Psychological & Behavioral Modeling

PSY6930: Topics in Psychology
Fall 2020, Class # 25557, Section 7129

Meeting room:	PSY0129 (Tuesday) / PSY0191 (Thursday)
Meeting times:	Tuesday 9:35-11:30 AM
	Thursday 9:35-10:25 AM
Instructor:	Dr. Peter Kvam
Office:	216 Psychology Building
Office hours:	Thursday 10:30-12:30 or by appointment
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Course Description

This course is aimed at developing the quantitative and computational skills that will allow students to better understand modeling approaches in psychology as well as develop and test their own generative models that explain human (and animal) behavior. The first part of the course will be skill-focused, covering the philosophy behind modeling and learning the statistical and computational tools needed to describe behavior using parametric models, looking at common distributions and functions used to describe observed data in terms of latent psychological processes. The second part of the course will be primarily discussion-based and examine several important applications of modeling approaches in areas like intertemporal choice (delay discounting), risky decision-making, categorization, learning, attention, and the corresponding dynamics. The final part of the course will be project-focused, with students working individually or in small groups on applying models to better understand the psychological processes underlying their own data (with class time devoted to troubleshooting and debugging)

Readings will consist of primary source articles including tutorials on different methods as well as papers implementing these methods to better understand specific psychological processes. Assignments and projects can be completed in the programming language of your choice, but it will be very helpful to have some basic background in a language like R, MATLAB, or Python.

Readings. This course does not have reading material that we will require you to purchase – anything that is necessary will be provided on eLearning / Canvas. However, the following textbooks may be helpful to many students who are interested in delving further into the topics we cover in class:

Busemeyer, J. R., Wang, Z. J., Townsend, J. T., & Eidels, A. (2015). The Oxford Handbook of Computational and Mathematical Psychology.

Batchelder, W. H., Colonius, H., Dzhafarov, E. N., & Myung, J. (Eds.). (2016). New Handbook of Mathematical Psychology: Volumes 1 & 2.

Objectives

The goal of this class is to provide students the skills needed to develop, test, and understand generative models of behavior. Students will develop a deeper understanding of how and why we use formal mathematical models as theoretical tools in psychology, and learn how these models can be applied in their own research to generate unique insights about psychological processes based on behavioral data.

Structure

This course will consist primarily of three modules as outlined in the description. There will be one take-home exam aimed at model estimation and a final project. In module 1, there will be small weekly assignments aimed at familiarizing students with the typical coding and statistics involved in model simulation, fitting, and recovery. In module 2, students will be responsible for leading class discussion on one of the substantive applications of modeling. In module 3, the focus of out-of-class work will be on projects.

Readings should be completed before the corresponding class in order to facilitate discussion during the class period.

Grading

Grades will be determined based on discussion, completion of assignments, the take-home exam, and final projects. This is the breakdown of the contributions:

Discussion: 40%

Regular attendance of class and involvement in discussions: 20%
Leading discussion (questions) for one topic in class: 20%

Assignments: 20%

Assignment #1 [Simulation & probability]:	5%	(9/10)
Assignment #2 [Maximum likelihoods]:	5%	(9/17)
Assignment #3 [Bayes / model recovery]:	5%	(9/24)
Assignment #4 [Deep learning]:	5%	(11/16)

Exams & projects: 40%

Take-home exam [Parameter estimation]:	15%	(10/6)
Final project paper:	20%	(12/16)
Final project presentation:	5%	(12/1-12/8)

For assignment of letter grades and grade points, we will follow the standard UF scale:

https://catalog.ufl.edu/graduate/regulations/

Letter grading will follow this scale:

93-100%	**A**	**73-76.9%**	**C**
90-92.9%	**A-**	**70-72.9%**	**C-**
87-89.9%	**B+**	**67-69.9%**	**D+**
83-86.9%	**B**	**63-66.9%**	**D**
80-82.9%	**B-**	**60-63.9%**	**D-**
77-79.9%	**C+**	**0-59.9%**	**E**

Absences

In general, acceptable reasons for absence from or failure to participate in class include career-relevant activities like academic conferences or workshops, illness, serious family emergencies, military obligation, severe weather conditions, religious holidays, participation in official university activities, or court-imposed legal obligations (e.g., jury duty or subpoena). All of these will be excused when it comes to discussion grades – just let the instructor know as soon as possible before class.

Respect and non-discrimination

Respect for fellow students and instructors is expected of all class attendees. Intentionally disruptive or disrespectful conduct affecting other students may result in removal from the class session or from the course altogether.

Sexual Harassment. Sexual Harassment is not tolerated in this class, in the Department of Psychology, or at the University of Florida. Sexual harassment includes: the inappropriate introduction of sexual activities or comments in a situation where sex would otherwise be irrelevant. Sexual harassment is a form of sex discrimination and a violation of state and federal laws as well as of the policies and regulations of the university. All UF employees and students must adhere to UF's sexual harassment policy which can be found here: https://hr.ufl.edu/forms-policies/policies-managers/sexual-harassment/. Please review this policy and contact a university official if you have any questions about the policy. As mandatory reporters, university employees (e.g., administrators, managers, supervisors, faculty, teaching assistants, staff) are required to report knowledge of sexual harassment to UF's Title IX coordinator. You can also complete a Sexual Harassment Complaint Form (Title IX) here: https://titleix.ufl.edu/title-ix-complaint-form/.

Accommodation for Disabilities. Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://disability.ufl.edu/) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Other notes

As the course description suggests, there will be substantial math and programming involved in the course. It is probably necessary to have some mathematical and statistical training (through undergraduate / introductory graduate-level statistics, and around Trigonometry / Pre-Calculus for math). It is also advisable to have some basic background in programming in R, Python, MATLAB, or another modeling language. Mastery of these languages is not necessary, but familiarity will help with assignments and projects. Examples in class will be in MATLAB but should be readily translatable to other languages (relevant packages are usually available in R or Python). The instructor will be available during office hours and by appointment to answer questions, assist in understanding the material, and provide guidance on final projects.

Studying and working together on assignments is permitted, but all assignments must be original and written in your own words. The University and instructors reserve the right to penalize any student who is guilty of academic misconduct, including but not limited to plagiarism, collusion, cheating, or discrimination or harassment in study groups. Students are welcome to use any resources at their disposal (notes, papers, internet) for take-home exams, but these should be completed on your own – i.e., not in groups, no stack exchange, no asking your advisor, etc.

Course schedule

Week	Topic	Reading
1	(8/24) Course introduction	Syllabus
2	(8/29) Philosophy of modeling + Programming in MATLAB (8/31) Common statistical distributions	Wilson & Collins (2019) Smaldino (2020)
2	(9/5) Simulation & probability density + Simulation in MATLAB (9/7) Maximum likelihood estimation	Kvam (preprint) Myung (2003)
3	(9/12) Bayes rule and null hypotheses + Using JASP for basic data analyses (9/14) Hierarchical Bayesian estimation	Wagenmakers et al (2018) van Doorn et al (2021) Lee (2011)
4	(9/19) Model recovery & identifiability + Reliability and validity of models (9/21) Evaluating model fit	Heathcote et al (2015) Haines et al (2023) Roberts & Pashler (2000)
5	**(9/26) NO MEETING – WORK ON TAKE-HOME EXAM**	
	(9/28) Item response theory	Reid et al (2007)
6	(10/3) Intertemporal choice + Accessing JAGS from JASP (10/5) Multinomial processing trees	Berns et al (2007) McKay Curtis (2010) Calanchini et al (2018)
7	(10/10) Risky decision-making + Exploratory factor analysis (10/12) Dynamic decision-making	Tversky & Kahneman (1979) Ratcliff et al (2016)
8	(10/17) Reinforcement learning + Machine learning for data analysis	Fu & Anderson (2006) Wixted (2020)

	(10/19) Signal detection theory	
9	(10/24) Social cognition + Intro to deep learning (10/26) Categorization & representation	Pleskac et al (2018) Kvam et al (2023) Nosofsky (1986)
10	(10/31) Structural equation modeling + Deep learning for parameter estimation (11/2) Associations & semantics	Hox & Bechger (1998) Sokratous et al (2023) Bhatia (2017)
11	(11/7) Multi-alternative choice + Deep learning for model classification (11/9) Continuous selections	Busemeyer et al (2019) Kvam (2019)
12	(11/14) Joint modeling + Joint modeling in JAGS (11/16) Bayesian cognition	Turner et al (2016) Griffiths et al (2010)
13	(11/21) Work on final projects	
(11/23) NO CLASS - THANKSGIVING		
14	(12/1) Modeling and the replication crisis + Work on final projects (12/3) Quantum cognition	Etz & Vandekerckhove (2016) Pothos & Busemeyer (2013)
15	(12/8) Work on final projects (12/10) Reading day – work on final papers	
(12/16) FINAL PROJECT PAPERS DUE		

THIS SYLLABUS IS SUBJECT TO CHANGE. PLEASE CHECK THE COURSE WEBSITE FOR UPDATED INFORMATION AND CURRENT VERSION.

Honor Pledge

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code." On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Course feedback

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

Additional readings for discussion leaders:

For each of the substantive topics (after take-home exam 1), we will have someone in the class lead discussion on the ideas and models presented in the assigned papers for that week. The discussion leader will also prepare a short summary of one additional paper of their choice on the topic for that day. Students are welcome to choose whatever paper they wish as long as it is related to the topic of the day. Here is a list of recommendations in each topic. It's just for reference; students are not at all obligated to stick to this list:

Signal detection

Luan, S., Schooler, L. J., & Gigerenzer, G. (2011). A signal-detection analysis of fast-and-frugal trees. *Psychological Review*, *118*(2), 316.

Factor analysis

Goretzko, D., Pham, T. T. H., & Bühner, M. (2021). Exploratory factor analysis: Current use, methodological developments and recommendations for good practice. *Current psychology*, *40*, 3510-3521.

Intertemporal choice

Dai, J., & Busemeyer, J. R. (2014). A probabilistic, dynamic, and attribute-wise model of intertemporal choice. *Journal of Experimental Psychology: General*, *143*(4), 1489.

Loewenstein, G., & Thaler, R. H. (1989). Anomalies: intertemporal choice. *Journal of Economic Perspectives, 3*(4), 181-193.

Multinomial processing trees

Bishara, A. J., & Payne, B. K. (2009). Multinomial process tree models of control and automaticity in weapon misidentification. *Journal of Experimental Social Psychology*, *45*(3), 524-534.

Erdfelder, E., Auer, T. S., Hilbig, B. E., Aßfalg, A., Moshagen, M., & Nadarevic, L. (2009). Multinomial processing tree models: A review of the literature. *Zeitschrift für Psychologie/Journal of Psychology*, *217*(3), 108-124.

Riefer, D. M., & Batchelder, W. H. (1988). Multinomial modeling and the measurement of cognitive processes. Psychological Review, 95 (3), 318-339.

Riefer, D. M., Knapp, B. R., Batchelder, W. H., Bamber, D., & Manifold, V. (2002). Cognitive psychometrics: Assessing storage and retrieval deficits in special populations with multinomial processing tree models. Psychological assessment, Vol 14(2), 184-201.

Subjective expected utility

Friedman, M., & Savage, L. J. (1952). The expected-utility hypothesis and the measurability of utility. *Journal of Political Economy*, *60*(6), 463-474.

Risky decision making

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and uncertainty*, *5*(4), 297-323.

Busemeyer, J. R., & Townsend, J. T. (1993). Decision field theory: a dynamic-cognitive approach to decision making in an uncertain environment. *Psychological Review*, *100*(3), 432-459.

Social cognition

Axt, J. R., & Johnson, D. J. (2021). Understanding mechanisms behind discrimination using diffusion decision modeling. *Journal of Experimental Social Psychology*, *95*, 104134.

Klauer, K. C., Voss, A., Schmitz, F., & Teige-Mocigemba, S. (2007). Process components of the Implicit Association Test: a diffusion-model analysis. *Journal of Personality and Social Psychology*, *93*(3), 353.

Reinforcement learning

Haines, N., Kvam, P. D., & Turner, B. M. (2023). Explaining the description-experience gap in risky decision-making: Learning and memory retention during experience as causal mechanisms. *Cognitive, Affective, & Behavioral Neuroscience*, 1-21.

Erev, I., & Barron, G. (2005). On adaptation, maximization, and reinforcement learning among cognitive strategies. *Psychological review*, *112*(4), 912.

Gershman, S. J. (2016). Empirical priors for reinforcement learning models. *Journal of Mathematical Psychology*, *71*, 1-6.

Bayesian cognition

Perfors, A., Tenenbaum, J. B., Griffiths, T. L., & Xu, F. (2011). A tutorial introduction to Bayesian models of cognitive development. *Cognition*, *120*(3), 302-321.

Jones, M., & Love, B. C. (2011). Bayesian fundamentalism or enlightenment? on the explanatory status and theoretical contributions of Bayesian models of cognition. *Behavioral and Brain Sciences, 34*, 169-231.

Sanborn, A. N., Griffiths, T. L., & Navarro, D. J. (2010). Rational approximations to rational models: alternative algorithms for category learning. *Psychological review*, *117*(4), 1144.

Tenenbaum, J. B., Kemp, C., Griffiths, T. L., & Goodman, N. D. (2011). How to grow a mind: Statistics, structure, and abstraction. *Science*, *331*(6022), 1279-1285.

Dynamic models

Pleskac, T. J., & Busemeyer, J. R. (2010). Two-stage dynamic signal detection: A theory of choice, decision time, and confidence. Psychological Review, 117 (3), 864-901.

Brown, S. D., & Heathcote, A. (2008). The simplest complete model of choice response time: Linear ballistic accumulation. *Cognitive psychology*, *57*(3), 153-178.

Associations & vector space semantics

Dumais, S. T. (2004). Latent semantic analysis. *Annual review of information science and technology*, *38*(1), 188-230.

Heuristics & cognitive architectures

Todd, P. M., & Dieckmann, A. (2005). Heuristics for ordering cue search in decision making. In *Advances in neural information processing systems* (pp. 1393-1400).

Anderson, J. R. (1996). ACT: A simple theory of complex cognition. *American psychologist*, *51*(4), 355.

Multi-alternative choice

Roe, R. M., Busemeyer, J. R., & Townsend, J. T. (2001). Multialternative decision field theory: A dynamic connectionst model of decision making. *Psychological Review*, *108*(2), 370-392.

Usher, M., & McClelland, J. L. (2001). The time course of perceptual choice: the leaky, competing accumulator model. *Psychological Review*, *108*(3), 550-592.

Continuous selections

Ratcliff, R. (2018). Decision making on spatially continuous scales. *Psychological review*, *125*(6), 888.

Smith, P. L. (2016). Diffusion theory of decision making in continuous report. *Psychological Review*, *123*(4), 425.

Structural equation modeling / joint modeling

Turner, B. M., Wang, T., & Merkle, E. C. (2017). Factor analysis linking functions for simultaneously modeling neural and behavioral data. *NeuroImage*, *153*, 28-48.

Kvam, P. D., Romeu, R. J., Turner, B. M., Vassileva, J., & Busemeyer, J. R. (2020). Testing the factor structure underlying behavior using joint cognitive models: Impulsivity in delay discounting and Cambridge gambling tasks. *Psychological Methods*.

Modeling and the replication crisis

Rouder, J. N., & Haaf, J. M. (2019). A psychometrics of individual differences in experimental tasks. *Psychonomic bulletin & review*, *26*(2), 452-467.

Quantum cognition

Pothos, E. M., & Busemeyer, J. R. (2009). A quantum probability explanation for violations of 'rational' decision theory. Proceedings of the Royal Society B-Biological Sciences, 276 (1665), 2171-2178.

Bruza, P. D., Wang, Z., & Busemeyer, J. R. (2015). Quantum cognition: a new theoretical approach to psychology. *Trends in cognitive sciences*, *19*(7), 383-393.

Busemeyer, J. R., Kvam, P. D., & Pleskac, T. J. (2020). Comparison of Markov versus quantum dynamical models of human decision making. *Wiley Interdisciplinary Reviews: Cognitive Science*, e1526.