

# Neural Mechanisms of Consciousness

## PSY 607 Spring 2021

*last updated Monday, February 22, 2021*



**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** Fridays 2:00–3:00 PM; <https://uoregon.zoom.us/j/9040862467>

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

**Readings** All course readings will be posted on Canvas.

### 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.

It's fine with me if you want to drop in to participate in the discussion without registering for the course. However, if not enough students register for the course it will get cancelled. So if you're planning to come anyway please register.

### **Papers/books:**

The papers or books will be selected by the students. Below is a list of great papers and books to choose from. But you don't need to pick something from this list — you can choose a different paper or book as long as it's directly related to the neural mechanisms of consciousness. If you choose a paper or book that's not on this list, please let me now well in advance so I can post it for the class.

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](http://dx.doi.org/10.1007/7854_2014_320).

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>.

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=mJRfIrR5g23hNm6hNsQ0JVSmgk>.

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](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>.

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

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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>.

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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>.

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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>.

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

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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>.

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## **Anesthesia and coma**

Bonhomme V, Staquet C, Montupil J, Defresne A, Kirsch M, Martial C, Vanhauzenhuysse 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>.

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