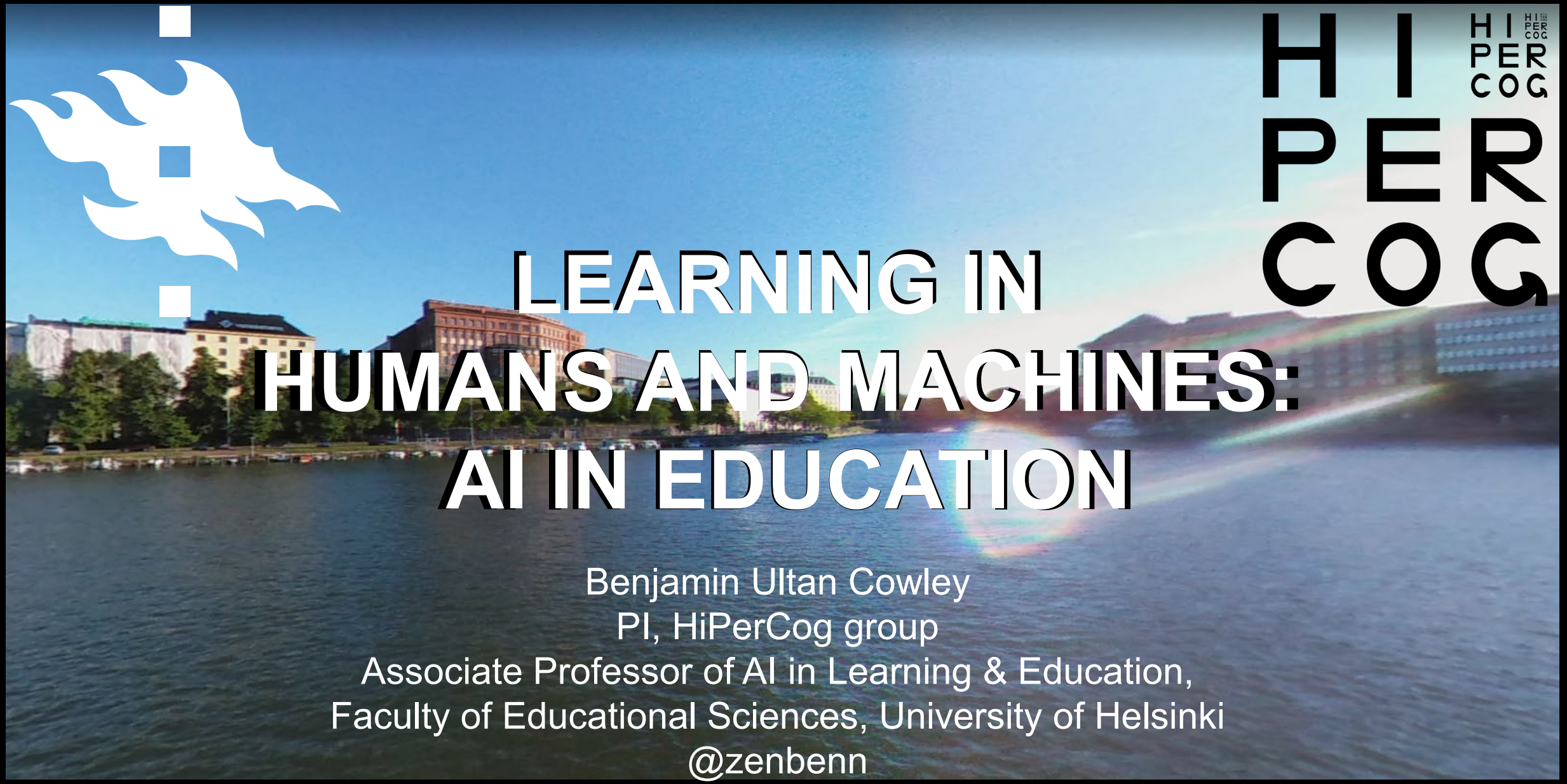
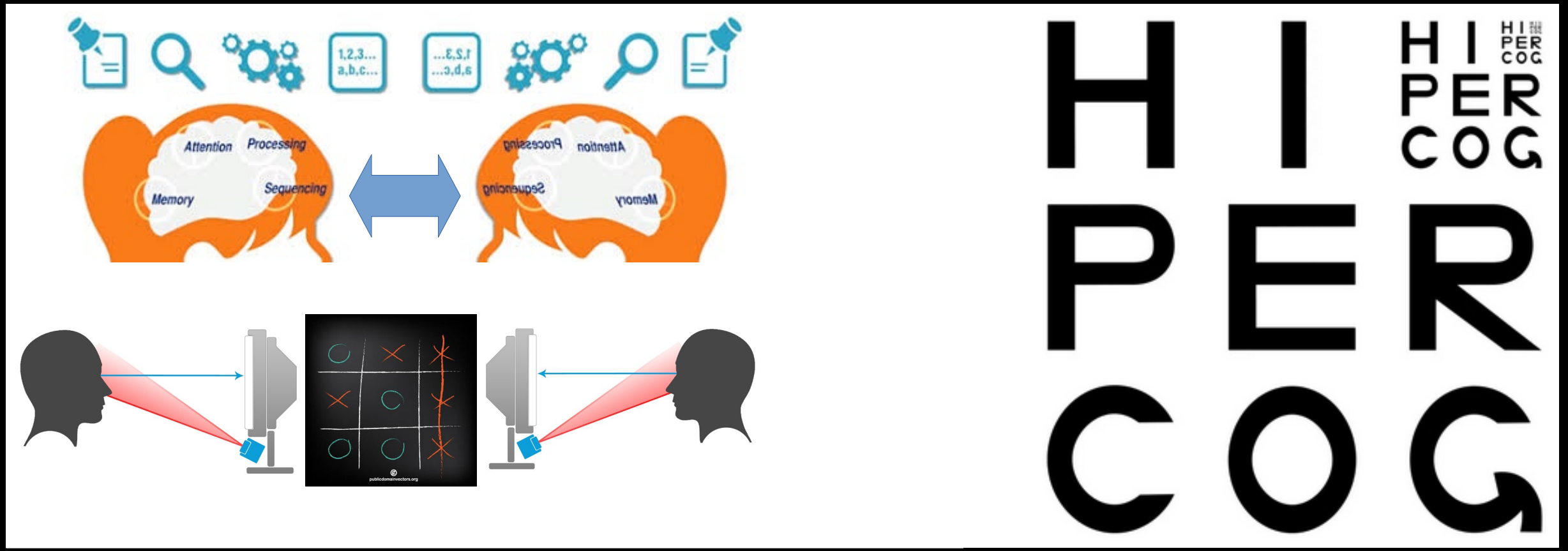


LEARNING IN HUMANS AND MACHINES: AI IN EDUCATION

Benjamin Ultan Cowley
PI, HiPerCog group
Associate Professor of AI in Learning & Education,
Faculty of Educational Sciences, University of Helsinki
@zenbenn

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI


1,2,3...
a,b,c...
Attention
Processing
Memory
Sequencing
publicdomainvectors.org

HI PER COG

HiPerCog group

NordForsk

SUOMEN AKATEMIA

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Outline

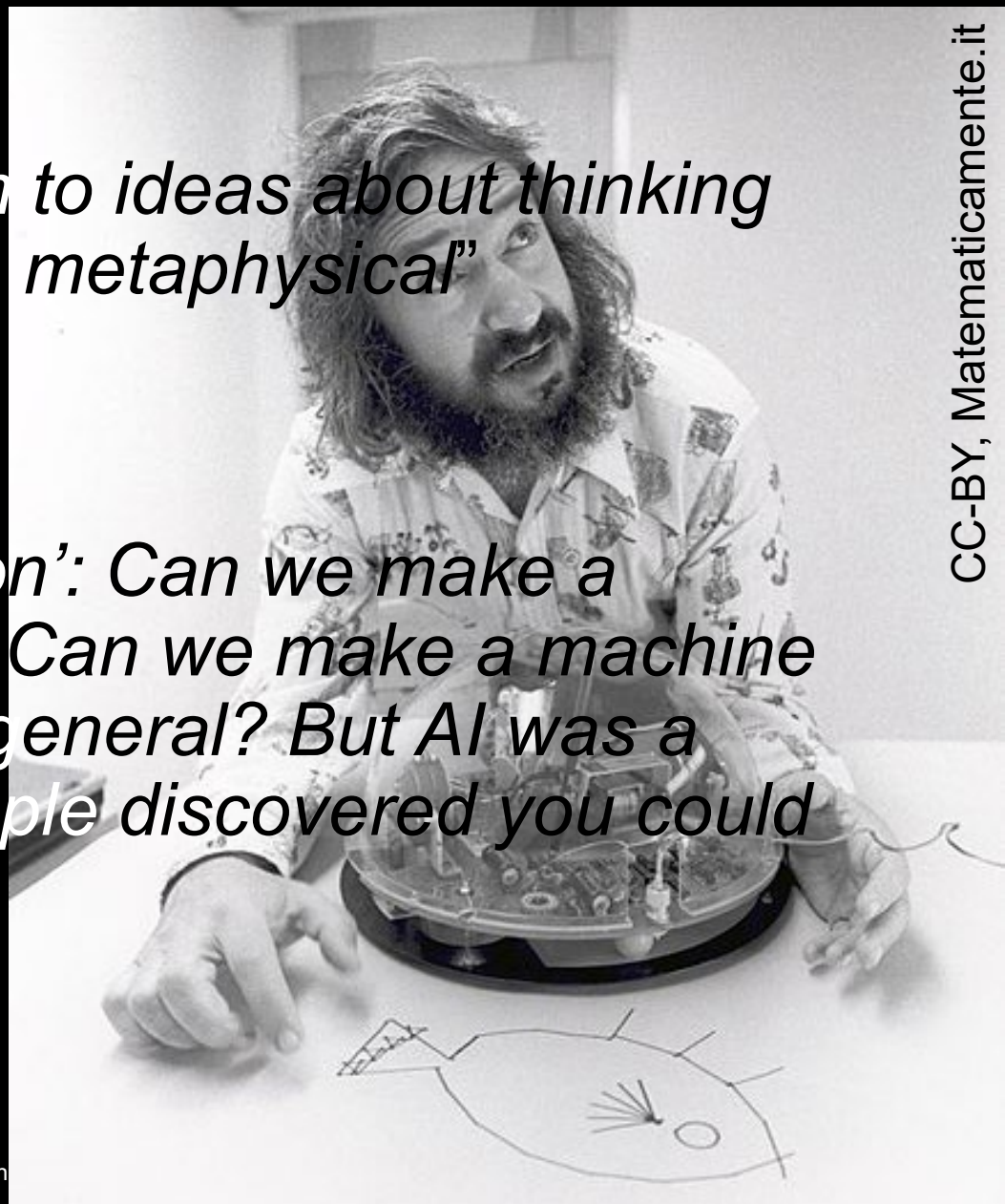
1. AI in Education (AIEd)
2. Learning in humans and machines
3. Solving games and teaching humans
4. AIEd for hybrid intelligence: "*Digital Aristotle*"
5. Study of computational thinking & chatGPT

AIEd

- "*The aim of AI is to give creative form to ideas about thinking that previously might have seemed … metaphysical*"
  - (Papert, 1980)

- "*We started with a big 'cosmic question': Can we make a machine to rival human intelligence? Can we make a machine so we can understand intelligence in general? But AI was a victim of its own worldly success. People discovered you could make … robots do accounting!*"
  - (Papert, 2002)

Seymour Papert, 1928 – 2016



Learning in humans and machines

What is learning?

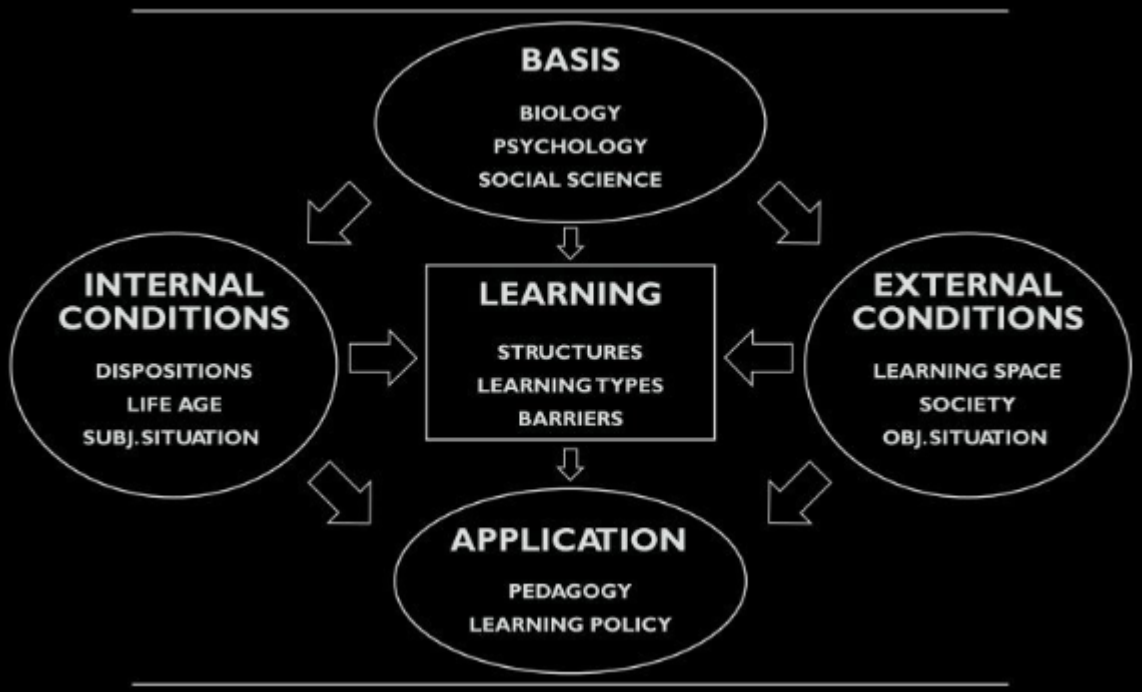
- what do you think learning is?

What is learning…in humans?

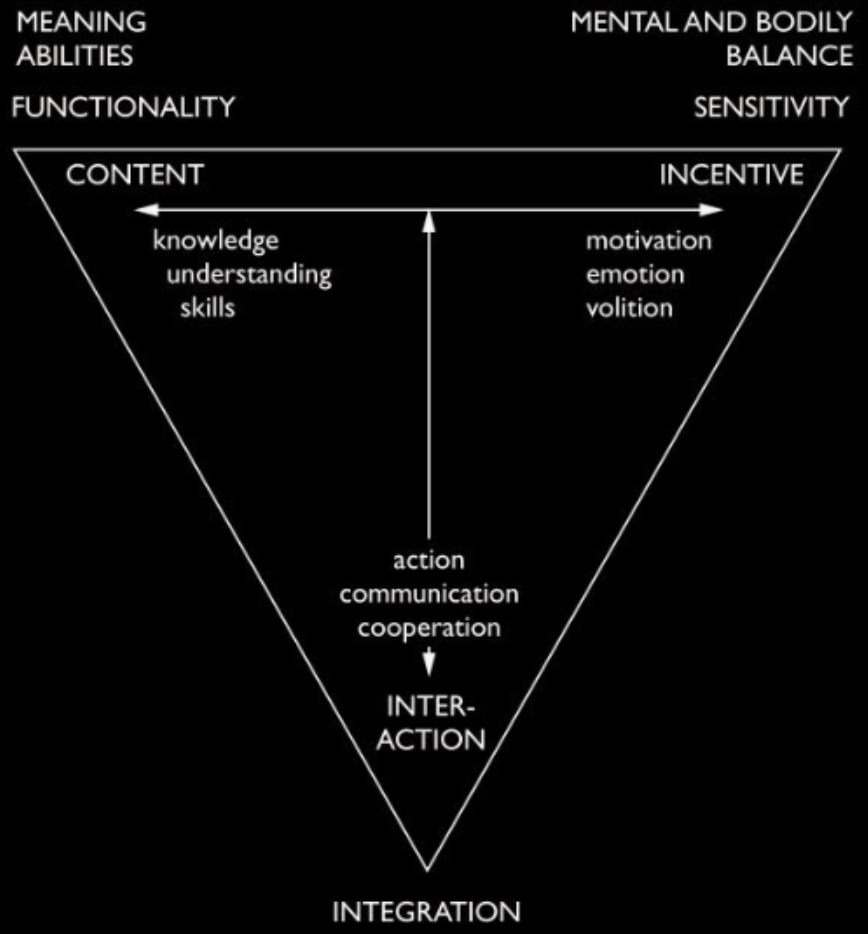
- "*Learning is a relatively enduring change in behavior resulting from experience*"

(Gazzaniga, *et al*, 3rd ed.)

What is learning…in humans?



(Illeris, 2018)



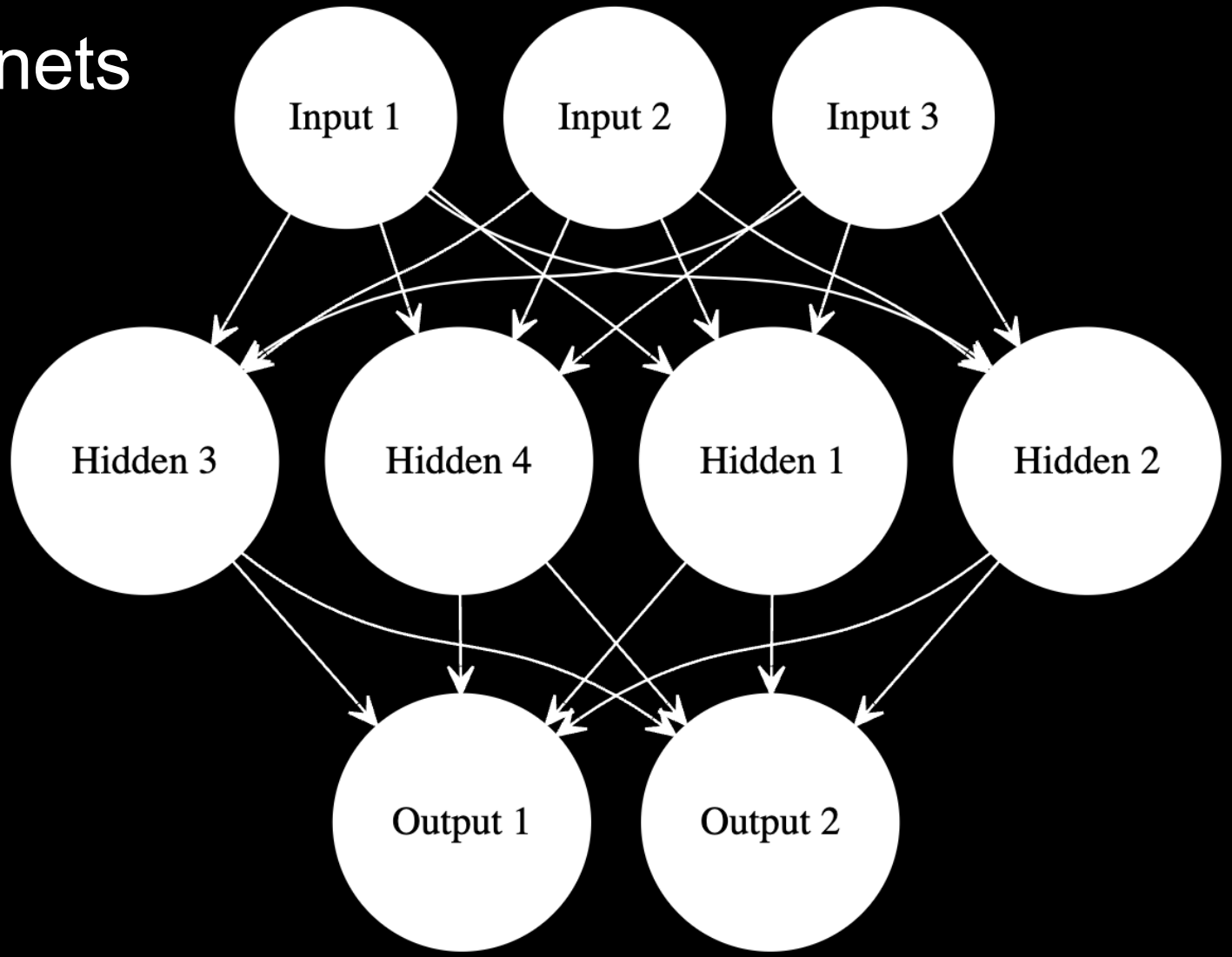
What is learning…in machines?

- "*Learning is a special form of dimensionality reduction...to create new features that didn't exist before*"

(Foerster, 2020)

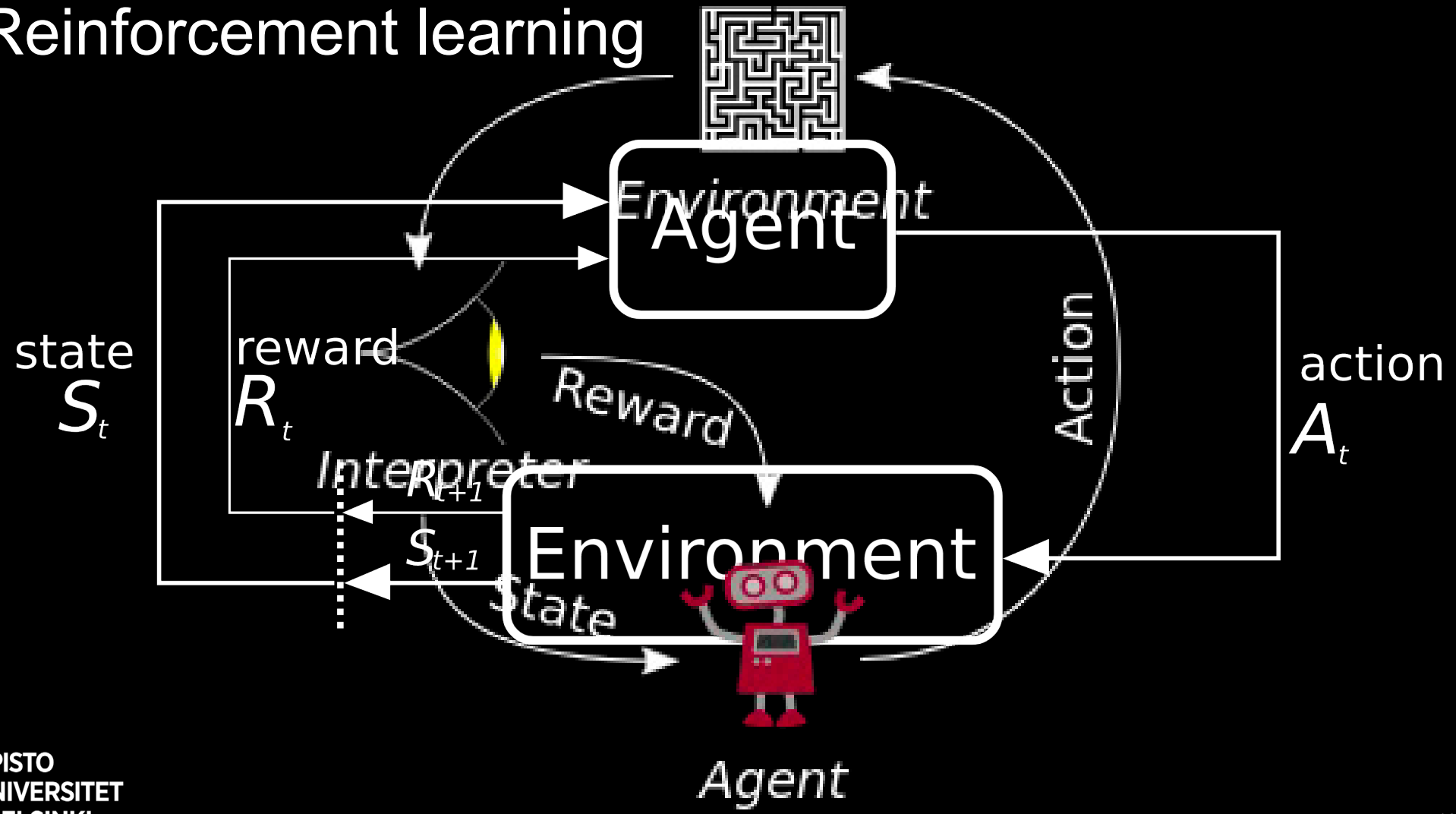
What is learning…in machines?

E.g. neural nets



What is learning…in machines?

E.g. Reinforcement learning



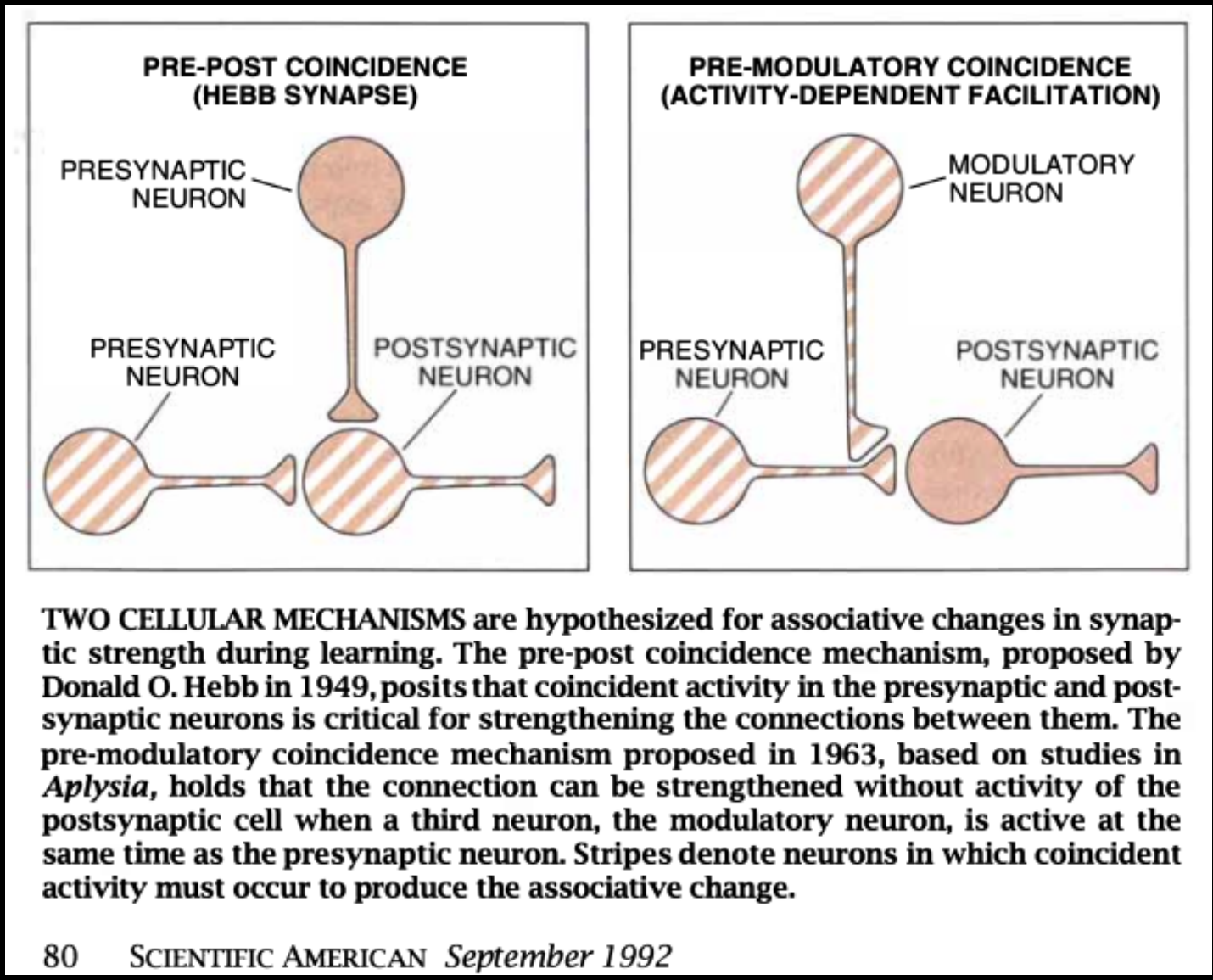
What is learning...in organisms?

- "*any process that in living organisms leads to permanent capacity change and which is not solely due to...maturation*"

(Illeris, 2018, p-7)

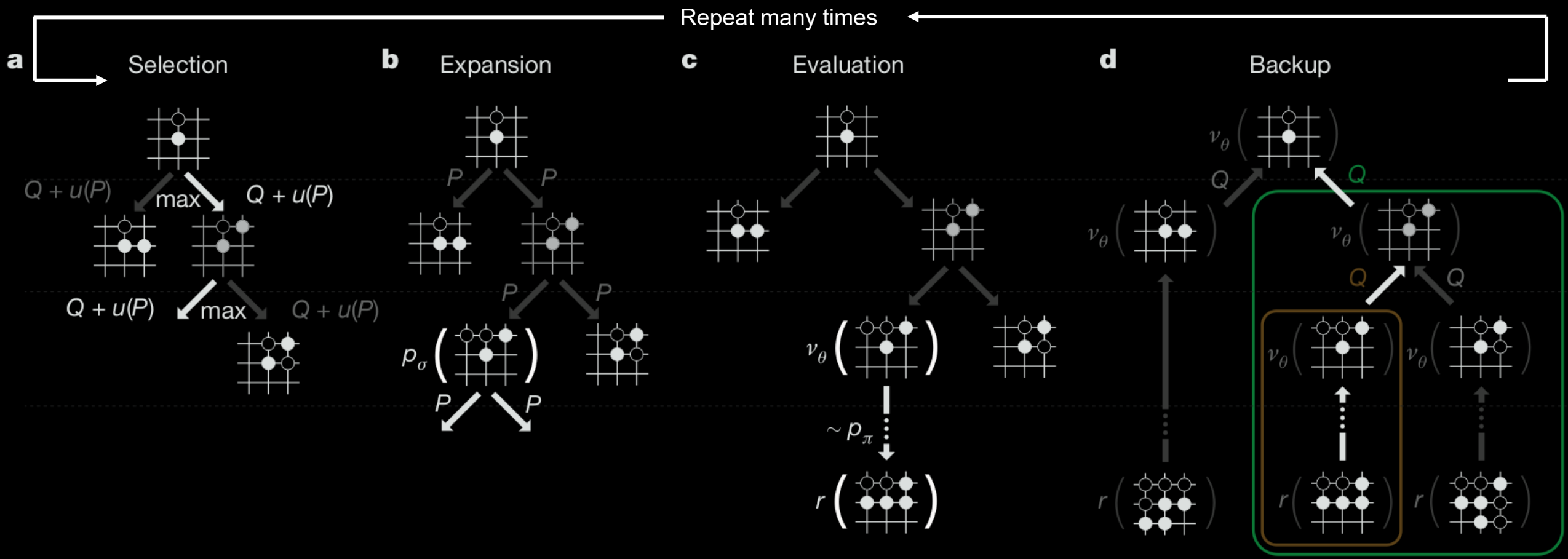
What is learning...in organisms?

- Hebbian:
  - "*Fire together, wire together*"
- Pre-modulatory:
  - *Fire together, inspire together*?



Solving games & teaching humans

Monte Carlo Tree Search



RESEARCH ARTICLE | PSYCHOLOGICAL AND COGNITIVE SCIENCES

Superhuman artificial intelligence can improve human decision-making by increasing novelty

Minkyu Shin, Jin Kim, Bas van Opheusden, and Thomas L. Griffiths Authors Info & Affiliations

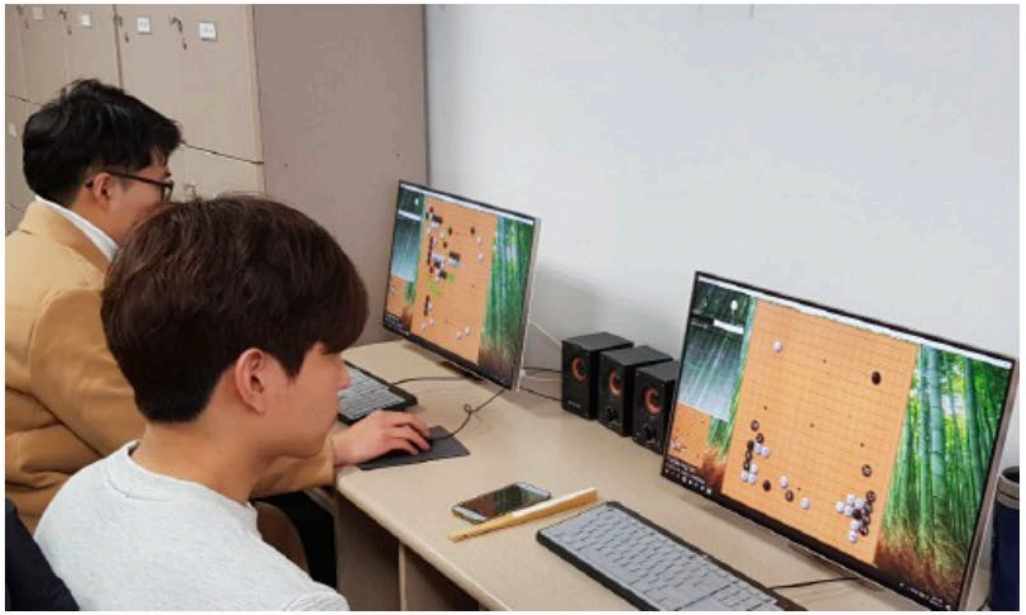
Edited by Michael Gazzaniga, University of California Santa Barbara College of Letters and Science, Santa Barbara, CA; received August 31, 2022; accepted December 19, 2022

March 13, 2023 | 120 (12) e2214840120 | https://doi.org/10.1073/pnas.2214840120

How to study humans learning from AI?

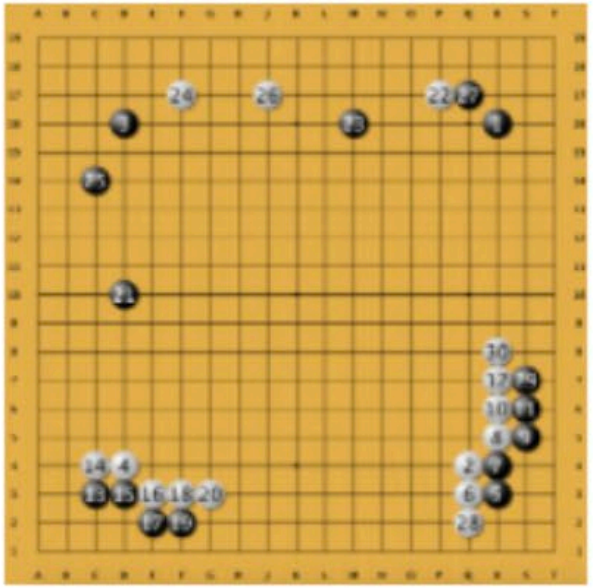
- Estimate the distance between human and AI decision quality
  - Move by move
- Track this measure to estimate human learning
  - Game by game
- Study South Korean Go players on mandatory military service
  - No internet = a natural experiment

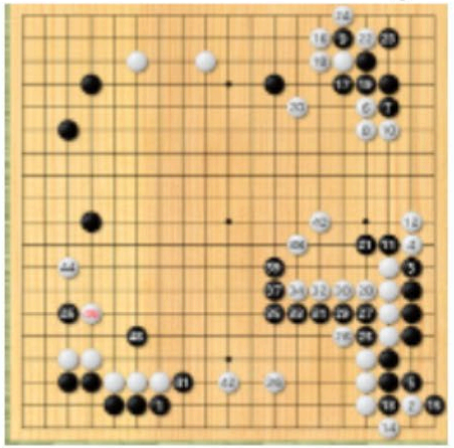
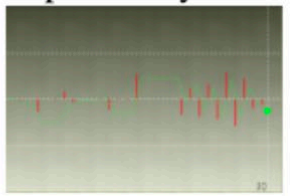
(a) Human Learning Before AI



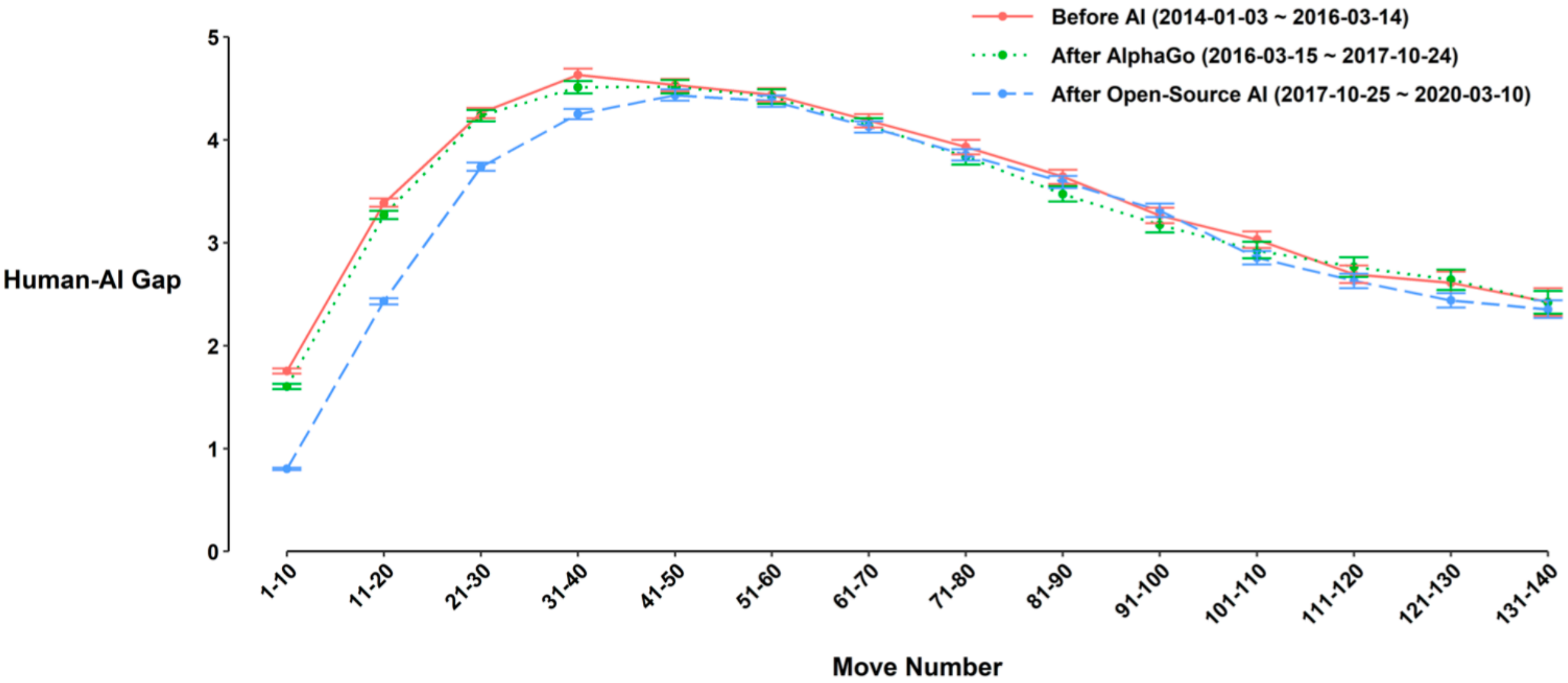
(b) Human Learning After AI

- AlphaGo shows *only* AI *actions*
- Open-source AI programs (Leela Zero) show AI *reasoning process*

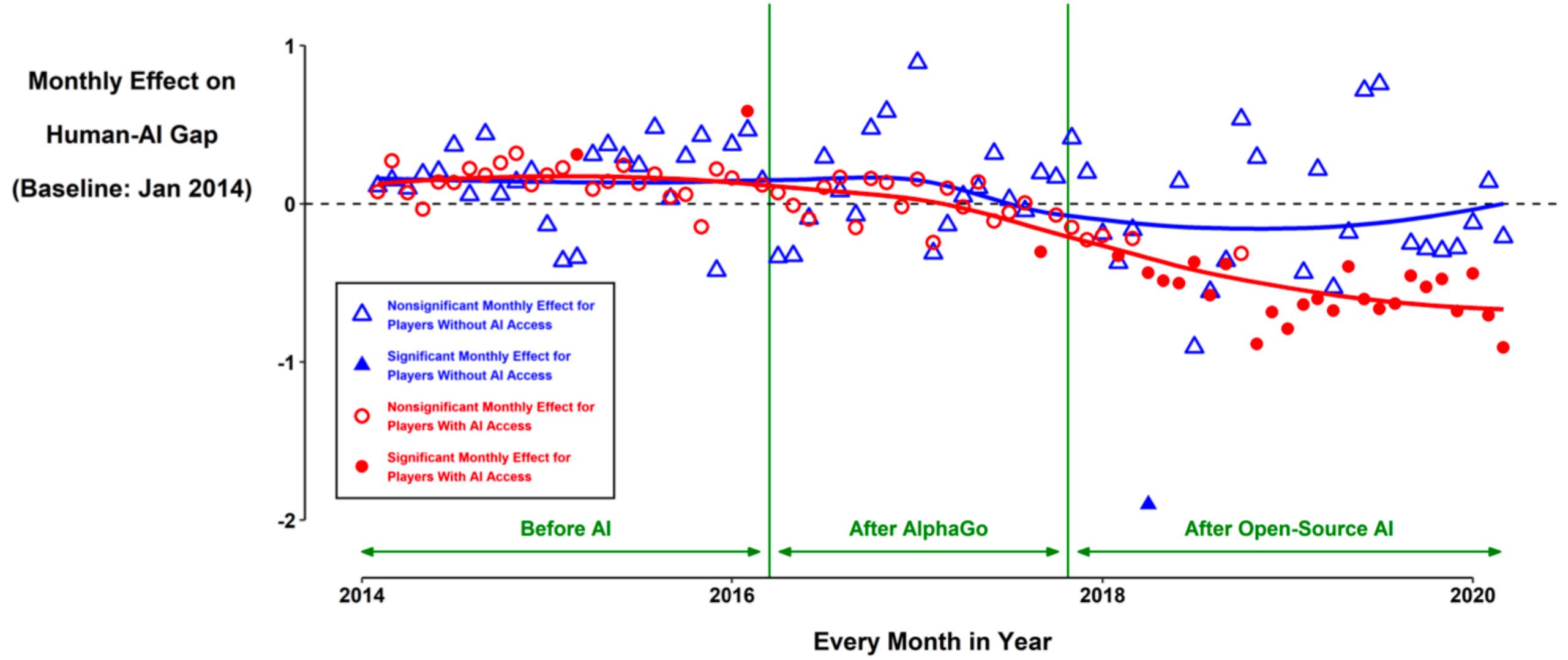
Event 1: AlphaGo, AlphaGoZero, and AlphaZero	Information to human players
	• AI's actions only (i.e., the sequence of positions AI placed a stone) • Human players do not observe (i) how AI could respond differently to the same situation (No Strategy) (ii) how AI predicts consequences of each actual or hypothetical response (No Evaluation)

Event 2: Open-source AI & Analysis Tools	Information to human players
Part 1. Candidate actions and Win prob of each candidate  Part 2. AI-simulated moves following the choice  Part 3. Current win probability of each player  Part 4. Change in win probability over the course of match 	• AI's Strategy & Evaluation, as well as Action • Human players observe (i) Strategy: – Candidate actions AI considers under the current state (Part 1) – Simulated sequences of actions following the current choice (Part 2) (ii) Evaluation: – Win Probability under the current state (Part 3) – Change in win probability as a consequence of each choice (Part 1) – Change in win probability throughout a match (Part 4)

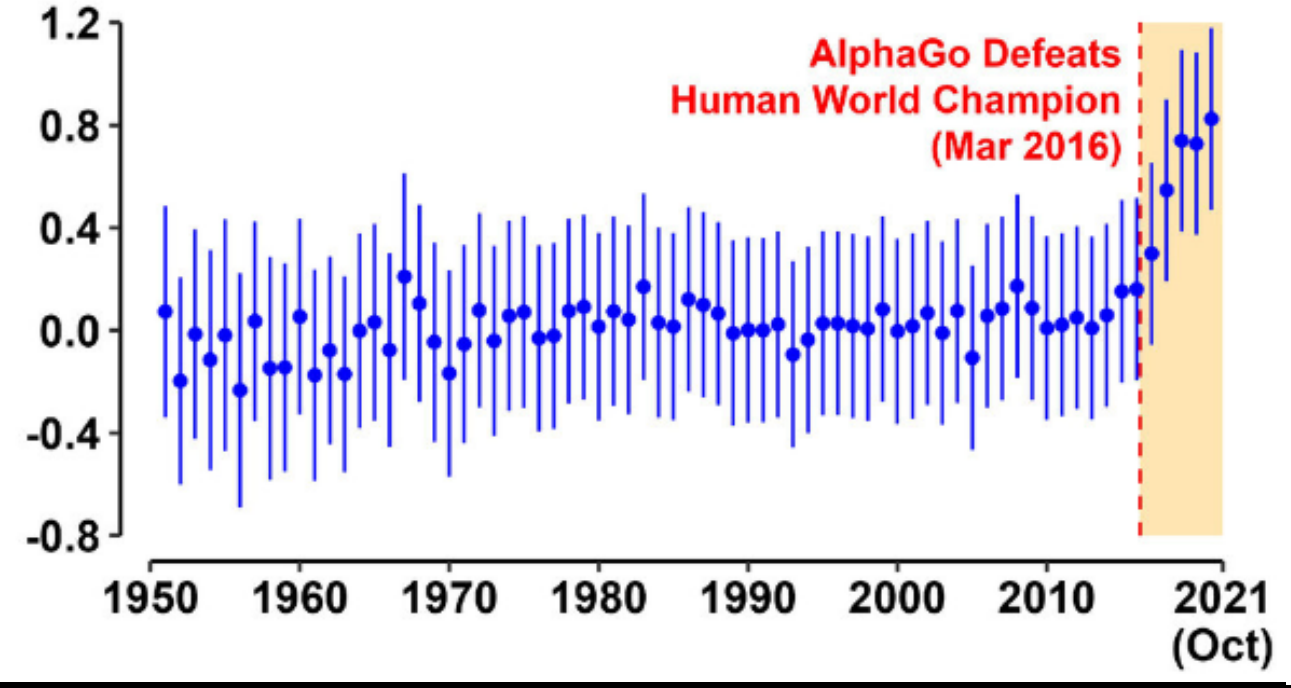
Study 1 results



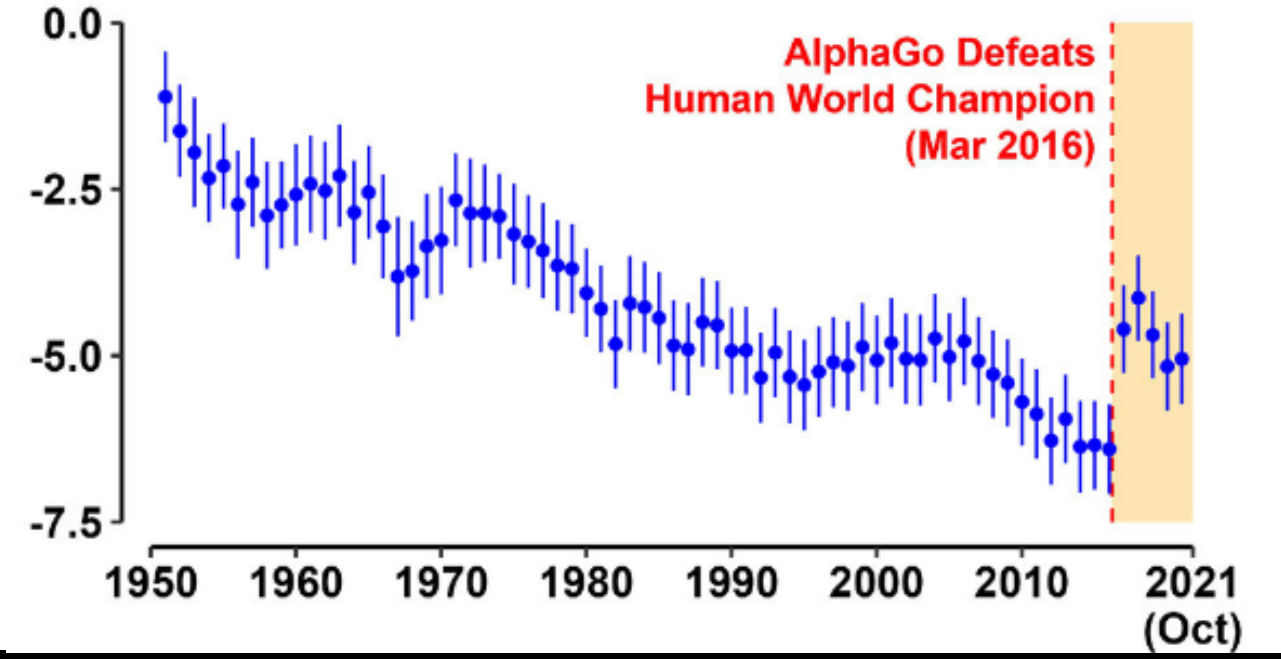
Study 1 results



Study 2 results



Decision quality index



Novelty index

“It made me question human creativity. When I saw AlphaGo’s moves, I wondered whether the Go moves I ha[d] known were the right ones. Its style was different, and it was such an unusual experience that it took time for me to adjust. AlphaGo made me realize that I must study Go more.” (1)

- Sedol Lee, a former world Go champion

AIEd for hybrid intelligence

Intelligent Tutor

- 343 B.C.
  - Aristotle & Alexander
- Teaching model
  - Universal knowledge (UK)
  - Intimate relationship (IR)
- A&A = UK + IR
  - Optimise learning potential
  - Possible with AI!

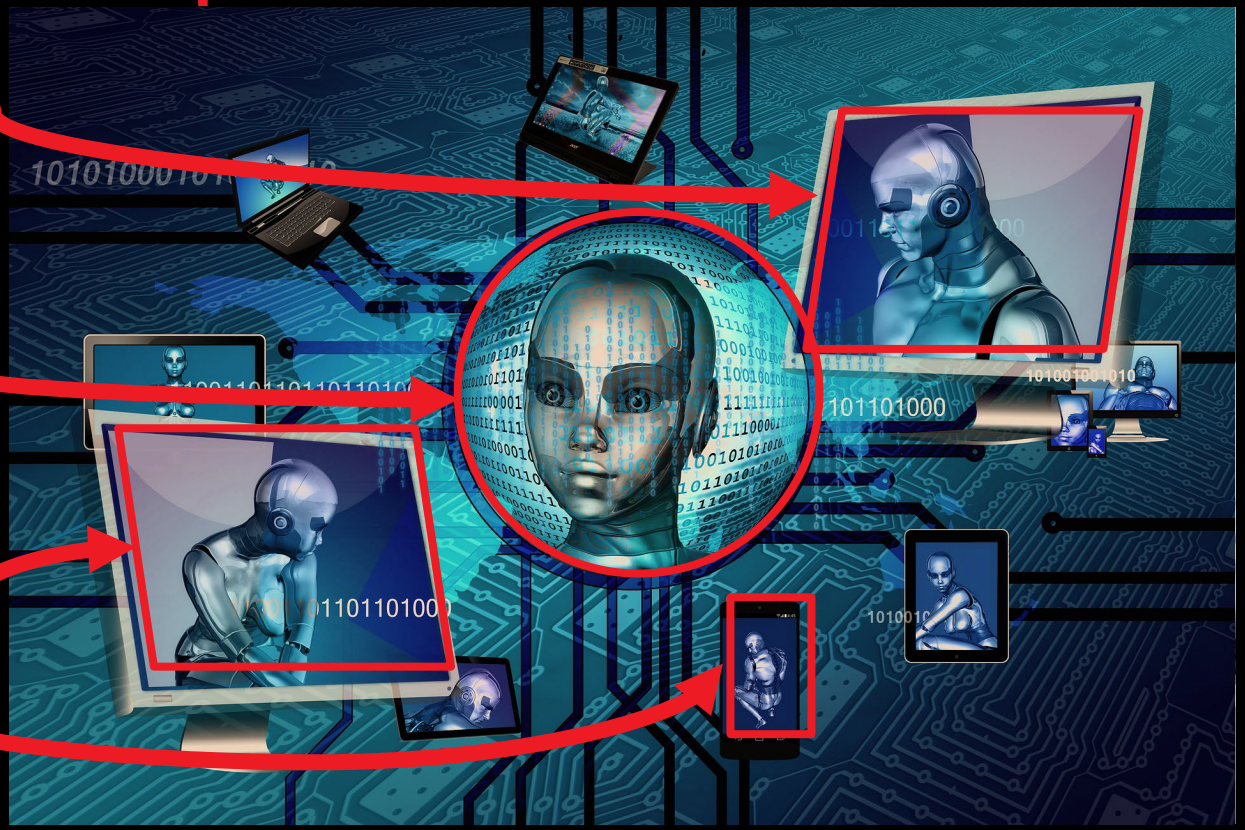
Image credit: Charles Laplante (1837–1903) via wikipedia

Other learning models

1)Teacher (pedagogue)

2)Learner (constructivism)

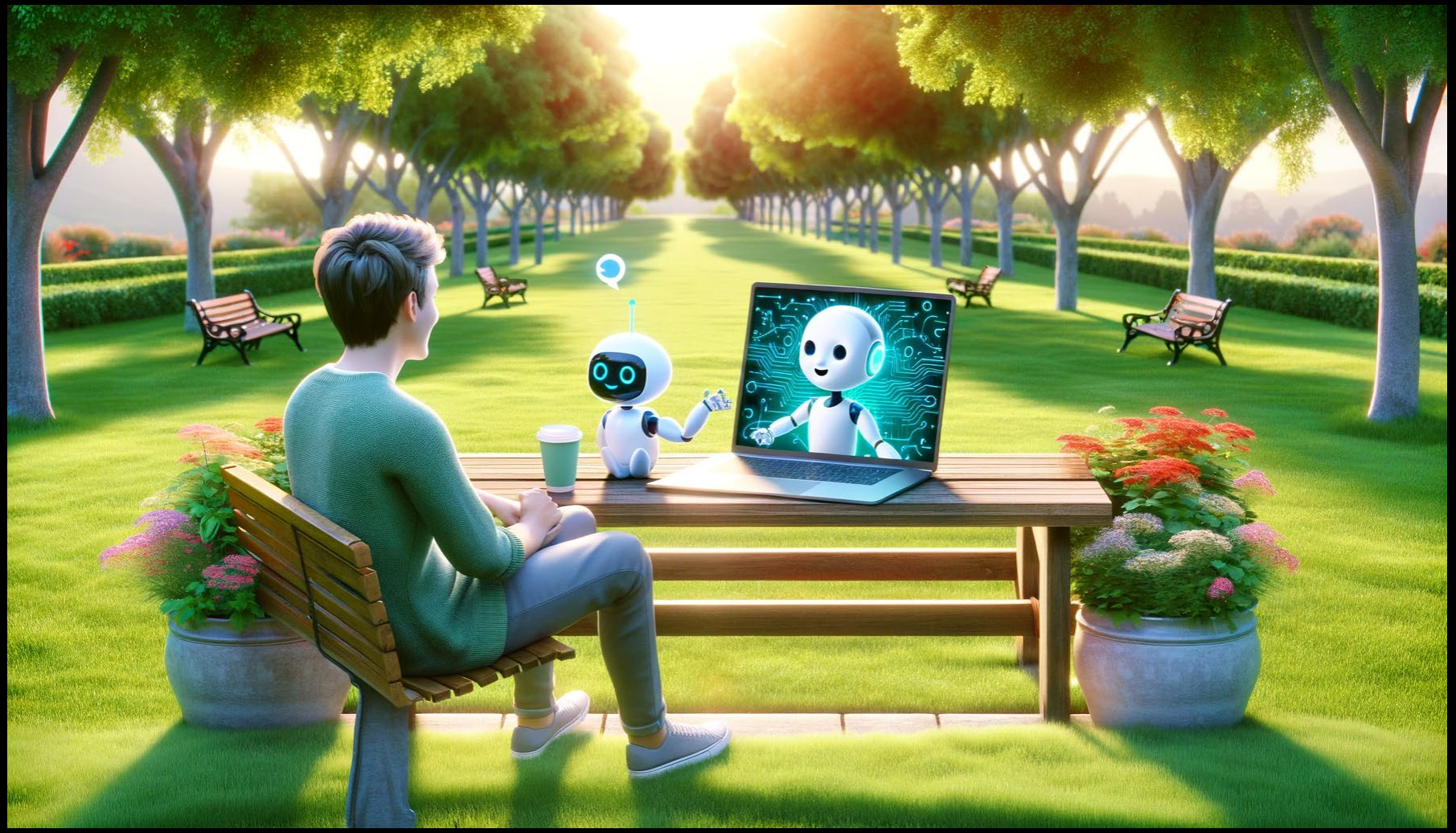
3)Peers (social constructivism)




GENERATIVE
AI
CODING
ART
TEXT
GAMING

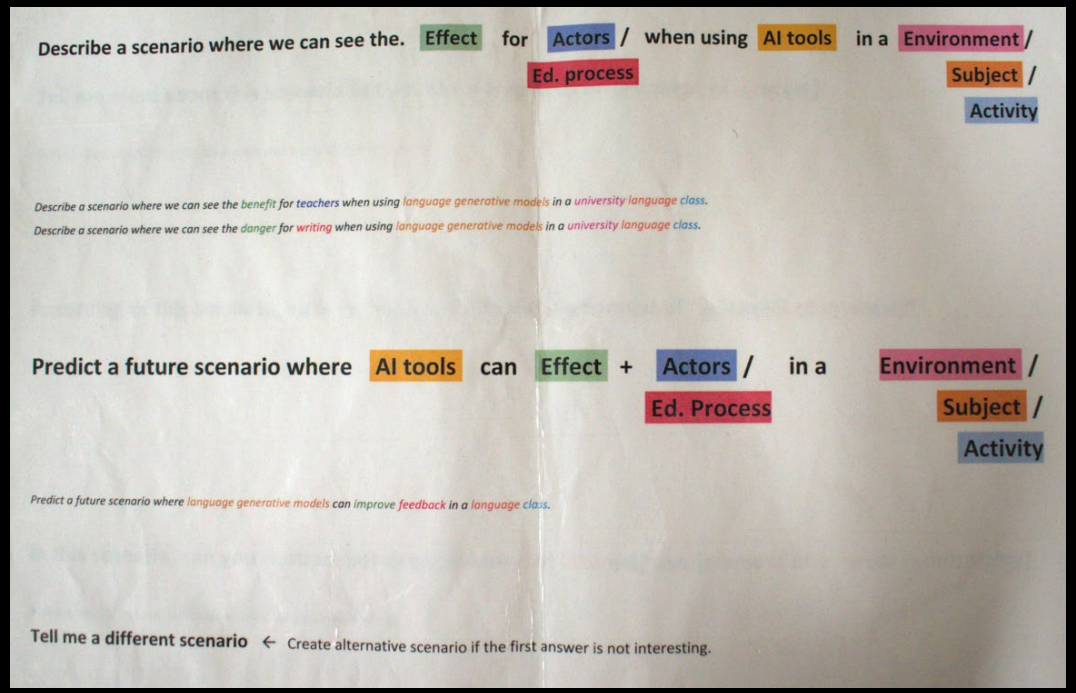
Computational thinking with chatGPT

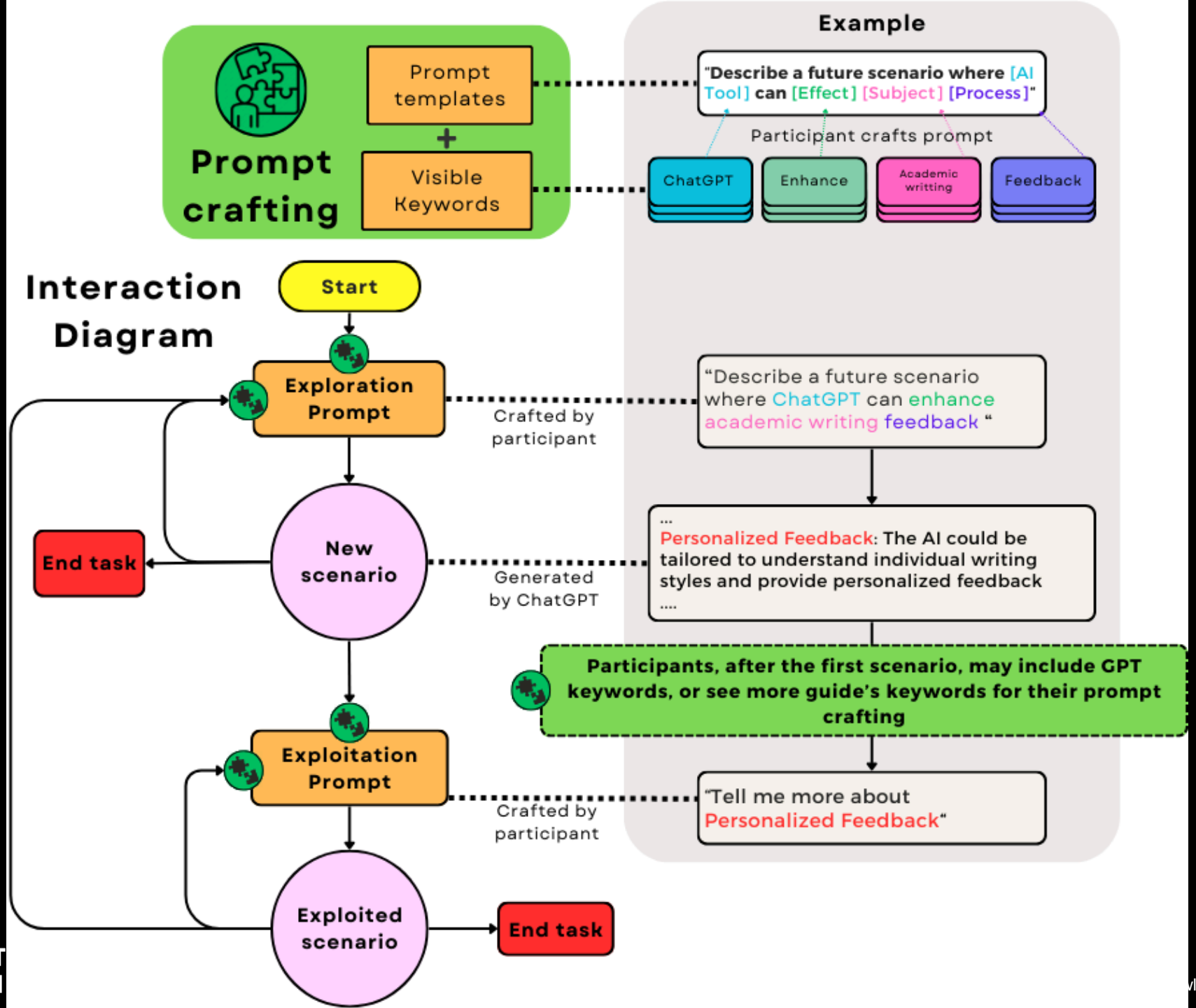
Computational thinking with chatGPT



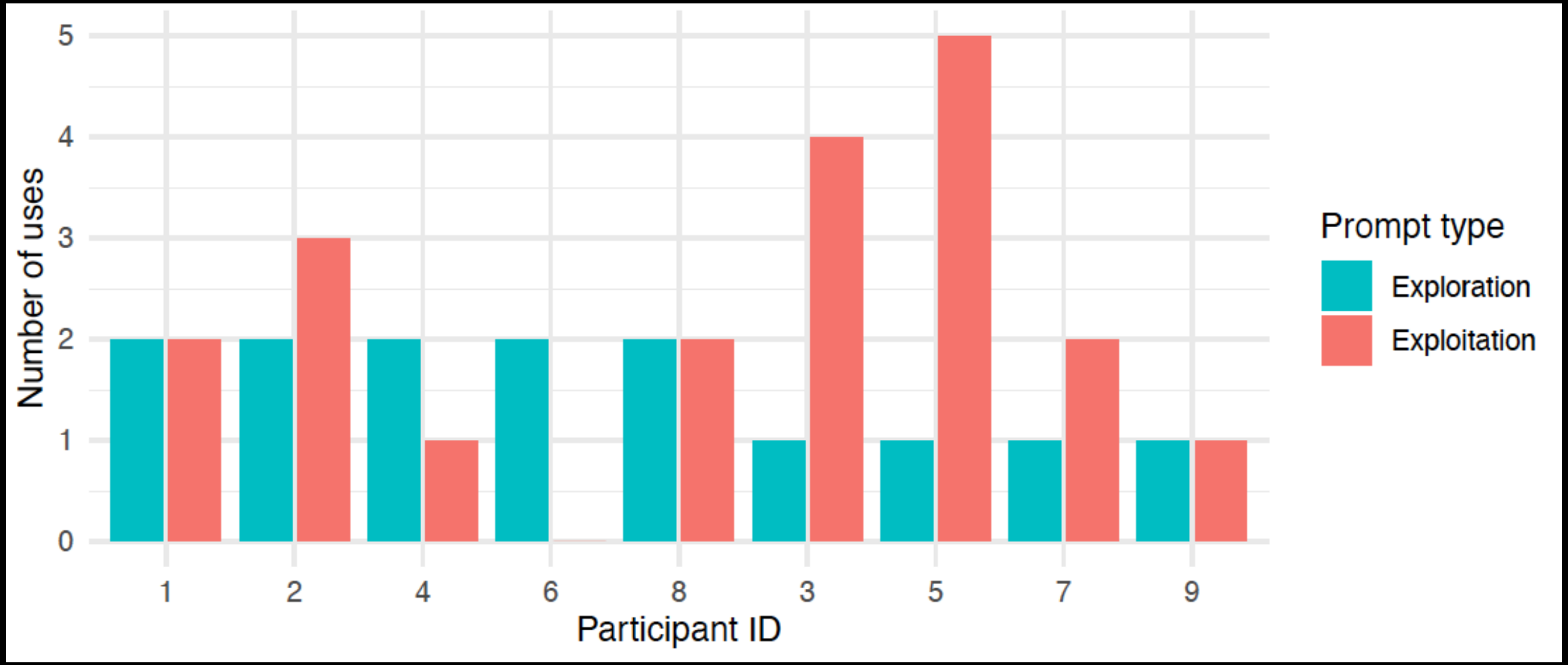
Computational thinking with chatGPT

- ‘Classroom’ study, n = 9 (5 f, 4m; age 30-40, mean 33)
- Guided-interaction design, exploratory analysis




Example
Prompt templates
+
Visible Keywords
Prompt crafting
"Describe a future scenario where [AI Tool] can [Effect] [Subject] [Process]"
Participant crafts prompt
ChatGPT
Enhance
Academic writting
Feedback
Interaction Diagram
Start
Exploration Prompt
Crafted by participant
"Describe a future scenario where ChatGPT can enhance academic writing feedback "
End task
New scenario
Generated by ChatGPT
...
Personalized Feedback: The AI could be tailored to understand individual writing styles and provide personalized feedback
....
Participants, after the first scenario, may include GPT keywords, or see more guide's keywords for their prompt crafting
Exploitation Prompt
Crafted by participant
"Tell me more about Personalized Feedback"
Exploited scenario
End task

Computational thinking behaviour?



Computational thinking self-report scale

Table 1. Dimensions of CTS

Dimensions	Description	Example of item
Creativity	Self-recognition of students and ability to develop genuine ideas different from the ordinary and find different solutions to a problem.	I like the people who are sure of most of their decisions.
Algorithmic thinking	The skill of understanding, applying, assessing and producing the algorithm.	I have a special interest in the mathematical processes.
Cooperation	Working together to achieve/complete a task.	In cooperation learning, I think that I attain/will attain more successful results because I am working in a group.
Critical thinking	The skill to analyse, make conscious judgements and using these to reach a decision.	I use systematic method to compare available options in order to reach a decision.
Problem-solving	The skills to plan and execute the solution.	I cannot apply the solution ways. I plan respectively and gradually.

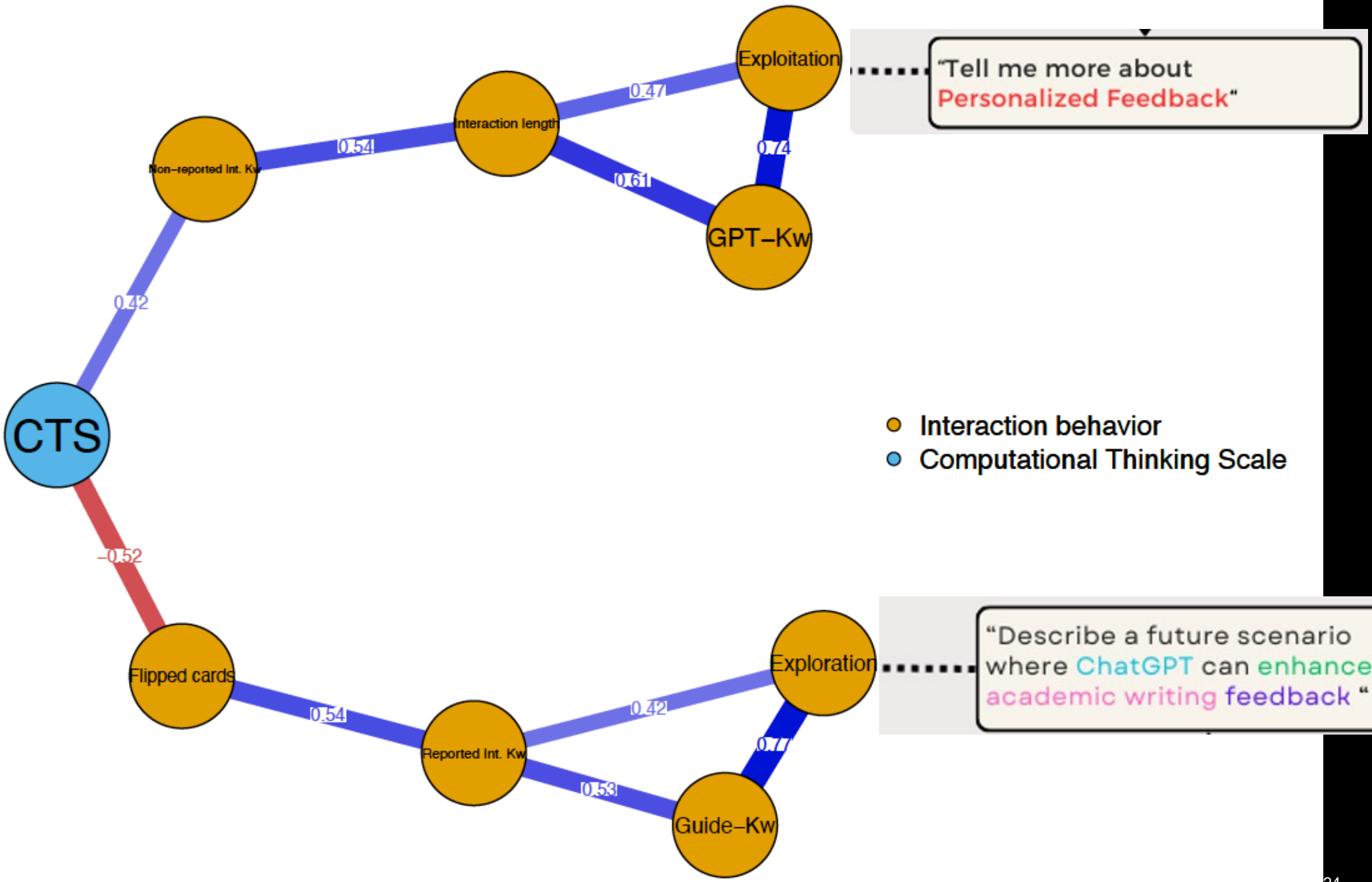
Table 3 Behavioral variables describing participants' interaction with ChatGPT

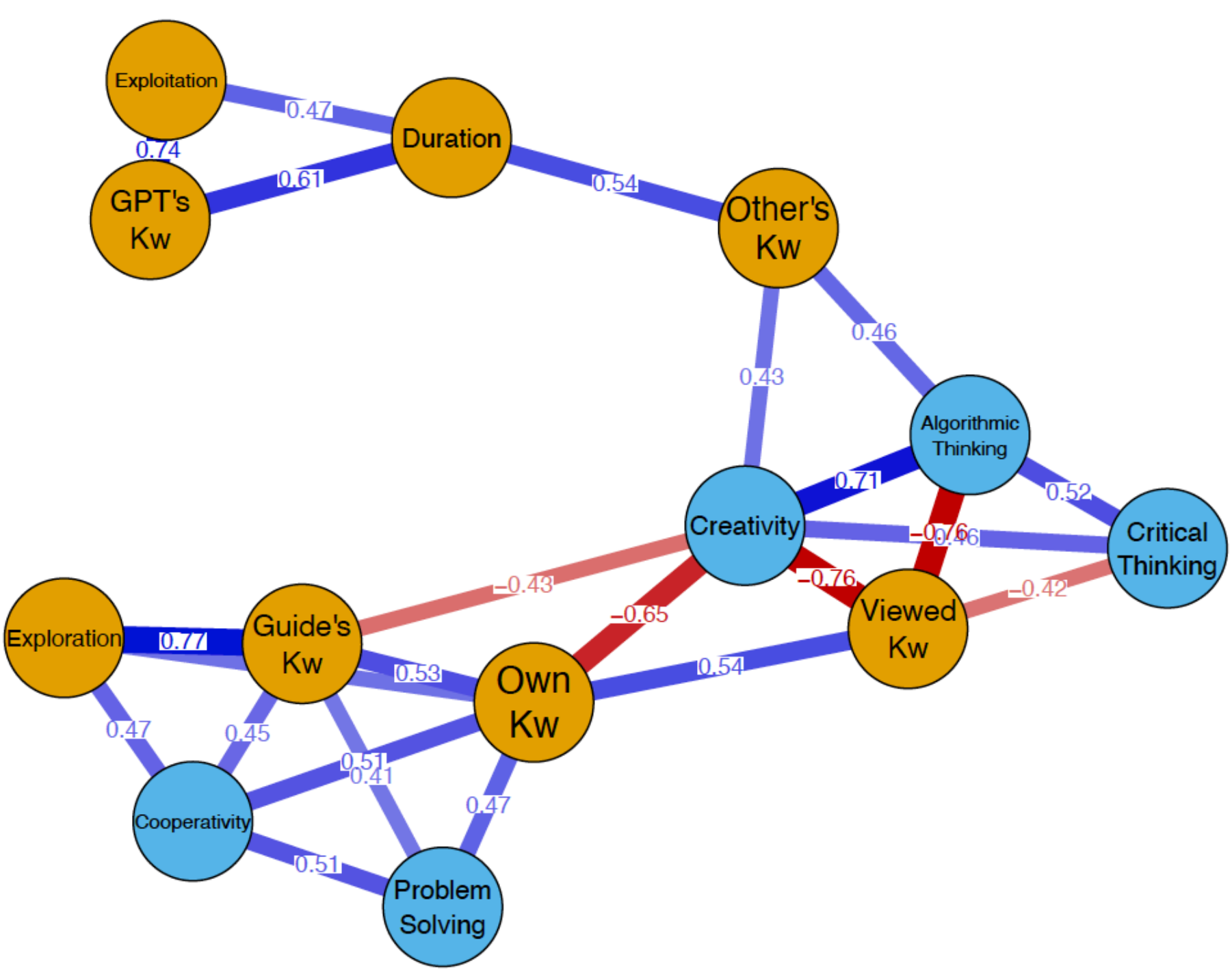
Code	Description
Exploration	N° of exploration prompts used
Exploitation	N° of exploitation prompts used
Viewed Kw	Max. rows of keywords participants managed to see during the interaction.
Guide's Kw	N° of used keywords sourced from the design
GPT's Kw	N° of used keywords sourced from the GPT-generated text
Own Kw	N° of used guide's keywords that the participant provided to the design
Other's Kw	N° of used guide's keywords that the participant did not provided to the design.
Time	Time length of the interaction, measured from the first prompt to the last.

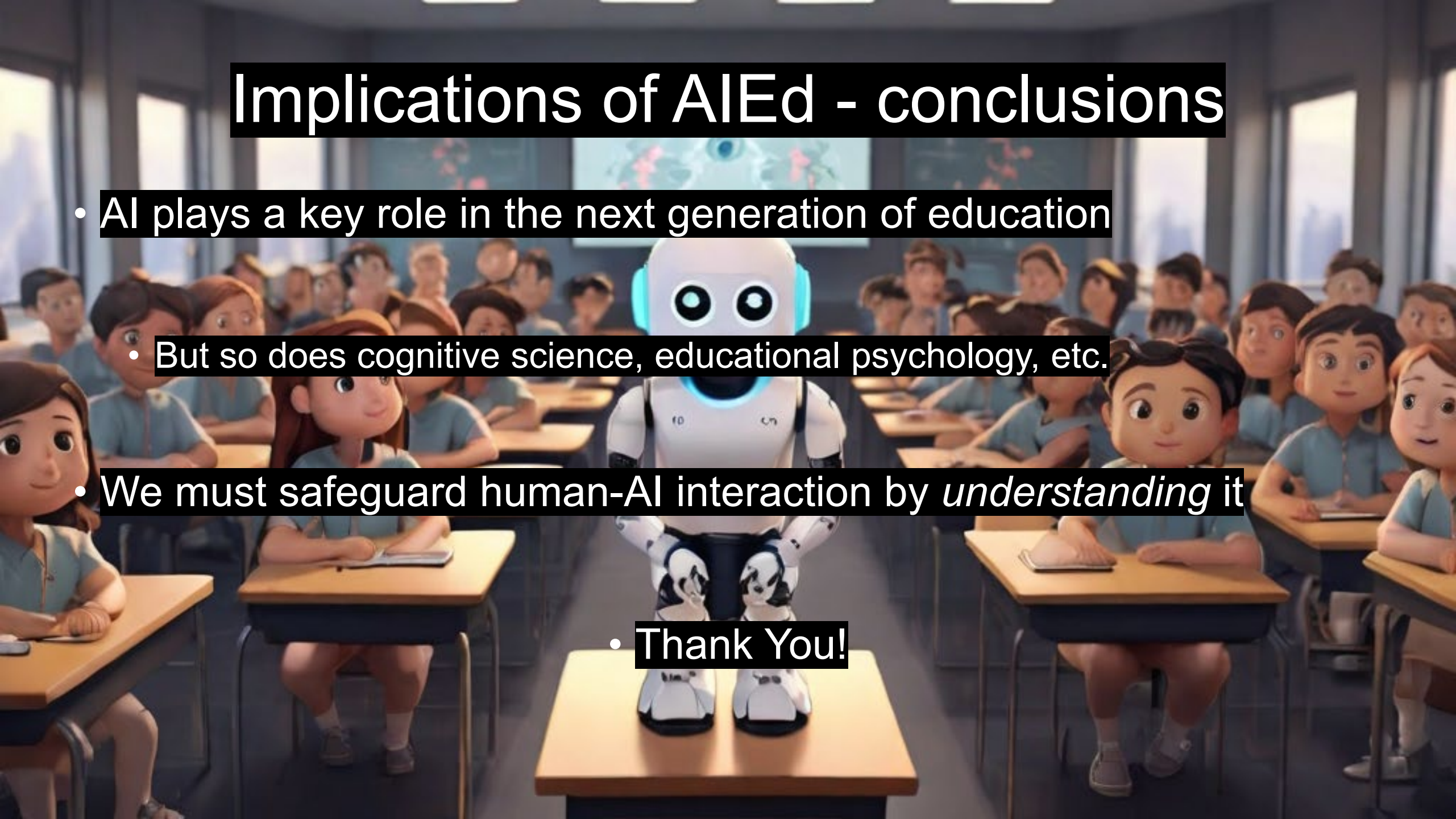
Table 4 Descriptive statistics of gathered data.

vars		n	mean	sd	min	max	range	se	type
1	Exploration	9.00	1.56	0.53	1.00	2.00	1.00	0.18	Discrete
2	Exploitation	9.00	2.22	1.56	0.00	5.00	5.00	0.52	Discrete
3	Viewed Kw	9.00	1.89	0.60	1.00	3.00	2.00	0.20	Discrete
4	GPT's KW	9.00	1.56	1.94	0.00	6.00	6.00	0.65	Discrete
5	Guide's Kw	9.00	8.33	2.65	5.00	12.00	7.00	0.88	Discrete
6	Own Kw	9.00	2.56	2.40	0.00	7.00	7.00	0.80	Discrete
7	Other's Kw	9.00	7.33	2.35	4.00	11.00	7.00	0.78	Discrete
8	Conversation duration [min]	9.00	14.79	8.58	4.03	30.22	26.18	2.86	Continuous
9	CTS score	9.00	100.78	11.70	82.00	119.00	37.00	3.90	Ordinal
10	Critical thinking	9.00	18.89	3.89	13.00	25.00	12.00	1.30	Ordinal
11	Algorithmic thinking	9.00	16.78	4.02	11.00	24.00	13.00	1.34	Ordinal
12	Cooperativity	9.00	15.33	2.78	11.00	20.00	9.00	0.93	Ordinal
13	Problem solving	9.00	20.67	2.87	15.00	24.00	9.00	0.96	Ordinal
14	Creativity	9.00	29.11	3.18	24.00	32.00	8.00	1.06	Ordinal

Note: CTS = Computational Thinking Scale.


Exploitation
"Tell me more about Personalized Feedback"
Interaction length
0.47
Non–reported Int. Kw
0.54
0.74
0.61
GPT–Kw
0.42
CTS
–0.52
Interaction behavior
Computational Thinking Scale
Exploration
"Describe a future scenario where ChatGPT can enhance academic writing feedback "
Flipped cards
0.54
0.42
Reported Int. Kw
0.77
0.53
Guide–Kw


Exploitation
Duration
GPT's Kw
Other's Kw
Algorithmic Thinking
Creativity
Critical Thinking
Exploration
Guide's Kw
Own Kw
Viewed Kw
Cooperativity
Problem Solving
0.47
0.74
0.61
0.54
0.43
0.46
0.71
0.52
−0.76
0.46
−0.43
−0.76
−0.42
−0.65
0.77
0.53
0.54
0.47
0.45
0.51
0.41
0.47
0.51



Implications of AIEd - conclusions

- AI plays a key role in the next generation of education
- But so does cognitive science, educational psychology, etc.
- We must safeguard human-AI interaction by *understanding* it
- Thank You!