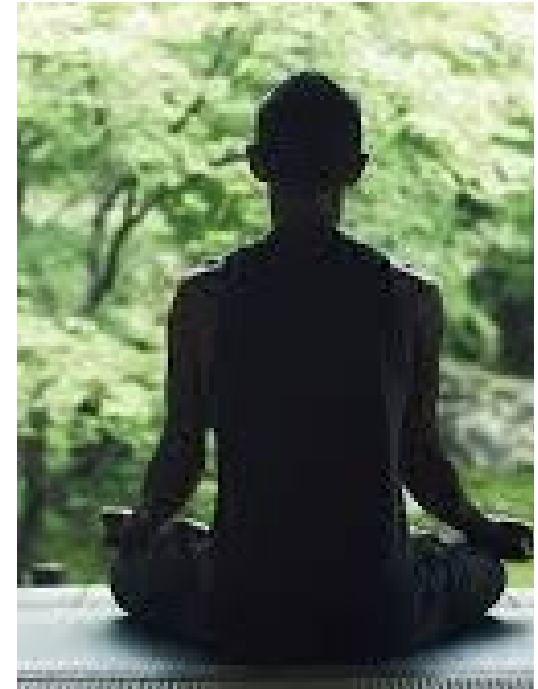
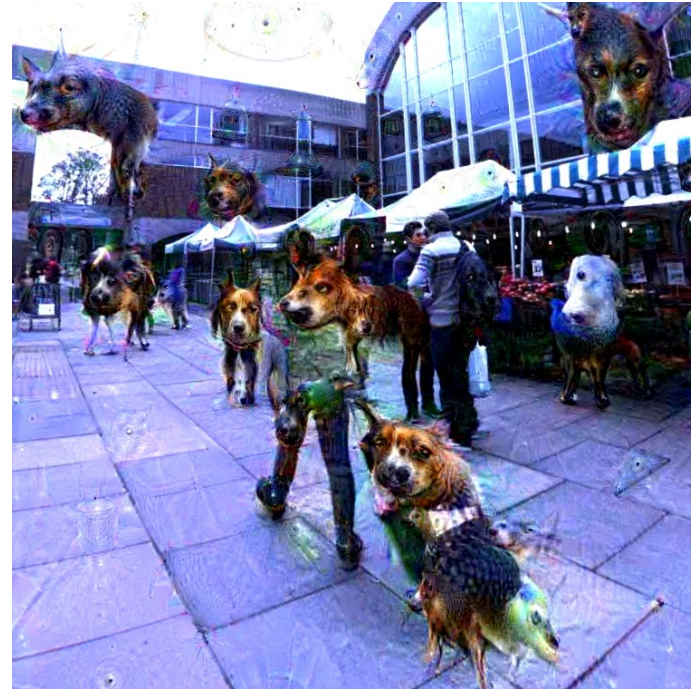
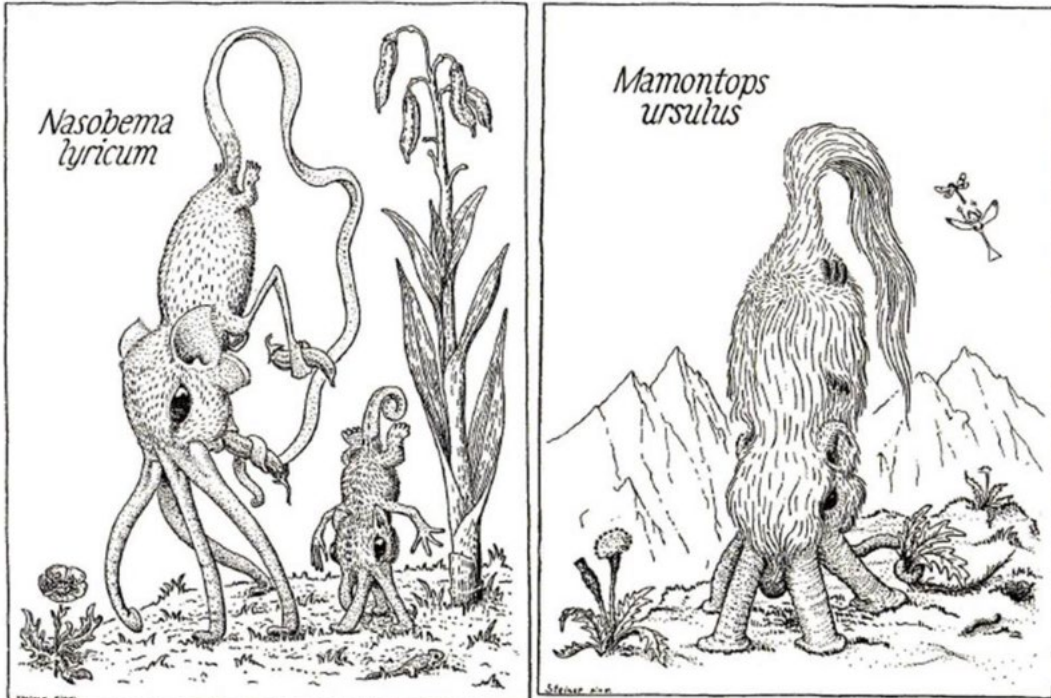


Virtual out-of-body experience

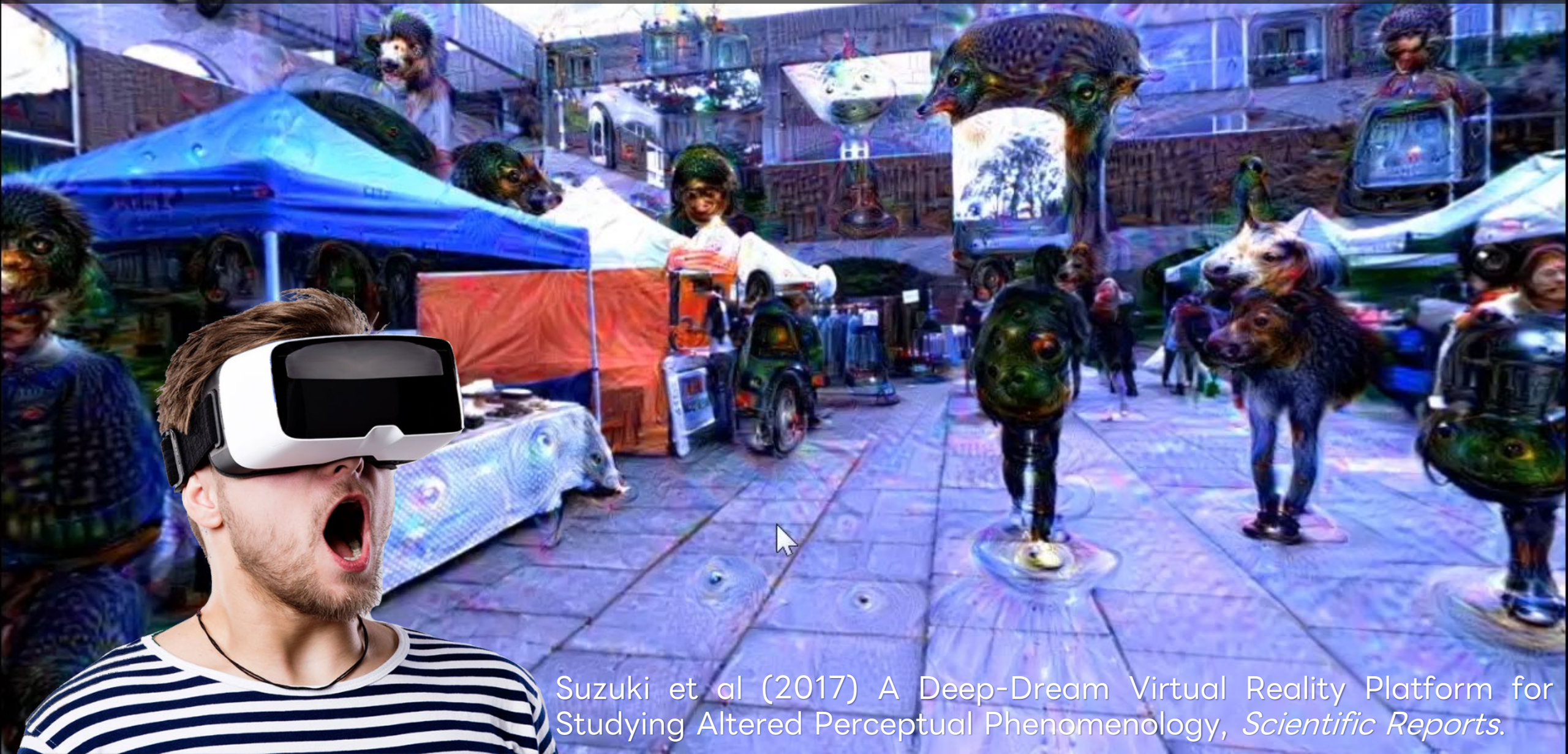
https://www.youtube.com/watch?v=4PQAc_Z2OfQ

Lenggenhager, et al. (2007) Video ergo sum: manipulating bodily self-consciousness, Science
Ehrsson (2007) The experimental induction of out-of-body experiences, Science

From “*Life-as-It-Could-Be*” To “*Mind-as-It-Could-Be*”



Hallucination Machine (Suzuki et al. 2017)



Suzuki et al (2017) A Deep-Dream Virtual Reality Platform for Studying Altered Perceptual Phenomenology, *Scientific Reports*.

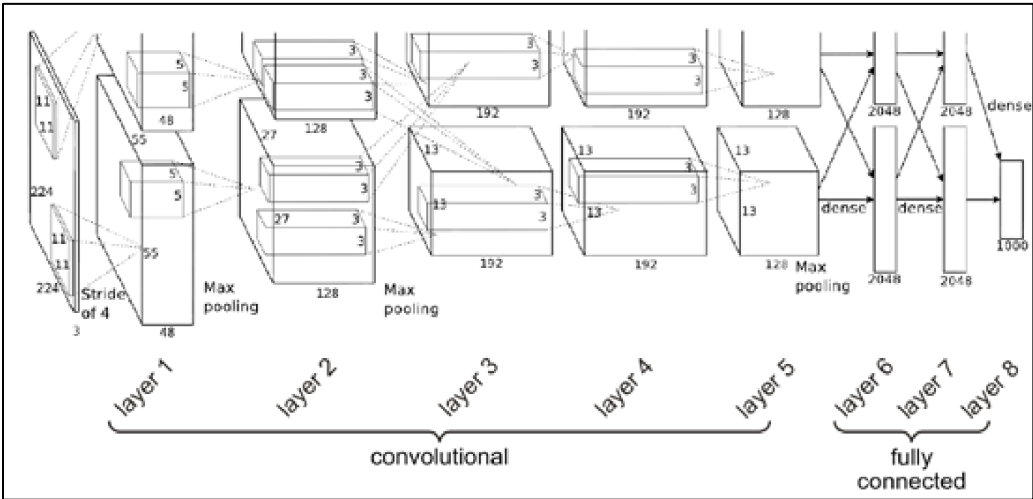
Deep Convolutional Neural Networks

Visual Object Classification Algorithm Competition

The ImageNet Challenge was won by a large margin by a deep-layered neural net model built by AlexNet (Krizhevsky et al., 2012)

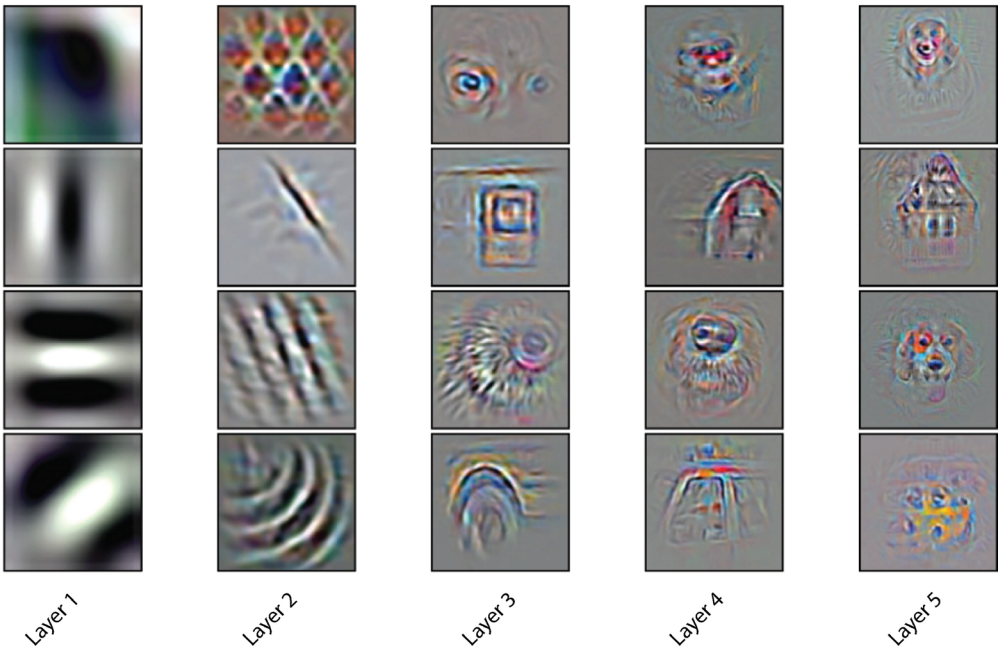
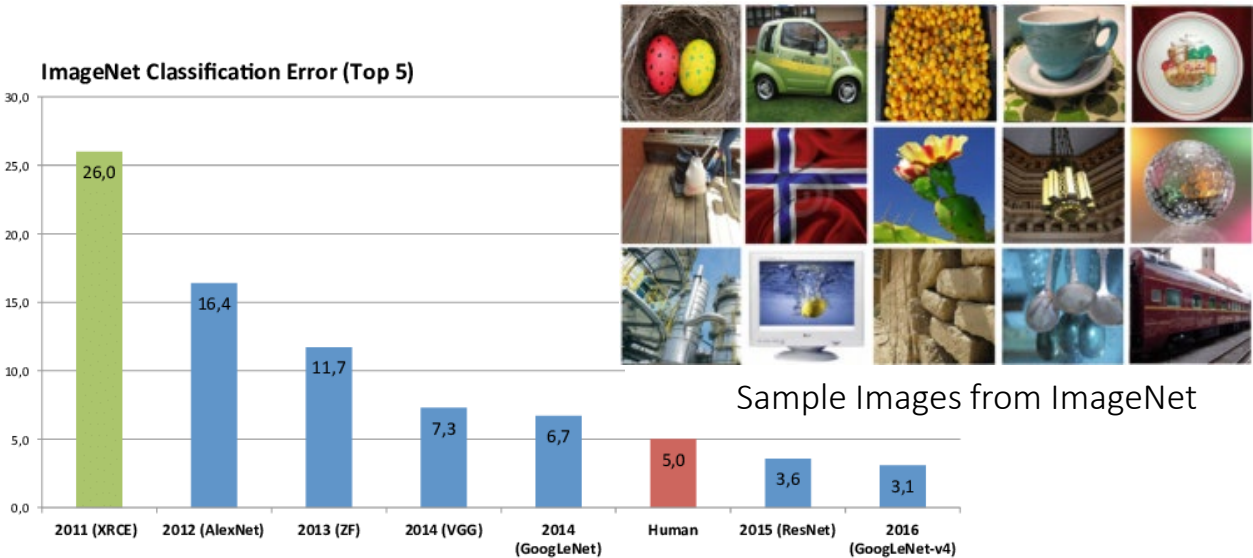
Deep Convolutional Neural Networks (DCNNs)

Hierarchical feature extraction (from pixels to lines, lines to parts, parts to a whole image) can be done automatically from the image data set



Kriegeskorte N. 2015.
Annu. Rev. Vis. Sci. 1:417–46

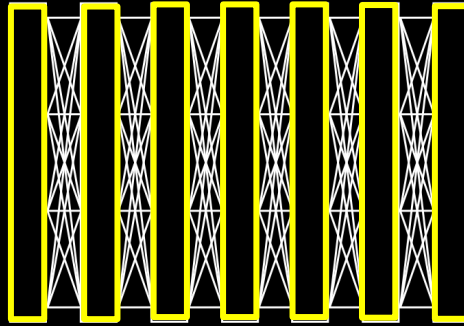
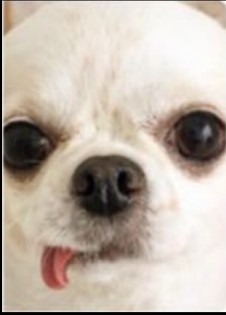
GoogLeNet (2014)



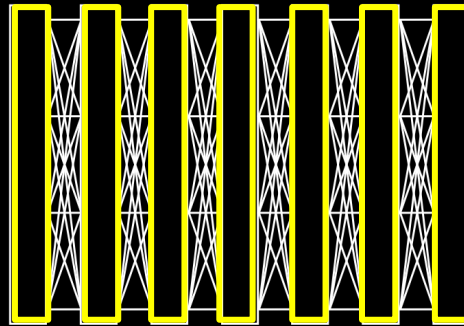
Artificial Visual Hallucinations



or

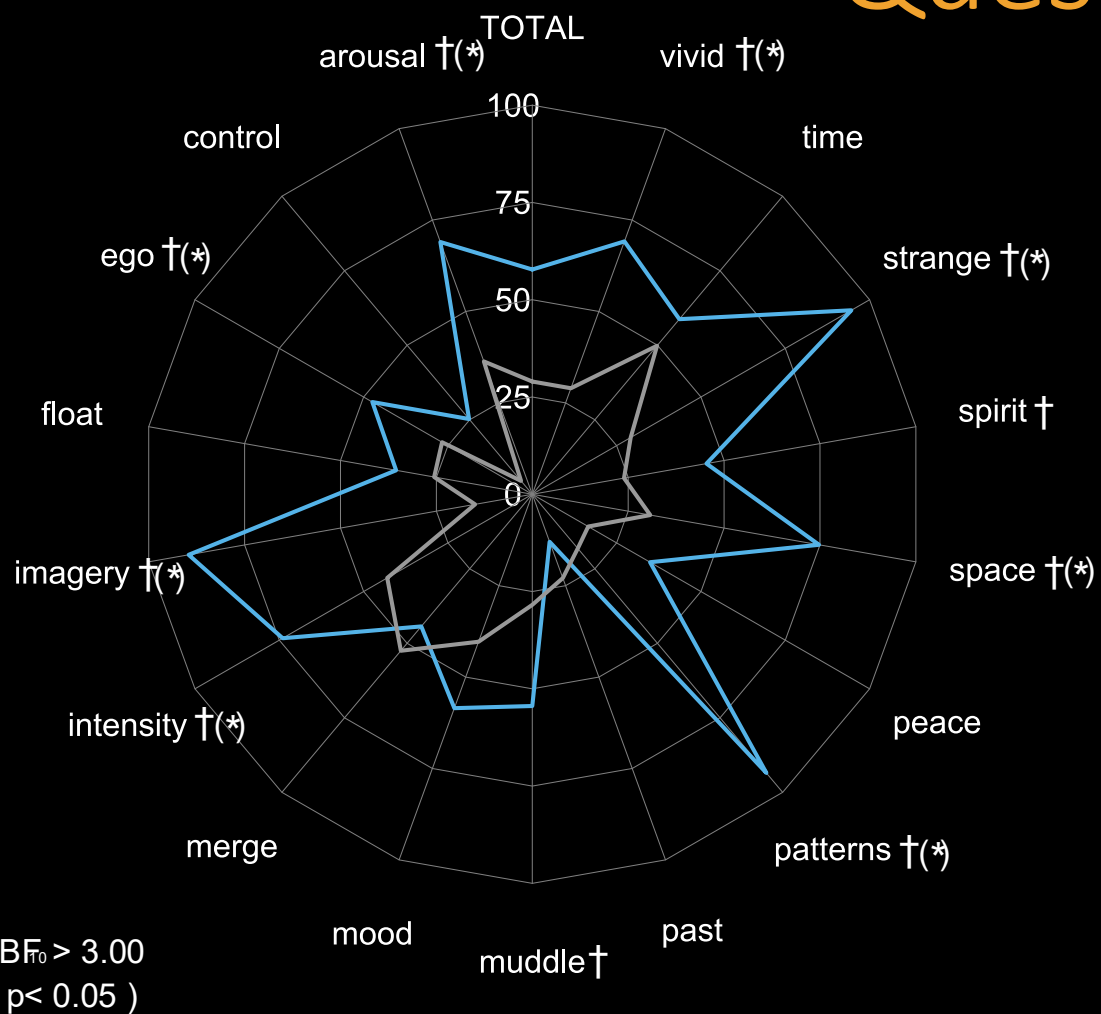


{dog, flower, cookie, ...}

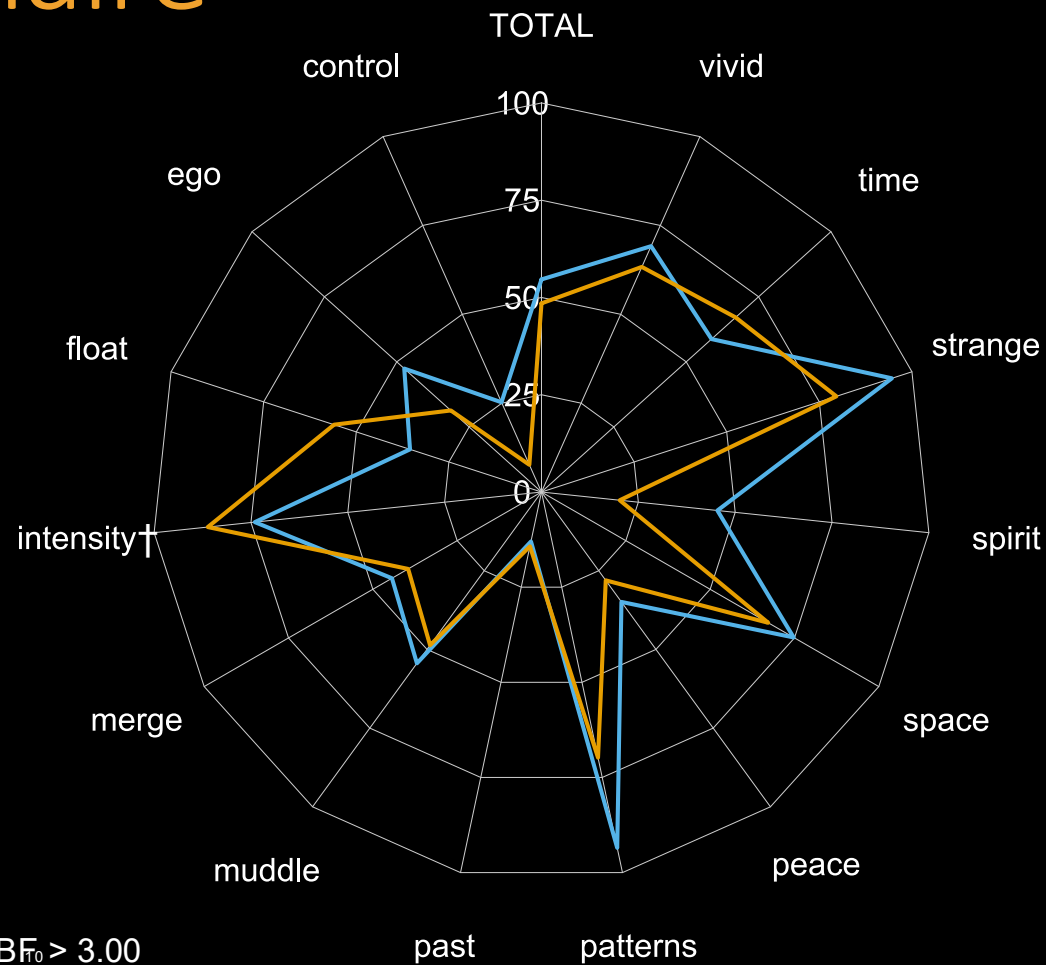


{dog, flower, cookie, ...}

Altered State of Consciousness Questionnaire



— Hallucination Machine — Control



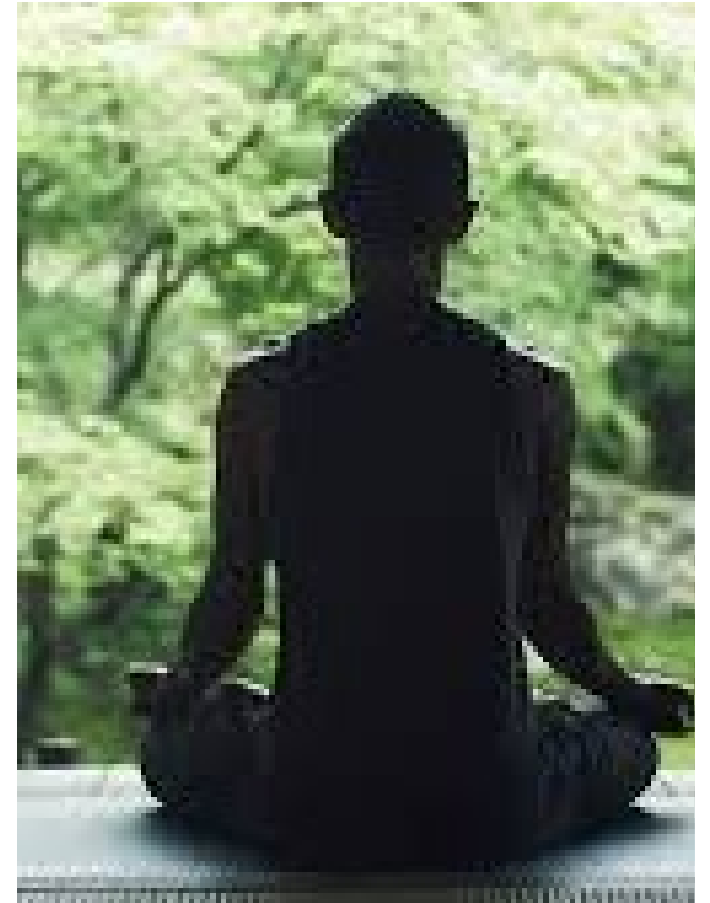
— Hallucination Machine — Psilocybin

Mindfulness

Mindfulness is the practice of intentionally focusing one's attention on the present moment (bodily sensations and the surrounding environment) and accepting experiences without evaluation or judgment

Various psychological and physiological benefits have been reported

- stress reduction
- emotional stability
- enhanced attention



“Being mode” and “doing mode” (Farb et al., 2015)

Being mode
(perceptual inference)

Doing mode
(active inference)

Mindfulness is explained by a “being mode,” wherein one distances oneself from thoughts and emotions, accepts sensory inputs as they are, and minimizes the influence of prior beliefs

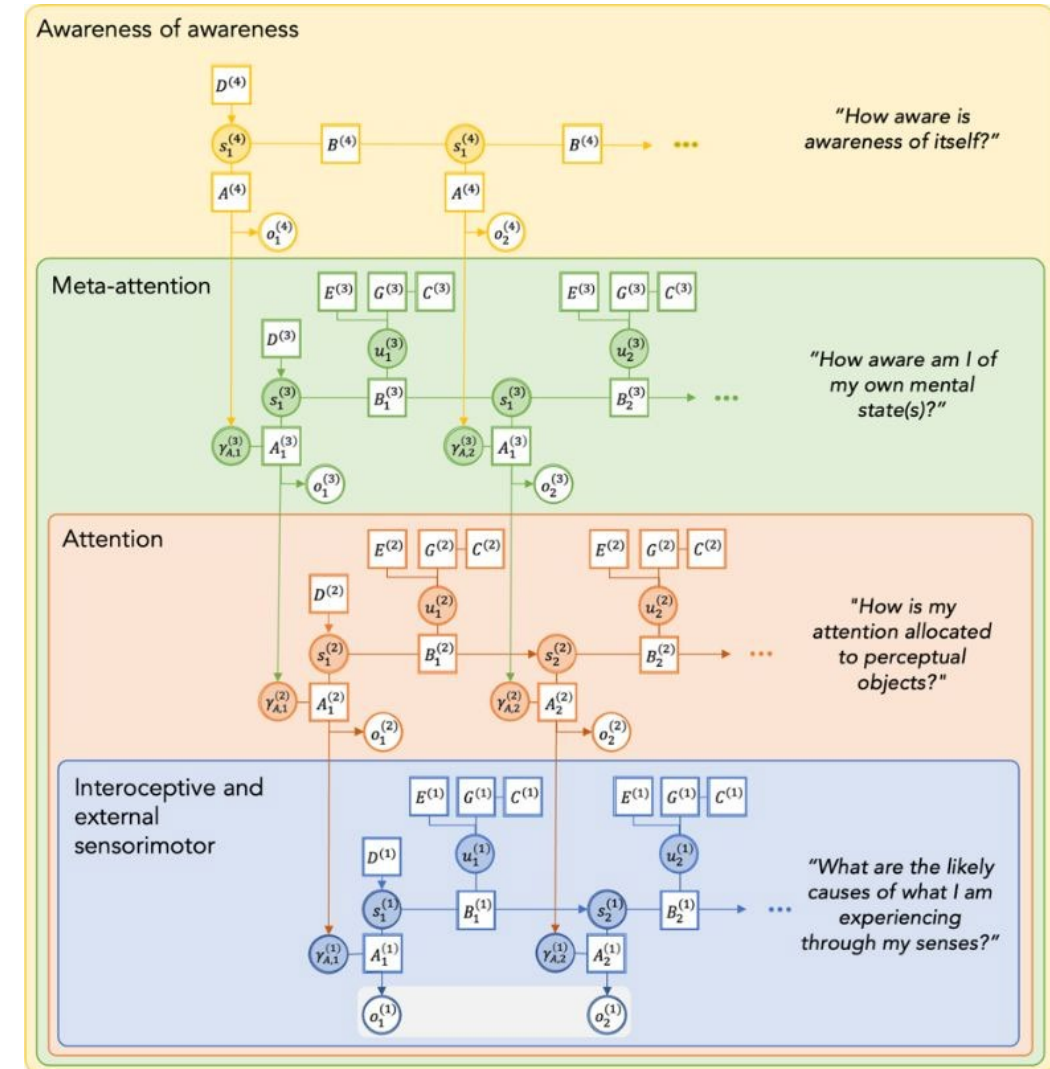


Mind-wandering is suggested to correspond to a “doing mode,” a process of attempting to control sensations and situations based on prior beliefs

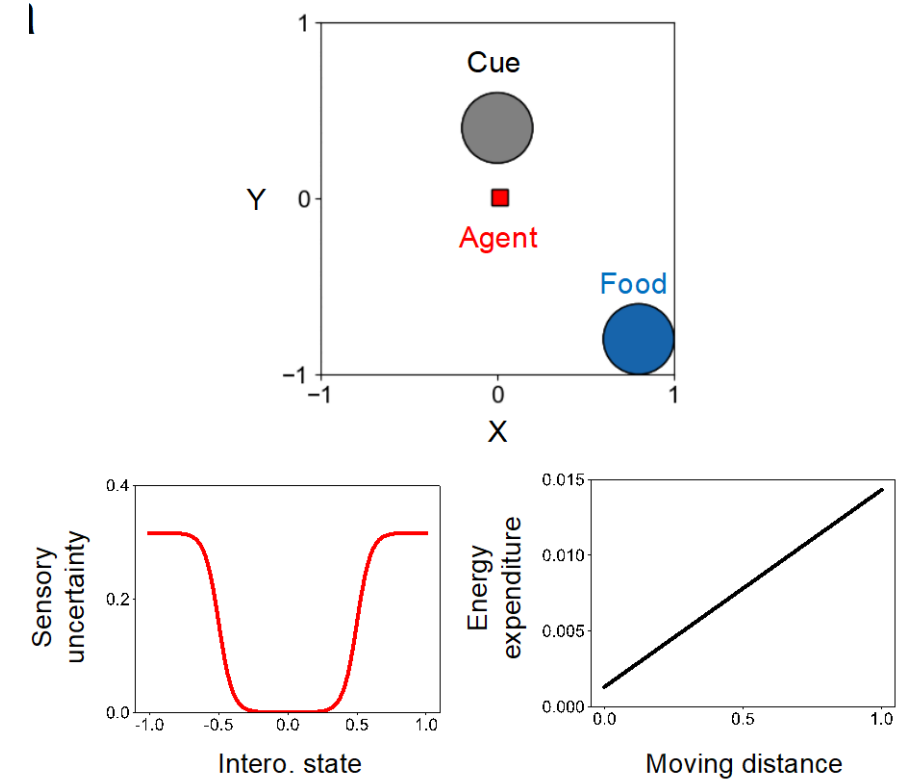
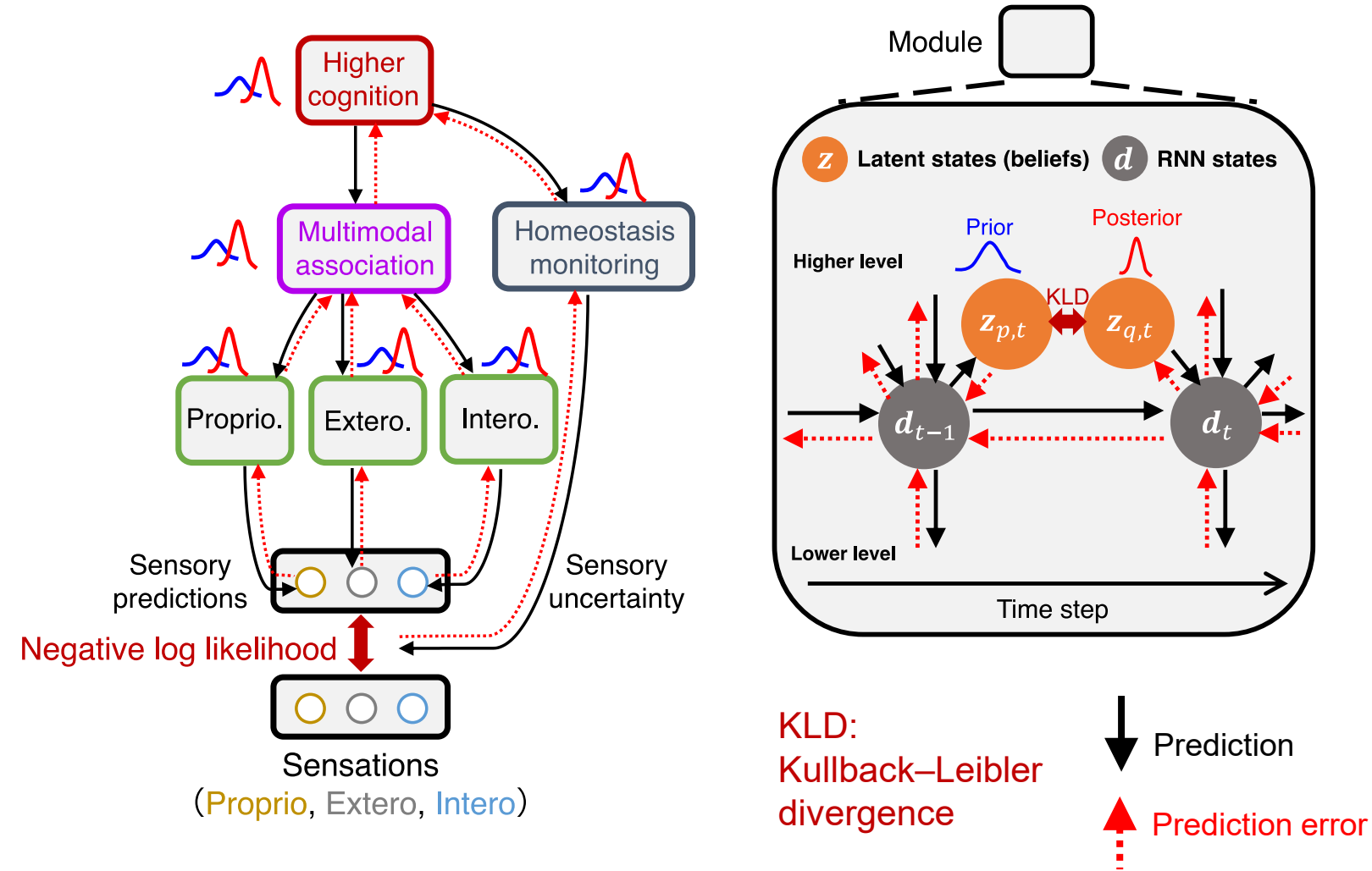


Meta-levels of attention in mindfulness

- **Level 4:** Self-reference, or attention toward the system itself (the totality of all its behaviors or modes)
- **Level 3:** Meta-attention toward attention allocation (mindfulness, awareness of mind-wandering)
- **Level 2:** Attention allocation ("being mode" and "doing mode", characterized by free-energy states)
- **Level 1:** Probabilistic generative modeling of the world (estimated precision serves as attention)



Multimodal Bayesian Homeostatic RNN (MBH-RNN)



Interoception: energy
Proprioception: body position
Exteroception: cue signal

Open Science in ALIFE

ALIFE at 30: Beer vs. Harvey

“The vast majority of research projects in ALife are **one-offs**... the literature is filled with many minor but *incommensurable variations on a theme*.” — Beer (2024)

BEER (2024) — THE DIAGNOSIS

ALife should grow up

- **Inconsistent peer review** — reviews span “accept” to “reject” for the same paper
- **Historical ignorance** — prior work duplicated with minor unmarked variations
- **One-offs, not programs** — idiosyncratic methods, shallow analysis, then dropped

→ Need *research programs*, not just projects

HARVEY (2024) — THE COUNTER

ALife as incubator

- A loose-knit, ever-changing community for new interdisciplinary conceptions
- AI, neural nets, GAs, deep learning all **started here, then left** — this is good
- Adult-norm gatekeeping in 1987 would have **rejected Beer himself**

→ ALife is for *the as-yet unborn*

Open code & pre-registration: a partial answer to Beer’s “one-offs” without sacrificing Harvey’s incubator

Beer, R. D. (2024) (A)Life as It Could Be. Artificial Life, 30(4), 539–545.

Harvey, I. (2024) Comment on Randall D. Beer's "(A)Life as It Could Be". Artificial Life, 30(4), 546–547.

Open Science in Computational Research

Replication rates in computational fields remain low (Hutson 2018; Pineau et al. 2021). Beyond shared data and papers, two practices are increasingly central:

PRACTICE 1

Open-Source Code

Share the experiment itself, not only its description.

PRACTICE 2

Pre-registration

Declare the analysis plan before observing the outcome.

Together they constrain researcher degrees of freedom and make computational claims verifiable.

Hutson, M. (2018). Artificial intelligence faces reproducibility crisis. *Science*, 359(6377), 725–726.

Pineau et al. (2021). Improving reproducibility in machine learning research. *J. Mach. Learn. Res.*

Open-Source Code

A paper describes a result; the code *is* the experiment — sharing it makes the claim falsifiable.

SOURCE

GitHub / GitLab — version-controlled source

ARCHIVE

Zenodo / Software Heritage — archival DOIs

LICENCE

MIT / BSD / Apache-2.0 — permissive licences lower the barrier to reuse

FAIR4RS: software should be Findable, Accessible, Interoperable, Reusable (Baker et al., 2022)

Pre-registration of Analyses

THE PROBLEM

Researcher Degrees of Freedom

Decisions easily retro-fitted to results:

- model architecture
- hyperparameter tuning
- train / test splits
- stopping criteria

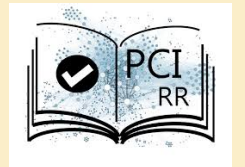
THE FIX

Deposit the Plan First

Time-stamp the analysis *before* observing the outcome — via: [Open Science Framework](#), [AsPredicted](#), [PCI Registered Reports](#)



ASPREDICTED



Pre-registered ML benchmarks: Forde & Paganini, 2019

REGISTERED REPORTS — peer review of the *plan*, not the result — decoupling publication from outcome

Open Science in Artificial Life

ALIFE is constructivist by definition — “**understanding by building**” makes code, model, and experiment a single artefact

A LONG TRADITION OF OPEN CODE

Tierra

Avida

Polyworld

OpenWorm

Framsticks

NetLogo

MASON

Mesa

Pre-registration for simulation: **declared parameter sweeps • seeds • exclusion rules**

Open Science is how “X-as-It-Could-Be” becomes a shared, cumulative programme

Three Take-aways

1

Understanding by Building

The constructivist approach is not a metaphor — it is a method. Once an artefact reproduces the phenomenon, its mechanism becomes analysable.

2

From Life to Mind

ALIFE supplies synthetic models of conscious phenomena — from artificial hallucinations to being-mode mindfulness — that we can probe and falsify.

3

Openness is Method

Open-source code and pre-registration turn computational claims into shared, cumulative knowledge — not solo demonstrations.

Acknowledgements



CHAIN

Center for Human Nature,
Artificial Intelligence, and Neuroscience

References:

Suzuki, Roseboom, Schwartzman, & Seth. (2017) A Deep-Dream Virtual Reality Platform for Studying Altered Perceptual Phenomenology. *Scientific Report*.

Idei, Tani, Ogata & Yamashita (2025) Future shapes present: autonomous goal-directed and sensory-focused mode switching in a Bayesian allostatic network model, *npj Complexity*, 2, 23.

Idei, Suzuki, and Yamashita, (2024) Awareness of being: A computational neurophenomenological model of mindfulness, mind-wandering, and meta-attentional control, *psyarxiv*.

Open Science:

Beer, R. D. (2024) (A)Life as It Could Be. *Artificial Life*, 30(4), 539–545.

Harvey, I. (2024) Comment on Randall D. Beer's "(A)Life as It Could Be". *Artificial Life*, 30(4), 546–547.

Hutson, M. (2018). Artificial intelligence faces reproducibility crisis. *Science*, 359(6377), 725–726.

Pineau et al. (2021). Improving reproducibility in machine learning research. *J. Mach. Learn. Res.*

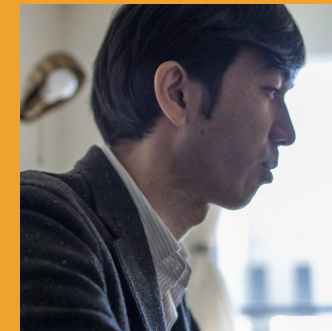
Barker et al. (2022) Introducing the FAIR Principles for research software. *Sci Data* 9, 622.



► David Schwartzman



► Anil Seth



► Yuichi Yamashita



► Hayato Idei

Contacts:

✉ ksk@chain.hokudai.ac.jp

✕ @ksk_s