Kognitionspsychologie II: Session 1
Introduction

Rui Mata, FS 2024

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Your instructors

Loreen Tisdall

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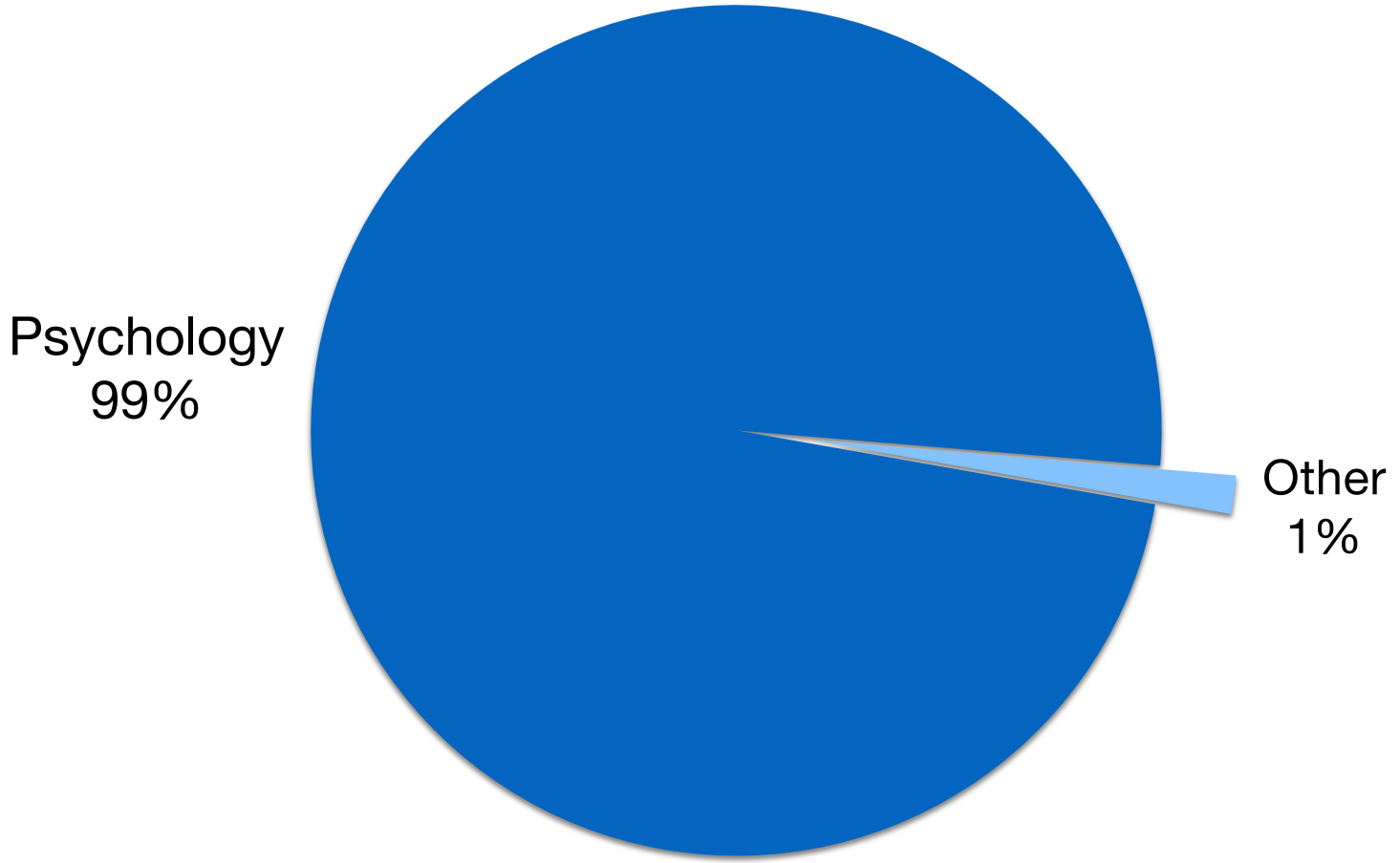
http://cds.unibas.ch

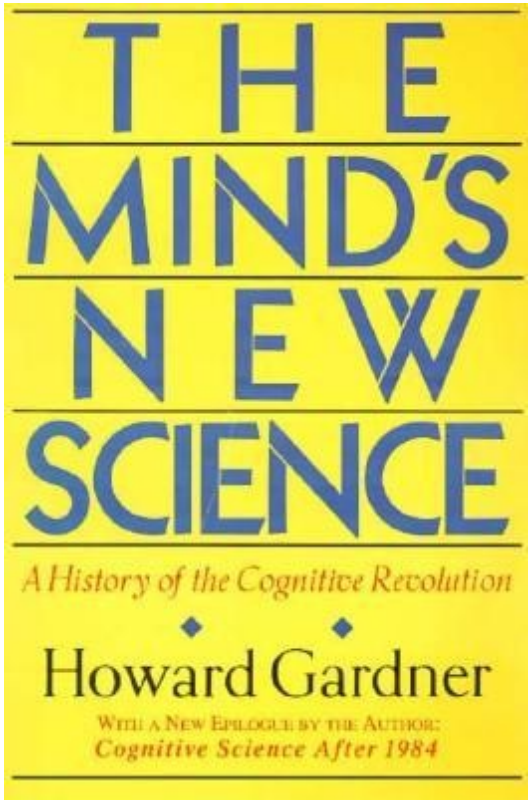
You



Learning Objectives for the Semester

You will…

- learn about central theories and models in key areas of psychology
- become familiarized with common methods used in psychology
- learn about examples of applications of psychology to real-world contexts
- reflect about the need for pluralistic explanations in psychology

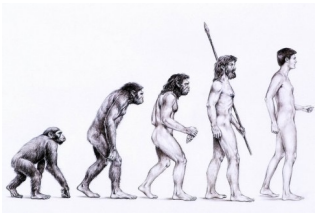
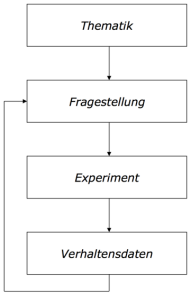
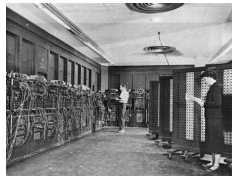
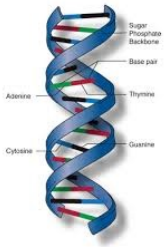
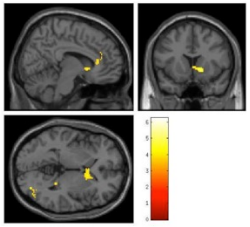
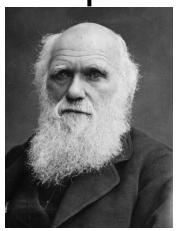


„The safest general characterization of the European philosophical tradition is that it consists of a series of footnotes to Plato“

Alfred North Whitehead

Gardner, H. (1985). *The mind's new science: A history of the cognitive revolution*. New York: Basic Books.

Is there nothing new under the sun?

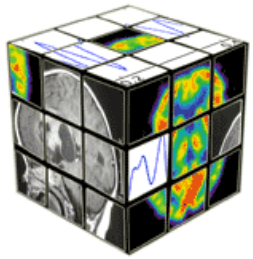
	Evolution	Empirical Method	Information Theory	DNA Structure	fMRI
Example			ENIAC: Electronic Numerical Integrator And Computer 		
Person	 Charles Darwin	 Wilhelm Wundt	 Claude Shannon	 James Watson & Francis Crick + Rosalind Franklin	 Seiji Ogawa
Discipline	Biology	Psychology	Computer Science	Genetics	Medicine
	1838	1879	1948	1953	1992

Learning Objectives for Today

- Place psychology within the Cognitive/Neuro/Affective Sciences
- Discuss pluralistic explanations: Aristotle, Marr, Tinbergen
- Discuss the role of evolutionary explanations in psychology
- Understand the course structure and the syllabus

Psychology and the other sciences…

http://cognitivesciencesociety.org/
(1979)



Cognitive Neuroscience Society

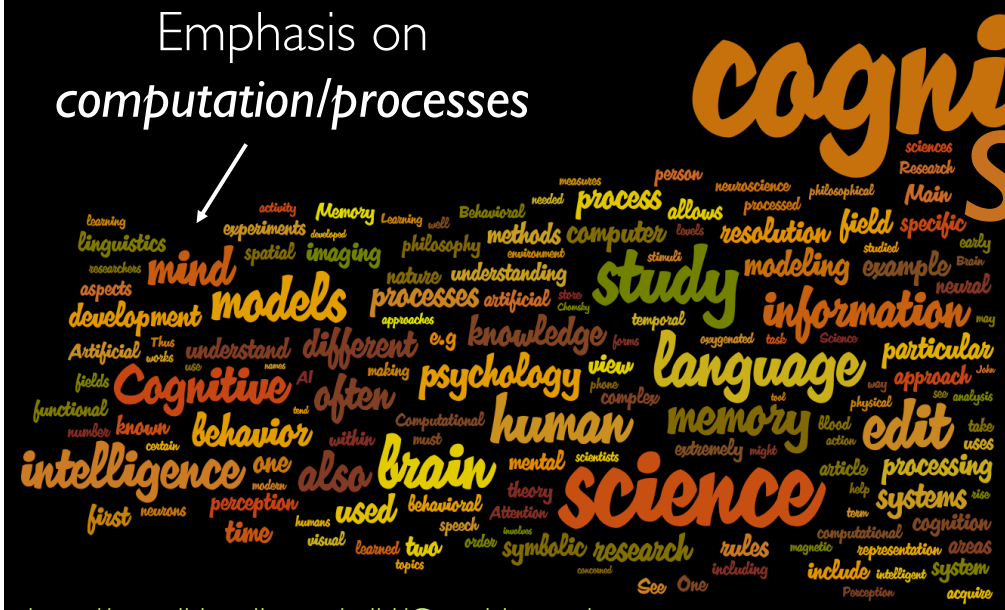
http://www.cogneurosociety.org
(1994)

The Society for Affective Science

http://www.society-for-affective-science.org
(2012)

The formation of societies can be seen as a symptom of attempts to place psychology in contact with a larger set of ideas and research agendas across the last few decades; from a focus on explanations of cognition as representation and computation (Cognitive Science), the role of biological implementation for behavior (Cognitive Neuroscience), to the affective and motivational bases of human behavior (Affective Science).

Emphasis on
computation/processes



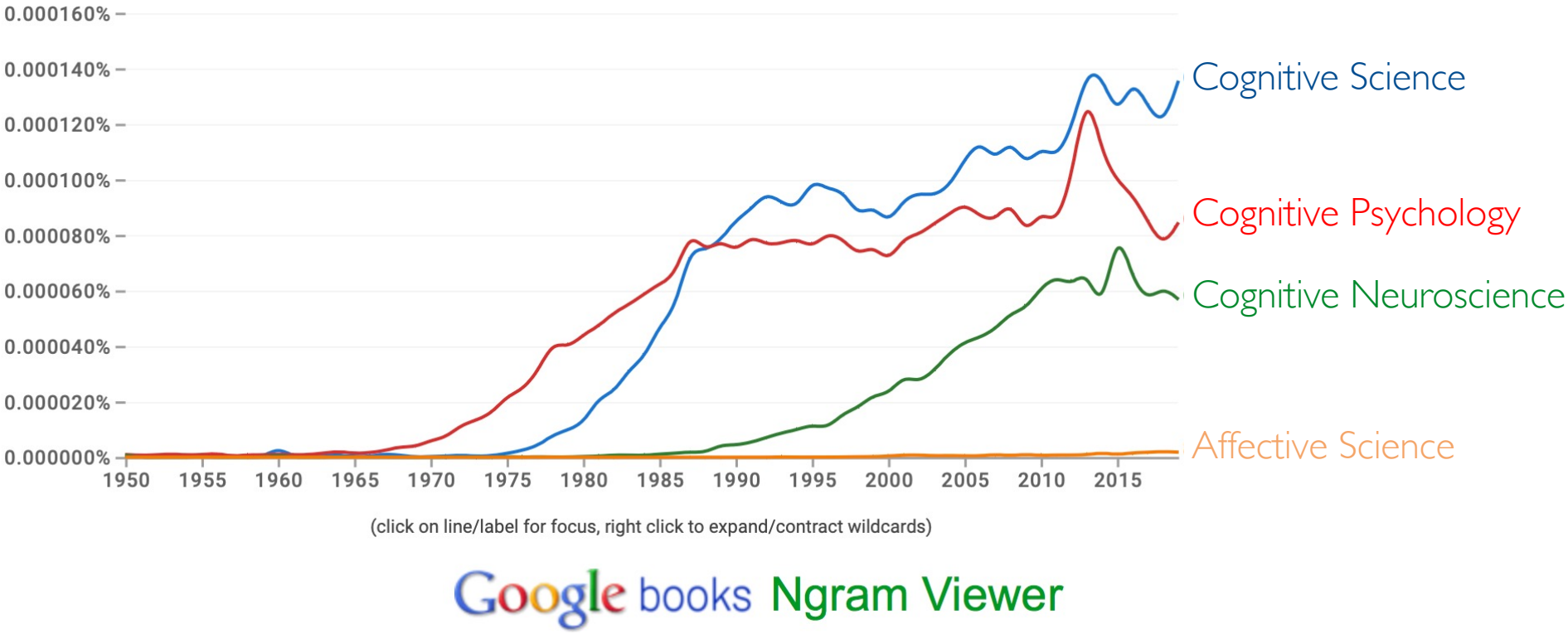
http://en.wikipedia.org/wiki/Cognitive_science

Emphasis on
neural implementation

http://en.wikipedia.org/wiki/Cognitive_neuroscience

Emphasis on *emotion*

http://en.wikipedia.org/wiki/Affective_science



Frequency of use of the terms ***Cognitive Science***, ***Cognitive Psychology***, ***Cognitive Neuroscience***, and ***Affective Science*** in the last ca. 70 years

Pluralistic Explanations

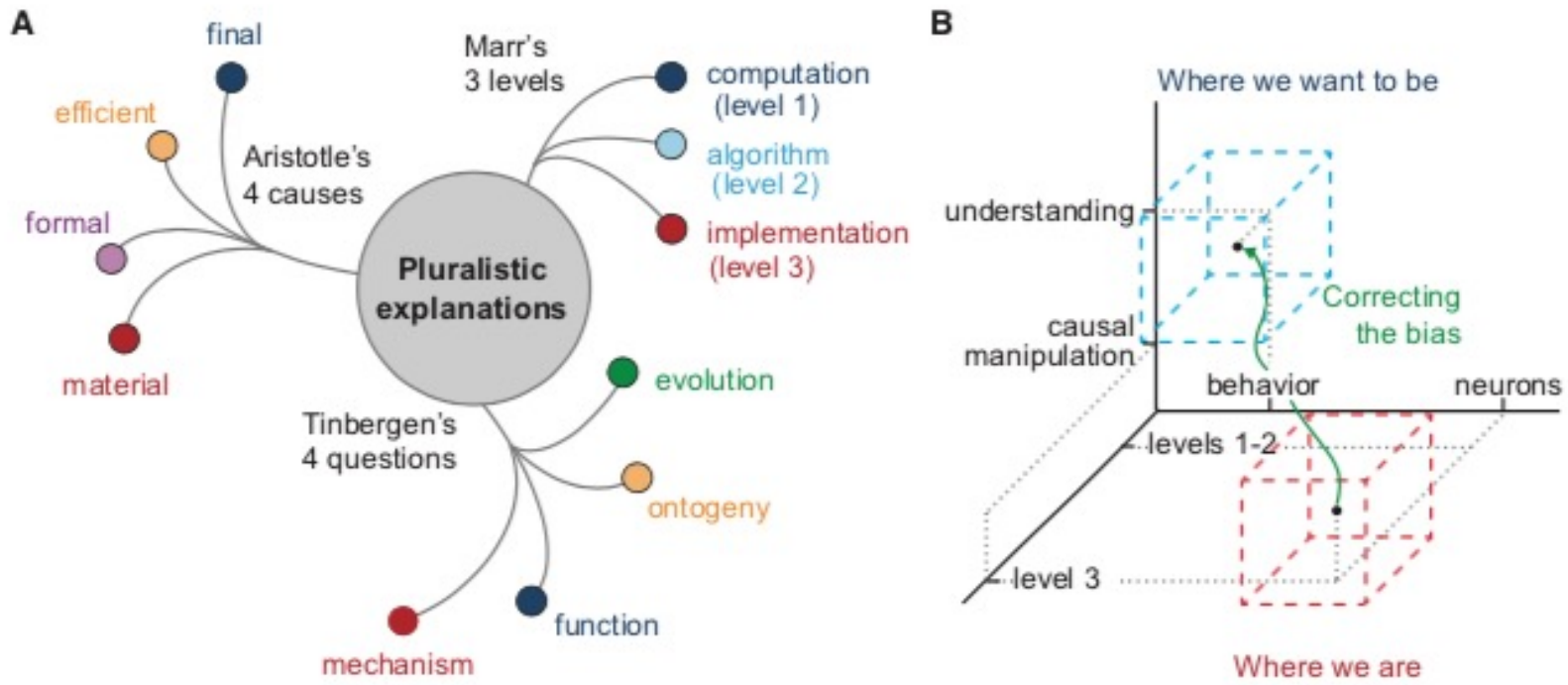


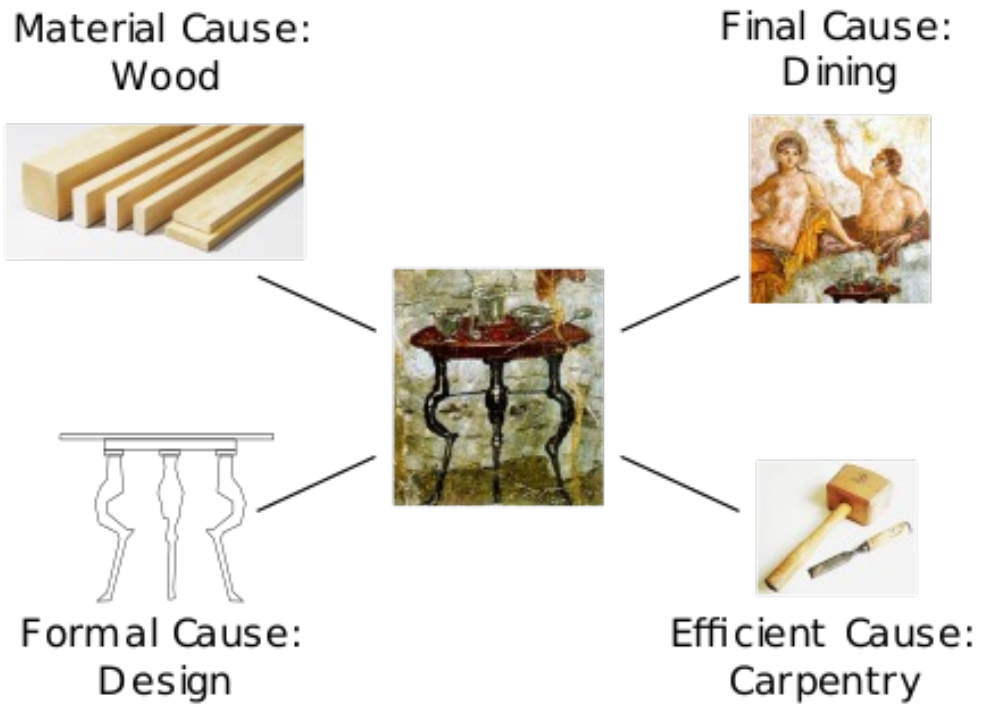
Figure 4. The Future History of Pluralistic Explanation

(A) That understanding of a phenomenon is multidimensional has long been appreciated. Aristotle posited four kinds of explanation: to explain "why" something changes, a polyhedric notion of causality is necessary; one that includes not only the material cause (what it is made out of), but also the other three "whys": formal (what it is to be), efficient (what produces it), and final (what it is for). Tinbergen also devised four questions about behavior: to go beyond its proximate causation (mechanism) to also considering its evolution, development, and real-world function. Marr's three levels are also shown.

(B) Three-dimensional space with axes of understanding-manipulation, behavior-neurons, and Marr's levels. The red box is where we are and the blue is where we should be.

Krakauer, J. W., Ghazanfar, A. A., Gomez-Marin, A., MacIver, M. A., & Poeppel, D. (2017). Neuroscience needs behavior: Correcting a reductionist bias. ***Neuron, 93***(3), 480–490. http://doi.org/10.1016/j.neuron.2016.12.041

Aristotle’s four causes

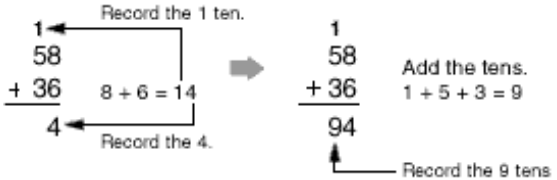


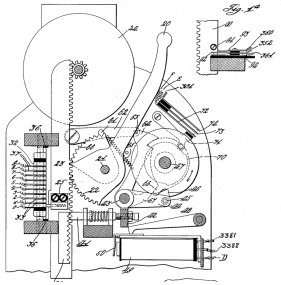
Marr's levels

- ***Computational level***: What is the goal of a given process/computation?
- ***Algorithmic level***: How can a goal be achieved using a particular set of inputs/outputs, which algorithm describes the required transformations?
- ***Implementational level***: How is an algorithm physically implemented (e.g., neural activity)?

Addition

$S_T = Z_1 + \ldots + Z_N$





David Marr (1945-1980)

Studied mathematics and physiology but later worked as a professor of Psychology at MIT. He integrated results from psychology, artificial intelligence, and neurophysiology to produce a new model of vision. He is particularly famous for proposing a three level view of how to understand information processing systems (see left).

Marr, D. C., & Poggio, T. (1977). From understanding computation to understanding neural circuitry. ***Neurosciences Research Program Bulletin, 15***(3), 470–488.

Tinbergen's four questions

Tinbergen argued that there are complementary categories of explanations, involving different kinds and objects of explanation.

FOUR AREAS OF BIOLOGY: FOUR QUESTIONS		Two objects of explanation	
		Developmental/historical A sequence that results in the trait	**Single form** The trait at one slice in time
Two kinds of explanations	**Proximate** Explains how organisms work by describing their mechanisms and their ontogeny	**Ontogeny** **Q: How does the trait develop in individuals?** A: Description of the trait's forms at sequential life stages, and the mechanisms that control development.	**Mechanism** **Q: What is the structure of the trait; how does it work?** A: Description of the trait's anatomy, physiology, regulation, and how the trait works to accomplish a function.
	Evolutionary Explains how a species came to its current form by describing a sequence of forms, and how they were influenced by selection and other evolutionary factors.	**Phylogeny** **Q: What is the phylogenetic history of the trait?** **A:** Description of the history of the trait as reconstructed from its phenotype and genotype precursors	**Adaptive significance** **Q: How have variations in the trait interacted with environments to influence fitness in ways that help to explain the trait's form?** A: Description of how variations in the trait have influenced fitness

Nesse, R. (2013), Tinbergen's four questions, organized: A response to Bateson and Laland. ***Trends in Ecology and Evolution, 28(12),*** 681-682.

Tinbergen, N. (1963) On aims and methods of ethology. ***Z. Tierpsychol, 20***, 410–433.

Nikolaas Tinbergen (1907-1988)

Ethologist, received the Nobel Prize for Medicine in 1973 for "discoveries concerning organization and elicitation of individual and social behaviour patterns". Tinbergen had a large impact on the field of ethology (i.e., the science of animal behavior) with his book ***The Study of Instinct*** (1951), in which he proposed to investigate innate behaviour that is not acquired or changed by learning.

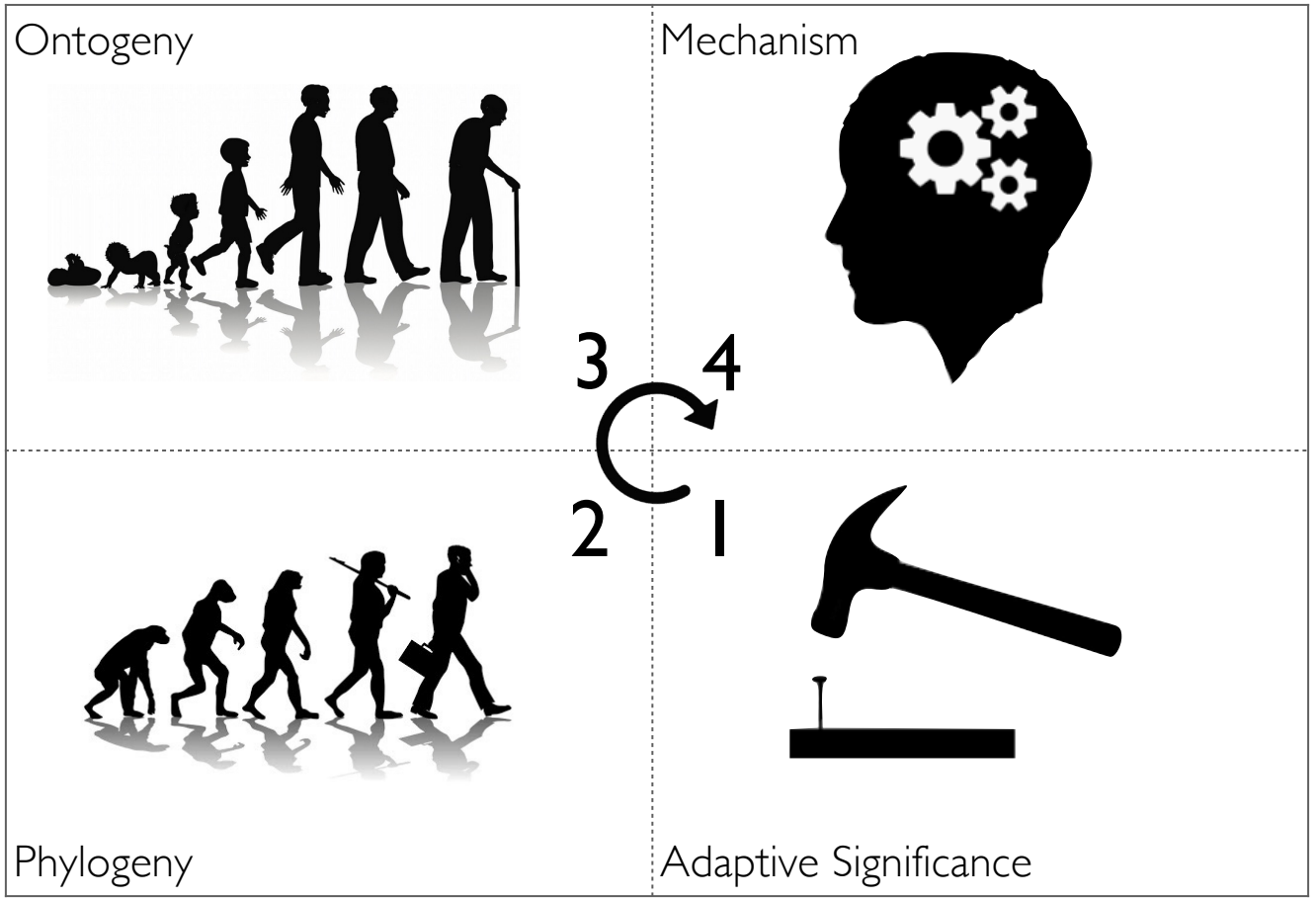
https://en.wikipedia.org/wiki/Tinbergen%27s_four_questions

Marr's Levels vs. Tinbergen's Questions

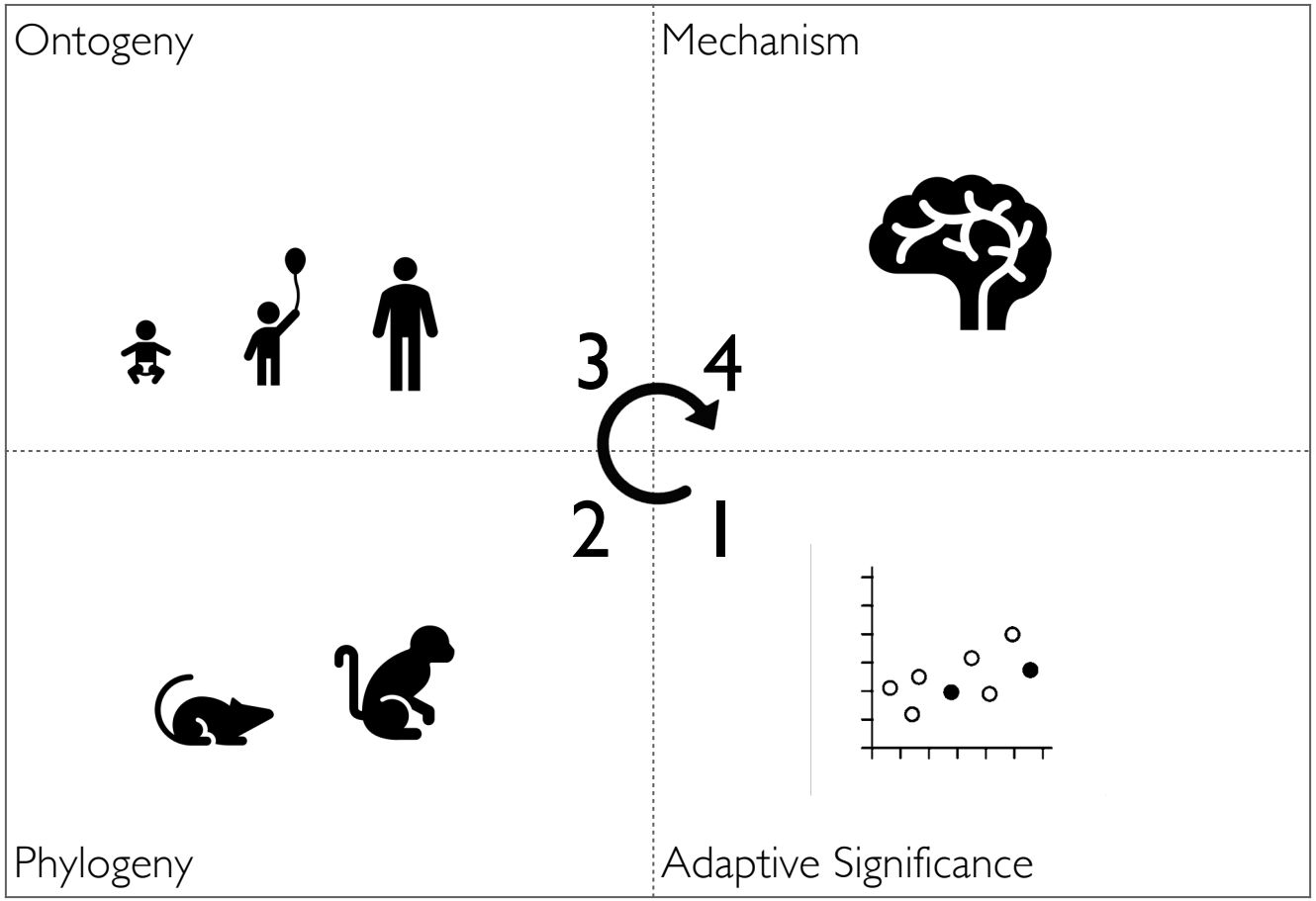
Computational Level
Algorithmic Level
Implementation Level

Ontogeny	**Mechanism**
Phylogeny	**Adaptive Significance**

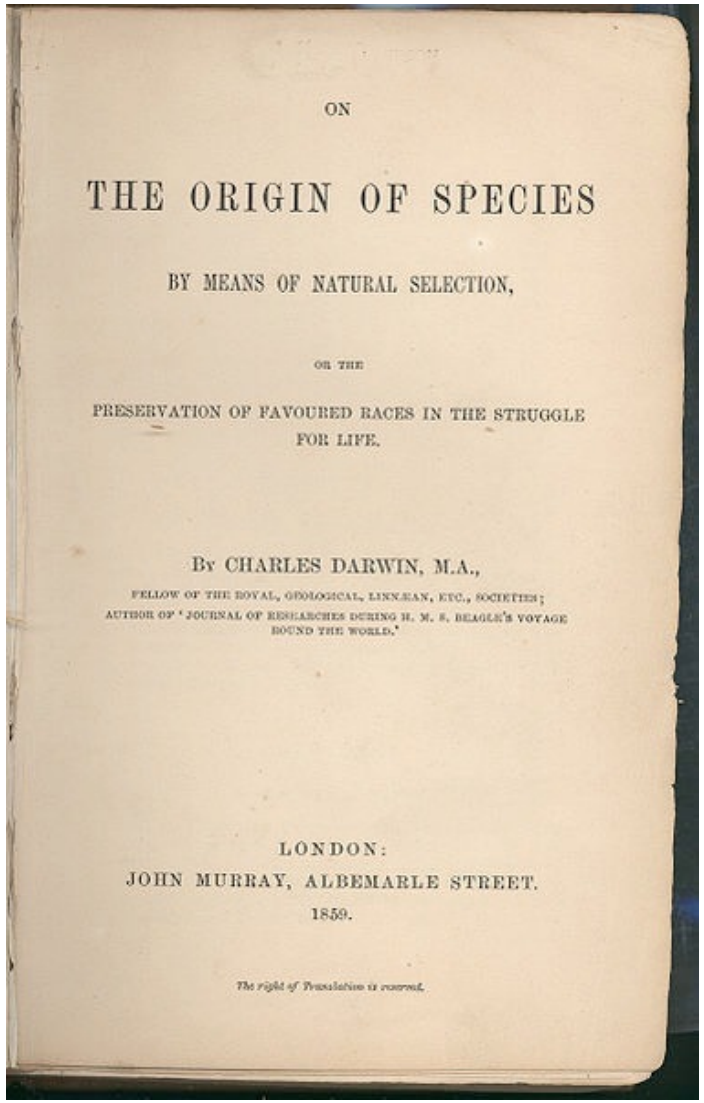
Intelligence



Intelligence



Evolutionary Theory and Psychology



ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNEAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

The right of Translation is reserved.

(1859)

"In the distant future I see open fields for far more important researches. Psychology will be based on a new foundation, that of the necessary acquirement of each mental power and capacity by gradation. Light will be thrown on the origin of man and his history."

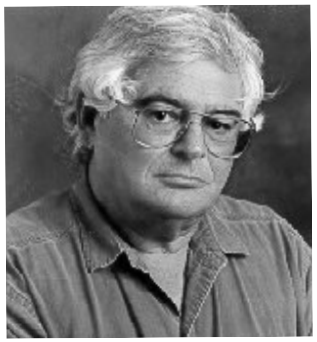
Charles Darwin, ***The Origin of Species***

Modularity

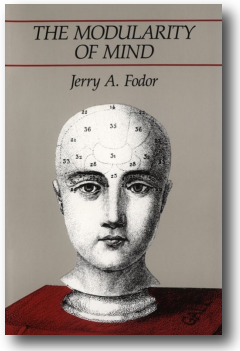
modularity: i.e., the degree to which a system's components may be separated and recombined; in cognitive science, the thesis of modularity of mind holds that the mind is composed of (at least some) independent, domain-specific processing modules.

weak modularity

Modularity applies to perceptual modules, which are informationally encapsulated and provide input to higher-order systems.



Jerry Fodor (1935-2017)

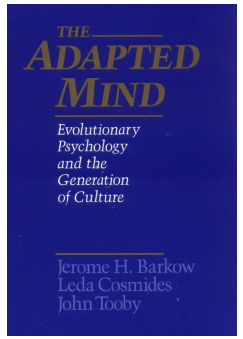


1983

strong modularity

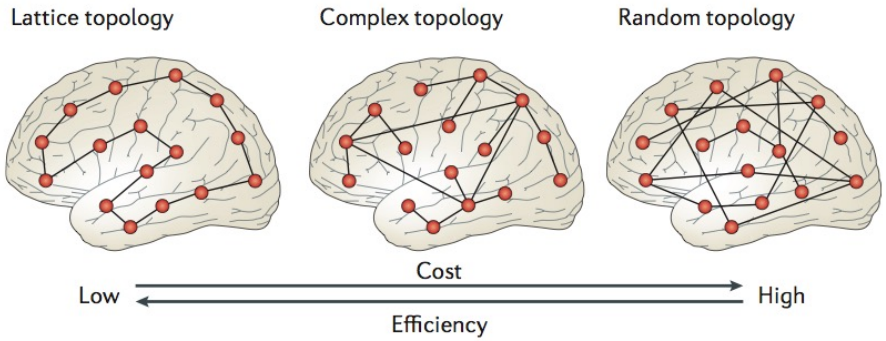
Our cognitive architecture consists of a confederation of hundreds or thousands of domain-specific (function specific) modules designed to solve adaptive problems from our evolution as a species of hunter-gatherers.

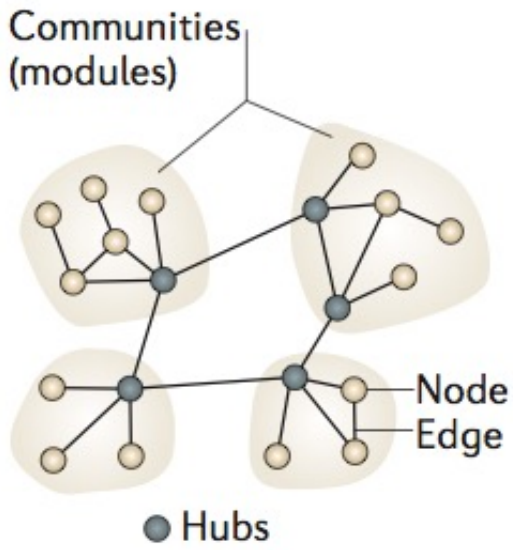
John Tooby (1952-2023)
Leda Cosmides (1957-)



1992

Modularity





Advantages of modular organization:

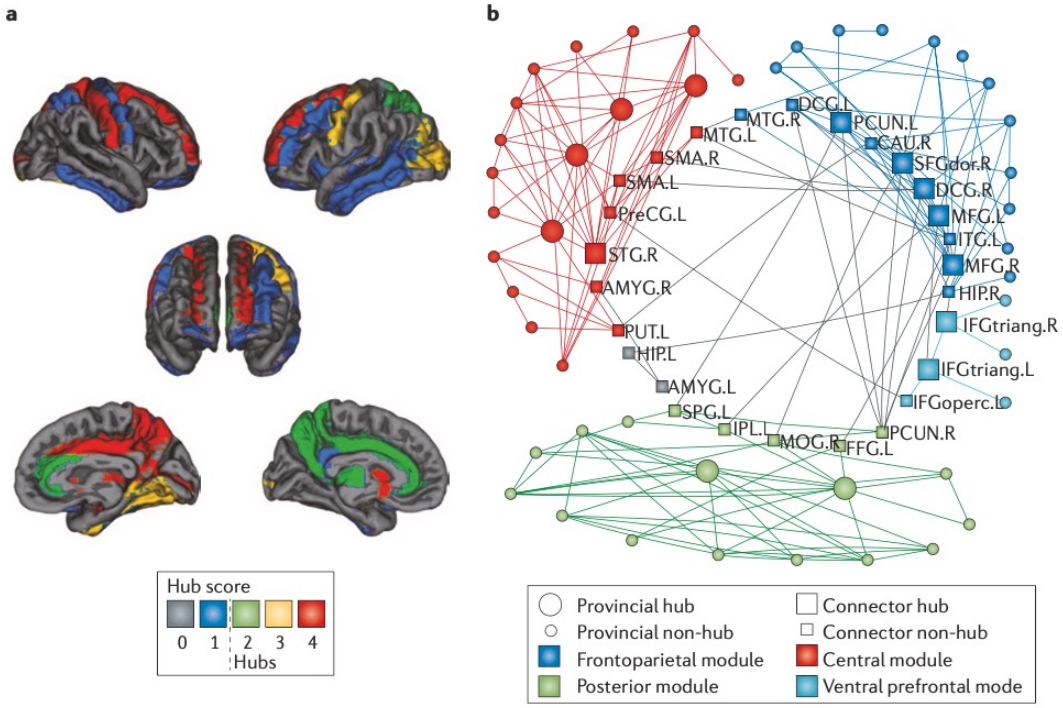
- helps conserve wiring costs and improving the local efficiency of specialized neural computations
- modules offer resilience against dynamic perturbations and small variations in structural connectivity;

Disadvantages of modular organization:

- functional integration between modules requires the addition of high-cost or long-distance axonal projections to interconnect spatially remote brain regions, which gives rise to connector hubs
- Hubs have a high participation index and can serve as a 'bottleneck' in the network.

Bullmore, E. & Sporns, O. (2012). The economy of brain network organization. ***Nature Reviews Neuroscience, 13***(5), 336-349.

Modularity



a | In human brain networks, some regions have more connections to the rest of the network, greater clustering and mediate a greater proportion of the shortest path connections between other regions. Such regions are called 'hubs' and include parts of medial parietal cortex, cingulate cortex and superior frontal cortex, indicated here by their 'hub score' (regions with a hub score of 2 or higher are defined as hubs). **b** | Human brain networks are also modular. Brain regions are colour-coded according to their membership in major modules comprising frontal (dark blue), central (red) and posterior (green) brain regions as well as a smaller module of inferior frontal regions (light blue). The connector hubs, which mediate most of the longer-distance inter-modular connections, are shown as a ring of square markers

Novel neuroimaging methods have increasingly allowed for a better empirical estimation of functional and structural modularity.

Bullmore, E. & Sporns, O. (2012). The economy of brain network organization. ***Nature Reviews Neuroscience, 13***(5), 336-349.

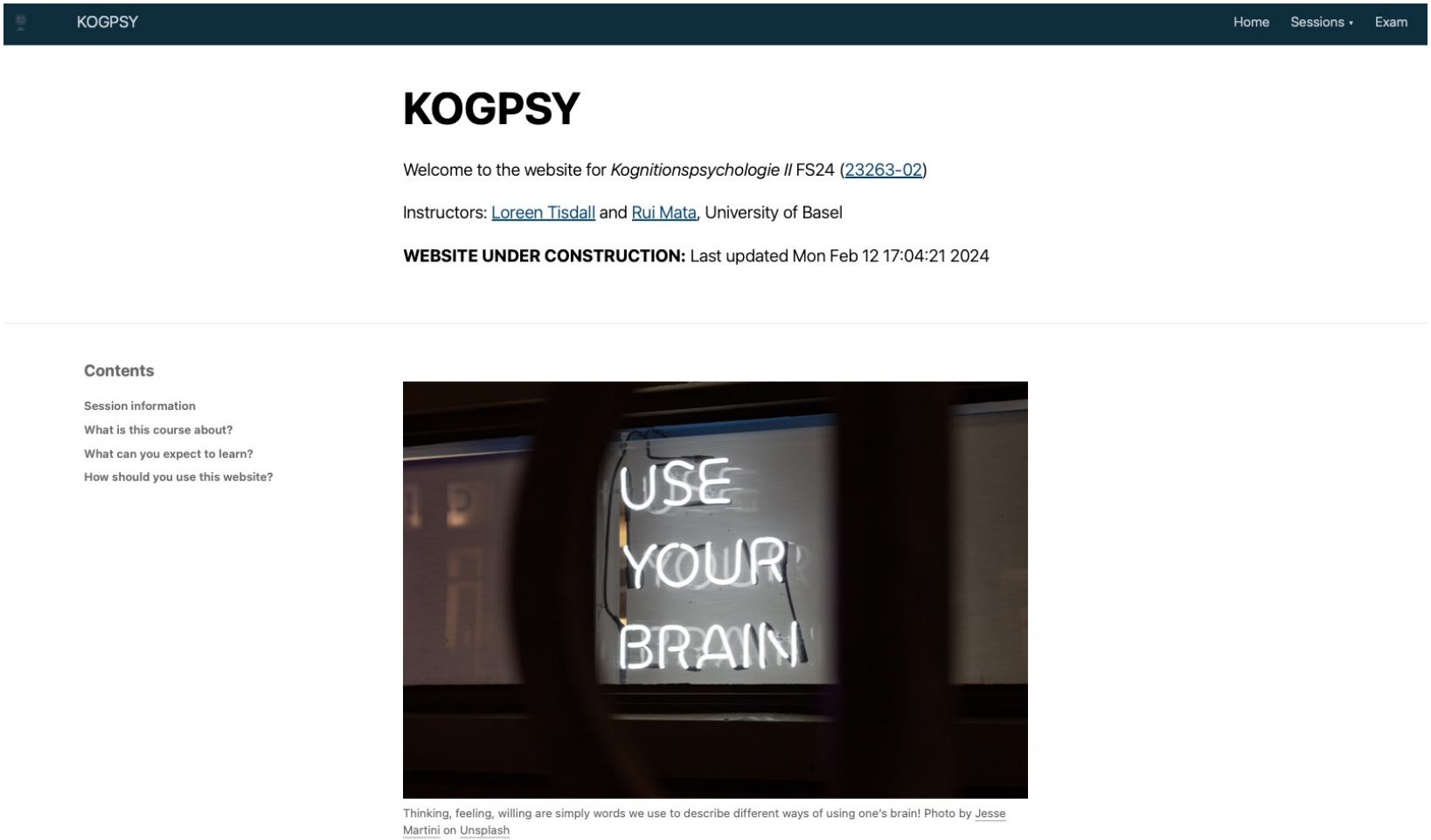
Summary

- **Psychology over time:** historically, psychology has had different goals; since the "cognitive revolution" there has been a focus on understanding cognition (e.g., perception, memory, language) resorting to concepts of representation and computation; more recently, there has been increased focus on biological implementation (cognitive neuroscience) and understanding both cognition and affect/motivation (affective science).

- **Pluralistic explanations**: philosophy (Aristotle) and the natural sciences (Marr, Tinbergen) have accepted that natural phenomena are multi-faceted and their understanding requires various forms of explanation; today, different but somewhat related views on relevant forms of explanation coexist (Marr's levels: computational, algorithmic, implementation; Tinbergen's questions: ontogeny, mechanism, phylogeny, adaptive significance).

- **Evolution**: evolutionary principles may be helpful to understand organizational principles of human psychology – including the idea of **modularity of mind** (i.e., the idea that a cognitive system is composed of somewhat independent, specialized modules); modern methods allow for more precise empirical answers concerning the organization of human psychology.

Course website



https://matarui.github.io/kogpsy/