

Syllabus

ECON 608: ADVANCED NEUROECONOMICS
University of Southern California
Fall 2022

Schedule: Tuesday 2:00 – 5:20 p.m.

Location: **SOS B45**

Instructor: Prof. **Giorgio Coricelli** Office Hours: Wednesday 11:00 – 12:00

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Textbook: **Neuroeconomics**, Decision Making and the Brain, 2nd Edition, Edited by Glimcher and Fehr, 2014. Additional readings (see list below) will be uploaded online. Additional readings will be provided online.

Midterm paper: 1500 words following the rules of The Journal of Neuroscience Journal Club (http://www.jneurosci.org/site/misc/ifa_features.xhtml)

Final project: Each student should develop a neuroeconomics project (experimental project or computational model proposal)

Exams: Midterm: final project (i.e. review paper or an experimental project) and project presentation

Grading:

Class participation	10%
Midterm (review paper)	40%
Final project	50%

Course Outline:

The objective of this course is to discuss advanced topics of Neuroeconomics. The topics to be covered and the required readings (**Chapters (CH)** from *Neuroeconomics* and *Readings (R)*) are:

Lecture 1:

Introduction. Experimental Methods in Cognitive Neuroscience (intro, CH 6)

Lecture 2:

The computation of value in goal-directed choice (CH 8, **R**)

Lecture 3:

Neural foundation of economic preferences. Normalization of value signals. Range adaptation. Choice consistency (CH 8, **R**)

Lecture 4:

Reward processing mechanisms. Value learning through reinforcement: the basics of dopamine and reinforcement learning (CH 15, **R**)

Lecture 5:

Modulators of the value signal: Risk (CH 9, Appendix Prospect theory in the brain, **R**)

Lecture 6:

Neural representation of uncertainty and risk (Ch9, **R**)

Lecture 7:

Modulators of the value signal: Time (CH 10) and Decision Biases in the Brain (CH 24, **R**)

Lecture 8:

Midterm Paper. The computation of social brain (CH 2, CH 27, **R**)

Lecture 9:

Altruism and Fairness (CH 11, **R**)

Lecture 10:

Trust and Reputation in economic exchange (CH 25, **R**)

Lecture 11:

The neural Basis of Strategic Choice I (CH 2, CH 25, **R**)

Lecture 12:

Perceptual decision making and models of rational inattention (CH 19, **R**)

Lecture 13:

Neuro-finance (**R**)

Reading list

Introduction. Experimental Methods in Cognitive Neuroscience (Lecture 1)

Neuroeconomics: the conciliation of brain and decision. Glimcher PW and Rustichini A, Science 2004

The computation of value in goal-directed choice (Lecture 2)

(R) Krajbich, C. Armel, A. Rangel, Visual fixations and comparison of value in simple choice. Nature Neuroscience, 2010, 13:1292-1298

Suggested readings

Antonio Rangel, Colin Camerer & P. Read Montague (2008) A framework for studying the neurobiology of value-based decision making. Nature Review Neuroscience

Luce, R.D. Response Times: Their Role in Inferring Elementary Mental Organization (Oxford University Press, Oxford, 1986).

Ratcliff, R. A theory of memory retrieval. Psychol. Rev. 85, 59–108 (1978).

Krajbich, I., Rangel, A. (2011). Multialternative drift-diffusion model predicts the relationship between visual fixations and choice in value-based choice. Proceedings of the National Academy of Sciences, 108(33), 13852-13857

N. Sullivan, C. Hutcherson, A. Harris, A. Rangel. Dietary self-control is related to the speed with which health and taste attributes are processed. Psychological Science, 2015, 26:122-134

E. Reutskaja, R. Nagel, C.F. Camerer, A. Rangel, Search dynamics in consumer choice under time pressure: An eye-tracking study. American Economic Review, 2011, 101:900-906

Neural foundation of economic preferences (Lecture 3)

(R) Padoa-Schioppa C, Assad JA (2006). Neurons in the orbitofrontal cortex encode economic value. Nature. 441 (7090): 223-6

(R) Léon Tremblay and Wolfram Schultz (1999). Relative reward preference in primate orbitofrontal cortex. Nature 398, 704-708

Suggested readings

Padoa-Schioppa C, Assad JA (2008). The representation of economic value in the orbitofrontal cortex is invariant for changes of menu. Nat Neurosci. 11 (1): 95-102

Camille et alii (2011). Ventromedial Frontal Lobe Damage Disrupts Value Maximization in Humans. The Journal of Neuroscience, May 18, 2011 31(20):7527–7532

Antonio Rangel, Colin Camerer & P. Read Montague (2008) A framework for studying the neurobiology of value-based decision making. Nature Review Neuroscience

T. Hare, S. Hakimi, A. Rangel. Activity in dlPFC and its effective connectivity to vmPFC are associated with temporal discounting. Frontiers in Neuroscience, 2014, 8:50

Reward processing mechanisms (Lecture 4)

(R) Schultz W, Dayan P, and Montague R. (1997) A Neural Substrate of Prediction and Reward. Science, 275 :1593-1599.

(R) O'Doerthy et al (2003), Temporal difference models and reward-related learning in the human brain, Neuron, 38,329-337

Suggested readings

Tobler et al (2005). Adaptive Coding of Reward Value by Dopamine Neurons. Science 11 March 2005: Vol. 307 no. 5715 pp. 1642-1645.

John O'Doherty et alii (2004). Dissociable Roles of Ventral and Dorsal Striatum in Instrumental Conditioning. Science 16 April 2004: Vol. 304 no. 5669 pp. 452-454.

Waelti P., Dickinson A., Schultz W. (2001). Dopamine responses comply with basic assumptions of formal learning theory. Nature 412, 43–48

- Schultz (2000). "Multiple reward signals in the brain." *Nature Review Neuroscience*, vol 1, December 2000, 199-206.
- Pessiglione M, Seymour B, Flandin G, Dolan R. J, Frith C. D (2006) Dopamine-dependent prediction errors underpin reward-seeking behaviour in humans. *Nature* 442: 1042–1045
- Palminteri, S., Khamassi, M., Joffily, M., Coricelli, G. (2015). Contextual modulation of value signals in reward and punishment learning. *Nature Communications*. 6, 8096.
- Dayan P, Balleine BW (2002) Reward, motivation, and reinforcement learning. *Neuron* 36: 285–298.
- Hackjin Kim, Shinsuke Shimojo, John P. O'Doherty (2006) Avoiding an Aversive Outcome Rewarding? Neural Substrates of Avoidance Learning in the Human Brain. *PLoS Biology*
- Rushworth MF, Noonan MP, Boorman ED, Walton ME, Behrens TE. (2011) Frontal cortex and reward-guided learning and decision-making. *Neuron*. 2011 Jun 23;70(6):1054-69
- Wunderlich K, Rangel A, O'Doherty JP. (2009) Neural computations underlying action-based decision making in the human brain. *Proc Natl Acad Sci U S A*. 2009 Oct 6;106(40):17199-204.
- Glascher J & Daw ND & Dayan P & O'Doherty JP (2010) States versus rewards: dissociable neural prediction error signals underlying model-based and model-free reinforcement learning. *Neuron*
- Lohrenz T, McCabe K, Camerer CF, Montague PR. (2007) Neural signature of fictive learning signals in a sequential investment task. *Proc Natl Acad Sci U S A*. 2007 May 29;104(22):9493-8.
- Boorman ED, Behrens TE, Woolrich MW, Rushworth MF. (2009) How green is the grass on the other side? Frontopolar cortex and the evidence in favor of alternative courses of action. *Neuron*. 2009 Jun 11;62(5):733-43
- Biele et alii (2011) The Neural Basis of Following Advice. *PLoS Biology*
- Behrens T. E. J, Hunt L. T, Woolrich M. W, Rushworth M. F. S (2008) Associative learning of social value. *Nature* 456: 245–249
- Boorman ED, Behrens TE, Rushworth MF. (2011) Counterfactual choice and learning in a neural network centered on human lateral frontopolar cortex. *PLoS Biol*. 2011 Jun;9(6):e1001093

Modulators of the value signal: Risk (Lecture 5)

- (R)** Kahneman, D., Tversky, A., 1979. Prospect theory: an analysis of decision under risk. *Econometrica*. 4, 263-291.
- (R)** Tversky, A., Kahneman, D. (1992): "Advances in Prospect Theory: Cumulative Representation of Uncertainty", *Journal of Risk and Uncertainty* 5, 297-323.

Suggested readings

- Tversky, A., Wakker, P., 1995. Risk attitudes and decision weights. *Econometrica*. 63, 1255-1280.
- Wakker, P.P., Tversky, A., 1993. An axiomatization of cumulative prospect theory. *J. Risk Uncertain*. 7, 147-176.
- Prelec, D., 1998. The probability weighting function. *Econometrica*. 66, 497-527.
- Yaari, M.E. (1987): "The Dual Theory of Choice under Risk," *Econometrica* 55, 95-115.
- Quiggin, J. (1982): "A Theory of Anticipated Utility", *Journal of Economic Behavior and Organization* 3, 323-343.
- Machina, M. J. and D. Schmeidler (1992): "A more Robust Definition of Subjective Probability," *Econometrica* 60, 745-780.
- Schmeidler, D. (1989): "Subjective Probability and Expected Utility without Additivity," *Econometrica* 57, 571-587
- Ghirardato, Paolo, Fabio Maccheroni, and Massimo Marinacci (2004): "Differentiating ambiguity and ambiguity attitude," *Journal of Economic Theory* 118, 133-173.
- Maccheroni, F., M. Marinacci, and A. Rustichini (2006): "Ambiguity Aversion, Rubustness, and the Variational Representation of Preferences, *Econometrica* 74, 1447-1498.

Neural representation of uncertainty and risk (Lecture 6)

(R) Preuschoff, P Bossaerts, and S R Quartz. Neural differentiation of expected reward and risk in human subcortical structures. *Neuron*, 51(3):381–390, 2006.

(R) Ming Hsu et alii (2006). Neural Systems Responding to Degrees of Uncertainty in Human Decision-Making. *Science*. 9 December 2005: Vol. 310 no. 5754 pp. 1680-1683

Suggested readings

Fiorillo CD, Tobler PN, Schultz W (2003) Discrete coding of reward probability and uncertainty by dopamine neurons. *Science* 299 (5614), 1898

Levy, I., Snell, J., Nelson, A.J., Rustichini, A., and Glimcher, P.W. (2010). Neural representation of subjective value under risk and ambiguity. *Journal of Neurophysiology*. 103(2):1036-47.

Tom et alii (2007). “The neural basis of loss aversion in decision making under risk”. *Science*. 26 January 2007: Vol. 315 no. 5811 pp. 515-518

Christopoulos G, Tobler PN, Bossaerts P, Dolan RJ, Schultz W (2009) Neural correlates of value, risk, and risk aversion contributing to decision making under risk *The Journal of Neuroscience* 29 (40), 12574-12583

A Huettel, C Jill Stowe, Evan M Gordon, Brent T Warner, and Michael L Platt. Neural signatures of economic preferences for risk and ambiguity. *Neuron*, 49(5):765–75

Levy, I., Snell, J., Nelson, A.J., Rustichini, A., and Glimcher, P.W. (2010). Neural representation of subjective value under risk and ambiguity. *Journal of Neurophysiology*. 103(2):1036-47

Payzan-LeNestour E, Dunne S, Bossaerts P, O’Doherty JP. (2013) The neural representation of unexpected uncertainty during value-based decision making. *Neuron*. 2013 Jul 10;79(1):191-201.

Payzan-LeNestour E, Bossaerts P. (2011). Risk, unexpected uncertainty, and estimation uncertainty: Bayesian learning in unstable settings. *PLoS Comput Biol*. 2011 Jan 20;7(1):e1001048.

De Martino B, Camerer CF, Adolphs R. (2010) Amygdala damage eliminates monetary loss aversion. *Proc Natl Acad Sci U S A*. 2010 Feb 23;107(8):3788-92.

Coricelli, G., Critchley, H.D., Joffily, M., O’Doherty, J.D., Sirigu, A., and Dolan, R.J. (2005). “Regret and its Avoidance: A Neuroimaging Study of Choice Behavior”. *Nature Neuroscience*, 8, pp. 1255 - 1262.

Mohr, P. N., Biele, G., & Heekeren, H. R. (2010). Neural Processing of Risk. *J Neurosci* 30:6613-6619.

Modulators of the value signal: Time (Lecture 7)

(R) McClure et alii (2004). Separate Neural Systems Value Immediate and Delayed Monetary Rewards. *Science* 15 October 2004: Vol. 306 no. 5695 pp. 503-507

(R) Kable, J.W., and Glimcher, P.W. (2007). The neural correlates of subjective value during intertemporal choice. *Nat Neuroscience*. 10(12): 1625 - 1633.

Suggested readings

Laibson D (1997). Golden eggs and hyperbolic discounting. *QJE* 443-477

Gul F, Pesendorfer W (2001). Temptation and self-control, *Econometrica*, 69(6), 1403-1435

Glimcher PW, Kable JW, Louie K (2007). Neuroeconomic studies of impulsivity: now or just as soon as possible? *AER*, 97(2), 102-147

Knutson, B., Wimmer, G. E., Rick, S., Hollon, N. G., Prelec, D., Loewenstein, G. (2008). Neural antecedents of the endowment effect. *Neuron*, 58, 814-822.

De Martino B, Kumaran D, Holt B, Dolan RJ. (2009) The neurobiology of reference-dependent value computation. *J Neurosci*. 2009 Mar 25;29(12):3833-42

Kenway Louie, Mel W. Khaw, and Paul W. Glimcher (2013) Normalization is a general neural mechanism for context-dependent decision making. *PNAS*

De Martino et alii (2006). Frames, Biases, and Rational Decision-Making in the Human Brain. *Science* 4 August 2006: Vol. 313 no. 5787 pp. 684-687

The computation of social brain and behavior (Lecture 8)

(R) Behrens T, Hunt L, Rushworth M. (2009) The Computation of Social Behavior. *Science* 29 May 2009: Vol. 324 no. 5931 pp. 1160-1164

Suggested readings

Rizzolatti G., Fadiga L., Gallese V., Fogassi L. Premotor cortex and the recognition of motor actions. *Cogn. Brain Res.*, 3 (1996), 131-141.

Amodio, D. M., & Frith, C. D. (2006). Meeting of minds: The medial frontal cortex and social cognition. *Nature Reviews Neuroscience*, 7, 268-277

Adolphs R (2010) Conceptual challenges and directions for social neuroscience. *Neuron* 65: 752–767.

Altruism and Fairness (Lecture 9)

(R) William Harbaugh, Ulrich Mayr, Dan Burghart. (2007). Neural Responses to Taxation and Voluntary Giving Reveal Motives for Charitable Donations. *Science*, June 15, 2007. 316:1622-1625

(R) Sanfey et alii (2003) The Neural Basis of Economic Decision-Making in the Ultimatum Game. *Science* 13 June 2003: Vol. 300 no. 5626 pp. 1755-1758

Suggested readings

Sanfey, A.G. (2007). Social decision-making: Insights from Game Theory and Neuroscience. *Science* 318, 598-602.

Rabin, Matthew, "Incorporating Fairness into Game Theory and Economics," *American Economic Review* 1993

Fehr E and Camerer CF (2007). Social neuroeconomics: the neural circuitry of social preferences. *Trends in Cognitive Sciences*, 11, 419-427.

Chang, L.J., Smith, A., Dufwenberg, M. & Sanfey, A.G. (2011). Triangulating the neural, psychological, and economic bases of moral sentiments. *Neuron*, 70, 560-572.

Reputation and Trust in economic exchange (Lecture 10)

(R) King-Casas et alii (2005). Getting to Know You: Reputation and Trust in a Two-Person Economic Exchange. *Science* 1 April 2005: Vol. 308 no. 5718 pp. 78-83

(R) Delgado et alii (2005). Perceptions of moral character modulate the neural systems of reward during the trust game. *Nature Neuroscience*. 8, 1611 – 1618

Suggested readings

Krueger F, McCabe K, Moll J, Kriegeskorte N, Zahn R, et al. (2007) Neural correlates of trust. *PNAS* 104: 20084–20089

Fouragnan, E., Chierchia, G., Greiner, S., Neveu, R., Avesani, P., and Coricelli, G. (2013). Reputational priors magnify striatal responses to violations of trust. *The Journal of Neuroscience*. 33(8):3602–3611

The neural Basis of Strategic Choice (Lecture 11)

(R) Coricelli, G., and Nagel, R. (2009). "Neural correlates of depth of strategic reasoning in medial prefrontal cortex". *Proceedings of the National Academy of Sciences USA*, 106, 23, pp. 9163-8.

(R) Hampton AN, Bossaerts P, O'Doherty JP. (2008) Neural correlates of mentalizing-related computations during strategic interactions in humans. *Proc Natl Acad Sci U S A*. 2008 May 6;105(18):6741-6.

Suggested readings

Nagel, R. (1995). Unraveling in guessing games: An experimental study. *Am Econ Rev* 85:1313-1326.

Camerer, C. F., Ho, T.-H., & Chong, J.-K. (2004). A cognitive hierarchy model of games. *Q J Econ* 119:861-898.

Crawford, V. P., Costa-Gomes, M. A., & Iriberry, N. (2013). Structural Models of Nonequilibrium Strategic Thinking: Theory, Evidence, and Applications. *J of Econ Lit* 51:5-62.

Bhatt MA, Lohrenz T, Camerer CF, Montague PR. (2010) Neural signatures of strategic types in a two-person bargaining game. *Proc Natl Acad Sci U S A*. 2010 Nov 16;107(46):19720-5

- Stahl D.O., & Wilson, P.W. (1995). On players' models of other players: Theory and experimental evidence. *Games Econ Behav* 10:218-254.
- Yoshida W, Dolan RJ, Friston KJ. (2008) Game theory of mind. *PLoS Comput Biol*. 2008 Dec;4(12):e1000254
- Yoshida W, Seymour B, Friston KJ, Dolan RJ. (2010) Neural mechanisms of belief inference during cooperative games. *J Neurosci*. 2010 Aug 11;30(32):10744-51
- Van Huyck, J. B., Battalio, R. C., & Beil, R. O. (1990). Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure. *Am Econ Rev* 80:234-248.
- Heinemann, F., Nagel, R., & Ockenfels, P. (2009). Measuring Strategic Uncertainty in Coordination Games. *Rev Econ Stud* 76:181-221.

Perceptual decision making and models of rational inattention (Lecture 12)

- (R)** Woodford, M. (2012) "Prospect Theory as Efficient Perceptual Distortion," January 2012. Published in AEA Papers and Proceedings.
- (R)** Sims, C. (2005). "Rational inattention: a research agenda".

Suggested readings

- Woodford, M. (2014) "Stochastic Choice: An Optimizing Neuroeconomic Model," AEA Papers and Proceedings.
- Masatlioglu, Y., D. Nakajima and E. Ozbay (2012): Revealed Attention," *American Economic Review* 102, 2183-2205.

Neuro-finance (Lecture 13)

- (R)** In the Mind of the Market: Theory of Mind Biases Value Computation during Financial Bubbles, by DeMartino et al, 2013 *Neuron*
- (R)** Kuhnen, C. M., & Knutson, B. (2005). The neural basis of financial risk taking. *Neuron*, 47, 763-770
- (R)** Frydman, C. et al. (2014) Using neural data to test a theory of investor behavior: an application to realization utility. *J. Finance* 69, 907–946

Suggested readings

- Frydman, C., and Camerer, C.F. (). The Psychology and Neuroscience of Financial Decision Making. *Trends in Cognitive Sciences*, September 2016, Vol. 20, No. 9
- Barberis, Nicholas, and Wei Xiong. 2009. "What Drives the Disposition Effect? An Analysis of a Long-standing Preference-based Explanation." *Journal of Finance* 64(2):751-784.
- Knutson, B., Bossaerts, P. (2007). Neural antecedents of financial decisions. *Journal of Neuroscience*, 27, 8174-8177
- Benartzi, Shlomo, and Richard Thaler, "Myopic Loss Aversion and the Equity Premium Puzzle," *Quarterly Journal of Economics* 1995, in ABE ch 22
- Odean, "Do Investors Trade Too Much?," *American Economic Review* 1999, in ABE ch 23
- Genesove and Mayer, "Loss Aversion and Seller Behavior: Evidence from the Housing Market," *Quarterly Journal of Economics* 2001, in ABE ch 24, ONLY pp633-635, 651-652
- Odean, Terrance and Brad Barber (2001). "Boys will be boys: gender, overconfidence, and common stock investment," *Quarterly Journal of Economics* 116: pp. 261–292.