**Abstract**

While ~~we~~ have learned much about how ~~humans~~ learn in relatively simple and static environments, ~~we know~~ less about how ~~they learn over time~~ in more complex environments such as those we encounter on a daily basis. In this paper we present results of an experiment in which participants learn the causal structure of systems of varying complexity. ~~Specifically, we asked our participants to represent their beliefs about the systems as Bayes Nets.~~ With the resulting data we ask how humans ~~learn in simple and in complex systems; how efficiently they~~ explore the space ~~of possible beliefs~~ and how closely the direction of their exploration is tied to their experience.

We have three main findings. First, we find that the rate of learning is constant across levels of complexity and much slower than it would be if learners were Bayesians, as had been proposed in economic theories. Second, the diversity of beliefs stays constantly higher in the more complex environment.

Third, we find that the time participants spend thinking between attempts to improve their models is positively correlated with the quality of the model changes, but this correlation decreases steeply as time passes. This finding suggests that human reasoners find later exploration difficult because their reasoning is conditioned by their past ideas. In other words, humans are unable to generate truly random signals (Jokar and Mikaili, 2012); they are pattern creators and pattern synthesizers. Once human reasoners have explored regions of the space, they tend to return and recombine the patterns that they have already generated in the past and find it difficult to generate truly novel ideas. As a result, learning becomes harder and slower over time.

These findings contribute to develop a more general theory of how people learn from data in dynamic and complex settings.

# References

T. Lombrozo, Trends in cognitive sciences **10**, 464 (2006).

J. R. Anderson, *Cognitive psychology and its implications* . (WH Freeman/Times Books/Henry Holt & Co, 1990).

M. Boyer and R. E. Kihlstrom, eds., *Bayesian models in economic theory* (North-Holland Pub. Co. ; Sole distributors for the U.S.A. and Canada, Elsevier Science Pub. Co Amsterdam ; New York : New York, N.Y, 1984) pp. viii, 317 p. :.

E. Prescott, Econometrica (1972).

M. Rothschild, Journal of Economic Theory (1974).

A. McLennan, Journal of Economic Dynamics and Control. (1984).

M. L., P. A., and R. Kihlstrom, "Bayesian models in economic theory," (Elsevier Science Ltd, 1984) Chap. Experimental Consumption and the "Rothschild effect" .

E. D. and K. N., Econometrica (1989).

K. N. and N. Y., International Economic Review (1989).

E. Jokar and M. Mikaili, Journal of Medical Signals and Sensors (2012).