Mathematical Applications in Psychology

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This is a short annotated bibliography of mathematical applications in Psychology. It was prepared for undergraduates at Harvard concentrating in Applied Math with a Psychology application area. I've found that many of these undergraduates (for whom I'm the academic advisor) are interested in both Math and Psychology but are unaware that there is a wealth of work at their intersection.

There is a subfield of Psychology known as *Mathematical Psychology*. This means something rather specific: it's a style of theorizing that relies heavily on a particular set of formal tools such as stochastic modeling and axiomatic methods.

Batchelder, W. H. (2010). Mathematical psychology. *Wiley Interdisciplinary Reviews: Cognitive Science, 1*, 759-765.

There is other psychological work using mathematical methods that doesn't explicitly identify as *Mathematical Psychology*. One tradition is in the subfield of *Psychometrics* (sometimes referred to as *Quantitative Psychology*), which uses statistical methods to characterize psychological constructs like intelligence and personality.

Jones, L. V., & Thissen, D. (2006). A history and overview of psychometrics. *Handbook of Statistics, 26*, 1-27.

Another tradition is in the subfield of *Psychophysics*, which studies the relationship between physical quantities and sensory percepts.

Stevens, S. S. (1960). The psychophysics of sensory function. *American Scientist, 48*(2), 226-253.

In the past few decades, the field of *Computational Cognitive Science* has emerged at the intersection of several fields (Psychology, Neuroscience, Artificial Intelligence, Linguistics, Physics, and Economics). There are many different (not necessarily incompatible) approaches. Below is a sample of some overviews that illustrates the diversity of approaches.

Gershman, S.J., Horvitz, E.J., & Tenenbaum, J.B. (2015). Computational rationality: A converging paradigm for intelligence in brains, minds and machines. *Science, 349*, 273-278.

Kriegeskorte, N., & Douglas, P. K. (2018). Cognitive computational neuroscience. *Nature Neuroscience, 21*, 1148-1160.

Busemeyer, J. R., & Johnson, J. G. (2008). Micro-process models of decision making. Cambridge Handbook of Computational Psychology, 302, 321.

Kahana, M. J. (2020). Computational models of memory search. *Annual Review of Psychology, 71*, 107-138.

Niv, Y. (2009). Reinforcement learning in the brain. ***Journal of Mathematical Psychology, 53,*** **139-154.**

Nowak, M. A., Komarova, N. L., & Niyogi, P. (2002). Computational and evolutionary aspects of language. ***Nature, 417,*** **611-617.**

Huys, Q. J., Browning, M., Paulus, M. P., & Frank, M. J. (2021). Advances in the computational understanding of mental illness. ***Neuropsychopharmacology, 46,*** **3-19.**

For a broader, relatively non-technical overview, I've written a book:

Gershman, S.J. (2021). ***What Makes Us Smart: The Computational Logic of Human Cognition.*** **Princeton University Press. Princeton: NJ.**

There is also an excellent interactive textbook on Bayesian approaches: ***Probabilistic Models of Cognition***.