Eric Schulz

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Employment History

since 2020 **Max Planck Research Group Leader.** Computational Principles of Intelligence Lab, MPI for Biological Cybernetics, Tübingen, Germany.

2017-2019 **Data Science Postdoctoral Fellow.** Harvard University, Cambridge, USA.

2013 **Volunteer.** Uganda Virus Research Institute, Entebbe, Uganda.

2012 – 2013 **Machine Learning Analyst.** Zalando, Berlin, Germany.

2008 – 2010 **Student Research Assistant.** MPI for Human Development, Berlin, Germany.

2006 – 2007 **Military Service.** United Nations Training Center, Hammelburg, Germany.

Education

2014 – 2017 **PhD Experimental Psychology.** University College London, UK.

2013 – 2014 **MRes Computer Science.** University College London, UK.

2011 – 2012 **MSc Applied Statistics.** University of Oxford, UK.

2010 – 2011 **MSc Cognitive and Decision Sciences.** University College London, UK.

2007 – 2010 **Vordiplom Psychology.** Humboldt University, Berlin, Germany.

Funding

2021-2025 **Volkswagen Artificial Intelligence and the Society of the Future Grant** to study curiosity in children and robots. (EUR 450,000)

2021-2024 **Univerisity of Tübingen Machine Learning Mini Graduate School** to study compositionality in minds and machines. (EUR 150,000)

2020-2023 **Jacobs Early Career Research Fellowship** for Highly talented young scholars working on child development. (EUR 150,00)

2020-2025 **Max Planck Research Group** on Computational Principles of Intelligence.

Publications

1. Binz, M., Gershman, S. J., Schulz, E., & Endres, D. (submitted). Heuristics from bounded meta-learned inference.
2. Ruggeri, A., Pelz, M., Gopnik, A., & Schulz, E. (submitted). Toddlers search longer when there is more information to be gained.
3. Wu, C. M., Schulz, E., Pleskac, T., & Speekenbrink, M. (submitted). Time to explore: adaptation of exploration under time pressure.
4. Brändle, F., Allen, K., Tenenbaum, J. B., & Schulz, E. (2021). Using games to understand intelligence.
5. Brändle, F., Binz, M., & Schulz, E. (2021). Exploration beyond bandits.
6. Saanum, T., Schulz, E., & Speekenbrink, M. (2021). Compositional generalization in multi-armed bandits. *Proceedings of the 43rd Annual Meeting of the Cognitive Science Society*.

7. Tomov, M., Schulz, E., & Gershman, S. J. (2021). Multi-task reinforcement learning in humans. *Nature Human Behaviour*.

8. Bertram, L., Schulz, E., Hofer, M., & Nelson, J. D. (2020). . the psychology of human entropy intuitions. *Proceedings of the 42nd Annual Meeting of the Cognitive Science Society*.

9. Brändle, F., Wu, C. M., & Schulz, E. (2020). What are we curious about? *Trends in Cognitive Sciences*, *24*(9), 685–687.

10. Dasgupta, I., Schulz, E., Tenenbaum, J. B., & Gershman, S. J. (2020). A theory of learning to infer. *Psychological Review*, *127*(3), 412.

11. Schulz, E. & Dayan, P. (2020). Computational psychiatry for computers. *iScience*, 101772.

12. Schulz, E., Franklin, N. T., & Gershman, S. J. (2020). Finding structure in multi-armed bandits. *Cognitive Psychology*, *119*, 101261.

13. Schulz, E., Quiroga, F., & Gershman, S. J. (2020). Communicating compositional patterns. *Open Mind*, *4*, 25–39.

14. Stojić, H., Schulz, E., P Analytis, P., & Speekenbrink, M. (2020). It's new, but is it good? how generalization and uncertainty guide the exploration of novel options. *Journal of Experimental Psychology: General*.

15. Wu, C. M., Schulz, E., Garvert, M. M., Meder, B., & Schuck, N. W. (2020). Similarities and differences in spatial and non-spatial cognitive maps. *PloS Computational Biology*.

16. Schulz, E., Betram, L., Hofman, M., & Nelson, J. D. (2019). Exploring the space of human exploration using entropy mastermind. In *Proceedings of the Forty-first Annual Conference of the Cognitive Science Society*.

17. Schulz, E., Bhui, R., Love, B. C., Brier, B., Todd, M. T., & Gershman, S. J. (2019). Structured, uncertainty-driven exploration in real-world consumer choice. *Proceedings of the National Academy of Sciences*, *116*(28), 13903–13908.

18. Schulz, E. & Gershman, S. J. (2019). The algorithmic architecture of exploration in the human brain. *Current Opinion in Neurobiology*, *55*, 7–14.

19. Schulz, E., Wu, C. M., Ruggeri, A., & Meder, B. (2019). Searching for rewards like a child means less generalization and more directed exploration. *Psychological Science*.

20. Wu, C. M., Schulz, E., Gerbaulet, K., Pleskac, T. J., & Speekenbrink, M. (2019). Under pressure: the influence of time limits on human exploration. In *Proceedings of the Forty-first Annual Conference of the Cognitive Science Society*.

21. Wu, C. M., Schulz, E., & Gershman, S. J. (2019). Generalization as diffusion: human function learning on graphs. In *Proceedings of the Forty-first Annual Conference of the Cognitive Science Society*.

22. Dasgupta, I., Schulz, E., Goodman, N. D., & Gershman, S. J. (2018). Remembrance of inferences past: Amortization in human hypothesis generation. *Cognition*, *178*, 67–81.

23. Dasgupta, I., Schulz, E., Smith, K. A., Tenenbaum, J. B., & Gershman, S. J. (2018). Learning to act by integrating mental simulations and physical experiments. In *Proceedings of the Fortieth Annual Conference of the Cognitive Science Society*.

24. Jones, A., Schulz, E., Meder, B., & Ruggeri, A. (2018). Active function learning. In *Proceedings of the Fortieth Annual Conference of the Cognitive Science Society*.

25. Krusche, M., Schulz, E., Guez, A., & Speekenbrink, M. (2018). Adaptive planning in human search. In *Proceedings of the Fortieth Annual Conference of the Cognitive Science Society*.

26 Rule, J., Schulz, E., Piantadosi, S. P., & Tenebaum, J. B. (2018). Learning list concepts through program induction. In *Proceedings of the Fortieth Annual Conference of the Cognitive Science Society*.

27 Schulz, E., Speekenbrink, M., & Krause, A. (2018). A tutorial on Gaussian process regression: Modelling, exploring, and exploiting functions. *Journal of Mathematical Psychology*, *85*, 1–16.

28 Schulz, E., Wu, C. M., Huys, Q. J. M., Krause, A., & Speekenbrink, M. (2018). Generalization and search in risky environments. *Cognitive Science*. doi:10.1101/227322

29 Wu, C. M., Schulz, E., Garvert, M. M., Meder, B., & Schuck, N. W. (2018). Connecting conceptual and spatial search via a model of generalization. In *Proceedings of the Fortieth Annual Conference of the Cognitive Science Society*.

30 Wu, C. M., Schulz, E., Speekenbrink, M., Nelson, J. D., & Meder, B. (2018). Exploration and generalization in vast spaces. *Nature Human Behaviour*.

31 Dasgupta, I., Schulz, E., & Gershman, S. J. (2017). Where do hypotheses come from? *Cognitive Psychology*, *96*, 1–25.

32 Dasgupta, I., Schulz, E., Goodman, N. D., & Gershman, S. J. (2017). Amortized hypothesis generation. In *Proceedings of the Thirty-Ninth Annual Conference of the Cognitive Science Society*.

33 Schulz, E., Klenske, E., Bramley, N. R., & Speekenbrink, M. (2017). Strategic exploration in human adaptive control. In *Proceedings of the Thirty-Ninth Annual Conference of the Cognitive Science Society*.

34 Schulz, E., Konstantinidis, E., & Speekenbrink, M. (2017). Putting bandits into context: how function learning supports decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition*.

35 Schulz, E., Tenenbaum, J. B., Duvenaud, D., Speekenbrink, M., & Gershman, S. J. (2017). Compositional inductive biases in function learning. *Cognitive Psychology*, *99*, 44–79.

36 Wu, C. M., Schulz, E., Speekenbrink, M., Nelson, J. D., & Meder, B. (2017). Mapping the unknown: The spatially correlated multi-armed bandit. In *Proceedings of the Thirty-Ninth Annual Conference of the Cognitive Science Society*.

37 Schulz, E., Huys, Q. J., Bach, D. R., Speekenbrink, M., & Krause, A. (2016). Better safe than sorry: Risky function exploitation through safe optimization. In *Proceedings of the Thirty-Eighth Annual Conference of the Cognitive Science Society*.

38 Schulz, E., Speekenbrink, M., Hernández-Lobato, J. M., Ghahramani, Z., & Gershman, S. J. (2016). Quantifying mismatch in bayesian optimization. In *NIPS Bayesian Optimization workshop*.

39 Schulz, E., Speekenbrink, M., & Meder, B. (2016). Simple trees in complex forests: Growing Take The Best by Approximate Bayesian Computation. In *Proceedings of the Thirty-Eighth Annual Conference of the Cognitive Science Society*.

40 Schulz, E., Tenenbaum, J. B., Duvenaud, D., Speekenbrink, M., & Gershman, S. J. (2016). Probing the compositionality of intuitive functions. In *Advances in Neural Information Processing Systems*.

41 Parpart, P., Schulz, E., Speekenbrink, M., & Love, B. C. (2015). Active learning as a means to distinguish among prominent decision strategies. In *Proceedings of the Thirty-Seventh Annual Conference of the Cognitive Science Society*.

42 Schulz, E., Konstantinidis, E., & Speekenbrink, M. (2015). Exploration-exploitation in a contextual multi-armed bandit task. In *International Conference on Cognitive Modeling* (pp. 118–123).

43 Schulz, E., Konstantinidis, E., & & Speekenbrink, M. (2015). Learning and decisions in contextual multi-armed bandit tasks. In *Proceedings of the Thirty-Seventh Annual Conference of the Cognitive Science Society*.

44 Schulz, E., Tenenbaum, J. B., Reshef, D. N., Speekenbrink, M., & Gershman, S. J. (2015). Assessing the perceived predictability of functions. In *Proceedings of the Thirty-Seventh Annual Conference of the Cognitive Science Society*.

45 Schulz, E., Speekenbrink, M., & Shanks, D. R. (2014). Predict choice – a comparison of 21 mathematical models. In *Proceedings of the Thirty-Sixth Annual Conference of the Cognitive Science Society*.

46 Cokely, E. T., Galesic, M., Schulz, E., Ghazal, S., & Garcia-Retamero, R. (2012). Measuring risk literacy: the berlin numeracy test. *Judgment and Decision Making*, *7*(1), 25.

47 Cokely, E. T., Ghazal, S., Galesic, M., Garcia-Retamero, R., & Schulz, E. (2012). How to measure risk comprehension in educated samples. *Transparent Communication of Health Risks*, 29–52.

48 Schulz, E., Cokely, E. T., & Feltz, A. (2011). Persistent bias in expert judgments about free will and moral responsibility: a test of the expertise defense. *Consciousness and Cognition*, *20*(4), 1722–1731.

Awards

2020 **Jacobs Research Fellowship** for building algorithms that learn and explore like children.

2018 **Robert J. Glushko Award** for Outstanding Doctoral Dissertation in Cognitive Science.

2017 **Harvard Data Science Postdoctoral Fellowship**.

2016 **UCL Bogue Research Fellowship** funding 3 month visit to Harvard and MIT.

EPS Grindley Award to attend the International Conference of Thinking.

SLMS Graduate School Conference Fund.

2015 **UCL Sully Award** for best PhD upgrade talk.

Cognitive Science Travel Award

2013 **ESPRC scholarship** funding both MRes and PhD at UCL by the Centre for Doctoral Training in Financial Computing and Analytics.

2011 **Haniel scholarship** funding MSc at the University of Oxford.

2010 **DAAD scholarship** funding MSc at University College London.

Invited Talks

2021 **IICCSSS.** Talk at Summer School.

University of Cologne. Peters Lab.

University of Ghent. Center for Cognitive Neuroscience.

TU Darmstadt. Center for Cognitive Science.

2020 **University of Tübingen.** Cognitive Science Colloquium.

University of New South Wales. Departmental Colloquium.

University of Oxford. Summerfield Lab Meeting.

Invited Talks (continued)

- **University of Warwick.** Cognitive Science Group.
- **The University of Edinburgh.** Computational Cognitive Science Group.

2019
- **Stanford University.** FriSem.
- **Max Planck Institute for Human Cognitive and Brain Sciences.** Guest Lecture.
- **Max Planck Institute for Biological Cybernetics.** MPRG Symposium.
- **Cognitive Lunch.** MIT.

2018
- **Ohio State Univeristy.** Brown bag seminar series. Invited by Jay Myung.
- **Early Childhood Cognition Lab.** Lab Meeting at MIT.
- **ONR Science of Autonomy.** Grant Review.
- **Ecole Normale Supérieure.** Workshop organized by Stefano Palminteri.
- **Cognitive Science Conference.** Symposium for Glushko award winners.

2017
- **ConCats seminar series.** New York University.
- **CBB Lunch.** Harvard University.
- **Cognitive Psychology Colloquium.** University of Göttingen.
- **Cognitive Science Colloquium.** University of Onsabrück.

2016
- **London Judgement and Decision Making Seminar.** University College London.
- **Gershman Lab Meeting.** Harvard University.
- **Coffee and Tea Talk.** Max Planck Institute for Human Development.

2015
- **Psychology Seminar Series .** City University.
- **Krause Lab Meeting .** ETH Zürich.
- **Oberauer Lab Meeting .** University of Zürich.
- **Economic Psychology Colloquium .** University of Basel.

Supervision

Postdocs

2021- **Mirko Thalmann**. Memory-efficient generalization.

2021- **Marcel Binz**. Resource-rational meta-learning.

Graduate Students

2021- **Susanne Haridi**. Scaling laws of human inference.

2021- **Akshay Jagadish**. Meta-learning psychiatric symptoms.

2021- **Tankred Saanum**. Compositional reinforcement learning.

2020- **Franziska Brändle**. A computational theory of fun.

2020- **Shuchen Wu**. A resource-rational account of chunking.

2020- **Alexander Kipnis**. Program induction in minds and brains.

2020- **Lion Schulz** (collaborating student). Misinformation search.

2020- **Lara Bertram** (collaborating student). Perception of entropy.

Master Students

2020-2021 **Lena Stocks**. Exploration as empowerment.

2020-2021 **Akshay Jagadish**. Meta-learning compositional inference.

Research Students

2021- **Can Demircan**. Bayesian cognitive maps.

Supervision (continued)

2021- **Lena Stocks**. Exploration as empowerment.

2020- **Tobias Ludwig**. Planning in generative bandits.

2020- **Kristin Witte**. Safe exploration.

Professional Service

since 2012 **Reviewer.** Proceedings of the National Academy of Sciences, Psychonomic Bulletin and Review, Journal of Experimental Psychology: General, Journal of Cognitive Neuroscience, Neural Information Processing and Systems, Cognitive Science Society, PLOS: Computational Biology, Journal of Experimental Psychology: Learning, Memory, and Cognition, Journal of Mathematical Psychology, Nature Human Behaviour, PLOS One, Developmental Science.

2021 **Workshop organizer.** Using Games to Understand Intelligence (jointly with Franziska Brändle and Kelsey Allen). Workshop at the Annual Meeting of the Cognitive Science Society.

2020 **Workshop organizer.** How to become a good scientist. Workshop at the Max Planck Institute for Biological Cybernetics.

2019 **Workshop organizer.** Heuristics, Hacks, and Habits (jointly with Ishita Dasgupta). Workshop at the Annual Meeting of the Cognitive Science Society.

Workshop organizer. Structure for Efficient Reinforcement Learning (jointly with Nick Franklin). Workshop at the Multi-Disciplinary Conference on Reinforcement Learning and Decision Making.

2018 **Workshop organizer.** Learning as program induction (jointly with Neil Bramley). Workshop at the Annual Meeting of the Cognitive Science Society.

2015-2017 **Seminar organizer.** London Judgement and Decision Making seminar series.

Teaching Experience

2014-2017 **Teaching assistant.** PSYCGR01: Statistics for graduate students.

Ad-hoc lecturer. PSYCGD04: Knowledge, Learning and Inference.

2015 **Teaching assistant.** COMPG011: Data Analytics using R.