Causality in Neuroscience
An Annotated Bibliography

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References

[1] Broad Institute, "Lectures on Causality: Jonas Peters (YouTube)," 2017. [Online]. Available: https://www.youtube.com/watch?v=zvrcyqcN9Wo&feature=youtu.be https://www.youtube.com/watch?v=zvrcyqcN9Wo

> This is what got us started in the topic. This is a seminar by Jan Peters consisting of four videos that gives us a really fun, accessible introduction to Causality. He is one of the authors of Elements of Causality book that we referred to in our seminar. We are kind of biased given that his orgins are in Tuebingen :)

[2] J. Campbell, "An Interventionist Approach to Causation in Psychology," in *Causal Learning: Psychology, Philosophy, and Computation*, 2010. [Online]. Available: https://www.nyu.edu/gsas/dept/philo/courses/consciousness05/Campbell.pdf

[3] F. Eberhardt, "Almost Optimal Intervention Sets for Causal Discovery," Tech. Rep. [Online]. Available: http://www.its.caltech.edu/ fehardt/papers/Eberhardt_UAI2008.pdf

[4] F. Eberhardt, "Causation and Intervention," Ph.D. dissertation, 2014. [Online]. Available: http://www.its.caltech.edu/ fehardt/papers/PhDthesis.pdf

[5] F. Eberhardt, C. Glymour, and R. Scheines, "N-1 Experiments Suffice to Determine the Causal Relations Among N Variables," Tech. Rep. [Online]. Available: http://www.its.caltech.edu/ fehardt/papers/EGS_draft2006.pdf

[6] F. Eberhardt, C. Glymour, and R. Scheines, "On the Number of Experiments Sufficient and in the Worst Case Necessary to Identify All Causal Relations Among N Variables," Tech. Rep. [Online]. Available: http://www.its.caltech.edu/ fehardt/papers/EGS_UAI2005.pdf

[7] F. Eberhardt and R. Scheines, "Interventions and Causal Inference," Tech. Rep. [Online]. Available: http://www.its.caltech.edu/ fehardt/papers/ES_draftPSA2006.pdf

[8] S. R. A. Fisher, "The Design of Experiments II," *Hafner Publishing Company*, 1971. [Online]. Available: http://www.medicine.mcgill.ca/epidemiology/hanley/tmp/Mean-Quantile/DesignofExperimentsCh-III.pdf

[9] S. J. Gershman, "Reinforcement learning and causal models," *Oxford Handbook of Causal Reasoning*, pp. 1–32, 2015.

[10] M. Grosse-Wentrup, D. Janzing, M. Siegel, and B. Schölkopf, "Identification of causal relations in neuroimaging data with latent confounders: An instrumental variable approach," *NeuroImage*, vol. 125, pp. 825–833, 2016. [Online]. Available: http://dx.doi.org/10.1016/j.neuroimage.2015.10.062

[11] M. Humphries, "Some limits on interpreting causality in neuroscience experiments," 2017. [Online]. Available: https://medium.com/the-spike/some-limits-on-interpreting-causality-in-neuroscience-experiments-f777a63650c7

[12] F. Huszár, "ML beyond Curve Fitting: An Intro to Causal Inference and do-Calculus," 2018. [Online]. Available: https://www.inference.vc/untitled/

Ferenc Huszar is a Machine Learning expert. In this series of his blog, he provides a very light and visual introduction

to causal inference, do-calculus, interventions, and counterfactuals. He nicely supports his explanations with graphics, simple examples, and small toy calculations.

[13] B. J. Lansdell and K. P. Kording, "Spiking allows neurons to estimate their causal effect," *bioRxiv*, p. 253351, feb 2019. [Online]. Available: https://www.biorxiv.org/content/10.1101/253351v4

[14] M. E. Lepperød, T. Stöber, T. Hafting, M. Fyhn, and K. P. Kording, "Inferring causal connectivity from pairwise recordings and optogenetics," *bioRxiv*, p. 463760, 2018. [Online]. Available: http://dx.doi.org/10.1101/463760 https://www.biorxiv.org/content/early/2018/11/06/463760.full.pdf+html

[15] V. Magloire, M. S. Mercier, D. M. Kullmann, and I. Pavlov, "GABAergic Interneurons in Seizures: Investigating Causality With Optogenetics," *The Neuroscientist*, p. 107385841880500, oct 2018. [Online]. Available: http://journals.sagepub.com/doi/10.1177/1073858418805002

[16] M. Mannino and S. L. Bressler, "Foundational perspectives on causality in large-scale brain networks," pp. 107–123, dec 2015.

[17] I. E. Marinescu, P. N. Lawlor, and K. P. Kording, "Quasi-experimental causality in neuroscience and behavioural research," *Nature Human Behaviour*, vol. 2, no. 12, pp. 891–898, dec 2018. [Online]. Available: http://www.nature.com/articles/s41562-018-0466-5

A recent review article by Konrad Kording and Iona Marinescu that pits theoretical (Pearl style) and empirical (ecometrics-based) techniques for determining causality against one another. {S: Konrad graciously accepted to come to Tuebingen amd give a talk on Causal Neuroscience. He even gave us his material for this workshop. Kudos to him to be such a great sport.

[18] J. Pearl, *Causality: models, reasoning and inference*. Springer, 2000, vol. 29. [Online]. Available: http://bayes.cs.ucla.edu/BOOK-2K/

With his introduction of do-calculus, Judea Pearl became the father of the predominating mathematical framework for causality today. This book contains his theorems and teachings in a mathematically very rigoous manner. It might be very heavy on somebody who is new to the material, but it is

a very good reference for readers that are somewhat familiar with the causality.

[19] J. Pearl, "Causal inference in statistics: An overview," *Statistics Surveys*, vol. 3, pp. 96–146, 2009. [Online]. Available: https://projecteuclid.org:443/euclid.ssu/1255440554

[20] J. Pearl and D. Mackenzie, *The Book of Why: The New Science of Cause and Effect*. Penguin Books Limited, 2018. [Online]. Available: https://books.google.de/books?id=EmY8DwAAQBAJ

A really accessible introduction to Causality given by the father of Causality, Judea Pearl. Thank the editor Dana Mackenzie for making it an easy to read book.

[21] J. D. Semedo, A. Zandvakili, A. Kohn, C. K. Machens, and B. M. Yu, "Extracting latent structure from multiple interacting neural populations," in *Advances in Neural Information Processing Systems*, vol. 4, no. January, 2014, pp. 2942–2950. [Online]. Available: https://papers.nips.cc/paper/5625-extracting-latent-structure-from-multiple-interacting-neural-populations

[22] R. Shanmugam, *Elements of causal inference: foundations and learning algorithms*. Cambridge, MA, USA: MIT Press, 2018, vol. 88, no. 16. [Online]. Available: https://mitpress.mit.edu/books/elements-causal-inference

[23] S. Shimizu, "LINGAM: NON-GAUSSIAN METHODS FOR ESTIMATING CAUSAL STRUCTURES," *Behaviormetrika*, vol. 41, no. 1, pp. 65–98, 2014. [Online]. Available: http://jlc.jst.go.jp/DN/JST.JSTAGE/bhmk/41.65?lang=en&from=CrossRef&type=abstract

[24] E. E. Steinberg, R. Keiflin, J. R. Boivin, I. B. Witten, K. Deisseroth, and P. H. Janak, "A causal link between prediction errors, dopamine neurons and learning," *Nature Neuroscience*, vol. 16, no. 7, pp. 966–973, jul 2013. [Online]. Available: http://www.nature.com/articles/nn.3413

A study that shows reward prediction errors signalled by DA neurons form necessary and sufficient condition for learning associations.

[25] A. Stroh and I. Diester, "Optogenetics: a new method for the causal analysis of neuronal networks in vivo," *e-Neuroforum*,

vol. 18, no. 4, pp. 81–88, jan 2012. [Online]. Available: http://www.degruyter.com/view/j/nf.2012.18.issue-4/s13295-012-0035-8/s13295-012-0035-8.xml

[26] F. Venmans, "Potential outcomes and randomized experiments," University of Mons, Tech. Rep., 2016. [Online]. Available: http://homepages.ulb.ac.be/ frycx/Slides Venmans 3.pdf

[27] S. Weichwald, T. Meyer, O. Özdenizci, B. Schölkopf, T. Ball, and M. Grosse-Wentrup, "Causal interpretation rules for encoding and decoding models in neuroimaging," *NeuroImage*, vol. 110, pp. 48–59, 2015. [Online]. Available: https://www.pathlms.com/ohbm/courses/1492/sections/1824/video_presentations/17193