

Neural Mechanisms of Consciousness
PSY 407 Spring 2025

last updated Monday, February 3, 2025



Overview We will review and discuss the leading hypotheses, dramatic controversies, and the latest research into the neural mechanisms of consciousness.

Objectives

- To improve skills and gain confidence in reading, presenting, and critically discussing scientific papers and hypotheses.
- To learn about some of the key concepts, perspectives, theories, and outstanding questions on the neuroscience of consciousness.
- To be able to articulate basic issues in neuroscience of consciousness.

Time and Place Tue/Thur 12:00–1:20 PM;

Instructor Mike Wehr
wehr@uoregon.edu
office hours: by appointment.

Readings All course readings will be posted on Canvas.

Presentations Your presentation date has already been randomly assigned. You are free to swap dates if both parties agree, just send me an email with all parties cc'd after reaching an agreement. Colored rows are joint presentations which could be on the same paper or different papers.

Student	Date of Presentation
	April 9
	April 16
	April 23
	April 30
	April 30
	May 7
	May 7
	May 14
	May 21
	May 28
	June 4

Grading

Presentation	50%
Class participation	50%

Format

This course will follow a seminar format. Each day we will discuss a paper or book. If it's a paper, you should read the paper before class. If it's a book, you should read the summary or book review (which we will post on Canvas) before class. One or two students will present the paper to the rest of the class. This student will also lead a group discussion of the paper (either during or following the formal presentation). Everyone is expected to participate by asking questions both during the presentation and afterwards in the discussion.

Expectations

This material can be challenging. Concepts tend to be slippery, intuitions often differ, and even basic definitions can be vexingly evasive. It is the nature of a seminar like this that student interest makes or breaks the experience. This does not mean that every person must be overly talkative, but rather that every person is expected to be engaged in the discussion, attend regularly, and keep up with the material. The vibe will be informal and based on the premise that none of us have any idea what we're talking about but presumably became neuroscientists in part because of a fascination with this question.

Papers/books:

The list of papers we will discuss is still under construction. Below are some papers and books that might be included.

Shared Paperpile folder with pdfs for many of the papers listed below: <https://paperpile.com/shared/Djpl6F>

Note that the categories below are partially overlapping, and in alphabetical order.

Journal articles

Amting JM, Greening SG, Mitchell DGV (2010) Multiple mechanisms of consciousness: the neural correlates of emotional awareness. *J Neurosci* 30:10039–10047 Available at: <http://dx.doi.org/10.1523/JNEUROSCI.6434-09.2010>.

Babiloni C, Vecchio F, Buffo P, Iacoboni M, Pistoia F, Sacco S, Sara M, Rossini PM (2014) Mechanisms of cortical neural synchronization related to healthy and impaired consciousness: evidence by quantitative electroencephalographic studies. *Curr Pharm Des* 20:4225–4238 Available at: <https://www.ncbi.nlm.nih.gov/pubmed/24025062>.

Bob P (2014) Psychophysiology of dissociated consciousness. *Curr Top Behav Neurosci* 21:3–21 Available at: http://dx.doi.org/10.1007/7854_2014_320.

Bonhomme V, Staquet C, Montupil J, Defresne A, Kirsch M, Martial C, Vanhauzenhuyse A, Chatelle C, Larroque SK, Raimondo F, Demertzi A, Bodart O, Laureys S, Gosseries O (2019) General Anesthesia: A Probe to Explore Consciousness. *Front Syst Neurosci* 13:36 Available at: <http://dx.doi.org/10.3389/fnsys.2019.00036>.

Calvey T, Howells FM (2018) An introduction to psychedelic neuroscience. *Prog Brain Res* 242:1–23 Available at: <http://dx.doi.org/10.1016/bs.pbr.2018.09.013>.

Cleeremans A (2005) Computational correlates of consciousness. *Prog Brain Res* 150:81–98 Available at: [http://dx.doi.org/10.1016/S0079-6123\(05\)50007-4](http://dx.doi.org/10.1016/S0079-6123(05)50007-4).

Crick F, Koch C (1990) Towards a neurobiological theory of consciousness. In: *Seminars in the Neurosciences*, pp 203 Available at: <http://opessoa.fflch.usp.br/sites/opessoa.fflch.usp.br/files/Crick-Koch-1990.pdf>.

Crick F, Koch C (1995) Are we aware of neural activity in primary visual cortex? *Nature* 375:121–123 Available at: <http://dx.doi.org/10.1038/375121a0>.

Crick F, Koch C (1998) Consciousness and neuroscience. *Cereb Cortex* 8:97–107 Available at: <http://dx.doi.org/10.1093/cercor/8.2.97>.

Crick F, Koch C (2003) A framework for consciousness. *Nat Neurosci* 6:119–126 Available at: <http://dx.doi.org/10.1038/nn0203-119>.

Dennett D (2000) Facing backwards on the problem of consciousness. *Explaining Consciousness--The "Hard Problem":33–36* Available at: <https://books.google.com/books?hl=en&lr=&id=t4KNDxsj7fcC&oi=fnd&pg=PA33&dq=daniel+dennett+consciousness&ots=o5cLayk83J&sig=mJRfIrR5g23hNmQ6hNsQ0JVSmgk>.

Dennett D (2001) Are we explaining consciousness yet? *Cognition* 79:221–237 Available at: [http://dx.doi.org/10.1016/s0010-0277\(00\)00130-x](http://dx.doi.org/10.1016/s0010-0277(00)00130-x).

Dennett DC (1995) *Animal Consciousness: What Matters and Why*. *Soc Res* 62:691–710 Available at: <http://www.jstor.org/stable/40971115>.

Dennett DC (1998) The evolution of consciousness. *Consciousness and Emotion in Cognitive Science: Conceptual and Empirical Issues* Taylor & Francis:99–120 Available at: <https://books.google.com/books?hl=en&lr=&id=SGYPEAAAQBAJ&oi=fnd&pg=PT27&dq=great+books+on+consciousness+and+the+brain&ots=pwwQsESgzW&sig=SQcZO-I8COcpKDI-gVPdQoPyaA>.

Dennett DC, Kinsbourne M (1992) Time and the observer: The where and when of consciousness in the brain. *Behav Brain Sci* 15:183–201 Available at: https://www.cambridge.org/core/product/identifier/S0140525X00068229/type/journal_article.

Di Perri C, Stender J, Laureys S, Gosseries O (2014) Functional neuroanatomy of disorders of consciousness. *Epilepsy Behav* 30:28–32 Available at: <http://dx.doi.org/10.1016/j.yebeh.2013.09.014>.

Frith CD (2019) The neural basis of consciousness. *Psychol Med*:1–13 Available at: <http://dx.doi.org/10.1017/S0033291719002204>.

Grossberg S (2017) Towards solving the hard problem of consciousness: The varieties of brain resonances and the conscious experiences that they support. *Neural Netw* 87:38–95 Available at: <http://dx.doi.org/10.1016/j.neunet.2016.11.003>.

Havlík M, Kozáková E, Horáček J (2017) Why and How. The Future of the Central Questions of Consciousness. *Front Psychol* 8:1797 Available at: <http://dx.doi.org/10.3389/fpsyg.2017.01797>.

Hobson JA (2009) REM sleep and dreaming: towards a theory of protoconsciousness. *Nat Rev Neurosci* 10:803–813 Available at: <http://dx.doi.org/10.1038/nrn2716>.

Kelz MB, García PS, Mashour GA, Solt K (2019) Escape From Oblivion: Neural Mechanisms of Emergence From General Anesthesia. *Anesth Analg* 128:726–736 Available at: <http://dx.doi.org/10.1213/ANE.0000000000004006>.

Koch C, Crick F (2001) The zombie within. *Nature* 411:893 Available at: <http://dx.doi.org/10.1038/35082161>.

Koch C, Massimini M, Boly M, Tononi G (2016) Neural correlates of consciousness: progress and problems. *Nat Rev Neurosci* 17:307–321 Available at: <http://dx.doi.org/10.1038/nrn.2016.22>.

Koch C, Tsuchiya N (2007) Attention and consciousness: two distinct brain processes. *Trends Cogn Sci* 11:16–22 Available at: <http://dx.doi.org/10.1016/j.tics.2006.10.012>.

León-Domínguez U, León-Carrión J (2019) Prefrontal neural dynamics in consciousness. *Neuropsychologia* 131:25–41 Available at: <http://dx.doi.org/10.1016/j.neuropsychologia.2019.05.018>.

Maier A, Tsuchiya N (2020) Growing evidence for separate neural mechanisms for attention and consciousness. *Atten Percept Psychophys* Available at: <http://dx.doi.org/10.3758/s13414-020-02146-4>.

Mashour GA, Roelfsema P, Changeux J-P, Dehaene S (2020) Conscious Processing and the Global Neuronal Workspace Hypothesis. *Neuron* 105:776–798 Available at: <http://dx.doi.org/10.1016/j.neuron.2020.01.026>.

Neisser J (2012) Neural correlates of consciousness reconsidered. *Conscious Cogn* 21:681–690 Available at: <http://dx.doi.org/10.1016/j.concog.2011.03.012>.

Northoff G, Lamme V (2020) Neural signs and mechanisms of consciousness: Is there a potential convergence of theories of consciousness in sight? *Neurosci Biobehav Rev* 118:568–587 Available at: <http://dx.doi.org/10.1016/j.neubiorev.2020.07.019>.

Owen M, Guta MP (2019) Physically Sufficient Neural Mechanisms of Consciousness. *Front Syst Neurosci* 13:24 Available at: <http://dx.doi.org/10.3389/fnsys.2019.00024>.

Penfield W (1959) The interpretive cortex; the stream of consciousness in the human brain can be electrically reactivated. *Science* 129:1719–1725 Available at: <http://dx.doi.org/10.1126/science.129.3365.1719>.

Pennartz CMA, Farisco M, Evers K (2019) Indicators and Criteria of Consciousness in Animals and Intelligent Machines: An Inside-Out Approach. *Front Syst Neurosci* 13:25 Available at: <http://dx.doi.org/10.3389/fnsys.2019.00025>.

Peper A (2020) A general theory of consciousness I: Consciousness and adaptation. *Commun Integr Biol* 13:6–21 Available at: <http://dx.doi.org/10.1080/19420889.2020.1713967>.

Perlovsky L (2008) Music and Consciousness. *Leonardo* 41:420–421 Available at: <https://doi.org/10.1162/leon.2008.41.4.420>.

Pinker S (1999) How the mind works. *Ann N Y Acad Sci* 882:119–127; discussion 128–134 Available at: <http://doi.wiley.com/10.1111/j.1749-6632.1999.tb08538.x>.

Pinker S (2007) The mystery of consciousness. *Time* 169:58–62, 65–66, 69–70 Available at: <https://www.ncbi.nlm.nih.gov/pubmed/17283674>.

Ruffini G (2017) An algorithmic information theory of consciousness. *Neurosci Conscious* 2017:nix019 Available at: <http://dx.doi.org/10.1093/nc/nix019>.

Searle JR (1990) Consciousness, explanatory inversion, and cognitive science. *Behav Brain Sci* 13:585–596 Available at: <https://www.cambridge.org/core/journals/behavioral-and-brain-sciences/article/consciousness-explanatory-inversion-and-cognitive-science/76941A89615EB7CA8924E6F2F107C125>.

Storm JF, Boly M, Casali AG, Massimini M, Olcese U, Pennartz CMA, Wilke M (2017) Consciousness Regained: Disentangling Mechanisms, Brain Systems, and Behavioral

Responses. *J Neurosci* 37:10882–10893 Available at: <http://dx.doi.org/10.1523/JNEUROSCI.1838-17.2017>.

Tallon-Baudry C (2011) On the neural mechanisms subserving consciousness and attention. *Front Psychol* 2:397 Available at: <http://dx.doi.org/10.3389/fpsyg.2011.00397>.

Tononi G (2005) Consciousness, information integration, and the brain. *Prog Brain Res* 150:109–126 Available at: [http://dx.doi.org/10.1016/S0079-6123\(05\)50009-8](http://dx.doi.org/10.1016/S0079-6123(05)50009-8).

Tononi G, Koch C (2008) The neural correlates of consciousness: an update. *Ann N Y Acad Sci* 1124:239–261 Available at: <http://dx.doi.org/10.1196/annals.1440.004>.

Touskova T, Bob P (2015) Consciousness, awareness of insight and neural mechanisms of schizophrenia. *Rev Neurosci* 26:295–304 Available at: <http://dx.doi.org/10.1515/revneuro-2014-0063>.

Zeki S (2008) The disunity of consciousness. *Prog Brain Res* 168:11–18 Available at: [http://dx.doi.org/10.1016/S0079-6123\(07\)68002-9](http://dx.doi.org/10.1016/S0079-6123(07)68002-9).

Review articles

Babiloni C, Vecchio F, Buffo P, Iacoboni M, Pistoia F, Sacco S, Sara M, Rossini PM (2014) Mechanisms of cortical neural synchronization related to healthy and impaired consciousness: evidence by quantitative electroencephalographic studies. *Curr Pharm Des* 20:4225–4238 Available at: <https://www.ncbi.nlm.nih.gov/pubmed/24025062>.

Calvey T, Howells FM (2018) An introduction to psychedelic neuroscience. *Prog Brain Res* 242:1–23 Available at: <http://dx.doi.org/10.1016/bs.pbr.2018.09.013>.

Cleeremans A (2005) Computational correlates of consciousness. *Prog Brain Res* 150:81–98 Available at: [http://dx.doi.org/10.1016/S0079-6123\(05\)50007-4](http://dx.doi.org/10.1016/S0079-6123(05)50007-4).

Crick F, Koch C (1998) Consciousness and neuroscience. *Cereb Cortex* 8:97–107 Available at: <http://dx.doi.org/10.1093/cercor/8.2.97>.

Crick F, Koch C (2003) A framework for consciousness. *Nat Neurosci* 6:119–126 Available at: <http://dx.doi.org/10.1038/nn0203-119>.

Di Perri C, Stender J, Laureys S, Gosseries O (2014) Functional neuroanatomy of disorders of consciousness. *Epilepsy Behav* 30:28–32 Available at: <http://dx.doi.org/10.1016/j.yebeh.2013.09.014>.

Grossberg S (2017) Towards solving the hard problem of consciousness: The varieties of brain resonances and the conscious experiences that they support. *Neural Netw* 87:38–95 Available at: <http://dx.doi.org/10.1016/j.neunet.2016.11.003>.

Havlík M, Kozáková E, Horáček J (2017) Why and How. The Future of the Central Questions of Consciousness. *Front Psychol* 8:1797 Available at: <http://dx.doi.org/10.3389/fpsyg.2017.01797>.

Hobson JA (2009) REM sleep and dreaming: towards a theory of protoconsciousness. *Nat Rev Neurosci* 10:803–813 Available at: <http://dx.doi.org/10.1038/nrn2716>.

Kelz MB, García PS, Mashour GA, Solt K (2019) Escape From Oblivion: Neural Mechanisms of Emergence From General Anesthesia. *Anesth Analg* 128:726–736 Available at: <http://dx.doi.org/10.1213/ANE.0000000000004006>.

Koch C, Massimini M, Boly M, Tononi G (2016) Neural correlates of consciousness: progress and problems. *Nat Rev Neurosci* 17:307–321 Available at: <http://dx.doi.org/10.1038/nrn.2016.22>.

Koch C, Tsuchiya N (2007) Attention and consciousness: two distinct brain processes. *Trends Cogn Sci* 11:16–22 Available at: <http://dx.doi.org/10.1016/j.tics.2006.10.012>.

León-Domínguez U, León-Carrión J (2019) Prefrontal neural dynamics in consciousness. *Neuropsychologia* 131:25–41 Available at: <http://dx.doi.org/10.1016/j.neuropsychologia.2019.05.018>.

Mashour GA, Roelfsema P, Changeux J-P, Dehaene S (2020) Conscious Processing and the Global Neuronal Workspace Hypothesis. *Neuron* 105:776–798 Available at: <http://dx.doi.org/10.1016/j.neuron.2020.01.026>.

Northoff G, Lamme V (2020) Neural signs and mechanisms of consciousness: Is there a potential convergence of theories of consciousness in sight? *Neurosci Biobehav Rev* 118:568–587 Available at: <http://dx.doi.org/10.1016/j.neubiorev.2020.07.019>.

Storm JF, Boly M, Casali AG, Massimini M, Olcese U, Pennartz CMA, Wilke M (2017) Consciousness Regained: Disentangling Mechanisms, Brain Systems, and Behavioral Responses. *J Neurosci* 37:10882–10893 Available at: <http://dx.doi.org/10.1523/JNEUROSCI.1838-17.2017>.

Tononi G (2005) Consciousness, information integration, and the brain. *Prog Brain Res* 150:109–126 Available at: [http://dx.doi.org/10.1016/S0079-6123\(05\)50009-8](http://dx.doi.org/10.1016/S0079-6123(05)50009-8).

Tononi G, Koch C (2008) The neural correlates of consciousness: an update. *Ann N Y Acad Sci* 1124:239–261 Available at: <http://dx.doi.org/10.1196/annals.1440.004>.

Touskova T, Bob P (2015) Consciousness, awareness of insight and neural mechanisms of schizophrenia. *Rev Neurosci* 26:295–304 Available at: <http://dx.doi.org/10.1515/revneuro-2014-0063>.

Zeki S (2008) The disunity of consciousness. Prog Brain Res 168:11–18 Available at: [http://dx.doi.org/10.1016/S0079-6123\(07\)68002-9](http://dx.doi.org/10.1016/S0079-6123(07)68002-9).

Books

Blackmore S (2013) Consciousness: An Introduction. Routledge. Available at: <https://play.google.com/store/books/details?id=WycuAgAAQBAJ>.

Blackmore S (2017) Consciousness: A Very Short Introduction. Oxford University Press. Available at: <https://play.google.com/store/books/details?id=JKY5DwAAQBAJ>.

Dehaene S (2014) Consciousness and the Brain: Deciphering How the Brain Codes Our Thoughts. Penguin. Available at: <https://play.google.com/store/books/details?id=CWw2AAAAQBAJ>.

Dennett DC (1993) Consciousness explained. Penguin uk. Available at: <http://www.nhoj.info/library/Dennett%20-%20Consciousness%20Explained.pdf>.

Dennett DC (2008) Kinds Of Minds: Toward An Understanding Of Consciousness. Basic Books. Available at: <https://play.google.com/store/books/details?id=nrtchsJKQeAC>.

Dennett DC (2010) Content and Consciousness. Routledge. Available at: <https://play.google.com/store/books/details?id=2lMuCgAAQBAJ>.

Gardner S (2009) Sartre's "Being and Nothingness": A Reader's Guide. Bloomsbury Publishing. Available at: <https://play.google.com/store/books/details?id=RAcdCgAAQBAJ>.

Koch C (2004) The Quest for Consciousness: A Neurobiological Approach. Roberts and Company. Available at: <https://play.google.com/store/books/details?id=7L9qAAAAMAAJ>.

Koch C (2017) Consciousness: Confessions of a Romantic Reductionist. MIT Press. Available at: <https://play.google.com/store/books/details?id=GFT5DwAAQBAJ>.

Koch C (2020) The Feeling of Life Itself: Why Consciousness Is Widespread But Can't Be Computed. MIT Press. Available at: <https://play.google.com/store/books/details?id=Mr74DwAAQBAJ>.

Penfield W (2015) Mystery of the Mind: A Critical Study of Consciousness and the Human Brain. Princeton University Press. Available at: <https://play.google.com/store/books/details?id=-mx9BgAAQBAJ>.

Searle JR, Dennett DC, Chalmers DJ (1997) The Mystery of Consciousness. New York Review of Books. Available at: <https://play.google.com/store/books/details?id=ZqsytrHg8LkC>.

Animal consciousness

Blackmore S (2013) *Consciousness: An Introduction*. Routledge. Available at: <https://play.google.com/store/books/details?id=WycuAgAAQBAJ>.

Calvey T, Howells FM (2018) An introduction to psychedelic neuroscience. *Prog Brain Res* 242:1–23 Available at: <http://dx.doi.org/10.1016/bs.pbr.2018.09.013>.

Dehaene S (2014) *Consciousness and the Brain: Deciphering How the Brain Codes Our Thoughts*. Penguin. Available at: <https://play.google.com/store/books/details?id=CWw2AAAAQBAJ>.

Dennett DC (1995) Animal Consciousness: What Matters and Why. *Soc Res* 62:691–710 Available at: <http://www.jstor.org/stable/40971115>.

Dennett DC (2008) *Kinds Of Minds: Toward An Understanding Of Consciousness*. Basic Books. Available at: <https://play.google.com/store/books/details?id=nrtchsJKQeAC>.

Frith CD (2019) The neural basis of consciousness. *Psychol Med*:1–13 Available at: <http://dx.doi.org/10.1017/S0033291719002204>.

Koch C (2004) *The Quest for Consciousness: A Neurobiological Approach*. Roberts and Company. Available at: <https://play.google.com/store/books/details?id=7L9qAAAAMAAJ>.

Koch C (2020) *The Feeling of Life Itself: Why Consciousness Is Widespread But Can't Be Computed*. MIT Press. Available at: <https://play.google.com/store/books/details?id=Mr74DwAAQBAJ>.

Pennartz CMA, Farisco M, Evers K (2019) Indicators and Criteria of Consciousness in Animals and Intelligent Machines: An Inside-Out Approach. *Front Syst Neurosci* 13:25 Available at: <http://dx.doi.org/10.3389/fnsys.2019.00025>.

Peper A (2020) A general theory of consciousness I: Consciousness and adaptation. *Commun Integr Biol* 13:6–21 Available at: <http://dx.doi.org/10.1080/19420889.2020.1713967>.

Storm JF, Boly M, Casali AG, Massimini M, Olcese U, Pennartz CMA, Wilke M (2017) Consciousness Regained: Disentangling Mechanisms, Brain Systems, and Behavioral Responses. *J Neurosci* 37:10882–10893 Available at: <http://dx.doi.org/10.1523/JNEUROSCI.1838-17.2017>.

Tononi G (2005) Consciousness, information integration, and the brain. *Prog Brain Res* 150:109–126 Available at: [http://dx.doi.org/10.1016/S0079-6123\(05\)50009-8](http://dx.doi.org/10.1016/S0079-6123(05)50009-8).

Anesthesia and coma

Bonhomme V, Staquet C, Montupil J, Defresne A, Kirsch M, Martial C, Vanhaudenhuyse A, Chatelle C, Larroque SK, Raimondo F, Demertzi A, Bodart O, Laureys S, Gosseries O (2019) General Anesthesia: A Probe to Explore Consciousness. *Front Syst Neurosci* 13:36 Available at: <http://dx.doi.org/10.3389/fnsys.2019.00036>.

Di Perri C, Stender J, Laureys S, Gosseries O (2014) Functional neuroanatomy of disorders of consciousness. *Epilepsy Behav* 30:28–32 Available at: <http://dx.doi.org/10.1016/j.yebeh.2013.09.014>.

Frith CD (2019) The neural basis of consciousness. *Psychol Med*:1–13 Available at: <http://dx.doi.org/10.1017/S0033291719002204>.

Kelz MB, García PS, Mashour GA, Solt K (2019) Escape From Oblivion: Neural Mechanisms of Emergence From General Anesthesia. *Anesth Analg* 128:726–736 Available at: <http://dx.doi.org/10.1213/ANE.0000000000004006>.

Mashour GA, Roelfsema P, Changeux J-P, Dehaene S (2020) Conscious Processing and the Global Neuronal Workspace Hypothesis. *Neuron* 105:776–798 Available at: <http://dx.doi.org/10.1016/j.neuron.2020.01.026>.

Pennartz CMA, Farisco M, Evers K (2019) Indicators and Criteria of Consciousness in Animals and Intelligent Machines: An Inside-Out Approach. *Front Syst Neurosci* 13:25 Available at: <http://dx.doi.org/10.3389/fnsys.2019.00025>.

Tononi G, Koch C (2008) The neural correlates of consciousness: an update. *Ann N Y Acad Sci* 1124:239–261 Available at: <http://dx.doi.org/10.1196/annals.1440.004>.