

The Neurobiology of Consciousness and Evolution of Language

Class description:	Your brain is a bizarre device, set in place through natural selection of your ancestors and your own experience. One thing that clearly separates your brain from the brain of any other non-human animal is the propensity of your brain for imagination and creativity. In this class we will dive into the neuroscience of imagination: from neurons to memory to neurological mechanism of generating novel conscious experiences. We will study what makes your brain unique and the selectional forces that shaped the brains of our ancestors. We will discuss what makes human language special and how it evolved. This interdisciplinary class is intended for paleoanthropologists who want to learn neuroscience, psychologists who are interested in the question of the origin of language, biologists who are interested in the uniqueness of the human mind, neuroscientists who want an exposure to paleoanthropology and linguistics, philosophers fascinated by neurological basis of behavior and other students interested in an understanding of the mind of a man and the evolution of the brain.	
Instructor:	Andrey Vyshedskiy, email: vysha@bu.edu Education: PhD in Neurobiology, MS in Biomedical Engineering, BS in Astrophysics.	
Class website:	http://stethographics.com/a3/	
Textbook:	On The Origin Of The Human Mind, Second Edition, by Andrey Vyshedskiy, Free PDF is available here: http://mobilereference.com/mind/mind.pdf Paperback is available at Amazon: http://www.amazon.com/gp/product/1492963615	
Office hours:	1 hour after the lecture	
Grading:	Journal articles presentations (three students per article)	35%
	If your group is not presenting, read the assigned journal article and generate at least one question for class discussion of the article (email the question along with the homework)	5%
	Homeworks (available on the website; write the answers, save as MWord, PDF, or make a photograph of your answers and email the file before the class to imagirationmailer@gmail.com ; PLEASE do not email to my other emails addresses! Expect to spend several hours working on each homework.)	20%
	Quizzes (7 questions, 15 min, once every three lectures (i.e. every Tue in the Summer). Each quiz is based on the last three homeworks that we have already discussed in class. Quizzes can also include rephrased questions from previous quizzes.)	40%
Guidelines for a journal article presentation	<ul style="list-style-type: none"> -As a scientist, you will make hundreds of presentations. It only makes sense to learn to enjoy making presentations as early as possible. -I will assign journal articles to each group of students. You will create a Power Point presentation and present these articles in class. When presenting an article please: <ul style="list-style-type: none"> -Clearly state the research questions addressed in the article -Provide background information for context -Select and carefully describe the most important results using the figures and tables from an article. Do the results adequately address the question? How well? -Describe methods as appropriate for understanding the results (What were they? Were they appropriate? Why?) If you did not understand something, we will try to figure it out together in class. 	
Participation in discussion of journal articles	Discussion of the scientific literature is important. It trains us all to be more rigorous. As you listen to the presentations, consider the work carefully and prepare your questions. Regular contributions during Discussion and during class are expected, and your participation will be part of your grade.	
Research slide presentation	<p>If you are taking this class, you probably have THE QUESTION that you wanted to answer for a long time. Any question. Really. Let's dig into literature and investigate. I will help you.</p> <p>If you need a suggestion for a research topic, please talk to me.</p> <ul style="list-style-type: none"> -When preparing your presentation, aim to make it informative and interesting. -A good presentation involves careful preparation and practice. Most likely you will need to use Power Point slides. Aim for a 15-20 min presentation followed by a 5-10 min discussion. 	
Grading	92-100 = A 88-91 = A- 84-87 = B+ 80-84 = B 76-79 = B-	

Legend: T =Topic of the lecture; R=Reading materials for the lecture; W=Watch these related videos; J=Journal club topic discussed at the end of the lecture

1	T	Open questions in evolutionary neuroscience. We start with evolution. Facts of hominin development. The main thing: language. But what is language? What makes modern humans so much different from other animals?
	W	-Becoming Human - 3 parts long Documentary: https://youtu.be/UfU7yghK9GQ?list=PLLoRNYgorqAm6g8udHKvGXEBwfgFG1keD
	R	-Part 2, Chapter 7
	J	No journal article presentation in the first lecture
Overview of System Neuroscience		
2	T	Where is consciousness in the nervous system? Organization of the brain. Neocortex-hippocampus system of encoding long-term memories of people, objects, facts and events; other memory systems. Functional localization in neocortex. Cortical plasticity.
	R	Appendix 2
	W	- Karolinska Research Lectures: Itzhak Fried (50min 2013): https://www.youtube.com/watch?v=0aBfUfqPk6M - Christof Koch a in the National Geographic Live! - Mapping the Brain (22min, 2014: at 8min there is the best presentation of a slice of a mouse brain with synapses): https://www.youtube.com/watch?v=7_drJyNMxbw - 3D brain: http://www.g2conline.org/2022 - The Brain: Teaching Modules. (1997). http://www.learner.org/resources/series142.html : 1. Organization and Evaluation of Brain Function, 25. Frontal Lobes and Behavior: The Story of Phineas Gage -Daniel Wolpert. TED lecture. http://www.ted.com/talks/daniel_wolpert_the_real_reason_for_brains.html Cases of retrograde amnesia are informing us on memory encoding in the neocortex-hippocampus system: - Patient HM: http://ed.ted.com/lessons/what-happens-when-you-remove-the-hippocampus-sam-kean - Patient EP has complete damage to hippocampus: https://youtu.be/CL-0gfpf_6g - Clive Wearing : 1) https://youtu.be/k_P7Y0-wgos ; 2) https://youtu.be/c62C_yTUyVg ; 3) Clive's brain damage is explained with brain scans: https://youtu.be/9BrCBq2FY_U
	J	All students - Ian Tattersall, "How we came to be Human" SciAm Dec 2001
3	T	Hemispatial neglect and conscious awareness. The sense of vision. Blindsight: Conscious vision versus unconscious vision.
	R	Part 1, Chapter 1, Appendix 4
	W	- Unilateral neglect example: http://www.youtube.com/watch?v=HFTBC1ixfNk - Prosopagnosia and Neglect examples from Brain Story, a 6-part series by the BBC: http://www.youtube.com/watch?v=ADchGO-0kGo - The Brain: Teaching Modules. (1997). http://www.learner.org/resources/series142.html : 8. Visual Information Processing: Elementary Concepts, 9. Visual Information Processing: Perception, 10. Perception: Inverted Vision -Podcast: Interview with a scientist who developed the technique of talking to patients in minimally conscious state: https://itunes.apple.com/us/podcast/nature-podcast/id81934659?mt=2&i=1000389386009
	J	All students: Fuster, "The Prefrontal cortex", Introduction; 2016, Christof Koch Neural correlates of consciousness: progress and problems
4	T	What is memory? Objects encoding in the brain. Neuronal ensembles: single neuron recording in humans, multi-neuron recordings in animals; visual recognition and memory recall of an object. Short-term vs. long-term memory. Neuronal ensembles of words, faces. Bistable images; visual agnosia;
	T	Principle of brain organization across motor and sensory modalities: Neural processes that underlie motor and sensory perception are also used in imagery of that modality.
	R	Part 1, Chapter 1; Nature feature, 2018: "How to see a memory" https://www.nature.com/articles/d41586-018-00107-4
	W	-TED-Ed cartoon: What if we could look inside human brains? - Moran Cerf: http://youtu.be/sewhbhmh0ECg -2015 Karolinska Research Lectures: Itzhak Fried: https://youtu.be/0aBfUfqPk6M -Wilder Penfield: https://www.youtube.com/watch?v=68MiW2KK1us -Small neuronal ensembles and Free Will (2011: Itzhak Fried @Fried et al., Neuron 69(3)): https://youtu.be/vP9N4HLIMC -Neuroscience of Free Will: TED talk by Moran Cerf: http://www.ted.com/talks/moran_cerf_this_scientist_can_hack_your_dreams (7:30min = Simpsons) --Stephen Kosslyn presents arguments for the idea that thoughts can be visual as well as linguistic (1hour): http://youtu.be/FkhU7i8hRK4 -Listen to Jeff Hawkins from Numenta on a theory about neocortical function and cortical columns: https://itunes.apple.com/us/podcast/brain-science-ginger-campbell-md-neuroscience-for-everyone/id210065679?mt=2&i=1000395312706 -Listen to Rodrigo Quiñero Podcasts: https://itunes.apple.com/us/podcast/brain-science-ginger-campbell-md-neuroscience-for-everyone/id210065679?mt=2&i=1000400670131 -If You are interested in details of how objects are encoding objects, look at the work by Jeff Hawkins: https://youtu.be/mP7neeymCUY ; https://youtu.be/LNRZD9YJCdI and many other papers and videos by Numenta: https://numenta.com/
	J	Groups 1, 2, and 3 are presenting articles in the folder: 03_ImageryAndPerception
Overview of Cognitive Neuroscience		
5	T	Neuronal binding by synchronization. Local vs. global synchronization. In this lecture, we are still staying inside the sensory posterior cortex.
	R	Part 1, Chapter 2
	W	- Wolf Singer (74min, 2013; start on 27min to avoid philosophy): https://youtu.be/WgEWMdV1Q4w?t=1594 - How synchrony can encode information (2011), Thomas Akam (5min video abstract): http://youtu.be/V95QKw8qmJ8
	J	Groups 4, 5, and 6 are presenting articles in the folder: 04_NeuronalEnsembles:
6	T	PFC role in activation of neuronal ensembles. Self-activation of neuronal ensembles during dreams. Review of neuronal ensembles; Binding neurons of the temporal lobe.
	R	Appendix 3
	W	-Earl Miller: Cognition is rhythmic (one hour, 2014): http://youtu.be/baFqP1mDCPk ; (20min, 2012): http://youtu.be/6QjIKr_vlec ; Here are Miller's publications: https://earlkmiller.org/publications-summary/
	J	See the articles folder: 05_Neuronal binding by synchronization
7	1	Imagination involves several neurologically distinct components. Imagining new objects in the process of Prefrontal Synthesis.

	R	2019, "Neuroscience of imagination and implications for hominin evolution": http://currentneurobiology.org/neurobiology/neuroscience-of-imagination-and-implications-for-humanevolution.pdf Part 1, Chapter 3, 4; Part 3, Chapter 11
	J	See the articles folder: 06_PFC role in activation of neuronal ensembles
8	T	Role of the prefrontal cortex in working memory, Mental Synthesis, and inhibition of urges. Functional imaging of the prefrontal cortex in healthy subjects; Neurological deficits associated with lesions of the prefrontal cortex; The prefrontal cortex in temporal organization of actions.
	T	Evolution of the prefrontal cortex. Human brain evolution in the context of primate brain evolution. Primate visual system.
	W	- 2018, Working Memory 2.0 - Earl K. Miller (20min) https://youtu.be/dhbbdCCASCg - Suzana Herculano-Houzel: What is so special about the human brain? https://www.ted.com/talks/suzana_herculano_houzel_what_is_so_special_about_the_human_brain - Podcast: Counting Neurons with Dr. Suzana Herculano-Houzel from Brain Science with Ginger Campbell, MD: Neuroscience for Everyone in Podcasts. https://itunes.apple.com/us/podcast/brain-science-ginger-campbell-md-neuroscience-for-everyone/id210065679?mt=2&i=100038481791 - Human Ape, Nat Geographic, 2008, DVD: footage of Povinelli, Bonobos Kanzi and Panbanisha and orangutans Knobi and Azy are extensively shown in the film; FOXP2; Whereas the human child is shown to be imitating the steps taken by one researcher to open a box and get a reward, the apes quickly eliminate the redundant steps.
	R	Part 3, Chapter 12 All groups re-read: Fuster, "The Prefrontal cortex", Introduction
	J	See the articles folder: 07_MS_PFC
9	T	PFC evolution: evolution of inhibition (The Candy Game), social function, and PFC control of neuronal ensembles in the posterior cortex.
	T	Isochronicity in neural networks. Experience changes myelination in humans
	R	Part 3, Chapter 12
	W	- DANIEL J. POVINELLI (20min lecture, 2013) - https://www.youtube.com/watch?v=kX49dlbfG9E ; experiment with weight concept in chimpanzees (8min, 2012): https://www.youtube.com/watch?v=pdvRhs4z1CI - The surprising science of alpha males Frans de Waal: https://youtu.be/BPSKLL8N0s
	J	08_PFC_evolution
		Research topic decision is due.
10	T	Critical periods in neurological system development. Critical period for language acquisition, feral children, deaf linguistic isolates. Critical period of human language acquisition: mechanics of speech, neurological bases.
	R	2017, "Linguistically deprived children: meta-analysis of published research underlines the importance of early syntactic language use for normal brain development": https://riajournal.com/article/20696/ Part 3, Chapter 12; Appendix 6
	W	- Genie: https://youtu.be/VjZolHCrC8E?t=5m40s - The beginning of Life (Netflix series): https://www.netflix.com/title/80107990 - Listen for podcast Words from radiolab: http://www.radiolab.org/story/91725-words/ - TED talk presenting a critical period for phoneme tuning: https://www.ted.com/talks/patricia_kuhl_the_linguistic_genius_of_babies#t-437098
	J	See the articles folder: 09_Isochronicity
		Evolutionary Neuroscience - "Nothing in Biology Makes Sense Except in the Light of Evolution" - Theodosius Dobzhansky
11	T	Evolutionary changes in the timing of brain development. Molecular biology of the human brain evolution. Evolution of the speech apparatus. The "nature" and "nurture" hypotheses.
	W	Becoming Human Documentary (2:34, 2013): http://youtu.be/YBp3SHp_Mwo (Alternative links: P1: http://youtu.be/AD47C8jP6Hw ; P2: http://youtu.be/kuT7N5aoP48 ; P3: http://youtu.be/HAAm1XHPdc)
	R	Part 3, Chapter 12
	J	See the articles folder: 10_CriticalPeriod
12	T	Functional lateralization of cerebral hemispheres. Corpus callosum. Why language is localized to one hemisphere?
	R	Part 2, Chapter 10
	W	- "Ape Genius" (52min, Nova, 2011) documents an amazing range of problems that can be solved by chimpanzees: http://www.pbs.org/wgbh/nova/apegenius/program.html (best quality: http://youtu.be/BSJI9_CMrcU ; alternative: http://youtu.be/zkiPCKINjX0) - TED talk by Jill Bolte Taylor: My stroke of insight: http://www.ted.com/talks/jill_bolte_taylor_s_powerful_stroke_of_insight?language=en - The Brain: Teaching Modules. (1997): 5. The Divided Brain: http://www.learner.org/vod/vod_window.html?pid=1573 - The girl with half brain recovered all movement: http://youtu.be/2MKNs15CWoU - Stephen Wiltshire draws Tokyo from memory: https://www.youtube.com/watch?v=95L-zmIBGd4 - M. Gazzaniga delivered a series of lectures in October 2009: http://www.ed.ac.uk/arts-humanities-soc-sci/news-events/lectures/gifford-lectures/archive/archive-2009-2010/prof-gazzaniga <ul style="list-style-type: none"> • Lectures 2 and 3 are very good. M. Gazzaniga discusses his own experiments on split-brain patients. • Lectures 4 to 6 are not worth your time unless you are very interested in the discussed topics. • Lecture 5 @40 min: theory of mind in split-brain patients
	J	See the articles folder: 11_MolecularBiology
13	T	Evolutionary driving forces: Neurobiology of visual identification of motionless objects. Evolutionary pressure from motionless predators. Comparative neurobiology: from the birth of hominins to modern humans. Evolution of brain volume, speech apparatus, body structure. Evolution of stone tools: neurobiology of stone tools manufacturing. Evolution of the visual system: humans are much better than chimpanzees at integrating local visual information into a global whole.
	R	Part 2, Chapter 8
	J	See the articles folder: 12_SplitBrain_and_Language
14	T	Integration of evolution of consciousness: from hydra to human nervous system. Language acquisition. Human language compared to animal communication systems. The dual origin of human language. Alternative theories of the human mind evolution.
	R	2019, "Language evolution to revolution: the leap from rich-vocabulary non-recursive communication system to recursive language 70,000 years ago was associated with acquisition of a novel component of imagination, called Prefrontal Synthesis, enabled by a mutation that slowed down the prefrontal cortex

		maturation simultaneously in two or more children – the Romulus and Remus hypothesis” https://riojournal.com/article/38546/ Part 2, Chapter 9
	W	-Washoe, Koko, and the social exchange of language in non-human primates: http://www.youtube.com/watch?v=3V_rAY0g9DM -Kanzi in a research session, converting human language to arbitrary symbols (3min): http://www.youtube.com/watch?v=wRM7vTrIliis ; another video on Kanzi (6min): http://youtu.be/pEk138lqaFo . -The best movie about Kanzi (4 x 15 min, 1990): (1) http://youtu.be/dBUHWoFnuB4 ; (2) http://youtu.be/MTFL7BgWloY ; (3) http://youtu.be/P-9U1b-LaAA ; (4) http://youtu.be/h7ldghtkKmA -Herbert S. Terrace - Nim Chimpsky DVD -The Brain: Teaching Modules. (1997): http://www.learner.org/resources/series142.html : 6. Language and Speech: Broca's and Wernicke's Areas -Broca's aphasia: http://www.youtube.com/watch?v=f2liMEbMnPM -Wernicke's aphasia: http://www.youtube.com/watch?v=aVhYN7NTIKU -National Geographic documentary about Andaman Tribe on an isolated island who likely split from other humans 60,000 YA: http://youtu.be/0Gxm7_y75uA
	J	See the articles folder: 13_Visual_Identification
15	T	Wish list of experiments. Autism. Problem solving by animals.
	W	- The woman who thinks like a cow (Temple Grandin): http://www.youtube.com/watch?v=46ycu3JFRrA http://www.youtube.com/watch?v=f-iy7GNsmm0 -Temple Grandin , Brain Science Podcast: http://brainsciencepodcast.com/bsp/2013/interview-temple-grandin-bsp-99 -Wendy Chung shares what we know about autism (TED) http://www.ted.com/talks/wendy_chung_autism_what_we_know_and_what_we_don_t_know_yet?language=en -Daniel Povinelli talk about animal art. All over the place. He hardly makes a point but discusses many examples of animal art: http://youtu.be/eFGYvtqJ6Bs
	R	Part 1, Chapter 6, Book conclusions, A wish list of experiments
	J	See the articles folder: 14_BrainVolume
16	T	Evolution of symbolic thinking. Human use of fire controversy: when did humans start using fire?
	J	See the articles folder: 15_AnimalPlanning_Autism_Traps_SymbolicThinking

Preparing for the class

Students with any level of neuroscience have enjoyed this class in the past. However, the more neuroscience background you have, the more you would enjoy the class. If you are considering to brush up your neuroscience, here are some resources:

1. The Fundamentals of Neuroscience online class | Harvard University : <https://www.mcb80x.org/course>
2. Introduction to Neuroscience I - Stanford: <https://youtu.be/5031rWXgdYo>
3. Neuroscience classes at MIT: <https://ocw.mit.edu/courses/brain-and-cognitive-sciences/>

In addition, here are some popular books related to the class material that I have enjoyed:

1. Masters of the Planet: The Search for Our Human Origins by Ian Tattersall
2. Becoming Human: Evolution and Human Uniqueness by Ian Tattersall
3. The Monkey in the Mirror: Essays on the Science of What Makes Us Human by Ian Tattersall
4. The Consciousness Instinct: Unraveling the Mystery of How the Brain Makes the Mind by Michael S. Gazzaniga
5. Tales from Both Sides of the Brain: A Life in Neuroscience by Michael S. Gazzaniga
6. Human: The Science Behind What Makes Your Brain Unique by Michael S. Gazzaniga
7. The Mind's Past by Michael S. Gazzaniga
8. The Gap: The Science of What Separates Us from Other Animals by Thomas Suddendorf
9. The Recursive Mind: The Origins of Human Language, Thought, and Civilization by Michael C. Corballis

Finally, here are some serious neuroscience books that I have enjoyed:

1. The Prefrontal Cortex, Fifth Edition by Joaquin Fuster
2. Principles of Neural Science by Eric R. Kandel and James H. Schwartz
3. The Case for Mental Imagery (Oxford Psychology Series) by Stephen M. Kosslyn
4. Principles of Brain Evolution by Georg F. Striedter
5. Man the Hunted: Primates, Predators, and Human Evolution by Donna Hart and Robert Wald Sussman