EAB 6750: Quantitative Methods

General	Instructor
T | Periods 7-8 (1:55 PM - 3:50 PM) R | Period 7 (1:55 PM - 2:45 PM)	Dr. Jesse Dallery Room 92, Psychology Office Hours: by appt. Email: dallery@ufl.edu Phone: 273-2182

Overview

One goal of a science of behavior is to discover invariance, or regularity in nature. As defined by the mathematician E. T. Bell, "invariance is changelessness in the midst of change, permanence in a world of flux, the persistence of configurations that remain the same despite the swirl and stress of countless transformations."

This course will introduce statistical and quantitative techniques in single-case research. These techniques attempt to detect and describe - amidst the flux - regularities in nature, whether treatment effects or physical processes. We will ask: What are the strengths and limitations of our approaches? How can we improve our detection techniques? What are contemporary mathematical models of operant behavior? How do we evaluate these models? Why are they important? Skinner provided the beginning of an answer to the last question:

> Beyond the collection of uniform relationships lies the need for a formal representation of the data reduced to a minimal number of terms. A theoretical construction may yield greater generality than any assemblage of facts... It will not stand in the way of our search for functional relations because it will arise only after relevant variables have been found and studied. Though it may be difficult to understand, it will not be easily misunderstood…" (Skinner, 1950/1972, p. 100).

Skinner's assessment of theory, however, was tempered by an emphatic recommendation that we must first establish an experimental analysis of how relevant variables affect behavior (Skinner, 1950/1972). In the case of a quantitative theory, for instance, the progression from experimental analysis to theory should increase the likelihood that the theory's parameters reflect the operation of definite variables and processes, rather than simply being "arbitrary constants." Of course, a progression from theory to further experimental analysis may also reveal novel functional relations and behavioral processes. Regardless of the sequence, quantitative theory may increase the generality and precision of our understanding of environment-behavior relations. Just as the universal law of gravitation yields considerable predictive and practical advantages over the statement that objects fall when dropped, a quantitative theory of behavior can move us beyond the statement that operant responding increases when reinforced (or any similar "assemblage of facts"). In short, a quantitative theory should

improve our ability to predict and influence behavior, which is a hallmark of behavior-analytic science.

As we progress through quantitative methods, we will also explore several models of operant behavior. These models will provide some theoretical backbone as we tackle techniques to analyze them.

This course will be challenging if you do not have a background in basic EAB. Please note that if you are not a student in the Behavior Analysis Program, we will need to discuss your enrollment in the course.

I have also selected readings to broaden your scholarly repertoires with respect to statistics, statistical thinking, and especially null hypothesis significance testing. The focus will be on thinking about statistics as opposed to calculating statistics.

The course will involve lectures, discussions, and several hands-on assignments.

Goals

1. Provide content and resources that may serve as an establishing operation for "behaving quantitatively"
2. Provide a solid foundation in quantitative analysis of environment-behavior relations
3. Increase the likelihood of reading quantitative articles, going to quantitative talks, and thereby deepening your knowledge of quantitative analysis and causes of behavior
4. Increase the likelihood of using quantitative models in your research and conducting bidirectional translation
5. Provide tools, techniques, and resources to improve analysis of single-case data
6. Provide tools, techniques, and resources to improve analysis of aggregated data (pre- and post-experiment)
7. Cultivate a critical thinking repertoire with respect to statistical analysis of behavioral data

Readings

The required text is Intuitive Biostatistics, Fourth Edition by Harvey Motulsky. It is available at the bookstore and online. I also recommend: Fitting models to biological data using linear and nonlinear regression (by Motulsky and Christopoulis). A pdf of the Fitting models book will be available in Canvas. You should also consider purchasing the book, particularly if you will be doing curve fitting and other quantitative techniques. Other readings will be available in Canvas.

I expect you to read the chapters and articles carefully. Write down any questions you have about the readings. Some of the material will be difficult, so take your time, re-read, and use me as a resource (e.g., email me if you have questions as you are reading).

Software

We will use Microsoft Excel and GraphPad Prism. Please have both installed within the first week of class.

Grading

Exams: There will be two exams, each worth 100 pts. I will provide a study guide for each test.

Class engagement: Class participation will be worth 100 points. You will have the opportunity to self-evaluate your participation at 2 timepoints during the semester. I will provide a rubric, and you will submit your grade. I will review your self-evaluation and either concur, or provide feedback and enter a lower or a higher number. The final participation grade will the sum of the 2 grades.

Category	Points	Grade	Percentage
Exams	200	A	93-100
		A-	90-93
Engagement	50	B+	87-90
		B	83-87
Total Points	250	B-	80-83
		C+	77-80

Note: This syllabus is subject to change. Changes will be announced in class and an updated syllabus will be available on the website.

Jan 14	**Introduction and Overview**
Jan 16	**Mathematics in the natural sciences and in behavior science** • Two Views: How Much Math Do Scientists Need? E.O Wilson & E. Frenkel (2013). • Marr M. J. (2015). Mathematics as verbal behavior. *Behavioural processes*, *113*, 75–80. https://doi.org/10.1016/j.beproc.2015.01.005 • Smith, L. D. (1990). Models, Mechanisms, and Explanation in Behavior Theory: The Case of Hull versus Spence. Behavior and Philosophy 18 (1):1-18. Recommended: • Winger, E. (1960). The unreasonable effectiveness of mathematics in the natural sciences. https://www.dartmouth.edu/~matc/MathDrama/reading/Wigner.html • Shull, R. L. (1991). Mathematical description of operant behavior: an introduction. In I. H. Iversen & K. A. Lattal (Eds.), Experimental Analysis of Behavior (Vol. 2, pp. 243-282). New York: Elsevier. (Call#: BF 319.5.O6 E97 1991). • Nevin J. A. (1984). Quantitative analysis. Journal of the experimental analysis of behavior, 42(3), 421–434. https://doi.org/10.1901/jeab.1984.42-421
Jan 21-23	**Delay discounting** • Odum A. L. (2011). Delay discounting: I'm a *k*, you're a *k*. Journal of the experimental analysis of behavior, 96(3), 427–439. https://doi.org/10.1901/jeab.2011.96-423 • Reed, D. D., Kaplan, B. A., & Brewer, A. T. (2012). A tutorial on the use of Excel 2010 and Excel for Mac 2011 for conducting delay-discounting analyses. Journal of applied behavior analysis, 45(2), 375–386. https://doi.org/10.1901/jaba.2012.45-375 Recommended • Mazur. (1987). An adjusting procedure for studying delayed reinforcement. In The effect of delay and of intervening events on reinforcement value. (pp. 55–73). Lawrence Erlbaum,.

	• Young M. E. (2018). Discounting: A practical guide to multilevel analysis of choice data. Journal of the experimental analysis of behavior, 109(2), 293–312. https://doi.org/10.1002/jeab.316 • Gilroy, S. P., & Hantula, D. A. (2018). Discounting model selection with area-based measures: A case for numerical integration. Journal of the experimental analysis of behavior, 109(2), 433–449. https://doi.org/10.1002/jeab.318 • Rachlin, H. (2006). Notes on discounting. Journal of the Experimental Analysis of Behavior, 85, 425- 435 • Bailey, A. J., Romeu, R. J., & Finn, P. R. (2021). The problems with delay discounting: a critical review of current practices and clinical applications. Psychological medicine, 51(11), 1799–1806. https://doi.org/10.1017/S0033291721002282
Jan 28-30	**Matching theory** • McDowell J. J. (1988). Matching theory in natural human environments. The Behavior Analyst, 11(2), 95–109. https://doi.org/10.1007/BF03392462 • Dallery, J. & Soto, P. (2013). Quantitative description of environment-behavior relations. Read pages 219--240. Recommended • M&C Chapters A and B (Fitting data with nonlinear regression, Linear regression) • McDowell, J. J (1989). Two modern developments in matching theory. *The Behavior Analyst*, 12, 153-166.
Feb 4-6	**Translating quantitative models** • Critchfield, T. S. (2009). What are we doing when we translate from quantitative models? The Behavior Analyst. • McDowell J. J. (2021). Empirical Matching, Matching Theory, and an Evolutionary Theory of Behavior Dynamics in Clinical Application. Perspectives on behavior science, 44(4), 561–580. https://doi.org/10.1007/s40614-021-00296-w Recommended: • Dallery, J., & Soto, P. L. (2004). Herrnstein's hyperbolic matching equation and behavioral pharmacology: review and critique. Behavioural pharmacology, 15(7), 443–459. https://doi.org/10.1097/00008877-200411000-00001 • Fisher, W. W., Greer, B. D., Mitteer, D. R., & Fuhrman, A. M. (2022). Translating quantitative theories of behavior into improved clinical treatments for problem behavior. Behavioural processes, 198, 104639. https://doi.org/10.1016/j.beproc.2022.104639
Feb 11-13	**Models of choice I** • Dallery & Soto. Pages 240-246 • Mazur, J. E. (2006). Mathematical models and the experimental analysis of behavior. *Journal of the Experimental Analysis of Behavior,* 85, 275-291
Feb 18-20	**Models of choice II** • Mazur J. E. (2001). Hyperbolic value addition and general models of

	animal choice. Psychological Review, 108(1), 96–112. https://doi.org/10.1037/0033-295x.108.1.96 OR • McDowell J. J. (2005). On the classic and modern theories of matching. Journal of the experimental analysis of behavior, 84(1), 111–127. https://doi.org/10.1901/jeab.2005.59-04 OR • Greer, B.D. and Shahan, T.A. (2019), Resurgence as Choice: Implications for promoting durable behavior change. Jnl of Applied Behav Analysis, 52: 816-846. https://doi.org/10.1002/jaba.573
Feb 25 **Feb 27**	**Exam 1** **No class**
Mar 4-6	**Getting started: Statistics, data types, and data visualization** • Chapter 1. The requisite boring stuff part I: Defining a statistic and the benefit of numbers • Chapter 2. The requisite boring stuff part II: Data types and data distributions • Poldrack: Data visualization Recommended • Skim: Manalow & Moeyaert (2106). Recommendations for choosing single-case data analytical techniques. • Church R. M. (1979). How to look at data: A review of John W. Tukey's Exploratory Data Analysis. Journal of the Experimental Analysis of Behavior, 31(3), 433–440. https://doi.org/10.1901/jeab.1979.31-433 • Parsonson & Baer (1992). Visual Analysis of Data and Current Research into the Stimuli Controlling It. In Krsatochwill & Levin (1992) Single-Case Research Design and Analysis • Tufte, E. R. (2001). The visual display of quantitative information (2nd ed.) CT: Graphic Press.
Mar 11-13	**Characterizing data: Central tendency and variability** • Chapter 3. How can we describe our data with numbers? Central tendency and point estimates • Chapter 4. Just how stable is responding? Estimating variability Recommended • Branch M. N. (2018). The "Reproducibility Crisis:" Might the Methods Used Frequently in Behavior-Analysis Research Help?. Perspectives on behavior science, 42(1), 77–89. https://doi.org/10.1007/s40614-018-0158-5 • Falligant, J.M., Kranak, M.P. & Hagopian, L.P. Further Analysis of Advanced Quantitative Methods and Supplemental Interpretative Aids with Single-Case Experimental Designs. Perspect Behav Sci 45, 77–99 (2022). https://doi.org/10.1007/s40614-021-00313-y • Shadish, W. R. (2014). Statistical Analyses of Single-Case Designs: The Shape of Things to Come. Current Directions in Psychological Science, 23: 139 • Manolov, R., Tanious, R., & Onghena, P. (2021). Quantitative Techniques and Graphical Representations for Interpreting Results from Alternating

	Treatment Design. Perspectives on behavior science, 45(1), 259–294. https://doi.org/10.1007/s40614-021-00289-9 • Manolov, R., Moeyaert, M., & Fingerhut, J. E. (2021). A Priori Justification for Effect Measures in Single-Case Experimental Designs. Perspectives on behavior science, 45(1), 153–186. https://doi.org/10.1007/s40614-021-00282-2
Mar 25-27	**Statistical significance and effect sizes** • Chapter 5. Just how good is my intervention? Statistical significance, effect sizes, and social significance • Hasley et al. (2015). The fickle P value generates irreproducible results. Nature Methods 12, 179–185 Recommended • Ioannidis, J. P. A.. (2005). Why Most Published Research Findings Are False. PLoS Medicine. • Leland Wilkinson and the Task Force on Statistical Inference (1999). Statistical Methods in Psychology Journals: Guidelines and Explanations. *The American Psychologist.* • Cohen, J. (1994). The earth is round (p < .05). American Psychologist, 49, 997–1003.
Apr 1-3	**Power analysis** • Chapter 7. How fast can I get to an answer? Sample size, power, and observing behavior • Kyonka, E. G. E. (2018). Tutorial: Small-N power analysis. Perspectives in Behavior Science. Recommended • Motulsky 20, 26 • Prajapati, Dunne, & Armstrong (2017). Sample size estimation and statistical power analysis. Optometry Today.
Apr 8-10	**Analysis of time-series data** • Chapter 8. Wait, you mean the clock is always ticking? The unique challenges time adds to statistically analyzing time series data • Parker, R. I., Vammest. K. J. (2011). Bottom-Up Analysis of Single-Case Research Designs. Journal of Behavioral Education. Recommended • Fisher, W. W., Kelley, M. E., & Lomas, J. E. (2003). Visual aids and structured criteria for improving visual inspection and interpretation of single-case designs. Journal of applied behavior analysis, 36(3), 387–406 •
Apr 15-17	**Putting it together** • Chapter 10. I suppose I should tell someone about the fun I've had: Chapter checklists for thinking, writing, and presenting statistics • Chapter 11. Through the looking glass: Probability theory, frequentist statistics, and Bayesian statistics • Ator N. A. (1999). Statistical inference in behavior analysis: Environmental determinants?. The Behavior Analyst, 22(2), 93–97. https://doi.org/10.1007/BF03391985

	• Davison M. (1999). Statistical inference in behavior analysis: Having my cake and eating it? The Behavior analyst, 22(2), 99–103. https://doi.org/10.1007/BF03391986 Recommended • Loftus, G. R. (1996) Psychology will be a much better science when we change the way we analyze data. Current Directions in Psychological Science, 5, 161-171. • Young, M. E. (2018). A place for statistics in behavior analysis. Behavior Analysis: Research and Practice, 18(2), 193-202. http://dx.doi.org/10.1037/bar0000099
Apr 22	Wrap Up
XX	Exam 2