# NACS 645 - Cognitive Science

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DEPARTMENT OF
PSYCHOLOGY



PROGRAM IN
NEUROSCIENCE &
COGNITIVE SCIENCE

# Format

# 28 classes; 26 *debates*; 13 students; 52 papers

| Week | Week range | Class days |
|---|---|---|
| 1 | (Sep 1 – Sep 7) | Tue Sep 2, Thu Sep 4 |
| 2 | (Sep 8 – Sep 14) | Tue Sep 9, Thu Sep 11 |
| 3 | (Sep 15 – Sep 21) | Tue Sep 16, Thu Sep 18 |
| 4 | (Sep 22 – Sep 28) | Tue Sep 23, Thu Sep 25 |
| 5 | (Sep 29 – Sep 5) | Tue Sep 30, Thu Oct 2 |
| 6 | (Oct 6 – Oct 12) | Tue Oct 7, Thu Oct 9 |
| 7 | (Oct 13 – Oct 19) | **Fall Break**, 10/16 |
| 8 | (Oct 20 – Oct 26) | Tue Oct 21, Thu Oct 23 |
| 9 | (Oct 27 – Nov 2) | Tue Oct 28, Thu Oct 30 |
| 10 | (Nov 3 – Nov 9) | Tue Nov 4, Thu Nov 6 |
| 11 | (Nov 10 – Nov 16) | Tue Nov 11, Thu Nov 13 |
| 12 | (Nov 17 – Nov 23) | Tue Nov 18, Thu Nov 20 |
| 13 | (Nov 24 – Nov 30) | 11/25, **Thanksgiving** |
| 14 | (Dec 1 – Dec 7) | Tue Dec 2, Thu Dec 4 |
| 15 | (Dec 8 – Dec 14) | Tue Dec 9, Thu Dec 11 (Last Week) |
| 16 | (Dec 15 – Dec 20) | (Exam Week) |

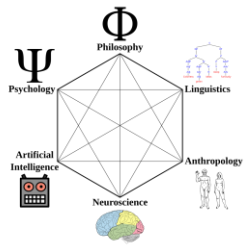
# Schedule

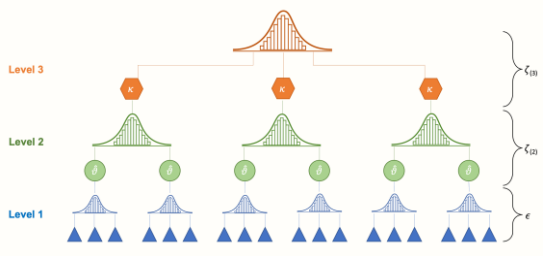
| Week | Class day | Topic |
|---|---|---|
| 1 | 9/2 | Organization, introductions, topics valid. |
| 1 | 9/4 | What is cognitive science, auction |
| 2 | 9/9 | Debate I |
| 2 | 9/11 | Debate II |
| 3 | 9/16 | Debate III |
| 3 | 9/18 | Debate IV |
| 4 | 9/23 | Debate V<br>Note: Pre-proposal due by 9PM |
| 4 | 9/25 | Debate VI |
| 5 | 9/30 | Debate VII |
| 5 | 10/2 | Debate VIII |
| 6 | 10/7 | Debate IX |
| 6 | 10/9 | Debate X |
| 7 | **Fall break** | **No class** |
| 7 | 10/16 | Debate XI |
| 8 | 10/21 | Debate XII<br>Note: Proposal due by 9PM |
| 8 | 10/23 | Debate XIII |

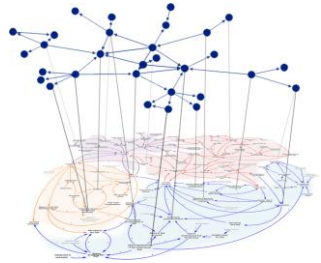
| Week | Class day | Topic |
|---|---|---|
| 9 | 10/28 | Debate XIV |
| 9 | 10/30 | Debate XV |
| 10 | 11/4 | Debate XVI |
| 10 | 11/6 | Debate XVII |
| 11 | 11/11 | Debate XVIII |
| 11 | 11/13 | Debate XIX<br>**Proposal blitz 1** (4/13) (slides due 9AM) |
| 12 | 11/18 | Debate XX<br>**Proposal blitz 2** (4/13) (slides due 9AM) |
| 12 | 11/20 | Debate XXI<br>**Proposal blitz 3** (5/13) (slides due 9AM), |
| 13 | 11/25 | Debate XXII<br>final paper auction |
| 13 | **Thanksgiving** | **No class** |
| 14 | 12/2 | Debate XXIII |
| 14 | 12/4 | Debate XXIV |
| 15 | 12/9 | Debate XXV |
| 15 | 12/11 | Debate XXVI |
| 16 | **12/16 (Exams)** | **No class - Final paper** (due 9PM) |
| 16 | **12/18 (Exams)** | **No class - Final paper peer-review** (9PM) |

# Goals

- **Understand core debates in cognitive science**
  - Compare and critique opposing theoretical perspectives (objective)
  - Link empirical findings to broader paradigms (objective)
- **Strengthen scientific communication (oral and written)**
  - Practice structured and respectful argumentation
  - Foster openness, collaboration, and intellectual flexibility
- **Develop research skills through staged milestones**
  - Flash talk
  - Opinion paper

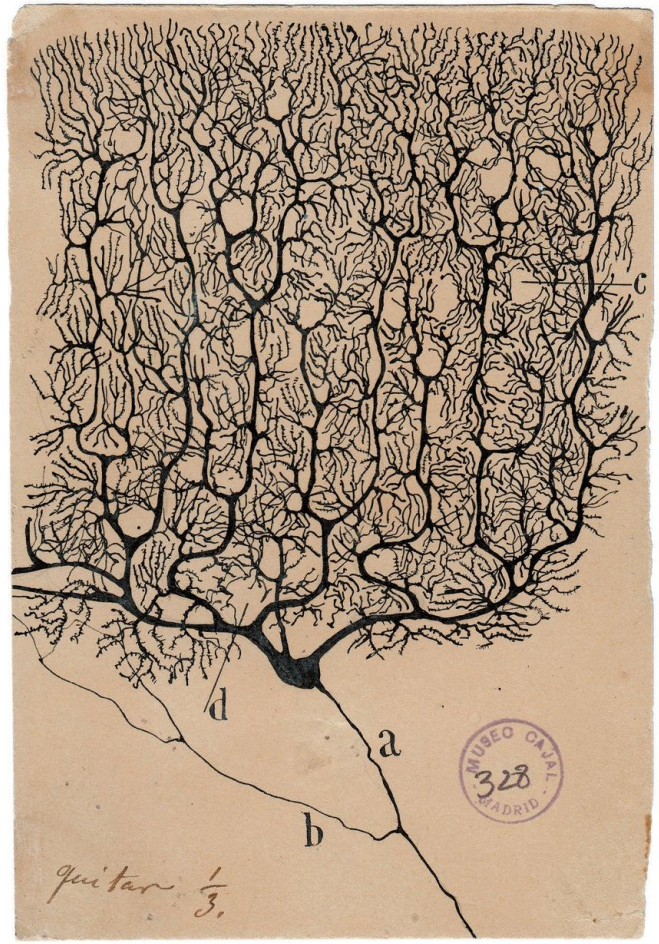


Photography: *10th Macy Conference*

# Guiding Principles of Class




- **Discussions on core debates**
- **Auction-based** choice of discussion themes
- **Rotating roles** (presenter, audience, rapporteur, reviewer)
- **Active engagement in class**
- **Peer-based and feedback-driven**
- **Cross-pollination** between backgrounds
- **Format may** collectively **be refined** throughout the sessions

Illustration: *Purkinje cell by Santiago Ramón y Cajal*

# Process

# Semester

- Two 1h45 sessions per week (**Tu&Th, 10-11:45am**)
- Each session: **2 papers** with ~opposing perspectives on a key question
- **Students rotate** through being discussion **leaders**, **rapporteurs** of sessions, **audience** and **reviewers** for their peers

- **Students present twice** – duos are allowed (means 3 presentations)
- **4 steps** that culminate in a **final opinion paper** (pre-proposal, proposal, blitz, paper)
- **Peer-review** for the final paper (structured, not anonymous)

Painting: *Raphaël,* ***The School of Athens, 1508-1512***

# Roles during Class

- **Instructor :**
  - Set context for each debate (introductory framing, why the question matters)
  - Start with an opening vote on “which side wins”
  - Moderate discussion, keep time, ensure balance and depth
- **Presenter (on stage):**
  - Review key arguments of the assigned paper
  - Defend a view based on the assigned papers
  - Lead structured discussion, drawing on peers’ posts and oral contributions
    - Respond to challenges and critiques
- **Audience:**
  - Read papers and post **at least 1** short discussion note before class
  - Ask clarifying/critical questions during debate
  - Engage in the wrap-up, synthesis discussion, that closes a debate
  - Vote on positions (pre- and post-debate)
- **Rapporteur**
  - Writes a synthesis of the debate/discussion

Image: *generated with ChatGPT-5*

# Week to Week

- By **9PM on Monday/Wednesday before class**:
  - All students have read the assigned pair of papers
  - The **Presenter** posts their debate plan (pre-debate) **on Canvas**
  - Each **non-Presenter** posts **at least one** short (≤200 words) discussion note:
    *Clarification, theoretical, or interpretation questions; points of confusion; data or evidence; claims; additional literature; adversarial paradigms; reconciliations; inconsistencies; whatever contributes*
  - The **rapporteur** posts their synthesis of the previous discussion
    - The **reviewers** review (min. one paragraph) the synthesis document
- **During class:**
  - Instructor introduces context, ensures structured flow, participates, and moderates
  - Debate/discussion led by student presenter(s)
  - Audience provide questions and participate actively
- **Across the semester:**
  - Students each lead 2 times & synthetize 2 times
  - Students each peer-review each others works (4 times)
  - Students each complete milestones for their opinion project

Photographies: *Donald O. Hebb (unknown); Michael Cook,* ***Majority Rules, Bus, 2014***

# How a Particular Class Unfolds


- **Instructor setup (5-10 mins)**
  - Brief introduction of the day's topic, context, and theoretical stakes
  - Sometimes includes an **opening vote**: which side is more convincing *before* discussion?
- **Student-led review (5-15 mins)**
  - Assigned students summarize the key points of their respective papers
  - Highlight assumptions, findings, and positions
- **Student-led discussion (~60 mins):**
  - Students defend their position, raise critiques, and address opposing arguments
  - Instructor moderates, ensuring balance and depth
  - The rest of the class contributes questions, drawing from their Canvas notes
- **Collective wrap-up (5-15 mins)**
  - Group discussion synthesizes key insights, arguments, and possible future directions
  - Sometimes includes a **closing vote**: we revisit positions after debate to reveal shifts in perspective
- **Feedback (5-10 mins)**
  - Constructive feedback from the audience on argumentation, discussion lead, etc.
- **Setting-up the next topic (<5 mins)**



Illustration: *Protein folds by computational biologist Lauren L. Porter*

# Auction

# Papers assignment – auction rules

- **Each student receives 100 points and must spend all of them.**
- **You must allocate points to at least 15 different themes; you may bid on more.**
- **You may place no more than 15 points on any single theme.**


- The 26 themes with the highest total points will be selected for the class.
- If two themes tie for the last slots, the one with bids from more students is chosen; if still tied, selection is random.

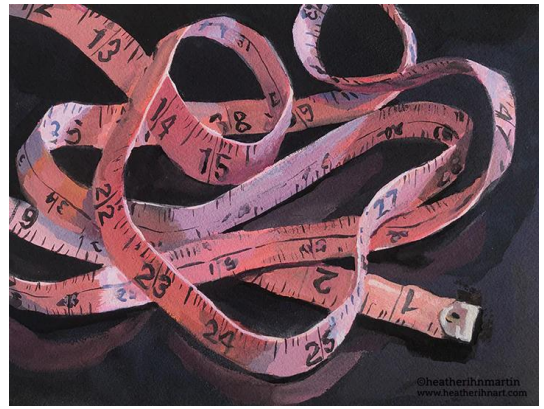
- For each winning theme, the student who placed the highest bid becomes the presenter; ties are broken randomly.
- The second-highest bidder becomes the rapporteur (synthesis memo writer) for that theme.
- The third and fourth-highest bidders become the peer reviewers of the rapporteur's memo.

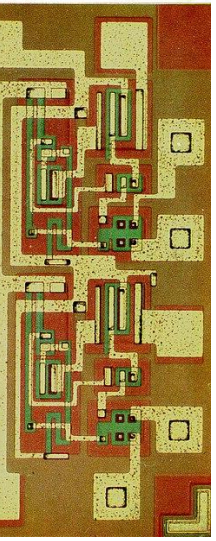
- Each student may present at most 2 themes, be rapporteur at most 2 times, and review at most 4 memos. If someone exceeds a quota, the role passes to the next highest bidder.
- A theme must have bids from at least 4 different students to qualify; ineligible themes are skipped and replaced by the next highest.

Image: *generated with ChatGPT-5*

# Grading

# Grading





- 1. Participation in Class - **15%** – GF
  relevant, prepared comments during class discussions
- 2. Participation in Board posts - **10%** – Good-Faith grading
  regular online contributions, thoughtful engagement
- 3. Presentations - **30%** – GF
  2 pre-debates: 10% & 2 discussions: 20%
  leading a class session; evaluated on preparation and facilitation
- 4. Synthesis - **15%** – GF
  2 post-debates: 10% + 2 peer-reviews: 5%
  synthesis memo – 2-peers peer-review
- 5. Opinion Project - **30%** – Standard grading
  pre-proposal: 2%; proposal: 3%; blitz: 5%; final paper: 15%; 2 peer-reviews: 5%
  2-peers peer-review for final paper

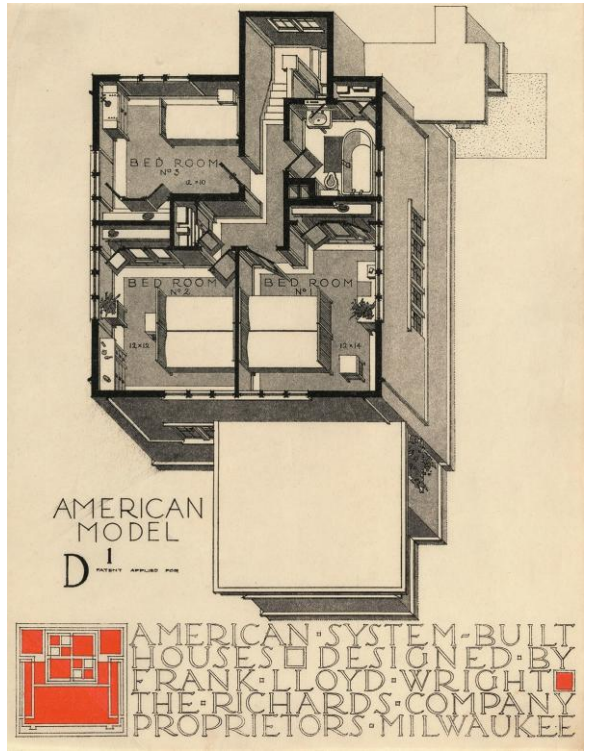


Painting: *Heather Ihn Martin*, ***Tape Measure***

# Pre-Debate Template

Pre-Debate Reflection Template (**min 500 words, max 1000 words**) (order not fixed)

- Summary of paper A & paper B
- Papers Connections:
  How do the 2 papers connect or separate?
- Paradigm Identification:
  Which paradigm(s) do these papers rely on?
- Strengths & Weaknesses:
  Point strengths and weaknesses of each paper
- Outside Papers:
  Introduce at least one outside paper and briefly explain how it supports or challenges the debate
- Defense Strategy:
  Summarize both the argument you will defend and your strategy

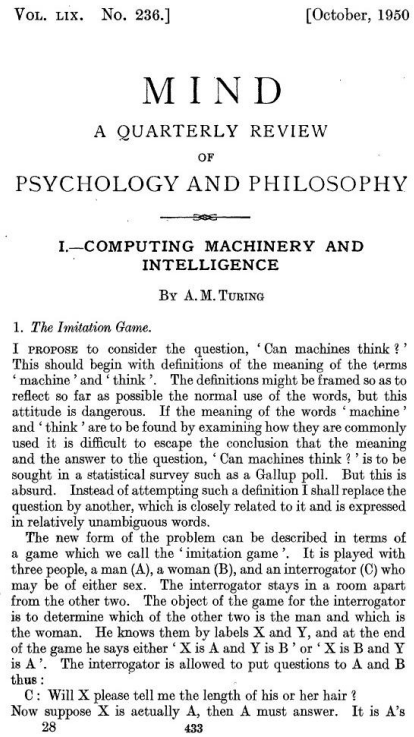





Drawing: *Frank Lloyd Wright,* ***American System-Built (Ready-Cut) Houses. Project, 1915 – 17***

# Post-Debate Memo

Post-Debate Synthesizing Memo (**min 1000 words, max 2000 words**) (suggestions)



VOL. LIX. No. 236.] [October, 1950

MIND

A QUARTERLY REVIEW

OF

PSYCHOLOGY AND PHILOSOPHY

I.—COMPUTING MACHINERY AND INTELLIGENCE

BY A. M. TURING

1. *The Imitation Game.*

I PROPOSE to consider the question, 'Can machines think?' This should begin with definitions of the meaning of the terms 'machine' and 'think'. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words 'machine' and 'think' are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, 'Can machines think?' is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.

The new form of the problem can be described in terms of a game which we call the 'imitation game'. It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game he says either 'X is A and Y is B' or 'X is B and Y is A'. The interrogator is allowed to put questions to A and B thus:

C: Will X please tell me the length of his or her hair?

Now suppose X is actually A, then A must answer. It is A's

28 433

- Synthetize presentation of papers
- Synthetize argument(s) of presenter(s)
- Include discussions brought by the audience
- Include wrap-up from the class
- Tie the discussion in class to current discussions in the community



Article: *Alan M. Turing, 1950,* ***Computing Machinery and Intelligence***

# Milestones in the Research Project

Related questions at intersection of own research and cog.sci.

## Pre-Proposal (2%) – due Oct 23

- Write up *two* possible debate questions (250 words each)
- For each: say what we know, what we don't know, and why it matters

## Proposal (3%) – due Oct 21

- Expand on *one* of those debate questions
- Review ≥ 5 recent primary references (since ~2010)
- Clarify the debate and outline your argument (~1000 words)

## Proposal Blitz (flash talk) (5%) – Nov 13 to 20

- Short 5 min talk with slides
- Present your developing argument, get feedback

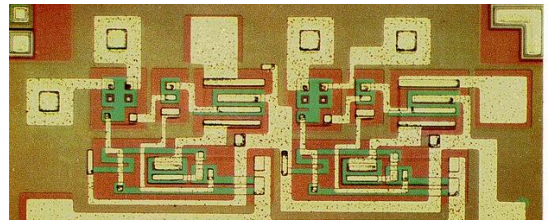

## Final Opinion Paper (15%) – Dec 16 to 18

- Full 2000-3000 words opinion paper (excluding refs)
- Incorporate earlier feedback
- Clarify the debate, present your argument, engage competing perspectives, take a clear stance by defending your position



Photography: *Michael Heizer's **The City,** by Jamie Hawkesworth*

# More on the Opinion Project



**Opinion project.** You will write/present four assignments that engage with a current debate in cognitive science. While you are encouraged to connect with themes from the course, your project does not have to be limited to the debates we cover in class. You may instead focus on another live issue in the field that intersects with your own research interests. The goal is to develop and defend a well-argued position on a debate, using evidence from the literature. The final product will be an opinion paper of 2000-3000 words that takes a clear stance and situates your argument within ongoing discussions.

- **a) Pre-proposal (2%).** Describe TWO debate questions you are interested in writing about. Each description is limited to 250 words and should directly address 3 points: 1) What we know about the issue, 2) What remains contested or unknown, and 3) Why is it important to resolve or clarify this debate.

- **b) Proposal (3%).** Based on feedback from your pre-proposal, you will select ONE debate question and write a short proposal that synthetizes at least five recent primary references (~since 2010). Your proposal should clarify the contours of the debate, summarize the key positions, and outline the personal argument you intend to make. This assignment should be ~1000 words (excluding references).

- **c) Proposal blitz (5%).** As you finalize your argument, you will prepare a short (~5 min; 3-5 slides) presentation of your proposal. This provides an opportunity to test your reasoning in front of your peers, receive real-time feedback, and refine your argument before completing the final paper.

- **d) Final opinion paper (15%).** Your final submission will be an opinion paper of 2000-3000 words. The paper should take a clear position on a current debate in cognitive science, provide a critical synthesis of relevant literature, evaluate competing perspectives, and defend your stance.

- **e) Peer-review (5%).** Each review should be approximately 250-500 words and should include: (1) a brief summary of the paper's question and argument, (2) strengths of the paper, (3) areas for improvement, and (4) constructive suggestions for revision.

Illustrations: ***NAND gate**, Radio Fernsehen Elektronik 10/1990,* found on *Moore's Law Wikipedia; Jaegwon Kim, 2011, **Philosophy of mind***

# Guidelines

# Preparation guidelines

- **Read both papers before class**. Focus on:
  - Key claims & evidence
  - Theoretical assumptions & paradigm
  - Points of weakness or limitation
  - Personal reflection
- **Post on Canvas (≤200 words) by the deadline**
- **Bring your notes to class**. You may need them to challenge presenters or contribute to synthesis
- **It's okay if some details are unclear**. Focus on what you *can* extract and how it connects to the bigger debate

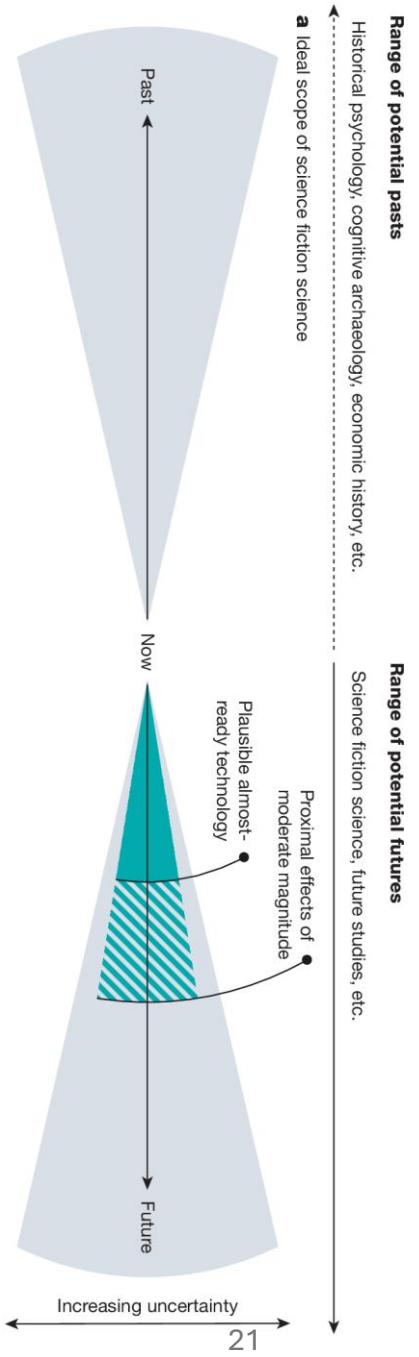



Image: *Fig. 2: A modified futures cone for sci-fi-sci. from Rahwan, Shariff et Bonnefon 2025,* ***The science fiction science method***

# Etiquette


- **Respectful disagreement** is expected and valued
- **Listen actively** - let peers finish before responding
- **Critique ideas**, not people
- **Aim to build** on others' arguments rather than only counter them
- **Aim for accurate and unambiguous** contributions rather than fuzzy or ambiguous
- **Keep contributions concise** so all voices can be heard
- Remember: **the goal is collective understanding**, not "winning"

Illustration: *Sydney Lumet, 1957,* ***12 Angry Men***

# Topics

# List of topics (ordered, **=new)

1. What is cognitive science?
2. What/Who is cogsci for?
3. Concepts 1: What are concepts?
4. Concepts 2: Are concepts embodied?
5. Concepts 3: Are numbers learned or innate?
6. Modularity 1: Is the mind modular?
7. Modularity 2: Is visual processing modular?
8. Modularity 3: Is face processing modular?
9. Bodily cognition: 4E (embodied, embedded, extended, enacted)**
10. Brain architecture 1: Connections**
11. Brain architecture 2: Populations**
12. Brain architecture 3: Representations**
13. Cognitive architecture 1: Predictions everywhere**
14. Cognitive architecture 2: Bayesian models
15. Cognitive architecture 3: Reinforcement learning**
16. Cognitive architecture 4: Unifications**
17. Innateness 1: Are object concepts innate?
18. Innateness 2: Language?
19. Method 1: Quantitative perspectives?**
20. Method 2: The need for paradigms**
21. Evolution of cognition: Did language come before or after?**
22. Social cognition 1: Why do humans cooperate?
23. Social cognition 2: Where does social cognition come from?
24. Social cognition 3: Are we cooperative or competitive?**
25. Social cognition 4: The neural need to infer others**
26. Social networks: Beliefs in crowds?**
27. Cultural psychology: East, west and between**
28. Cultural neuroscience: East, west and the brain**
29. Cognitive systems 1: Reasoning with heuristics and biases*
30. Cognitive systems 2: Memory
31. Thinking 1: Two systems to decide*
32. Thinking 2: Model-free vs model-based**
33. Thinking 3: Collective knowledge?
34. Thinking 4: The most rational definition of rationality**
35. NeuroAI 1: Should AI be part of cognitive science?
36. NeuroAI 2: From the brain to AI - and AI to the brain **
37. NeuroAI 3: Cognitive properties of LLMs**

# Topics 1

- 01. WHAT IS COGNITIVE SCIENCE?
  - 1. Turing, A.M. (1950). Computing machinery and intelligence. Mind, 59, 433-460.
  - 2. Marr, D. (2000). Vision. In R. Cummins & D. D. Cummins (Eds.), Minds, Brains, and Computers: The Foundations of Cognitive Science (pp. 69–83). Blackwell Publishers.
- 02. WHAT/WHO IS COGSCI FOR?
  - 1. Mook, D. G. (1983). In defense of external invalidity. American Psychologist, 38(4), 379-387.
  - 2. Thomas, A. K., McKinney de Royston, M., & Powell, S. (2023). Color-evasive cognition: the unavoidable impact of scientific racism in the founding of a field. Current Directions in Psychological Science, 32(2), 137-144.
- 03. CONCEPTS 1: WHAT ARE CONCEPTS?
  - 1. Mervis, C. B., & Rosch, E. (1981). Categorization of natural objects. Annual Review of Psychology, 32, 89–115.
  - 2. Armstrong, S. L., Gleitman, L. R., & Gleitman, H. (1983). What some concepts might not be. Cognition, 13,263-308.
- 04. CONCEPTS 2: ARE CONCEPTS EMBODIED?
  - 1. Barsalou, L. W. (2016). On staying grounded and avoiding quixotic dead ends. Psychonomic Bulletin & Review, 23(4), 1122-1142.
  - 2. Leshinskaya, A., & Caramazza, A. (2016). For a cognitive neuroscience of concepts: Moving beyond the grounding issue. Psychonomic Bulletin & Review, 23(4), 991-1001.
- 05. CONCEPTS 3: NUMBERS
  - 1. Sarnecka, B. W., & Wright, C. E. (2013). The idea of an exact number: Children's understanding of cardinalityand equinumerosity. Cognitive Science, 37(8), 1493-1506.
  - 2. Jara-Ettinger, J., Piantadosi, S., Spelke, E. S., Levy, R., & Gibson, E. (2017). Mastery of the logic of natural numbers is not the result of mastery of counting: Evidence from late counters. Developmental Science, 20, e12459.
- 06. MODULARITY 1: WHAT'S THE STRUCTURE OF MENTAL PROCESSES?
  - 1. Fodor, J. A. (1983). The modularity of mind (part 3, input systems as modules). MIT press, pp. 47-101.
  - 2. Prinz, J. (2006). Is the mind really modular? Contemporary Debates in Cognitive Science. Ed. RJ Stainton, 22-36.
- 07. MODULARITY 2: IS VISUAL PROCESSING MODULAR?
  - 1. Pylyshyn, Z. (1999). Is vision continuous with cognition? The case for cognitive impenetrability of visual perception. Behavioral and Brain Sciences, 22, 341-365.
  - 2. Lupyan, G. (2015). Cognitive penetrability of perception in the age of prediction: Predictive systems are penetrable systems. Review of Philosophy and Psychology, 6, 547-569.
- 08. MODULARITY 3: IS FACE PROCESSING MODULAR?
  - 1. Schalk, G., Kapeller, C., Guger, C., Ogawa, H., Hiroshima, S., Lafer-Sousa, R., ... & Kanwisher, N. (2017). Facephenes and rainbows: Causal evidence for functional and anatomical specificity of face and color processing in the human brain. Proceedings of the National Academy of Sciences, 114(46), 12285-12290.
  - 2. Gomez, J., Barnett, M., & Grill-Spector, K. (2019). Extensive childhood experience with Pokémon suggests eccentricity drives organization of visual cortex. Nature Human Behaviour, 3(6), 611-624.

# Topics 2

- 09. BODILY COGNITION: 4E (embodied, embedded, extended, enacted) **
  - 1. Varela, F. J. (1997). Patterns of life: Intertwining identity and cognition. Brain and cognition, 34(1), 72-87.
  - 2. Cappuccio, M. L. (2017). Mind-upload. The ultimate challenge to the embodied mind theory. Phenomenology and the Cognitive Sciences, 16(3), 425-448.
- 10. BRAIN ARCHITECTURE 1: CONNECTIONS **
  - 1. Bullmore, E., & Sporns, O. (2012). The economy of brain network organization. Nature reviews neuroscience, 13(5), 336-349.
  - 2. Reimann, M. W., Nolte, M., Scolamiero, M., Turner, K., Perin, R., Chindemi, G., ... & Markram, H. (2017). Cliques of neurons bound into cavities provide a missing link between structure and function. Frontiers in computational neuroscience, 11, 266051.
- 11. BRAIN ARCHITECTURE 2: POPULATIONS **
  - 1. Behrens, T. E., Muller, T. H., Whittington, J. C., Mark, S., Baram, A. B., Stachenfeld, K. L., & Kurth-Nelson, Z. (2018). What is a cognitive map? Organizing knowledge for flexible behavior. Neuron, 100(2), 490-509.
  - 2. Saxena, S., & Cunningham, J. P. (2019). Towards the neural population doctrine. Current opinion in neurobiology, 55, 103-111.
- 12. BRAIN ARCHITECTURE 3: REPRESENTATIONS **
  - 1. Brette, R. (2019). Is coding a relevant metaphor for the brain?. Behavioral and Brain Sciences, 42, e215.
  - 2. Kriegeskorte, N., & Diedrichsen, J. (2019). Peeling the onion of brain representations. Annual review of neuroscience, 42(1), 407-432.
- 13. COGNITIVE ARCHITECTURE 1: PREDICTIONS EVERYWHERE **
  - 1. Rao, R. P., & Ballard, D. H. (1999). Predictive coding in the visual cortex: a functional interpretation of some extra-classical receptive-field effects. Nature neuroscience, 2(1), 79-87.
  - 2. Litwin, P., & Miłkowski, M. (2020). Unification by fiat: Arrested development of predictive processing. Cognitive Science, 44(7), e12867.
- 14. COGNITIVE ARCHITECTURE 2: BAYESIAN MODELS
  - 1. Tenenbaum, J. B., Kemp, C., Griffiths, T. L., & Goodman, N. D. (2011). How to grow a mind: Statistics, structure, and abstraction. Science, 331, 1279-1285.
  - 2. Marcus, G. F., & Davis, E. (2013). How robust are probabilistic models of higher-level cognition? Psychological Science, 24, 2351-2360.
- 15. COGNITIVE ARCHITECTURE 3: REINFORCEMENT LEARNING **
  - 1. Schultz, W., Dayan, P., & Montague, P. R. (1997). A neural substrate of prediction and reward. Science, 275(5306), 1593-1599.
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