Preliminary syllabus; updates expected

Special topics: Neuroeconomics and Decision Making
Spring 2009, Tuesday/Thursday 12-1:15 PM, Meyer TBA
Crosslisted as V89.0300.011 (Psych) and V80.0302.011 (CNS)
Website for readings, announcements, etc: on Blackboard, http://classes.nyu.edu
Instructor: Nathaniel Daw, daw -at- cns.nyu.edu
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Office hours: TBA

Note:

Substantially the same course was offered by the same instructor under the title "Special topics: Decision making." You should not take this course if you have already taken that one.

Course description:

In the neural sciences, experimental understanding is constrained by theory: that is, clear theoretical understanding of a function is needed in order to understand how to manipulate and measure the neural mechanisms that support that function. Recently, this has led neural researchers studying decision-making to seek insights from economics.

Choosing which action to take is as ubiquitous to everyday life as it is crucial to survival. Good decision-making is presumably subject to strong evolutionary selection; poor decision making is associated with many neurological and psychiatric disorders. This course explores how humans and animals make decisions, drawing broadly on many perspectives including particularly the nexus of psychological, neuroscientific, and economic considerations, but also ethological and computational ones. The course is organized around modules considering decision making in several sorts of tasks; for instance, by foraging animals or by humans in competitive multiplayer interactions. Our approach to each will be framed by a normative analysis of the problem and of theories purporting to describe how rational subjects optimally should approach it. This sets up a number of empirical questions. Behaviorally, do subjects live up to this ideal? Are their (frequent) failures to do so traceable to identifiable psychological or neural constraints? And how are the operations and constructs of the solution implemented, approximated, or represented in neural tissue?

At the core of the course will be a study of "reinforcement learning," that is the problem of learning to make good choices via trial and error and without explicit instruction. We will study how this problem relates to classic conditioning work from behavioral psychology, review algorithmic approaches to it from computer science, and examine neurophysiological evidence that the midbrain dopamine system and its targets are crucially involved in these functions. We will further consider the implications of this for drug addiction, motor disorders such as Parkinson's disease, and psychiatric disorders such as schizophrenia.

Prerequisites:

This is an upper-level undergraduate elective, and crosslisted in psychology and neural science. It accordingly covers a broad range of topics and it is understood that students with different backgrounds will be differentially prepared (and differentially excited) for different parts of it. An important component of the course will be the formal, mathematical analysis of decision problems, which will depend on a basic competence with simple probabilistic computations.

For psychology students, prerequisites are Statistics (V89.0009 or V89.0010) and Cognitive Neuroscience (may substitute Cognition). For neural science students, the prerequisite is Introduction to Neural Science (V80.0100) and Statistics as a co-requisite or with permission of the instructor. Also recommended is Behavioral and Integrative Neuroscience.

Course Requirements:

There is no course textbook. Readings will be articles (about 1-2 per session) from the primary literature, posted on Blackboard. Often these will be primary data articles expanding on one detail from the week's lecture. The lectures will thus be broader than the readings and students are responsible for the additional material covered only in the lectures. Students are also expected to keep up with the assigned readings. That said, it would be appropriate (and easier) to read them immediately after, rather than immediately before, each class.

Although there is no official course textbook, there are several that cover various aspects of the course, and one ("Neuroeconomics") that covers a big fraction of it. Where possible, I have placed them on reserve at Bobst library (they are listed under the psychology course number), and I will be assigning relevant chapters from others and posting them electronically. I am *not* recommending that anyone purchase any of these books, and they are *not* required other than the chapters I assign. They are just provided as a reference in case you are lost or want background. They are:

Glimcher et al., *Neuroeconomics*
: If you wanted one, this is it: various chapters cover much of the class

Barron, *Thinking & Deciding*
: chapters 5, 10-12 cover much of the first month of the course

Dayan & Abbott, *Theoretical Neuroscience*
: chapter 9 covers much of the second month, will post when time comes

Camerer, *Behavioral Game Theory*
: early chapters cover the last module

There will be 4 short problem sets to practice the technical material. These will be passed out near the beginning of most modules, and due one week later.

There will also be 3 quizzes, at the end of about every other module. They will largely consist of short answer questions. They are not cumulative.

Finally, there will be a short term paper (of about ten pages, though the quality is more important than the length). This will center around proposing an experiment to further test some issue discussed in class, a discussion of the rationale for the experiment, its relation to readings from the

literature, and predictions about the results. It will be due at the final exam time for the course. (There will be no final exam.)

Grades:

33% Problem sets
33% Quizzes
33% Final paper

Preliminary topics & readings:

Meeting	Date	Topic	Readings	Notes
1		Introduction / overview		
2		Math refresher: Probabilities, expectations, Bayes' theorem	Handout	
Module 1: Lotteries				
3		Normative theory: Expected utility & risk sensitivity	Machina (1987) Economic Perspectives 1:121-154	Problem Set 1 out
4		Behavior: violations & paradoxes	... continue w/ Machina	
5		Descriptive theory: Prospect theory	Tversky & Kahneman (1981) Science 211:453-458	Problem Set 1 due
			Tom et al. (2007) Science 315:515-518	
6		Neural representations of decision variables	Platt & Glimcher (1999) Nature 400:233-238	
			Padoa-Schioppa & Assad (2006) Nature 441:223-226	
7		Risk: ethology & learning	Kacelnik & Bateson (1996) Amer. Zool. 36:402-434	
Module 2: Learning & decision making				
8		Prediction & Pavlovian conditioning: Normative & descriptive	Rescorla & Wagner (1972) in Classical Conditioning II	Problem Set 2 out
		Rescorla/Wagner, Kalman filter		
9		Instrumental conditioning: Normative & descriptive	Herrnstein & Prelec (1991), J Econ Persp 5:137-156	
		matching law, melioration, rate maximization		Problem Set 2 due
10		Quiz I / Catchup / Discuss term paper		
11		Neural and behavioral measures of learning	Sugrue et al. (2004) Science 304:1782-1787	
12		The explore/exploit dilemma	Cohen et al. (in press) Proc Royal Society	
13		Uncertainty, surprise, and neuromodulation	Yu & Dayan (2005) Neuron 46:681-692	
Module 3: Learning & decision making II, sequential tasks				
14		Normative theory:	Handout	
		Reinforcement learning & dynamic programming		
15		Dopamine neurophysiology	Schultz et al. (1997) Science 275:1593-1599	Problem Set 3 out
16		Basal ganglia and movement disorders	Delong (1990) TINS 13:281-285	
17		Habits and prefrontal-striatal interactions	Daw et al. (2006) in Bezard volume	Problem Set 3 due
18		Neuromodulation and psychiatric disorders	TBA (Cohen schizophrenia work?)	
19				
20		Discounting: behavioral, ethological, neural	Kacelnik (1997) in Human Psychological Adaptation	
21		Quiz 2 / Catchup		
Module 4: Decision formation				
22		Evidence accumulation &	Handout	
		the sequential likelihood ratio test		
23		Neurophysiology & behavior: evidence accumulation	Gold & Shadlen (2002) Neuron 36: 299-308	
			(also: Brody, Rangel)	
Module 5: Multiplayer games				
24		Normative theory: Equilibrium, mixed strategies	Handout	Problem Set 4 out
25		Games with humans: violations of equilibrium,	Camerer (2003) TICS 7:225-231	
		bounded iterative reasoning		
26		Games: learning and emotion	Sanfey et al. (2003) Science, 300:1755-1758	Problem Set 4 due
27		Animals, electrophysiology	Barraclough et al (2004) Nat. Neurosci 7:404-410	
28		Wrapup / Quiz 3		