# Charley M. Wu

*Curriculum Vitae*

*AI Research Building*
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*Nationality: Canadian*


## Academic Background

### Current Position

2020 – present **Independent Research Group Leader**, *Human and Machine Cognition Lab*, University of Tübingen, Tübingen, Germany.
Jointly funded by the Excellence Cluster "Machine Learning for Science" and the Tübingen AI center.

### Previous Positions

2019 – 2020 **Post-Doctoral Fellow**, *Department of Psychology*, Harvard University, Cambridge, MA.
Advised by Fiery A. Cushman and Samuel J. Gershman.

2019 **Post-Doctoral Fellow**, *Center for Adaptive Rationality (ARC)*, Max Planck Institute for Human Development, Berlin, Germany.

2018 **Visiting Research Fellow**, *Computational Cognitive Neuroscience Lab; hosted by Samuel J. Gershman*, Harvard University, Cambridge, MA.

2016-2019 **Pre-Doctoral Fellow**, *Center for Adaptive Rationality (ARC) and Center for Adaptive Behavior and Cognition (ABC)*, Max Planck Institute for Human Development, Berlin, Germany.

2014-2015 **Research Assistant**, *Center for Adaptive Behavior and Cognition (ABC)*, Max Planck Institute for Human Development, Berlin, Germany.

2014 **Student Research Scientist**, *PetaByte Research*, Budapest, Hungary.

2013-2014 **Research Assistant**, *Intelligent Software Agents and New Media Group*, Austrian Institute for Artificial Intelligence (OFAI), Vienna, Austria.

2009 **Research Assistant**, *Center for Human Evolution, Cognition, and Culture (HECC)*, University of British Columbia, Vancouver, Canada.

## Education

2016-2019 **Dr. rer. nat. (Ph.D.) Psychology**, *Humboldt University of Berlin*, Berlin, Germany, *Summa Cum Laude*.

2013-2015 **M.Sc. Cognitive Science**, *University of Vienna*, Vienna, Austria, *with Distinction*.

2004-2009 **B.A. Philosophy**, *University of British Columbia*, Vancouver, Canada, *Dean's List*.

## Funding

2022 **Computational Summer School on Modeling Social and Collective Behavior (COSMOS) Konstanz 2022**, *William K. and Katherine W. Estes Fund*, Co-Organizer: Wataru Toyokawa, $18k.

2021 **Cumulative Culture in AI** (Postdoc funding), *Tübingen AI Center, supported by the Federal Ministry of Education and Research (BMBF)*, Co-PI: Claudio Tennie, ∼ €115k.

2021 **Compositionality in Minds and Machines** (Mini-graduate School), *Innovation Fund Program of the Cluster of Excellence "Machine Learning: New Perspectives for Science"*, University of Tübingen, Co-PI: Martin Butz, ∼ €114k.

2021 **Machine Learning for Education** (Mini-graduate School), *Innovation Fund Program of the Cluster of Excellence "Machine Learning: New Perspectives for Science"*, University of Tübingen, Co-PI: Álvaro Tejero-Cantero, ∼ €114k.

2019 **Dean's Competitive Fund for Promising Research**, *Harvard University*, Cambridge, MA (written with and awarded to Sam Gershman), $33,353 (USD).

2019 **Glushko and Samuelson Student Travel Grant**, *40th Annual Conference of the Cognitice Science Society*, Montreal, QC, $500 (USD).

2016-2019 **Pre-Doctoral Fellowship**, *International Max Planck Research School on Adapting Behavior in a Fundamentally Uncertain World*, Joint PhD Fellowship in Psychology, Economics, and Law, ∼€100k.

2011-2012 **Joseph-Armand Bombardier Canada Graduate Scholarship**, *Social Sciences and Humanities Research Council of Canada (SSHRC)*, Canada, $17,500 (CAD), *Declined*.

## Publications

### In Prep

submitted Collins, R. N., Mandel, D. R., Karvetski, C. W., **Wu**, C. M., & Nelson, J. D. (submitted). The wisdom of the coherent: improving correspondence with coherence-weighted aggregation. *PsyarXiv*. doi:10.31234/osf.io/fmnty

Giron, A. P., Ciranka, S., Schulz, E., van den Bos, W., Ruggeri, A., Meder, B., & **Wu**, C. M. (submitted). Developmental changes in learning resemble stochastic optimization. *PsyArXiv*. doi:10.31234/osf.io/9f4k3

in press Ludwig, T., **Wu**, C. M., & Schulz, E. (in press). Connecting exploration, generalization, and planning in correlated trees. In *Proceedings of the 44rd Annual Conference of the Cognitive Science Society*. Toronto, Canada: Cognitive Science Society.

### Peer reviewed

2022 Ciranka, S., Linde-Domingo, J., Padezhki, I., Wicharz, C., **Wu**, C. M., & Spitzer, B. (2022). Asymmetric learning facilitates human inference of transitive relations. *Nature Human Behaviour*. doi:https://doi.org/10.1038/s41562-021-01263-w

Dezza, I. C., Schulz, E., & **Wu**, C. M. (Eds.). (2022). *The Drive for Knowledge: The Science of Human Information-Seeking*. Cambridge: Cambridge University Press.

**Wu**, C. M., Schulz, E., Pleskac, T. J., & Speekenbrink, M. (2022). Time pressure changes how people explore and respond to uncertainty. *Scientific Reports*, *12*, 1–14. doi:https://doi.org/10.1038/s41598-022-07901-1

**Wu**, C. M., Vélez, N., & Cushman, F. A. (2022). Representational exchange in human social learning: Balancing efficiency and flexibility. In I. C. Dezza, E. Schulz, & C. M. Wu (Eds.), *The Drive for Knowledge: The Science of Human Information-Seeking*. Cambridge: Cambridge University Press.

2021 Humaidan, D., Otte, S., Gumbsch, C., **Wu**, C. M., & Butz, M. V. (2021). Latent event-predictive encodings through counterfactual regularization. In T. Fitch, C. Lamm, H. Leder, & K. Teßmar-Raible (Eds.), *Proceedings of the 43rd Annual Conference of the Cognitive Science Society* (pp. 1726–1731). Vienna, Austria: Cognitive Science Society. eprint: 2105.05894

Meder, B., **Wu**, C. M., Schulz, E., & Ruggeri, A. (2021). Development of directed and random exploration in children. *Developmental Science*, e13095. doi:10.1111/desc.13095

**Wu**, C. M., Ho, M. K., Kahl, B., Leuker, C., Meder, B., & Kurvers, R. H. (2021). Specialization and selective social attention establishes the balance between individual and social learning. In T. Fitch, C. Lamm, H. Leder, & K. Teßmar-Raible (Eds.), *Proceedings of the 43rd Annual Conference of the Cognitive Science Society* (pp. 1921–1927). Vienna, Austria: Cognitive Science Society. doi:10.1101/2021.02.03.429553

**Wu**, C. M., Schulz, E., & Gershman, S. J. (2021). Inference and search on graph-structured spaces. *Computational Brain & Behavior*, 125–147. doi:10.1007/s42113-020-00091-x

Zuberer, A., Kucyi, A., Yamashita, A., **Wu**, C. M., Walter, M., Valera, E. M., & Esterman, M. (2021). Integration and segregation across large-scale intrinsic brain networks as a marker of sustained attention and task-unrelated thought. *NeuroImage*, *229*, 117610. doi:10.1016/j.neuroimage.2020.117610

2020 Brändle, F., **Wu**, C. M., & Schulz, E. (2020). What are we curious about? *Trends in Cognitive Science*. doi:10.1016/j.tics.2020.05.010

**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*, 1–28. doi:10.1371/journal.pcbi.1008149

2019 Analytis, P. P., **Wu**, C. M., & Gelastopoulos, A. (2019). Make-or-break: chasing risky goals or settling for safe rewards? *Cognitive Science*, *43*, e12743. doi:10.1111/cogs.12743

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*, *30*(11), 1561–1572. doi:10.1177/0956797619863663

Tump, A. N., **Wu**, C. M., Bouhlel, I., & Goldstone, R. L. (2019). The evolutionary dynamics of cooperation in collective search. In A. Goel, C. Seifert, & C. Freksa (Eds.), *Proceedings of the 41st Annual Conference of the Cognitive Science Society* (pp. 883–889). Montreal, QB: Cognitive Science Society. (Joint first authorship.)

**Wu**, C. M., Schulz, E., Gerbaulet, K., Pleskac, T. J., & Speekenbrink, M. (2019). Under pressure: The influence of time limits on human exploration. In A. Goel, C. Seifert, & C. Freksa (Eds.), *Proceedings of the 41st Annual Conference of the Cognitive Science Society* (pp. 1219–1225). Montreal, QB: Cognitive Science Society. (Joint first authorship.)

**Wu**, C. M., Schulz, E., & Gershman, S. J. (2019a). Generalization as diffusion: human function learning on graphs. In A. Goel, C. Seifert, & C. Freksa (Eds.), *Proceedings of the 41st Annual Conference of the Cognitive Science Society* (pp. 3122–3128). Montreal, QB: Cognitive Science Society.

**Wu**, C. M., Schulz, E., & Gershman, S. J. (2019b). Searching for rewards in graph-structured spaces. In *Proceedings of the 2019 Conference on Cognitive Computational Neuroscience*. doi:10.32470/CCN.2019.1041-0

2018 Bouhlel, I., **Wu**, C. M., Hanaki, N., & Goldstone, R. L. (2018). Sharing is not erring: pseudo-reciprocity in collective search. In T. T. Rogers, M. Rau, X. Zhu, & C. W. Kalish (Eds.), *Proceedings of the 40th Annual Conference of the Cognitive Science Society* (pp. 156–161). Austin, TX: Cognitive Science Society. (Joint first authorship.)

Schulz, E., **Wu**, C. M., Huys, Q. J., Krause, A., & Speekenbrink, M. (2018). Generalization and search in risky environments. *Cognitive Science*, *42*, 2592–2620. doi:10.1111/cogs.12695

**Wu**, C. M., Schulz, E., Garvert, M. M., Meder, B., & Schuck, N. W. (2018a). Connecting conceptual and spatial search via a model of generalization. In T. T. Rogers, M. Rau, X. Zhu, & C. W. Kalish (Eds.), *Proceedings of the 40th Annual Conference of the Cognitive Science Society* (pp. 1183–1188). Austin, TX: Cognitive Science Society.

**Wu**, C. M., Schulz, E., Speekenbrink, M., Nelson, J. D., & Meder, B. (2018b). Generalization guides human exploration in vast decision spaces. *Nature Human Behaviour*, *2*, 915–924. doi:10.1038/s41562-018-0467-4

2017 **Wu**, C. M., Meder, B., Filimon, F., & Nelson, J. D. (2017). Asking better questions: how presentation formats influence information search. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *8*, 1274–1297. doi:doi:10.1037/xlm0000374

**Wu**, C. M., Schulz, E., Speekenbrink, M., Nelson, J. D., & Meder, B. (2017). Mapping the unknown: the spatially correlated multi-armed bandit. In G. Gunzelmann, A. Howes, T. Tenbrink, & E. J. Davelaar (Eds.), *Proceedings of the 39th Annual Meeting of the Cognitive Science Society* (pp. 1357–1362). Austin, TX: Cognitive Science Society.

2016 Barkoczi, D., Analytis, P. P., & **Wu**, C. M. (2016). Collective search on rugged landscapes: a crossenvironmental analysis. In A. Papafragou, D. Grodner, D. Mirman, & J. Trueswell (Eds.), *Proceedings of the 38th Annual Conference of the Cognitive Science Society* (pp. 918–923). Austin, TX: Cognitive Science Society.

## Teaching

2022 **Cognitive maps and model-based reinforcement learning**, *Graduate Training Center for Neuroscience, Masters Seminar*, University of Tübingen, DE, Co-taught with Philipp Schwartenbeck.

2022 **Tutorial on Modeling Social Learning and Collective Behavior**, *The Computational Summer school on Modeling Social and collective behavior (COSMOS)*, Konstanz, DE, [Code notebooks].

2022 **Scientific reasoning: Crafting research questions and arguments**, *Computation and Cognition Tübingen Summer Internship (CaCTüS) workshop*, Max Planck Institute for Biological Cybernetics, Tübingen, Germany.

2021 **Generalization in Reinforcement Learning**, *Guest lecture: Introduction to Cognitive Psychology*, University of Ghent, Ghent, Belgium (via Zoom) [Slides].

2020 **Scientific Thinking: the Art of Communicating Ideas**, *"Becoming a good scientist" workshop*, Max Planck Institute for Biological Cybernetics, Tübingen, Germany (via Zoom).

2020 **Computational Modeling**, *Graduate student workshop*, Max Planck Institute for Biological Cybernetics, Tübingen, Germany (via Zoom).

2019-2020 **Representation Learning in Reinforcement Learning Seminar**, *Co-organizer and regular Speaker*, Harvard University, Center for Brain Science, Cambridge, MA. [Notes].

2015-2019 **Berlin Machine Learning Seminar**, *Regular Speaker*, Berlin, Germany.

2018 **Introduction to Computational Modeling**, *Graduate and undergraduate workshop*, MPRG: iSearch Research Retreat, Bensdorf, Germany.

2018 **Intro to Cognitive Modeling**, *Course*, Max Planck Institute for Human Development, Berlin, Germany. (Teaching Assistant to Dr. Björn Meder).

2017 **Fast-and-frugal Trees and Models of Information Search**, *Workshop*, ABC Research Retreat, Schloss Ringberg, Germany.

2017 **Computational Models of Cognition**, *Lecture*, Berlin School of Mind and Brain (PhD Program), Humboldt University, Berlin, Germany.

2016-2017 **Math and Methods Tutorial Series**, *Organizer and regular speaker*, Center for Adaptive Behavior and Cognition (ABC), Berlin, Germany.

2016 **A Statistical Framework for Model Comparisons**, *Tutorial*, ABC Research Retreat, Gut Gremmelin, Germany.

## Supervision

### Theses Supervised

**Alexandra Witt**. Department of Computer Science, University of Tübingen. PhD Thesis: *The Neural and Behavioral Basis for Social Learning and Theory of Mind Inference.* (2021-Present)

**Mani Hamidi**. Department of Computer Science, University of Tübingen. PhD Thesis: *Keeping it Systematically Simple: Heuristics for the control of representation complexity over the course of learning* (2021-Present)

**Jonas Müller**. Department of Cognitive Science, University of Tübingen. Masters Thesis: *Emerging Social Behavior in Evolutionary Reinforcement Learning Simulations* (2022-Present)

**Sebastian Breit**. Department of Cognitive Science, University of Tübingen. Masters Thesis: *In search of lost memories: modeling forgetful generalization* (2021-Present)

**Anna Giron**. Department of Cognitive Science, University of Tübingen. Masters Thesis: *The Trajectory of Learning and Exploration Over the Lifespan* (2020-2021)

**Theresa Horn**. Department of Cognitive Science, University of Tübingen. Bachelors Thesis: *Use of Visual and Spatial Information in Human Search Behaviour* (2021)

**Kimberly Gerbaulet.** Institute of Cognitive Science, University of Osnabrück. Masters Thesis: *Under pressure: the effect of time pressure on directed and random exploration.* (2018-2019)

### Thesis Advisory Committee

**Andria Smith**. PhD student. Organizational Leadership and Diversity (Max Planck Institute for Intelligent Systems) & Human and Machine Cognition Lab, University of Tübingen. 2022 - present; as co-advisor)

**Hanqi Zhou**. PhD student. Machine Learning Collaboratory & Human and Machine Cognition Lab, University of Tübingen. Co-advisor. (2022 - present; as co-advisor)

**Ori Press**. PhD student. Computational Vision and Neuroscience, University of Tübingen. (2022 - present)

**Manuel Traub**. PhD student. Cognitive Modeling group, University of Tübingen. (2021 - present)

**Ruiqi He**. PhD student. Rationality Enhancement Group, Max Planck Institute for Intelligent Systems. (2020 - present)

**Lovis Hendrich**. PhD student. Rationality Enhancement Group, Max Planck Institute for Intelligent Systems. (2020 - present)
**Christian Gumbsch**. PhD student. Autonomous learning, Max Planck Institute for Intelligent Systems. (2019 - present)

### Graduate Student Projects

**Frederic Becker**. Masters student. Department of Machine Learning, University of Tübingen. *Analysis of Neural Networks with Linearized Layer Transformations*. (2022-Present)
**Nir Moneta**. PhD student. Max Planck Institute for Human Development, Berlin. *Rewards Distort Neural Representations of Abstract Visual Stimuli*. (2020-Present)
**Susanne Haridi**. PhD student. Max Planck School of Cognition. *The scalability of human inference*. (2020-Present)
**Franziska Brändle**. PhD student. Max Planck Institute for Biological Cybernetics. *A computational theory of fun*. (2020-Present)
**Kornelius Raeth**. Masters student. Department of Machine Learning, University of Tübingen. *Influence of reward structures on Hippocampal sequence generation*. (2021-2022)
**Tobias Ludwig**. Masters student. Graduate Training Center for Neuroscience, University of Tübingen. *Planning and generalization on generative graph-structured bandits*. (2020-2022)
**Simon Ciranka**. PhD student. Center for Adaptive Rationality (ARC), Max Planck Institute for Human Development. *Asymmetric learning facilitates human inference of transitive relations.*. (2019-2021)
**Imen Bouhlel**. PhD student. Department of Economics, Université de Nice. *Sharing is not erring: How environments can encourage pseudo-reciprocity in collective human search*. (2016-2019)
**Alan Novaes Tump**. PhD student. Center for Adaptive Rationality, Max Planck Institute for Human Development. *The evolutionary dynamics of cooperation in collective search*. (2018-2020)
**Ahmad Dawud**. Masters Student. Institute of Cognitive Science, University of Osnabrück. *Collective search and rugged landscapes*. (2017-2019)
**Alexander Djamali**. Masters student. Department of Physics, Ludwig Maximilian University of Munich. *Information search: Finding better questions*. (2016-2017)

### Undergraduate Student Projects

**Grace Deng**. Bachelor student. Brown University. *Cumulative cultural evolution drives the rise and decline of virtual online communities*. (2020-2021)

## Professional Service

**Associate editor.** Open Mind, MIT Press
**Steering Committee Member** of the Cluster of Excellence – Machine Learning for Science, University of Tübingen (2021-Present)
**Co-Organizer** of The Computational Summer school on Modeling Social and collective behavior (COSMOS) 2022, Konstanz, DE
**Neuromatch mentor** (2021)
**Organizer** of Cognition, Collectives, and Human Culture Workshop (part of CogSci 2020), Toronto, Canada (2020)
**Organizer** of the 17th annual Summer Institute on Bounded Rationality, Berlin, Germany (2018)
**PhD Representative** for the Max Planck Institute for Human Development (2017-2018)
**Ad-hoc Reviewer** for Nature Communications, Nature Human Behaviour, Scientific Reports, PLOS Computational Biology, Cognition, Cognitive Psychology, Artificial Intelligence, Computational Brain and Behavior, Journal of Experimental Psychology: Learning, Memory, and Cognition, Cognitive, Affective, and Behavioral Neuroscience, Cognitive Science, Cognitive Computational Neuroscience, Cognitive Science Society, Mind & Society, Futures & Foresight Science, and the National Science Foundation.

## Technical Skills

**Programming Languages:** R, Python, Matlab, Julia, JavaScript, HTML, jQuery, PHP, CSS, and LaTeX.

**Additional Software Skills:** MongoDB, MySQL, Singularity, Tensorflow, Redis, and Adobe Creative Suite.

**Languages:** English (Native), German (B2), Chinese (Mandarin/Shanghainese; mother tongue), French (B1), Spanish (B1), and Russian (A1)

## References

Prof. Dr. Fiery Cushman
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William James Hall, 33 Kirkland Street, Cambridge, MA 02138
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Prof. Dr. Samuel J. Gershman
Department of Psychology and Center for Brain Sciences, University of Harvard
Northwest Lab Building, 52 Oxford Street, Cambridge, MA 02138
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Prof. Dr. Björn Meder
Health and Medical University Potsdam
Olympischer Weg 1, 14471 Potsdam, Germany
bjoern.meder[at]health-and-medical-university.de

Prof. Dr. Jonathan D. Nelson
School of Psychology, University of Surrey
388 Stag Hill, Guildford GU2 7XH, UK
jonathan.d.nelson[at]gmail.com