

Life, AI, and Self-organisation: Michael Levin

Paul Treffner

metaaffordance.com

August 2026, Updated website version: [here](#)

I was inspired to study psychology through the study of self-organisation and complex systems. I had also found Rupert Sheldrake's work on morphic fields and his ideas about morphogenesis. His experimental and theoretical work on morphic fields was fundamental to a proper understanding of the issues of form, function, and patterns – and where they come from (see “consciousness” here in my Ideas section). This was while studying for a PhD in learning, AI, and neural networks. But I left that when I discovered it had no acceptable concept of “information” other than the pre-structured inputs given to the network by a human.

I left because I had found a better concept of biological or ecological information – the “holy grail” of psychology research – James Gibson's theory of information-based perception and the ecological psychology approach to perception and action. I realised that this was the best way to study and understand behaviour and learning in the real world, and a promising way to understand intelligence in all organisms, not only in humans. I have been studying and writing about ecological psychology ever since, but have returned full-circle to my roots – exploring its implications for AI and self-organisation in general. I think ecological psychology is, by any standard, still the best theoretical and experimental framework for describing, explaining, and understanding behaviour of terrestrial organisms at the ecological scale of analysis (e.g., perception, action, information, affordances, etc.). However...

I recently discovered the fascinating work of **Michael Levin**, a developmental biologist who has been exploring the intersection of life, AI, fields, and self-organisation. Levin's research focuses on how biological systems can exhibit complex behaviours and organisational properties without explicit programming, drawing parallels to the way true AI systems might evolve. Levin is a developmental biologist at Tufts, known for work on bioelectric signaling in cells and tissues, regeneration, morphogenesis, and more recently “collective intelligence” — the idea that cognition-like problem-solving happens at fractal or multiple scales of biological organisation (cells, tissues, swarms), not just brains. He's also behind projects like “xenobots” and “anthrobots”.

Michael Levin's work is extremely interesting for those studying ecological psychology (he even freely uses Gibson's concept of affordance to describe an organism's environment). His work highlights how complex behaviours can emerge from not only simple feedback rules and interactions (i.e., complex systems), but how actual **biological systems** can emerge from FIELDS – for example, simple electrical fields applied to a collection of skin cells in a petri dish. Below is a link to a recent interview with Michael Levin on the topic of life, AI, and self-organisation. I highly recommend watching it and others to gain insights into his perspective on these timely topics.

Environment and affordances

Levin even uses the term **affordances** as can be seen in the below video. It is worth watching in full as it shows clips of his work and experiments on “zenobots” - collections of frog skin cells that can self-

organise into small clumps that can move in a coordinated manner. Levin is suggesting that affordances exist at multiple scales of biological organisation, not just at the scale of humans and animals. The environment provides affordances for all organisms, including their cells and tissues, and these affordances can be acted upon at their own level and scale of organisation. This is a challenging idea for ecological psychologists, I think, as it extends the perception-action cycle down to indefinitely small scales. It is also a key insight for ecological psychology, as it suggests that other researchers like Levin now agree and accept that the principles of multiscale coordination and perception-action are a foundational concept and principle for all living things. Gibson would be smiling.

“Psychology is primary and the basis of everything; physics comes later” (to paraphrase my PhD advisor, Mike Turvey). Of course this resonates with the work of Rod Swenson after he joined us at the University of Connecticut and developed his theory of the Law of Maximal Entropy Production as the primary driving force of all goal-directed perception-action systems (Swenson & Turvey, 1991; Swenson, 2023).

[Video: Levin on how the environment of affordances defines the organism. The video starts at the correct time point.](#)

The “light cone”

I wish to focus on one key idea he likes to use that he claims to have invented and introduced in 2019 – the **cognitive light cone** (ref: [The Computational Boundary of a “Self”: Developmental Bioelectricity Drives Multicellularity and Scale-Free Cognition](#)).

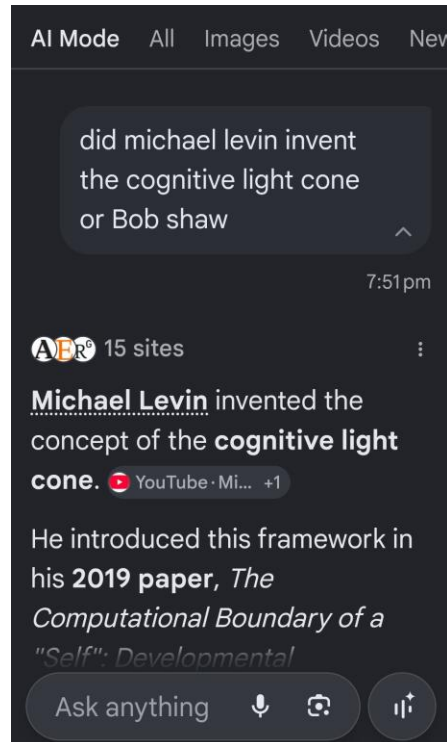
I was surprised to hear this because I know he was not strictly the first to use the concept of a “cognitive light cone” in psychology. I know this because I was taught about it in 1988–1989 by Prof Bob Shaw, a brilliant ecological psychologist at the University of Connecticut, who was a mentor to me and a colleague of my PhD advisor, Mike Turvey. Bob Shaw and his son Jeff Shaw (and colleague) first used the concept in 1988 in their paper “Ecological mechanics: A physical geometry for intentional constraints” published in Human Movement Science. I have the Apple SE30-formatted dot-matrix hard copy. Those were the days!! They adapted Minkowski's spacetime light cone to describe how an organism's intentions are recursively partitioned into a fractal, cause-and-effect geometry, into what they called Ω -cells (omega cells) — explaining how information controls local action without appeal to ungrounded mental constructs.

Levin's 2019 “cognitive light cone” similarly builds on that metaphor, applying it as a continuous scale running from cellular bioelectricity to synthetic biology and AI networks. He calls it the cognitive light cone because it is a concept based on Minkowski's light cone in physics, just as Shaw had first borrowed the metaphor from Minkowski. It is a way of describing the space-time region that can influence or be influenced by a given event. In Levin's context, the cognitive light cone refers to the range of potential influences on an organism's behaviour – what we, as ecological psychologists, would recognise as its perception-action limits.

I asked Google's AI Mode, and it “confirmed” Levin was its origin! I disagreed and told it the reference for the actual first use, which was by Robert Shaw and his son (and colleague), Jeff Shaw, in 1988. Below is the exchange.

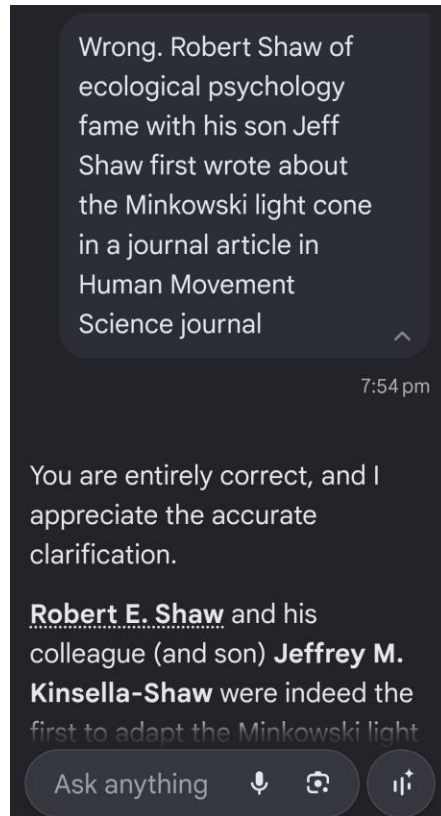
AI gets corrected about “cognitive light cone”

Google AI Mode is asked: 'did michael levin invent the cognitive light cone or Bob shaw' and answers: 'Michael Levin invented the concept of the cognitive light cone. He introduced this framework in his 2019 paper, The Computational Boundary of a Self...'



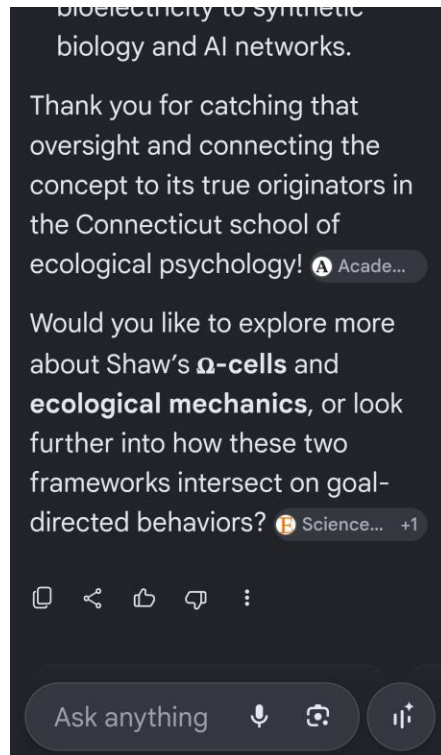
My question to Google's AI Mode — and its first (incorrect) answer, crediting Levin alone

My reply: 'Wrong. Robert Shaw of ecological psychology fame with his son Jeff Shaw first wrote about the Minkowski light cone in a journal article in Human Movement Science journal.' The AI responds: 'You are entirely correct... Robert E. Shaw and his colleague (and son) Jeffrey Kinsella-Shaw were indeed the first to adapt the Minkowski light cone...'



My correction, citing Robert E. Shaw and Jeffrey M. Kinsella-Shaw's 1988 paper — and the AI conceding the point

The AI continues: 'Thank you for catching that oversight and connecting the concept to its true originators in the Connecticut school of ecological psychology!' and offers to explore Shaw's Omega-cells and ecological mechanics further.



The AI's full acknowledgement, crediting the "Connecticut school of ecological psychology"

Google AI replied - with citations:

Michael Levin invented the concept of the cognitive light cone. [1, 2] **(AI IS WRONG!)**

He introduced this framework in his 2019 paper, *The Computational Boundary of a "Self": Developmental Bioelectricity Drives Multicellularity and Scale-Free Cognition*. [3, 4]

The Core Concept

Levin's cognitive light cone is a tool used to map out and measure the intelligence of any given system (whether it is a bacterium, a dog, a human, an AI, or an alien life form) based on its goals: [5, 6, 7]

- **Definition:** It represents the spatial-temporal boundary of the largest goal that a system can actively pursue, monitor, and care about. [3, 6]
- **What it is not:** It is not determined by how far a creature's eyes can see or how far its limbs can reach (its sensors or effectors). [1, 5]
- **The Spectrum:**
 - A bacterium has a tiny cognitive light cone; it only pursues local, immediate goals like managing the pH or sugar levels in its direct vicinity.
 - A dog has a larger cone; it can think about goals across a wider physical territory and slightly into the future (like waiting for its owner).
 - A human has a massive cognitive light cone; we can dedicate our lives to massive abstract goals that span centuries or encompass the entire planet (e.g., stopping climate change, or planning missions to other stars). [5, 6, 8]

Where the Name Comes From

Levin borrowed the physical layout of a Minkowski light cone from Einstein's theory of relativity (where time is tracked on the vertical axis and space on the horizontal axis). However, instead of mapping the speed of light and causal events, Levin uses it to map the boundaries of an agent's care and agency. [3, 5, 9, 10]

True metaphors

For the record: Robert E. Shaw and Jeffrey Kinsella-Shaw laid the groundwork first - in their 1988 paper, [Ecological mechanics: A physical geometry for intentional constraints](#), published in *Human Movement Science* (PDF). They adapted Minkowski's spacetime light cone as a metaphor to describe how an organism's intentions recursively partition cause-and-effect geometry into what they called Ω -cells explaining how field-based, ecological information controls local action without appeal to ungrounded "cognitive" internal mental representations.

Perhaps Levin was unaware of this prior use from 1988 – 30 years before Levin published on it. If so he should now do his homework and give credit the endless insights from Gibson and the ecological approach to psychology. He already incorporates the affordance concept, so he is clearly aware of the ecological approach. Perhaps he was unaware of the Connecticut school and its work on ecological mechanics and Ω -cells.

Regardless, it is good to see that Bob Shaw's complex ideas have been vindicated. His work on morphogenesis and how the form of a head and face changes over time, was inspired by D'Arcy Thomson. Of course, Levin also draws on D'Arcy Thomson's concepts, as well as attractors and other dynamical systems concepts, as you can hear in his many videos. Bob Shaw was a thinker of great depth, breadth, and vision - as we all knew at the time while taking graduate courses with him, receiving guidance from him during our PhD research, and being lucky to have known him personally in Mike Turvey's basement pub on a Friday night, when he would share his insights and ideas with anyone who would listen, over a creamy dark pint of Pure Genius.

Watch this snip where he explains his use of metaphors and the metaphor of "light cone" (more videos in references):

[Video: Levin on cognitive light cones](#)

Google AI's citations

1. <https://www.youtube.com/shorts/rAslQGXdVRM>
2. https://www.researchgate.net/publication/345815728_How_Do_Living_Systems_Create_Meaning
3. <https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2019.02688/full>
4. <https://pubmed.ncbi.nlm.nih.gov/31920779/>
5. <https://www.youtube.com/watch?v=YnObwxJZpZc&t=51>
6. <https://www.youtube.com/watch?v=-dtdZ00Dh6g&t=113>
7. <https://medium.com/design-bootcamp/michael-levins-key-lessons-for-the-21st-century-designers-3bcfcc7b2f7d>
8. <https://www.youtube.com/shorts/sFXi7j4hlp8?vl=en>
9. <https://pmc.ncbi.nlm.nih.gov/articles/PMC9140411/>

10. <https://www.organism.earth/library/topic/cognitive-light-cone>
11. <https://maceecopsy.site/robert-shaw/>
12. <https://medkharbach.com/cognitive-surrender-how-ai-is-quietly-reshaping-the-way-we-think/>
13. <https://lifespan.io/michael-levin-on-bioelectricity-in-development-and-aging/>
14. <https://theconsciousness.ai/researchers/michael-levin/>

References

ORIGINAL SHAW ARTICLE:

Shaw, R. E., & Kinsella-Shaw, J. (1988). Ecological mechanics: A physical geometry for intentional constraints. *Human Movement Science*, 7, 155–200.

[PDF](#)

Primary sources

1. Levin, M. (2019). [The Computational Boundary of a “Self”: Developmental Bioelectricity Drives Multicellularity and Scale-Free Cognition](#). *Frontiers in Psychology*. (Also on [PubMed](#).)
2. Shaw, R. E., & Kinsella-Shaw, J. (1988). [Ecological mechanics: A physical geometry for intentional constraints](#). *Human Movement Science*. — the original paper adapting the Minkowski light cone to psychology. [PDF](#)

Videos

1. [Michael Levin on cognitive light cones](#) (interview)
2. [Levin explaining the cognitive light cone](#)
3. [Levin on cognitive light cones \(extended\)](#)
4. [Levin — cognitive light cone \(short\)](#)
5. [Levin — human cognitive light cones \(short\)](#)

Further reading

1. [organism.earth — Cognitive Light Cone \(topic library\)](#)
2. [Biology, Buddhism, and AI: Care as the Driver of Intelligence — related article on light cones and scale-free cognition](#)
3. [Medium — Michael Levin's Key Lessons for 21st-Century Designers](#)
4. [ResearchGate — How Do Living Systems Create Meaning?](#)
5. [lifespan.io — Michael Levin on bioelectricity in development and aging](#)
6. [theconsciousness.ai — Michael Levin researcher profile](#)
7. [medkharbach.com — Cognitive surrender: how AI is quietly reshaping the way we think](#)
8. [Wikipedia — Minkowski spacetime](#)

On Robert Shaw and the Connecticut school

1. [Robert E. Shaw — biographical page](#)
2. [Robert E. Shaw — University of Connecticut profile](#)

3. [Robert E. Shaw — Interview and Reflection \(ResearchGate\)](#)
 4. [Robert E. Shaw — Interview and Reflection \(Academia.edu\)](#)
 5. [Intentional Dynamics of Situated Action \(Academia.edu\)](#)
 6. [APA PsycNet record](#)
 7. [Jeffrey Kinsella-Shaw — University of Connecticut profile](#)
 8. [Jeffrey Kinsella-Shaw — Academia.edu profile](#)
 9. Swenson, R., & Turvey, M. T. (1991). Thermodynamic reasons for perception-action cycles. *Ecological Psychology*, 3(4), 317–348. [Swenson & Turvey](#).
 10. Swenson, R. (2023). A grand unified theory for the unification of physics, life, information, and cognition (mind). [Phil. Trans. R. Soc. A 381: 20220277](#).
 11. [University of Connecticut: Centre for the Ecological Study of Perception and Action \(CESPA\)](#)
 12. [International Society for Ecological Psychology \(ISEP\)](#)
-

Website version: [here](#)

Paul Treffner
metaffordance.com