Human and Machine Cognition Lab

What makes humans so uniquely intelligent?
How do people make the best use of limited cognitive resources?
What are the unique algorithms we use to learn from other people?

Lab Rotations and BSc/MSc Thesis Projects

hmc-lab.com

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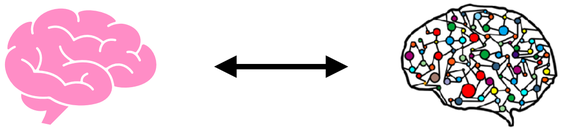
About the HMC Lab

The HMC Lab is an Independent Research Group led by Dr. Charley Wu, with the goal of understanding the gap between human and machine learning.



Our research methods include:

- online experiments (commonly in the form of interactive games)
- lab-based virtual reality experiments
- computational modeling of behavior (e.g., decisions, search trajectories, and reaction times)
- evolutionary models and simulations
- developmental studies (comparing children and adults)
- neuroimaging using fMRI/EEG
- analyzing large scale real-world datasets

We also have a rich collaboration network of researchers from Harvard, Princeton, UCL, and multiple Max Planck Institutes around Germany. To find out more, visit the lab website at **www.hmc-lab.com**

Project 1: Concept Generalization through Cultural Transmission Chains

Research question

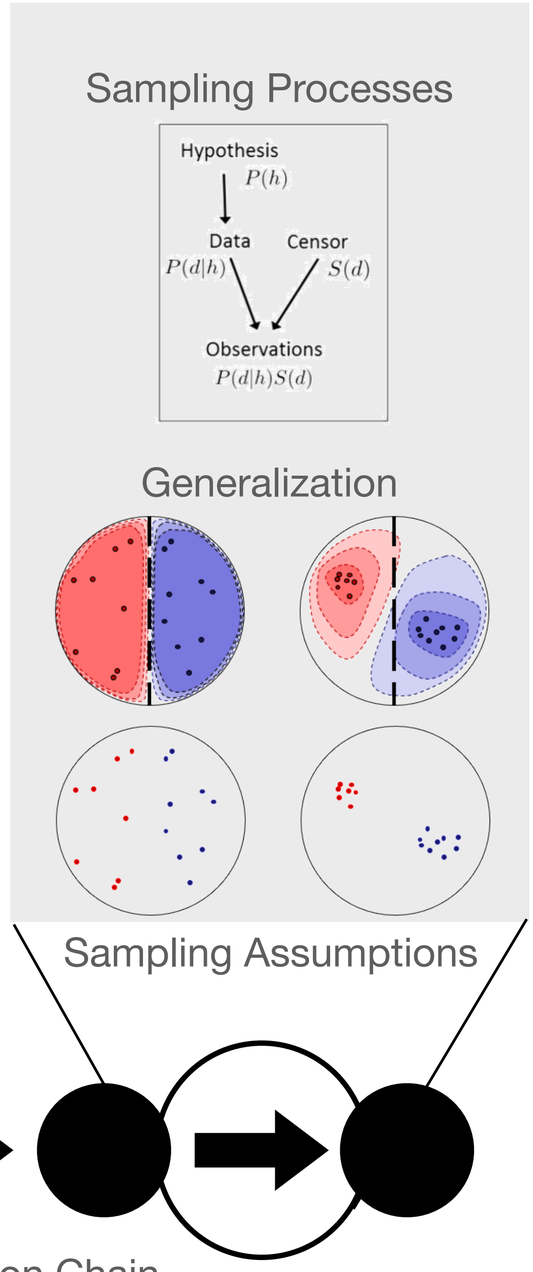
Many cross-cultural differences map onto the *Analytic-Holistic dimension* (Nisbett et. al. 2001; De Oliveira et. al. 2017). People from more holistic cultures prefer more complex causal models and mixtures of models; analytic thinkers prefer parsimony instead. Holistic persons also default to family-resemblance categories over the more rules-based classification systems preferred by people from analytic cultures. This occurs even when both groups are presented with the same stimuli. However, if cognition is about optimal responses to computational problems, why do people in different cultures arrive at different representations?

Approach

- Will test the hypothesis that differences in *ecological sampling* produce different levels of reliance on *Bayesian Occam's Razor* in Bayesian updating (Blanchard et. al. 2018)
    - When environmental observations are *weakly sampled* (Gweon & Tenenbaum 2010), individuals develop complex, unparsimonious, context-bound concepts and theories
    - When they are *strongly sampled,* individuals develop a preference for simple, parsimonious concepts and theories enabling generalization to distant contexts
- The hypothesis will be tested using a simple classification task; visual stimuli that vary across multiple perceptual dimensions are sampled strongly or weakly from underlying categories. Sampling is expected to produce differences in generalization curves.
- Individuals will then transmit their knowledge to the next generation using examples, as part of transmission chains. As sampling is affected by features of the chain (how many individuals does a learner receive examples from? How different are the received examples from what the learner will experience themselves?), different social sampling regimes will produce differences in generalization. In other words, different concepts will develop as part of different "cultures" in the lab.

Scope

- Develop or adapt a set of visual stimuli with manipulable perceptual features
- Program an online experiment (HTML/JavaScript/CSS) with inter-participant dependencies and transmission chain dynamics
- Learn about computational modeling of generalization and cultural evolution
- This project is in collaboration with Harvard and MIT



Project 2: Pedagogy and Tool Discovery

Research Question

Tool use is a key signature of human intelligence (Rawlings & Legare, TICS 2020),
yet the cognitive mechanisms underlying how we develop and innovate upon tools is not well understood.

Here, we focus on the role of pedagogy in amplyifying individual innovations and unlocking cumulative cultural evolution

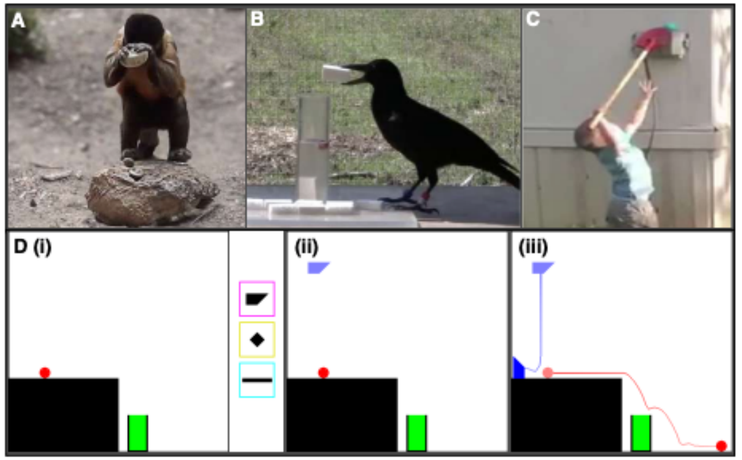
Approach

- Innovate upon a previous experiment (Allen*, Smith*, & Tenenbuam (PNAS 2020), where participants selected which tool they found most useful
- Here, we will allow people to develop their own tools and implement a transmission chain, where the solutions or instructions from one generation of participants will be passed along to the next
- Study the key ingredients for cumulative culture in tool use (e.g., observational learning vs. explicit pedagogy) and which task dimensions are most sensitive to pedagogy (e.g, opaque vs. transparent causal structure)

Scope

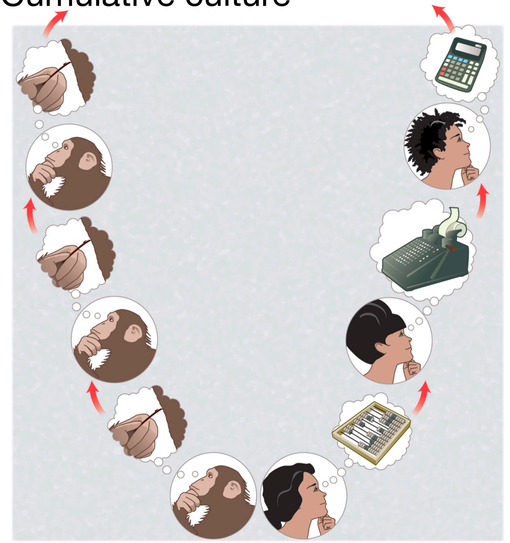
- Learn to design and implement an online experiment based on previous online experiment code (experience with Javascript/HTML/PHP highly recommended)
- Analyze data and perform statistical analyses (experience with Python/R encouraged)
- Collaboration with MIT and Deepmind

Tool use in animals and humans



Allen*, Smith*, & Tenenbuam (PNAS 2020)

Cumulative culture



Kurzban & Barrett (Sci, 2012)

Project 3: Propose your own project!

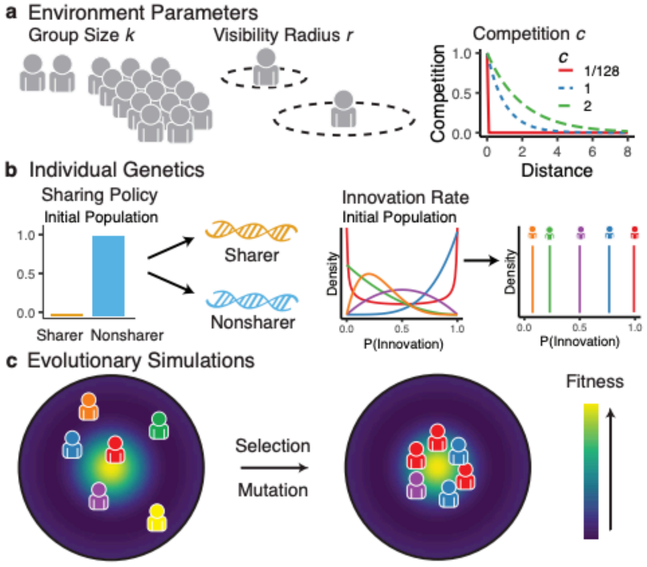
- Take the reigns and propose your own research project! To make things feasible within the rotation period or for a thesis, here are some suggestions of projects with existing data/code that could be built upon:

- **How does cooperation arise in competitive environments?** Through a series of agent-based and evolutionary simulations, we found that unconditional sharing of information can be beneficial, even in the absence of traditional reciprocity or reputation-based mechanisms. Many open questions, new environments, and learning mechanisms that can be tested

- **Why do people systematically under-generalize? Why are people systematically biased towards performing local search?** These are unexplained questions from a series of previous papers studying the search for rewards in spatially structured (Wu et al., 2018) and conceptually structured (Wu et al., 2020), and graph-structured environments (Wu et al., 2021). All the code and data are publicly available (1, 2, 3)

- **Note**: proposing your own project requires a high level of independent thinking and ability to craft an interesting and obtainable research question

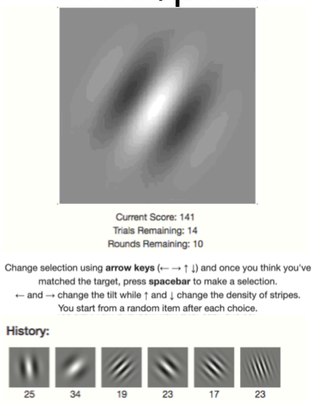
Evolutionary simulations



Spatial

7	5	10	22	32	32	28	24	22	26	33
6	11	19	29	38	41	42	40	37	36	40
22	27	30	35	43	50	53	53	51	49	46
45	44	38	36	40	46	47	49	54	55	48
61	55	46	40	37	32	27	31	44	52	44
62	59	57	54	44	27	14	17	33	46	45
53	59	68	71	59	36	17	15	28	45	51
46	57	71	77	67	47	26	18	27	45	56
45	56	65	67	60	46	29	20	27	42	55
51	57	58	53	47	40	30	23	28	40	49
60	62	58	47	39	38	35	31	35	41	46

Conceptual



Graph-structured