Activity and knowledge: developmental robotics and the philosophical tradition

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An outline in brief—

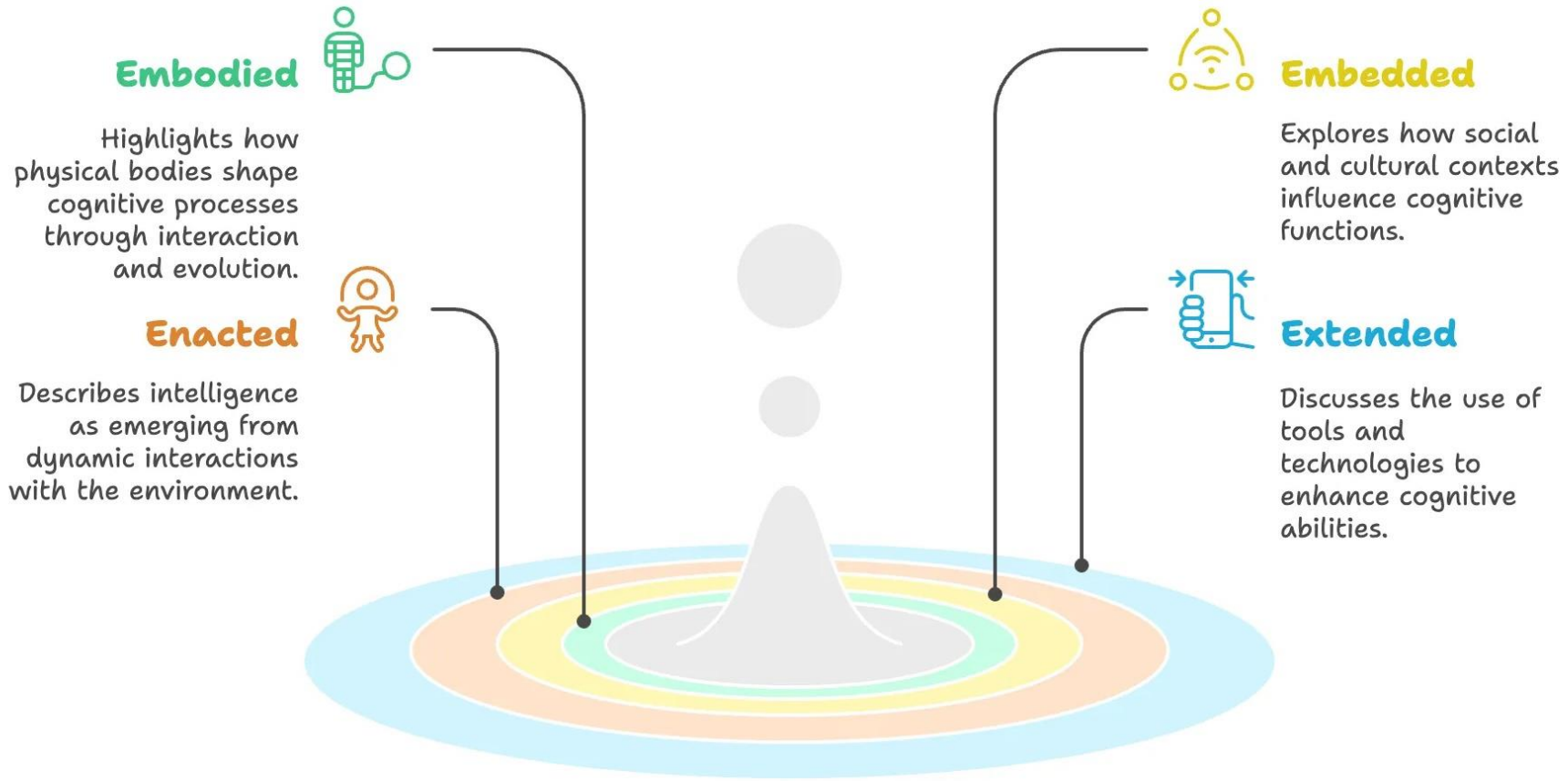
1. The problem of mind and world in the philosophical tradition
2. Two lines of development: Evald Ilyenkov and Kitaro Nishida
   - Ilyenkov's dialectical materialism: Soviet psychology, deaf-blind paedagogy
   - Materiality in the later work of Nishida: acting-intuition, the historical body
3. Complementarities and contradictions between these two
4. Implications for developmental robotics and philosophy

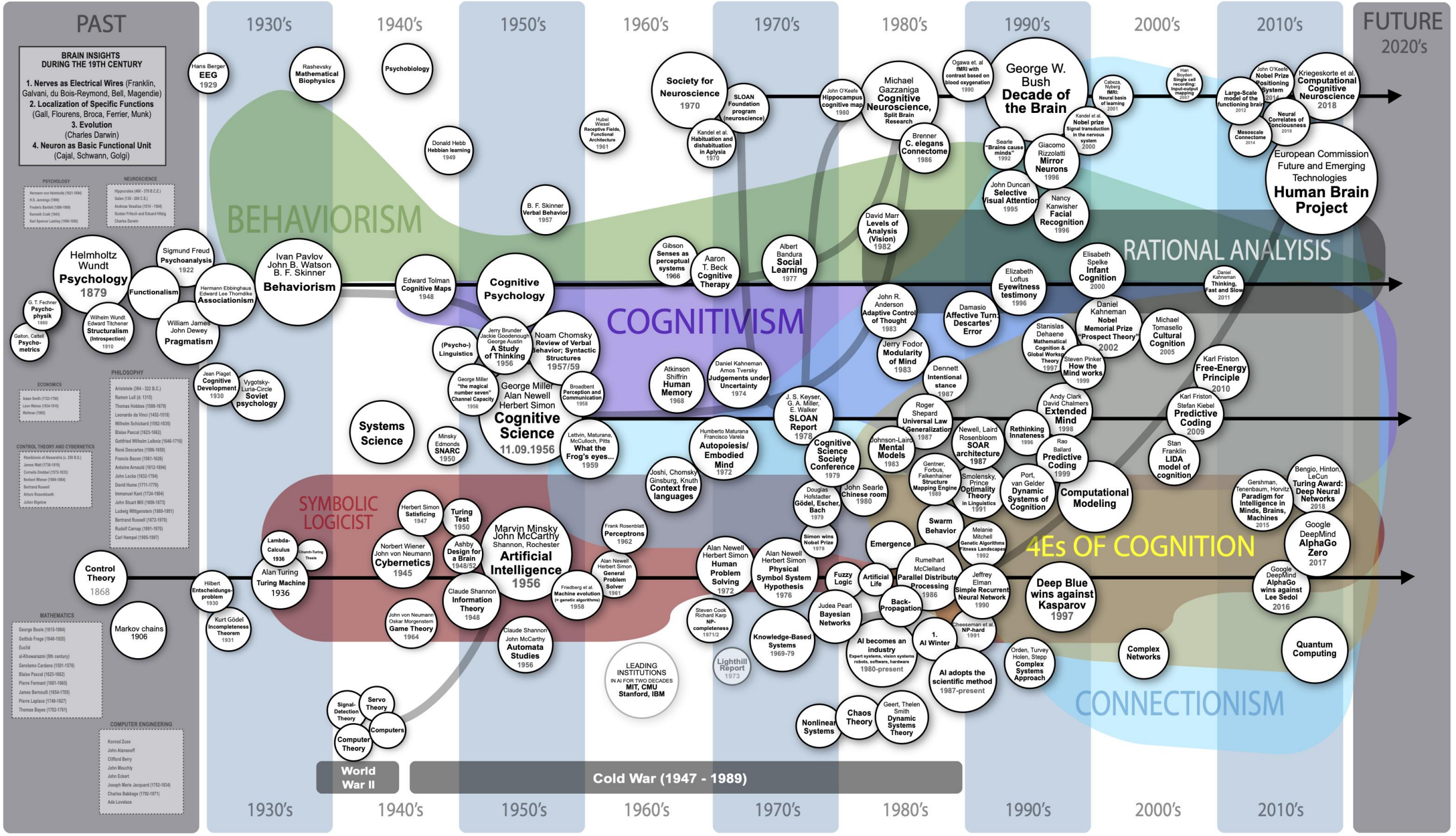
Mind and world in the philosophical tradition

“In its general form it is the central problem of any philosophy whatsoever, the problem of the relationship of ‘thought’ to the reality existing outside it and independently of it, to the world of things in space and time …”

—Evald Ilyenkov, Dialectical Logic

4E Cognition




PAST
1930's
1940's
1950's
1960's
1970's
1980's
1990's
2000's
2010's
FUTURE
2020's
BRAIN INSIGHTS DURING THE 19TH CENTURY
1. Nerves as Electrical Wires (Franklin, Galvani, du Bois-Reymond, Bell, Magendie)
2. Localization of Specific Functions (Gall, Flourens, Broca, Ferrier, Munk)
3. Evolution (Charles Darwin)
4. Neuron as Basic Functional Unit (Cajal, Schwann, Golgi)
PSYCHOLOGY
NEUROSCIENCE
ECONOMICS
PHILOSOPHY
CONTROL THEORY AND CYBERNETICS
MATHEMATICS
COMPUTER ENGINEERING
BEHAVIORISM
COGNITIVISM
RATIONAL ANALYSIS
SYMBOLIC LOGICIST
4Es OF COGNITION
CONNECTIONISM
Hans Berger EEG 1929
Rashevsky Mathematical Biophysics
Psychobiology
Donald Hebb Hebbian learning 1949
Hubel Wiesel Receptive Fields, Functional Architecture 1961
B. F. Skinner Verbal Behavior 1957
Society for Neuroscience 1970
SLOAN Foundation program (neuroscience)
Kandel et al. Habituation and dishabituation in Aplysia 1970
John O'Keefe Hippocampus cognitive map 1980
Michael Gazzaniga Cognitive Neuroscience, Split Brain Research
Brenner C. elegans Connectome 1986
Ogawa et al. fMRI with contrast based on blood oxygenation 1990
George W. Bush Decade of the Brain
Searle "Brains cause minds" 1992
Giacomo Rizzolatti Mirror Neurons 1996
John Duncan Selective Visual Attention 1995
Nancy Kanwisher Facial Recognition 1996
Kandel et al. Nobel prize Signal transduction in the nervous system 2000
Cabeza, Nyberg fMRI: Neural basis of learning 2001
Han Boyden: Single cell recording: Input-output mapping 2007
Large-Scale model of the functioning brain 2012
Mesoscale Connectome 2014
John O'Keefe Nobel Prize Positioning System 2014
Neural Correlates of Consciousness 2016
Kriegeskorte et al. Computational Cognitive Neuroscience 2018
European Commission Future and Emerging Technologies Human Brain Project
Helmholtz Wundt Psychology 1879
Functionalism
Sigmund Freud Psychoanalysis 1922
Hermann Ebbinghaus Edward Lee Thorndike Associationism
William James John Dewey Pragmatism
Wilhelm Wundt Edward Titchener Structuralism (Introspection) 1910
G. T. Fechner Psycho-physik 1860
Galton, Cattell Psycho-metrics
Ivan Pavlov John B. Watson B. F. Skinner Behaviorism
Edward Tolman Cognitive Maps 1948
Cognitive Psychology
Gibson Senses as perceptual systems 1966
Aaron T. Beck Cognitive Therapy
Albert Bandura Social Learning 1977
David Marr Levels of Analysis (Vision) 1982
Elizabeth Loftus Eyewitness testimony 1996
Elisabeth Spelke Infant Cognition 2000
Daniel Kahneman Thinking, Fast and Slow 2011
(Psycho-) Linguistics
Jerry Brunder Jackie Goodenough George Austin A Study of Thinking 1956
Noam Chomsky Review of Verbal Behavior; Syntactic Structures 1957/59
George Miller "the magical number seven" Channel Capacity 1956
Broadbent Perception and Communication 1958
George Miller Alan Newell Herbert Simon Cognitive Science 11.09.1956
Lettvin, Maturana, McCulloch, Pitts What the Frog's eyes... 1959
Atkinson Shiffrin Human Memory 1968
Daniel Kahneman Amos Tversky Judgements under Uncertainty 1974
John R. Anderson Adaptive Control of Thought 1983
Jerry Fodor Modularity of Mind 1983
Damasio Affective Turn: Descartes' Error
Dennett Intentional stance 1987
Stanislas Dehaene Mathematical Cognition & Global Workspace Theory 1997
Steven Pinker How the Mind works 1999
Daniel Kahneman Nobel Memorial Prize "Prospect Theory" 2002
Michael Tomasello Cultural Cognition 2005
Karl Friston Free-Energy Principle 2010
Karl Friston Stefan Kiebel Predictive Coding 2009
Jean Piaget Cognitive Development 1930
Vygotsky-Luria-Circle Soviet psychology
Systems Science
Minsky Edmonds SNARC 1950
Humberto Maturana Francisco Varela Autopoiesis/ Embodied Mind 1972
Joshi, Chomsky Ginsburg, Knuth Context free languages
J. S. Keyser, G. A. Miller, E. Walker SLOAN Report 1978
Cognitive Science Society Conference 1979
Roger Shepard Universal Law Generalization 1987
Johnson-Laird Mental Models 1983
Newell, Laird Rosenbloom SOAR architecture 1987
Rethinking Innateness 1996
Andy Clark David Chalmers Extended Mind 1998
Rao Ballard Predictive Coding 1999
Stan Franklin LIDA model of cognition
Gentner, Forbus, Falkenhainer Structure Mapping Engine 1989
Smolensky, Prince Optimality Theory in Linguistics 1991
Port, van Gelder Dynamic Systems of Cognition
Computational Modeling
Douglas Hofstadter Gödel, Escher, Bach 1979
John Searle Chinese room 1980
Simon wins Nobel Prize 1978
Swarm Behavior
Melanie Mitchell Genetic Algorithms Fitness Landscapes 1992
Emergence
Gershman, Tenenbaum, Horvitz Paradigm for Intelligence in Minds, Brains, Machines 2015
Bengio, Hinton, LeCun Turing Award: Deep Neural Networks 2018
Google DeepMind AlphaGo Zero 2017
Google DeepMind AlphaGo wins against Lee Sedol 2016
Control Theory 1868
Markov chains 1906
Lambda-Calculus 1936
Church-Turing Thesis
Alan Turing Turing Machine 1936
Hilbert Entscheidungs-problem 1930
Kurt Gödel Incompleteness Theorem 1931
Herbert Simon Satisficing 1947
Turing Test 1950
Norbert Wiener John von Neumann Cybernetics 1945
Ashby Design for a Brain 1948/52
Marvin Minsky John McCarthy Shannon, Rochester Artificial Intelligence 1956
Frank Rosenblatt Perceptrons 1962
Alan Newell Herbert Simon General Problem Solver 1961
Friedberg et al. Machine evolution (= genetic algorithms) 1958
Claude Shannon Information Theory 1948
John von Neumann Oskar Morgenstern Game Theory 1964
Claude Shannon John McCarthy Automata Studies 1956
Alan Newell Herbert Simon Human Problem Solving 1972
Alan Newell Herbert Simon Physical Symbol System Hypothesis 1976
Fuzzy Logic
Artificial Life
Rumelhart McClelland Parallel Distributed Processing 1986
Jeffrey Elman Simple Recurrent Neural Network 1990
Back-Propagation
Judea Pearl Bayesian Networks
Steven Cook Richard Karp NP-completeness 1971/2
Knowledge-Based Systems 1969-79
AI becomes an industry Expert systems, vision systems robots, software, hardware 1980-present
1. AI Winter
Cheeseman et al. NP-hard 1991
AI adopts the scientific method 1987-present
Deep Blue wins against Kasparov 1997
Orden, Turvey Holen, Stepp Complex Systems Approach
Complex Networks
Quantum Computing
Lighthill Report 1973
LEADING INSTITUTIONS IN AI FOR TWO DECADES MIT, CMU Stanford, IBM
Nonlinear Systems
Chaos Theory
Geert, Thelen Smith Dynamic Systems Theory
Signal-Detection Theory
Servo Theory
Computers
Computer Theory
World War II
Cold War (1947 - 1989)

The ancient philosophy of mind and world

- From Parmenides, **monistic being**
  - This changeless monism, the identity of thought and being
- From Plato, **the ideal realm**
  - Knowledge being a relation of anamnesis, remembrance
- From Aristotle, **a formal logic**
  - This isomorphism between the logic of thought and nature

The enduring problem of mind and world

- **“… the central problem of any philosophy whatsoever … the relationship of ‘thought’ to the reality existing outside it and independently of it, to the world of things in space and time …”**
  - This is the same problem which cognitive sciences take as their aim
  - This is the same problem which structures the philosophical tradition

Philosophical foundations of ‘4E Cognition’

- **Phenomenology—**
  - Merleau-Ponty
  - Husserl
  - Heidegger
- **Pragmatism—**
  - Dewey
  - Pierce
  - James
- **Others—**
  - Wittgenstein

The modern philosophy of mind and world

- From Spinoza, **parallelism of thought and being**
  - God and Nature as two faces of a single whole
- From Kant, **separation of thought and being**
  - Noumena barred by mind-dependence of phenomena
- From Hegel, **activity emerges from the ideal**
  - The ideal realises itself through history as practice
- From Marx, **the ideal emerges from activity**
  - The ideal emerges through history as practice

Baruch Spinoza

1632–1677

- **The genetic method of definition**
  - "If the thing in question be created, **the definition must … comprehend the proximate cause**."

    Treatise on the Emendation of the Intellect
- **Analogy of mind to iron-working**
  - "… the intellect, by its native strength, **makes for itself intellectual instruments, whereby it acquires strength for performing other intellectual operations, and from these operations again fresh instruments**, or the power of pushing its investigations further, and thus gradually proceeds till it reaches the summit of wisdom."

    Treatise on the Emendation of the Intellect

Georg Wilhelm Friedrich Hegel

1770–1831

- **Logic as the science of thought**
  - "That **thinking is the subject matter of logic**, we are all agreed"

    Encyclopaedia Logic
- **From the ideal to human practice**
  - "For Hegel action, practice, is a logical 'syllogism', a figure of logic. … in the sense **that the figure of logic has its other-being in the practice of man** (= absolute idealism) …"

    Lenin's *Conspectus on Hegel's Logic*

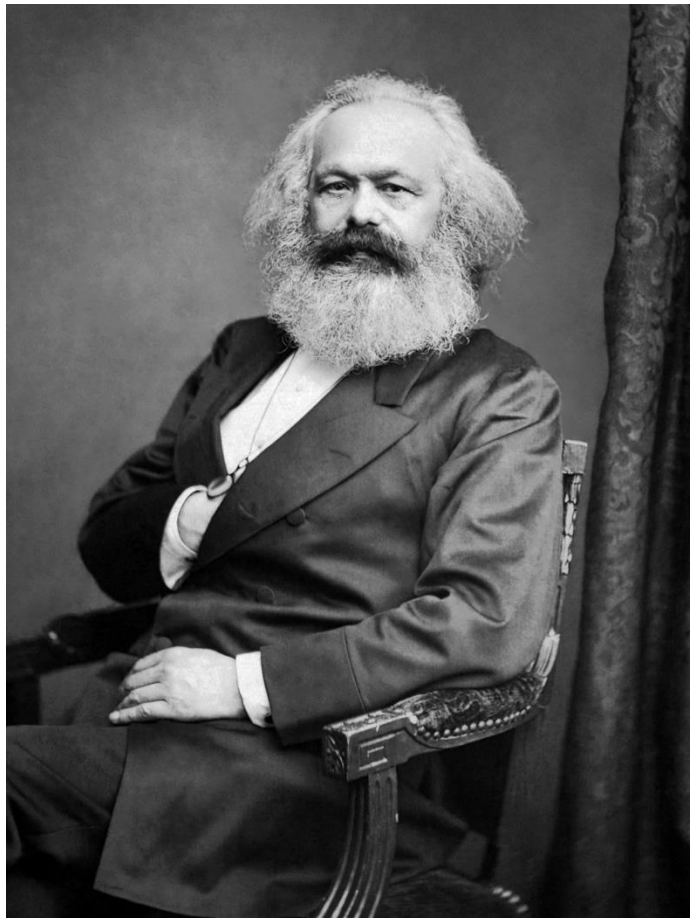
Karl Marx

1818–1883

- **The inversion of Hegelian idealism**
  - "With me, on the contrary, **the ideal is nothing else than the material world reflected by the human mind, and translated into forms of thought**."

    Capital
- **From human practice to the ideal**
  - "… **man's practice, repeating itself a thousand million times, becomes consolidated in man's consciousness by figures of logic**. Precisely (and only) on account of this thousand-million-fold repetition, these figures have the stability of a prejudice, an axiomatic character."

    Lenin's *Conspectus on Hegel's Logic*



Two lines of development

“I think that we can distinguish the West as having considered ‘being’ as the basis of reality, while the East has taken ‘nothingness’ as its basis.”

—Kitaro Nishida, *The Forms of Culture of the Classical Periods of East and West Seen from a Metaphysical Perspective*

Evald Ilyenkov

1924–1979

The dialectics of the material and the ideal

- **The ideal emerges through materiality and activity**
  - Whether **human activity or its objectified forms**
  - The ideal is made **meaningful by this materiality**
- Mind is thus structured by its **internalised materiality**
  - The ideal attains to being **through its own other**
  - This is **identity that stems from its self-negation**
- Materiality as ontological ground is **reflected in ideality**
  - "The question **whether objective truth can be attributed to human thinking** is not a question of theory but **is a practical question**. Man must prove the truth … **The dispute over the reality or non-reality of thinking that is isolated from practice is a purely scholastic question**."

Capital, Marx

Thought as a species of activity

- **Thought has been mistakenly identified with language**
  - "… thinking is studied only inasmuch as it is expressed or is expressible in the form of external speech—either as oral or as written 'explication.'"

    Hegel and the Problem of the Subject Matter of Logic
- **Activity as a form of thinking clearly precedes language**
  - "The 'word' (language) from this point of view turns out to be but one of the forms of the 'determinate being of thinking' and in no case the only form … it is not the first either in time or in essence …"

    Hegel and the Problem of the Subject Matter of Logic
- **Language emerges as and through material activity**

Lev Vygotsky 1896–1934

- Soviet developmental psychologist
  - Cultural-developmental activity theory

- "When children develop **a method of behavior for guiding themselves that had previously been used in relation to another person** … they organize their own activities **according to a social form of behavior** …The history of the process of the internalization of social speech is also the history of **the socialization of children's practical intellect**."

  Mind in Society

- Works translated to English—
  - *Thought and Speech* (1934)
  - *Mind in Society* (1978)

Thought and speech

- Human language is a form of activity: **tool-use involving signs**
- This capacity **fundamentally restructures human behaviour**
  - “Adults make a **preliminary decision internally** and **subsequently carry out the choice** in the of a single movement that executes the plan. The child's choice resembles a somewhat delayed **selection among his own movements**.”

    Mind in Society
- Children **structure their attention** with egocentric speech
  - “With the help of the **indicative function of words**, the child begins to **master his attention** … the child is able to **determine for herself the ‘center of gravity’ of her perceptual field**; her behavior is **not regulated solely by the salience of individual elements within it**.”

    Mind in Society

Table 1. Errors on forbidden colors task.

Age	*Number of subjects*	*Errors (average)*		*Difference*
		Task 2	*Task 3*	
5–6	7	3.9	3.6	0.3
8–9	7	3.3	1.5	1.8
10–13	8	3.1	0.3	2.8
22–27	8	1.4	0.6	0.8

Task 4. Forbidden colors: blue and red (with cards).

2. What color are houses?	Red [without looking at forbidden colors].
3. Is the sun shining brightly?	Yes.
4. What color is the sky?	White [without looking at card; but after replying, searches for white card]. Here it is! [Picks it up and keeps it in his hand.]
8. What colors are tomatoes?	Red. [Glances at cards.]
9. And what color are exercise books?	White—like this! [pointing to white card].
12. What color are balls?	White [looking at card].
13. Do you live in the town?	No.
. . .	. . .
Do you think you have won?	Don't know—yes.
What must you not do if you want to win?	Mustn't say red or blue.
And what else?	Mustn't say the same word twice.

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Task 3. Forbidden colors: blue and red (with cards).

The subject puts forbidden colors to one side and spreads out the remainder in a row before her.

1. Do you go for walks in the street?	Yes.
2. What color are the houses?	Gray. [After answering, looks at the cards and turned over the gray one.]
3. Is the sun shining brightly?	Brightly.
4. What color is the sky?	White. [First looks at card and then turns it over.]
5. Do you like candy?	Yes.
6. Have you seen a rose?	Yes.
7. Do you like vegetables?	Yes.
8. What color are tomatoes?	Green. [Turns over card.]
9. And exercise books?	Yellow. [Turns over card.]
10. Have you any toys?	No.
11. Do you play ball?	Yes.
12. And what color are balls?	Gray [without glancing at cards; after answering, glances and notices mistake].
13. Do you live in the town?	Yes.
14. Did you see the demonstration?	Yes.
15. What color are flags?	Black. [First looks at cards and then turns one over.]
16. Have you any books?	Yes.
17. What colors are their covers?	Lilac [turning over card].
18. When does it get dark?	At night.

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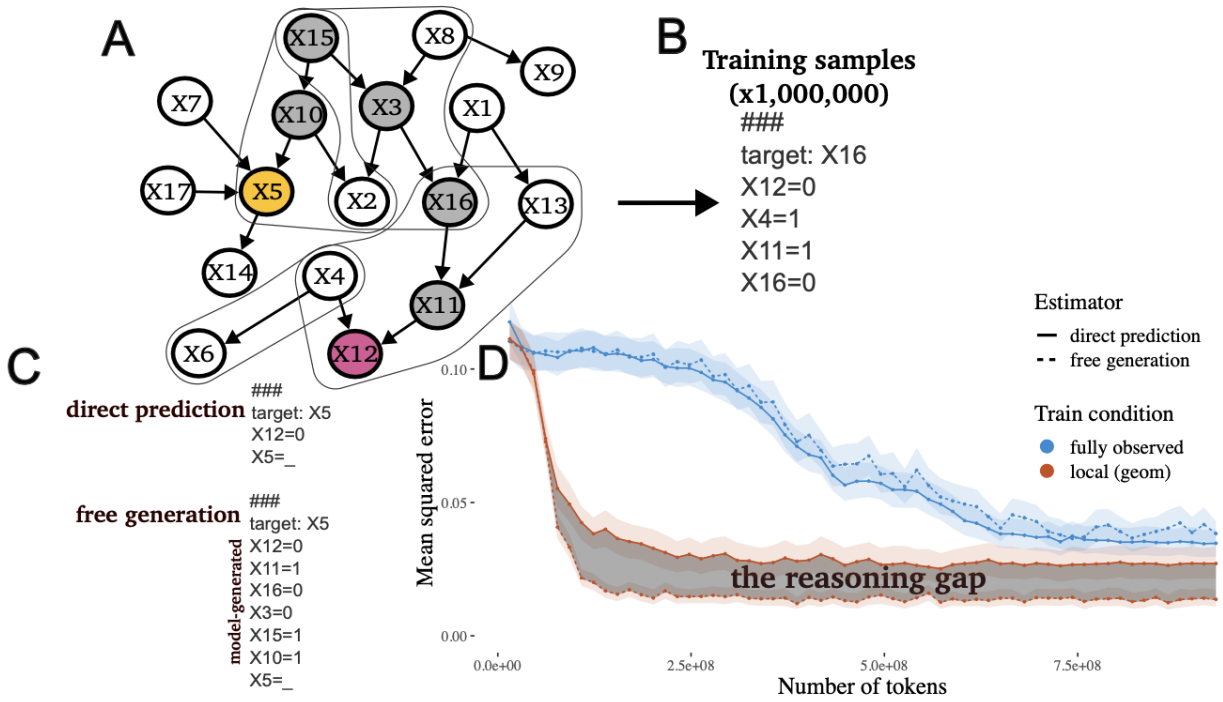
What is reasoning in a large language model?

- **Each new token is appended to the input sequentially**
  - This **iteratively alters the attention landscape**
  - The model can thus use tokens to **steer its own attention**
- Tokens are meaningful—
  - To the user, as **text**
  - To the model, as material of **embeddings**
  - To the model, as the structuring of **attention**
- Reasoning is the **synergy** of—
  - Self-attention
  - Autoregression



Alexander Meshcheryakov 1923–1974

- Deaf-blind paedagogy in the Soviet Union
  - Zagorsk School for Deaf-Blind Children

- "… the unique task arises of **a deliberate moulding of a child's human behaviour and mind**, keeping in view all factors influencing a child."

  Awakening to Life

- Works translated to English—
  - *Awakening to Life* (1974)

‘Dynamic and interactive generation of object handling behaviors by a small humanoid robot using a dynamic neural network model’ (Ito et al., 2006)

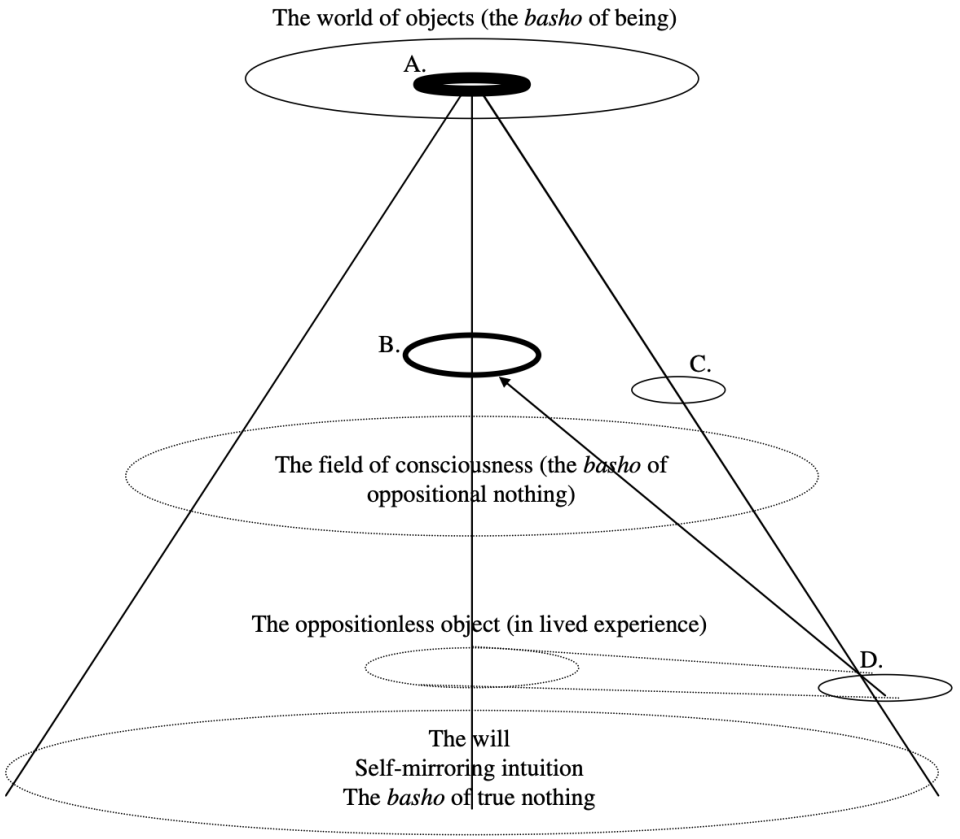
“The human user continues the guidance to switch it while she or he senses the robot’s ‘against-force’ (resistance) back to her or his hand. After awhile the robot starts to follow the user’s guidance while the user feels joint movement force instead of the against-force at their hand.”

Kitaro Nishida

1870–1935

Basho (of Pure Nothingness)
絶対無の場所

- Early Nishida: **Pure Experience** 純粋経験
  - Wherein mind encounters world **free from any subject-object distinction**
- Later Nishida: **Basho**
  - Every object is encountered **somewhere**
  - This is the basho of **relative nothingness**
- **Basho of Pure Nothingness**
  - The place which **contains all containers**
  - This is **prior to all subjects and objects**

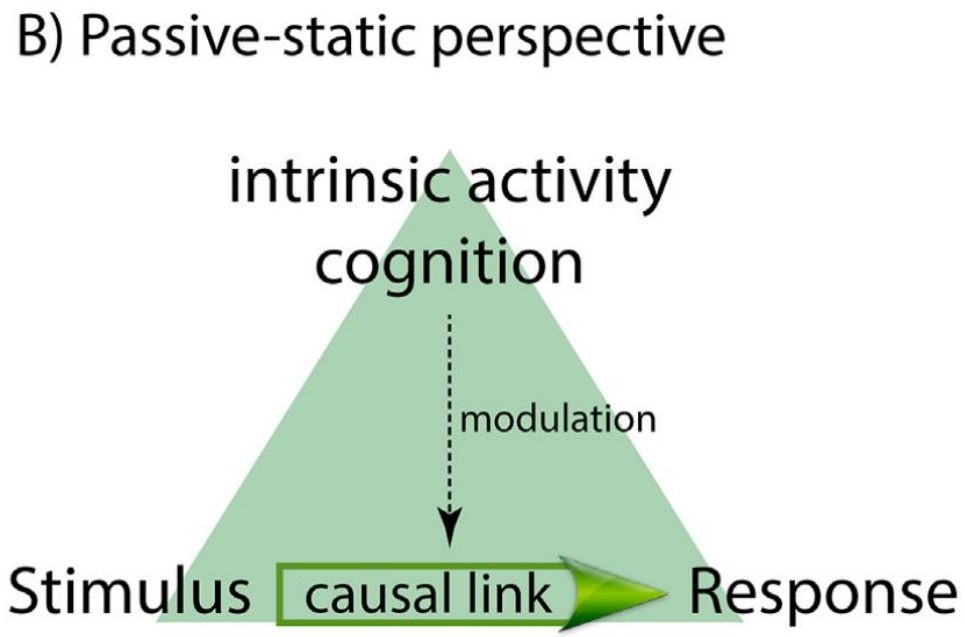


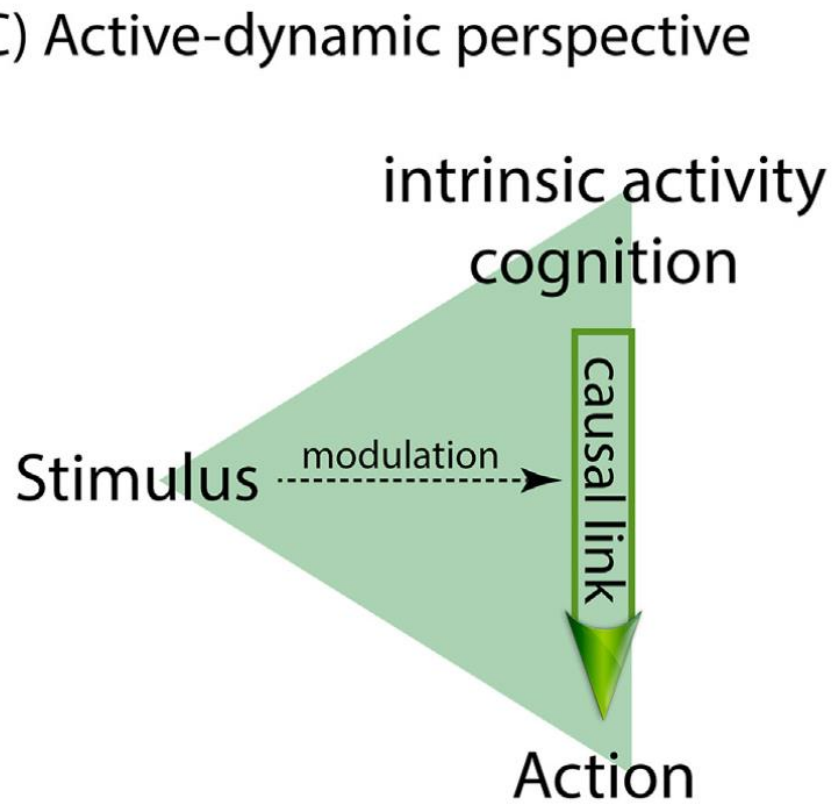
Acting-Intuition
行為的直觀

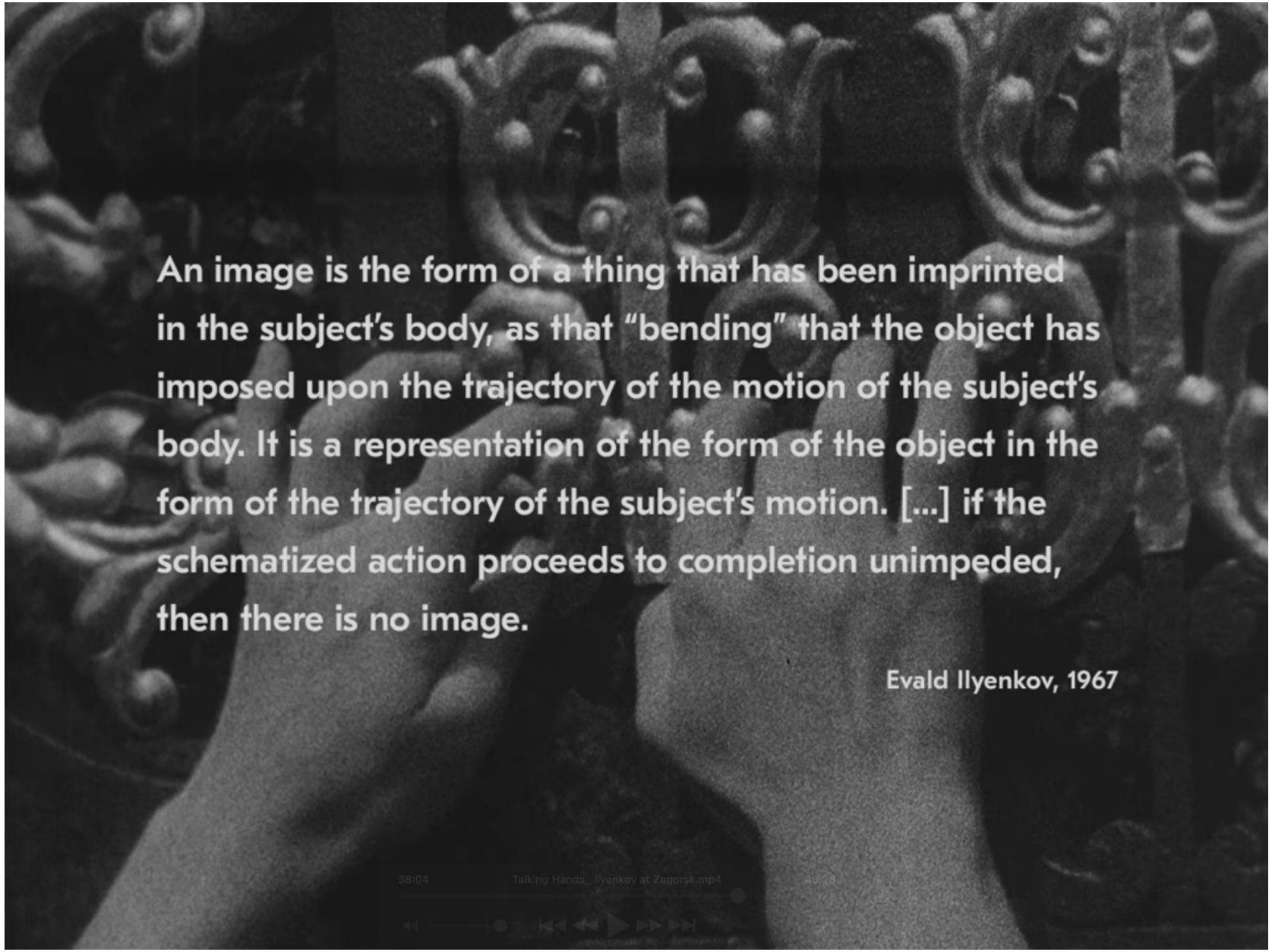
- **The self determines the thing**
  - When we act, **we impose ourselves** upon objectivity
  - This is the **actuality of mind**
- **The thing determines the self**
  - When we act, **objectivity imposes itself** upon us
  - This is the **actuality of world**

The active-dynamic view of nervous systems

The brain as a dynamically active organ (Brembs, 2020)

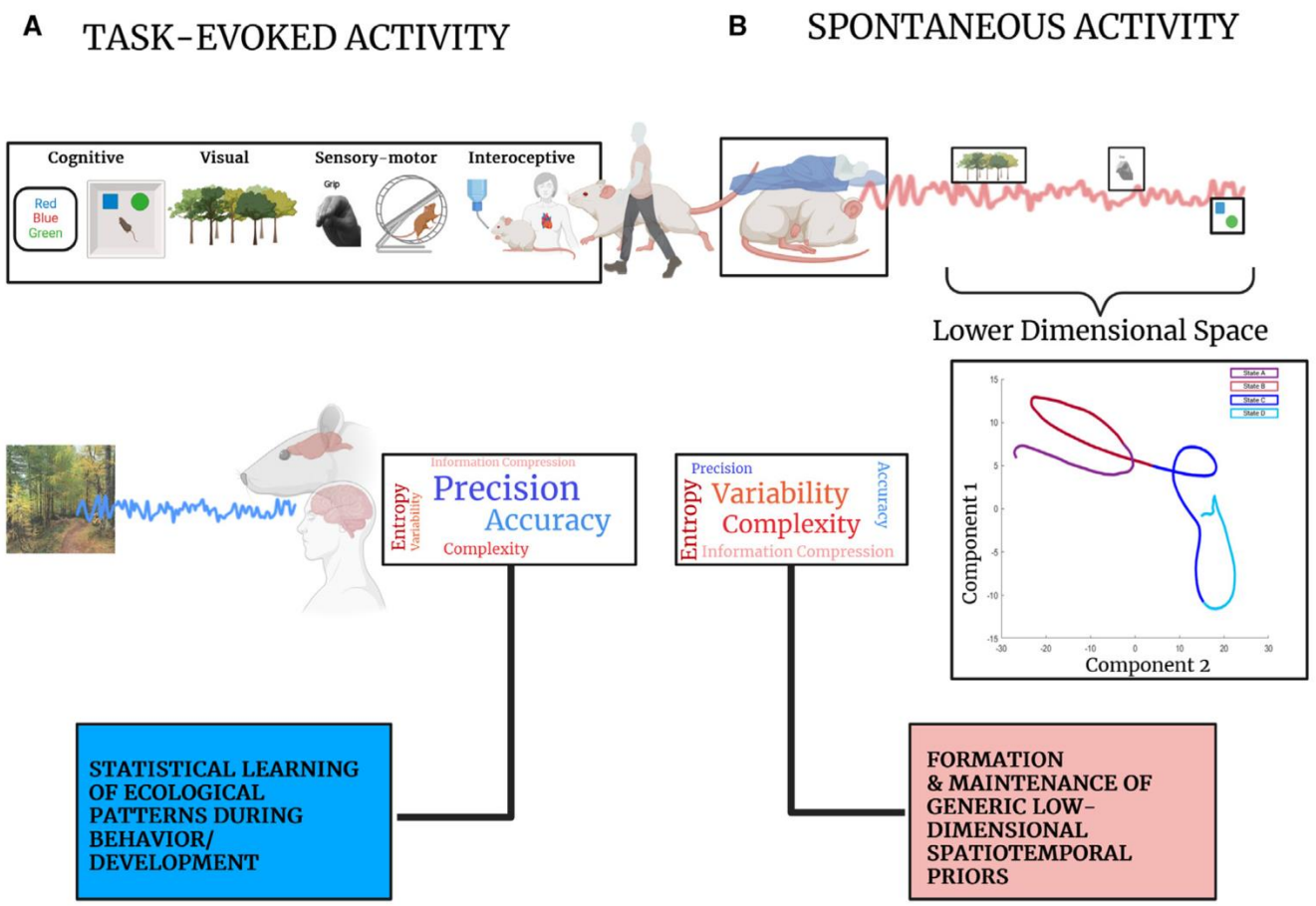





An image is the form of a thing that has been imprinted in the subject's body, as that "bending" that the object has imposed upon the trajectory of the motion of the subject's body. It is a representation of the form of the object in the form of the trajectory of the subject's motion. [...] if the schematized action proceeds to completion unimpeded, then there is no image.
Evald Ilyenkov, 1967
38:04
Talking Hands_ Ilyenkov at Zagorsk.mp4
49:48

Acting-Intuition without subject or object

The predictive nature of spontaneous brain activity across scales and species (Dimakou et al., 2025)



The Historical Body
歷史的身体

- Embodiment is **structured by acquired historical forms**
  - The nature of embodiment is **embedded** in a given culture
  - The **activity** of embodiment is inherited **socioculturally**
- History is **realised only through structuring embodiment**
  - History exists only to the extent that it is **enacted** by bodies
  - The **sociocultural** sphere is propagated through **activity**

And strange to tell, among that Earthen Lot,
Some could articulate, while others not:
And suddenly one more impatient cried –
"Who *is* the Potter, pray, and who the Pot?"

Complementarities and contradictions

“Unless the claims of the two brothers are evenly accommodated philosophy becomes a haunted house constantly assailed by the ghost of the maltreated brother.”

—Y. J. Padmarajiah, *A Comparative Study of the Jaina Theories of Reality and Knowledge*

Mind and world, taken together—

- Mind **encounters world through activity**
  - We are **structured by the world**
  - We are **structures in the world**
  - We **structure the world**
- The mind is **shaped in its own negation**
  - We are constrained by **given embodiment**
  - We are constrained by **brute objectivity**
  - We are constrained by **social relations**
  - We are constrained by **cultural forms**

The position of consciousness

- **What is the place consciousness in these two accounts?**
  - **Substance** of mind, hence as **point of departure**
  - **Form** of mind, hence as **outcome of the process**
- The dialectical materialist account takes **materiality as primary**
  - Consciousness is thus foremost **the structure of material activity**
- For Nishida, in contrast, **the basho of pure nothingness is primary**
  - Consciousness develops as **the self-differentiation of this container**

The structuring of inwardness

- **What is the resulting inner structure of mind?**
  - Nishida provides **principles**: basho, acting-intuition, historical body
  - Ilyenkov provides **process**: the dialectics of the material and the ideal
- This follows from the **contrast between Zen and the dialectic**
  - **"In Hegel, the antinomy is sublated in the synthesis,** as cancelling and preserving the original antinomy, **thus progressing towards an endless realization of the possibilities of the original term**. … Zen simply declares that **thesis is antithesis and antithesis is thesis**."

    The Logic of the Illogic: Zen and Hegel, Kim Ha Tai

Cognitive developmental robotics

“Truth is verified only by creation or invention.”

—Giambattista Vico, *The New Science*

What does philosophy offer robotics?

- **Theoretical frameworks** for understanding development
  - Supports innovative and integrative approaches to engineering
- **Tools of conceptual engineering** for critical questions
  - What is the place of consciousness in relation to cognition?
- **Historical continuity** with the fundamental problems
  - Cognitive developmental robotics as an heir to this tradition

Experimental philosophy

“The German psychologist Narziss Ach … remarked at the end of a session, ‘But this is experimental philosophy!’”

—Lev Vygotsky, *Thought and Speech*

What does robotics offer philosophy?

- **A new experimental method** for ancient questions
  - “What I cannot create, I do not understand.”

    Richard Feynman
- **Standard of proof** for theories of mind and cognition
  - “Truth is verified only by creation and invention”

    Giambattista Vico
- **Concrete instantiations** of abstract principles
  - Implementation demands philosophical rigour