

UNIVERSITY OF SUSSEX
SCHOOL OF PSYCHOLOGY

Neuroscience of Consciousness

Masters (level 7): Code 993C8

15 Credits

Spring term 2017

Course Convenor: Prof. Anil Seth

Most of the questions you need answers to about this course are in this document. Please read it fully and carefully before your first lecture/seminar.

This document concerns the structure and content of the course. If you have questions about procedures, please consult the School of Psychology Administration Office in Pev1 2A13 or via psychology@sussex.ac.uk.

COURSE INFORMATION & REQUIREMENTS

Course Structure, Aims and Objectives

Consciousness is one of the last remaining frontiers of scientific exploration, and theories and methods in neuroscience are at the frontline of this endeavour. This course aims to give a thorough background in the current state-of-the-art in consciousness science, with an emphasis on the perspective from cognitive neuroscience. Topics covered include: measuring and studying consciousness; states of consciousness (including waking, dreaming, hypnosis and the vegetative state); visual consciousness (including the different roles of visual cortex and the frontoparietal network, and blindsight and neglect as disorders of visual awareness); implicit learning and metacognition; psychiatric disturbances of consciousness (e.g., hallucinations, depersonalization); interoceptive awareness and emotion; consciousness and cortical plasticity (including synaesthesia, phantom limbs and sensory substitution); computational models of consciousness; biological models of consciousness, and evolutionary approaches to consciousness.

Course Learning Outcomes

By the end of the course, a successful student should be able to:	
1	Evaluate the pros and cons of the main current approaches in consciousness science.
2	Describe how the methods of cognitive neuroscience can be used to study conscious experience and its underlying mechanisms
3	Discuss the main neuroscientific theories in consciousness science
4	Understand how consciousness science can shed light on psychiatric and neurological disorders such as vegetative state and schizophrenia

Pre-Requisites

None

Course Contact Information

Convenor: **Professor Anil Seth**
 Location: Chichester 1, 106 (Informatics and Engineering)
 Telephone: 01273 678549
 E-mail: a.k.seth@sussex.ac.uk
 Web: www.anilseth.com, www.sussex.ac.uk/sackler
 Course web: see Study Direct.

Teaching and Learning

The syllabus and timetable details for the course are available via Sussex Direct.

Lectures/Seminars

There will be 11 lecture sessions, each 2 hours long (with a short break). Most weeks there will also be seminar sessions where the week's topic will be discussed in more detail. There are key papers (see below) to read **in advance** of each seminar. Where possible, a 'Scholarpedia' (www.scholarpedia.org) article (or other web resource) is also given for each sessionⁱ. Online resources and suggested books are listed below. The course will be delivered by multiple lecturers, each presenting on their own particular area of expertise. Please note that the details and ordering of each session are subject to alteration before and during the course.

For the seminar sessions you are expected to prepare discussion questions in advance. In particular, **you are expected to prepare a single 'best' question and post it to the forum on study direct**. These questions will be used to frame the discussion.

To avoid disruption to the majority, please try to arrive at least 5 minutes before the start time of the lecture.

I'm sure you're aware that all the study skills advice in existence suggests that straightforward 'absorption' of material (i.e., reading, listening, rote-learning and memorising) should take up about 20% of learning time. The other 80% should come from 'interrogating' that information (e.g., looking for links, attempting to summarise and synthesise, looking for strengths and weaknesses and possible improvements, applying to different areas, etc.).

Student Feedback Sessions

Your course convenor (Anil Seth) will hold an 'office hour / feedback clinic' each **Monday 2pm-3pm** during teaching weeks. Students may use this time (without appointment) to discuss or ask about anything course-related. You may also send messages about the course via email to Anil (always include 993C8 in the subject line) or by using the Study Direct forum (see below).

Study Direct

You will be accessing course materials and using the course forum in Study Direct. This is the best way to share ideas amongst your fellow students and ask questions about the course. In general, course convenors and tutors would prefer to receive queries via the Study Direct course forum than by email. For this course there will be a dedicated 'forum' for each lecture/seminar session, encouraging further discussion between the students and the lecturer/convenor.

ⁱ *Scholarpedia* is an online resource modeled on *Wikipedia* but incorporating formal 'peer review'. Unlike *Wikipedia* articles, *Scholarpedia* articles are citeable in academic papers (and in MSc term papers!).

Books and Reading

There are no specific textbooks for this course. Consciousness Science is an emerging multidisciplinary subject, and while much has been written about it, there is not yet any consensus on a 'standard text' in the field. Having said this, the following books provide very useful background (in alphabetical order).

30 Second Brain

Anil K. Seth (Ed) Ivy Press, 2014

A simple but highly accessible treatment of key questions in neuroscience, with quite a bias towards consciousness. Stuff you may know already, but still maybe worth a look. Most chapters written by Sackler Centre & Sussex researchers.

Cognition, Brain, and Consciousness

Bernard Baars

Academic Press, 2010 (2nd edition)

A cognitive neuroscience textbook but one with an emphasis on consciousness, as befits one of the pioneers in the field.

Consciousness and the Brain

Stanislas Dehaene

Viking, 2014

An excellent survey of the frontiers of consciousness science, from one of the pioneers of the field. The book emphasizes cognitive neuroscience approaches to consciousness science, and strongly advocates versions of 'global workspace' theory.

Consciousness: An Introduction

Susan Blackmore

Hodder Education, 2010

A basic introductory text, readable but doesn't go very deep.

Consciousness: A user's guide

Adam Zeman

Yale University Press, 2004

An accessible 'grand tour' of consciousness, emphasizing both philosophical and neurological aspects. Leavened with some fascinating case studies.

Consciousness: Confessions of a Romantic Reductionist

Christof Koch

MIT Press, 2012

A fascinating and surprisingly autobiographical account from one of the pioneers in the field.

Consciousness: Philosophical, Psychological, and Neural theories

David Rose

Oxford University Press, 2006

A very clear summary of current perspectives in consciousness science, covers quite a lot of ground and covers it well.

(The) Ego Tunnel

Thomas Metzinger
Basic Books 2010

An excellent and highly readable precis of Metzinger's ideas on consciousness, especially those about the existence (or nonexistence) of the 'self'. According to Metzinger, everything we experience is a 'virtual self in a virtual reality'.

Hallucinations

Oliver Sacks
Picador, 2012

One of his last and best books. Some wonderfully evocative descriptions of various kinds of disturbances of consciousness. Oliver Sacks died in 2015 and is deeply missed.

(The) Man Who Wasn't There

Anil Ananthaswamy
Penguin, 2015

An insightful exploration of self-consciousness through the various ways it can go wrong. Combines the relevant neuroscience with a personal touch as the author meets people with various strange conditions.

Phi: A Voyage from the Brain to the Soul

Giulio Tononi
Pantheon, 2012

A recent account of what is currently the most influential theory of consciousness: integrated information theory, told in a lyrical fashion. Make of it what you will.

(The) Predictive Mind

Jakob Hohwy
Oxford University Press, 2013

An excellent and readable summary of the new and powerful theory of 'predictive processing' which provides an excellent framework in which to think about consciousness science. On this theory, our experience is the brain's best guess of the causes of its sensory input.

(The) Ravenous Brain: How the New Science of Consciousness Explains our Insatiable Search for Meaning

Daniel Bor
Basic Books, 2012

A fairly recent account of the new science of consciousness, by Dan Bor, a research fellow (now visiting) at the Sackler Centre.

Waking, Dreaming, Being: Self and Consciousness in Neuroscience, Meditation, and Philosophy

Evan Thompson
Cambridge University Press, 2014

A deep and highly interesting exploration of how Eastern traditions of meditation and philosophy can join with neuroscience to inform a new 'science of the mind'. Thompson is a pioneer in the 'enactive' tradition linking mindfulness and meditation to modern currents in cognitive science and neuroscience.

Assessment

Formal assessment for *Neuroscience of Consciousness* comprises an essay (80%) and an essay (paper précis) (20%).

The précis (max 1000 words excluding references) is a summary of a current research paper – selected from a range of options, which will be made available. A good précis will summarize and contextualize the main findings, and point out implications and limitations. Essays should be a maximum of 3000 words *excluding references*. A list of suggested essay topics will be made available; students are also welcome to choose their own title (in which case they should check it with the convenor). *A good essay will integrate content from more than one teaching session.*

The assessment criteria for assessed essays and précises will be made available on the Study Direct course site.

Following submission, you will receive qualitative feedback in addition to your grade. The qualitative feedback will be available online usually within 15 working days. The grade will be available for you to view on your Sussex Direct site within 15 working days.

Assessment information

Assessments deadlines and methods of submission can be found on your assessment timetable via Sussex Direct.

Information on the following can be found at the link below:

- Submitting your work
- Missing a deadline
- Late penalties
- Exceptional circumstances
- Exams
- Help with managing your studies and competing your work
- Assessment Criteria

<http://www.sussex.ac.uk/psychology/internal/students/examinationsandassessment>

E-submission

From 2016/17, Masters and MRes students taking PG year modules will usually be asked to submit assessments electronically where assessments are text-based, for example, an essay. Your Sussex Direct - Assessment Deadlines & Exam Timetable will give all assessment details, including whether the assessment is to be submitted via e-submission through Sussex Direct or via a different method. Feedback for all e-submission assessments will also be provided electronically.

Please refer to the frequently asked questions available on the following webpage for further information:

<http://www.sussex.ac.uk/tel/submission/students/esubmission>
<http://www.sussex.ac.uk/tel/submission/students/faqs>
www.sussex.ac.uk/adqe/standards/examsandassessment/esubmission

Attendance, Absence and Engagement

You are expected to be 'in attendance' at the University for the full duration of the published term dates for your course of study. That means you should be regularly attending lectures, seminars, labs etc. and committing time to your studies to be in a position to comply with academic and administrative expectations.

The university has an 80% attendance policy in place, so it's really important that you let us know if you are ill or cannot attend classes so that we can register this as a notified absence.

If you are unable to attend your seminars or workshops, you need to send an email to psychologyabsence@sussex.ac.uk setting out the following information:

- Seminar(s) / workshop(s) that you will be absent from (list all of them)
- Tutor name
- Brief reason for absence

Please see the following link for further information:

<http://www.sussex.ac.uk/psychology/internal/students/attendance>

Student Evaluation

The module convenor will create opportunities for you to provide feedback (online, on paper, and/or in person) on your experience of the module during the term. In addition, you will be asked to complete an online course evaluation questionnaire at the end of every term, and this will provide an opportunity for you to comment on each module as well as the course overall.

Lecture Overview

LECTURE 1

Introduction to consciousness science

Prof. Anil Seth

This introductory lecture will give a brief historical background to consciousness science, followed by a summary of 'where we are', highlighting key concepts, controversies, challenges, and approaches to unravelling the neural mechanisms underlying conscious experience. We will focus on (i) the contrastive approach, comparing conscious and unconscious conditions (content and level), and (ii) the importance of measurement, and of moving from correlation towards explanation in connecting the phenomenology of consciousness to its neural mechanisms.

Essential Reading

- Dehaene, S. and Changeux, J.-P. (2011). "Experimental and theoretical approaches to conscious processing." Neuron **70**(2):200-227
- Seth, A.K. (2016). The real problem. Aeon (published November 2, 2016).

Recommended Reading

- Aru, J., et al. (2012). "Distilling the neural correlates of consciousness." Neurosci Biobehav Review **36**(2): 737-46.
- Bayne, T., Hohwy, J., and Owen, A.M. (2016). "Are there levels of consciousness?" Trends Cogn Sci **20**(6):405-13.
- Boly, M., Seth, A.K., et al. (2013). "Consciousness in humans and non-human animals: Recent advances and future directions." Frontiers in Psychology **4**: 625.
- Koch, C., et al. (2016). "Neural correlates of consciousness: progress and problems". Nature Reviews Neuroscience **17**(5):307-21
- Seth, A. K. (in press). The fall and rise of consciousness science. In *The Return of Consciousness* (ed., A. Haag).

Web resource

<https://aeon.co/essays/the-hard-problem-of-consciousness-is-a-distraction-from-the-real-one>

LECTURE 2**States of consciousness**

Prof. Anil Seth

This lecture will describe the various states of consciousness, both normal (waking, sleeping, dreaming, daydreaming) and abnormal (e.g., epilepsy, coma, vegetative and minimally conscious states, anaesthesia, hypnosis, somnambulism, etc.). What do they have in common? How do they differ? We will explore what analysis of these conditions can tell us about the neural mechanisms underpinning normal consciousness in humans. We will also ask how understanding more about the neuroscience of consciousness can help diagnose and perhaps even treat severe brain injuries leading to coma, vegetative state, etc.

Essential Reading

- Casali, A.G. et al. (2013). "A theoretically based index of consciousness independent of sensory processing and behavior." Sci Trans Med **14**(5): 198.
- Owen, A. M., N. D. Schiff, et al. (2009). "A new era of coma and consciousness science." Prog Brain Res **177**: 399-411.

Recommended Reading

- Alkire, M. T., A. G. Hudetz, et al. (2008). "Consciousness and anesthesia." Science **322**(5903): 876-880.
- Massimini, M., F. Ferrarelli, et al. (2005). "Breakdown of cortical effective connectivity during sleep." Science **309**(5744): 2228-2232
- Monti, M. M., A. Vanhaudenhuyse, et al. (2010). "Willful modulation of brain activity in disorders of consciousness." N Engl J Med **362**(7): 579-589.
- Naci, L., Sinai, J., and Owen, A.M. (2017). "Detecting and interpreting conscious experiences in behaviourally non responsive patients". Neuroimage **145**:304-313
- Nir, Y. and G. Tononi (2010). "Dreaming and the brain: from phenomenology to neurophysiology." Trends Cogn Sci **14**(2): 88-100.
- Oakley, D. A. and P. W. Halligan (2009). "Hypnotic suggestion and cognitive neuroscience." Trends Cogn Sci **13**(6): 264-270.

Scholarpedia

[http://www.scholarpedia.org/article/Vegetative state](http://www.scholarpedia.org/article/Vegetative_state)

LECTURE 3**Visual consciousness**

Dr. Daniel Bor

Some philosophers argue that visual consciousness is a non-physical process and therefore is independent of the brain. This lecture will show both how such arguments are flawed and the extent of progress neuroscientists are making to explain how the brain supports our ability to see. Whereas the previous lecture centred on different *levels* of consciousness, this lecture will use vision to explore how different *contents* of consciousness arise. We will focus on biological markers of conscious contents using neuroimaging and single unit recording techniques, which have been cleverly combined with quirks of the perceptual system (e.g. binocular rivalry and visual illusions) in normal humans and other primates. We will also examine fascinating neurological patient groups (e.g. blindsight and neglect), which shed further light on how the brain generates conscious vision. The relative role of different parts of the visual system and the fronto-parietal network in supporting consciousness will be covered. Finally, the relationship between visual awareness and attention will be discussed.

Essential Reading

- Bor, D. and Seth, A.K. (2012) "Consciousness and the prefrontal parietal network: Insights from attention, working memory and chunking." Frontiers in Psychology. **3**:63
- Dehaene, S. and Changeux, J.-P. (2011). "Experimental and theoretical approaches to conscious processing." Neuron **70**(2):200-227 [re-read the 'contents' parts]
- Rees, G. (2007). "Neural correlates of the contents of visual awareness in humans." Philos Trans R Soc Lond B Biol Sci **362**(1481): 877-86.

Recommended Reading

- Brascamp, J., Blake, R. and Knapen, T., (2015). "Negligible fronto-parietal BOLD activity accompanying unreportable switches in bistable perception." Nature neuroscience. **18**:1672-1678.
- Cohen, M. A., G. A. Alvarez and K. Nakayama (2011). "Natural-scene perception requires attention." Psychol Sci **22**(9): 1165-72.
- Ffytche, D. H. and S. Zeki (2011). "The primary visual cortex, and feedback to it, are not necessary for conscious vision." Brain **134**(Pt 1): 247-57
- Fleming, S. M., R. S. Weil, et al. (2010). "Relating introspective accuracy to individual differences in brain structure." Science **329**(5998): 1541-3.
- Kanai, R., B. Bahrami and G. Rees (2010). "Human parietal cortex structure predicts individual differences in perceptual rivalry." Current Biology **20**(18):1626-1630.
- King, J.-R., Pescetelli, N., and S. Dehaene (2016). "Brain mechanisms underlying the brief maintenance of seen and unseen sensory information" Neuron **92**:1122-1134.
- Overgaard, M., K. Feh, K et al. (2008). "Seeing without seeing? Degraded conscious vision in a blindsight patient." PLoS One **3**(8): e3028.
- van Boxtel, J. J. A., N. Tsuchiya and C. Koch (2010). "Consciousness and attention: On sufficiency and necessity." Frontiers in Psychology **2**:12.

Scholarpedia <http://www.scholarpedia.org/article/Blindsight>

LECTURE 4**Implicit perception and implicit learning**

Dr. Ryan Scott

This lecture will examine the topic of implicit learning and unconscious knowledge. We will discuss the everyday experience of implicit learning and the challenges and potential benefits of its experimental investigation. Methods for studying subliminal perception will be outlined and the key experimental paradigms used in studying implicit learning will be described. Different approaches to assessing the conscious status of knowledge will be examined, and the potential bases for implicit knowledge explored. Finally, we will turn to the properties of implicit knowledge and the apparent limits of implicit learning - what can and can't be learnt implicitly – and will discuss how this may have implications for (explicit) consciousness.

Essential Reading

- Dienes, Z. (2012). "Conscious versus unconscious learning of structure." In P. Rebuschat & J. Williams (Eds), *Statistical learning and language acquisition*. Mouton de Gruyter Publishers (pp. 337 - 364).
- Kouider, S., & Dehaene, S. (2007). "Levels of processing during non-conscious perception: A critical review of visual masking." *Philosophical Transactions of the Royal Society B: Biological Sciences*, **362**, 857–875.

Recommended Reading

- Dienes, Z. (2008). "Subjective measures of unconscious knowledge." *Progress in Brain Research* **168**: 49-64.
- Kouider, S. V. de Gardelle, et al. (2010). "How rich is consciousness? The partial awareness hypothesis." *Trends Cogn Sci* **14**(7): 301-307.
- Newell, B. R., and Shanks, D.R. (2014) "Unconscious influences on decision making: A critical review". *Behavioral and Brain Sciences*, **37**(1).
- Reber, P.,J. (2013) "The neural basis of implicit learning and memory: A review of neuropsychological and neuroimaging research". *Neuropsychologia*, **51**: 2026 - 2042.
- Scott, R. B. and Z. Dienes (2008). "The conscious, the unconscious, and familiarity." *Journal of experimental psychology: Learning, memory, and cognition* **34**(5): 1264-1288.
- Sterzer, P. et al. (2014) "Neural processing of visual information under interocular suppression: a critical review." *Front. Psychol.* **5**:453

Scholarpedia

http://www.scholarpedia.org/article/Implicit_learning

LECTURE 5**Theories and models of consciousness**

Prof. Anil Seth

This lecture will address the challenge of coming up with a neurobiological theory of consciousness. How can we explain why certain neural areas and/or neural dynamics are associated with consciousness (both level and content), whereas others are not? It can be argued that a good theory is both most lacking and most needed in consciousness science, both in order to drive new experiments and interpret existing data. We will discuss a range of theories, from Bernard Baars' 'global workspace', Dehaene's 'neuronal workspace', and Lamme's 'neural stance on consciousness' to Edelman's 'neural Darwinism' and Tononi's 'information integration theory of consciousness'. We will also discuss relevant experimental evidence, e.g. data linking neuronal synchrony to consciousness. (And we'll see, along the way, that so-called 'quantum theories' are probably unnecessary at this point.)

Essential Reading

- Dehaene and Changeux (2011). "Experimental and theoretical approaches to conscious processing." Neuron **70**(2):200-227. [worth reading the theory bits again]
- Tononi, G. et al. (2016). "Integrated information theory: from consciousness to its physical substrate". Nature Reviews Neuroscience **17**(7):450-61.

Recommended Reading

- Baars, B. et al (2013). "Global workspace dynamics: cortical 'binding and propagation' enables conscious contents". Frontiers in Psychology **4**:200
- Edelman, G. M. (2003). "Naturalizing consciousness: a theoretical framework." Proc Natl Acad Sci U S A **100**(9): 5520-5524.
- Gaillard, R., S. Dehaene, et al. (2009). "Converging intracranial markers of conscious access." PLoS Biol **7**(3): e61.
- Lau, H., & Rosenthal, D. (2011) "Empirical support for higher-order theories of conscious awareness". Trends in Cognitive Sciences **15**(8):365-73.
- Sasai S, Boly M, Mensen A, Tononi G (2016). "Functional split brain in a driving/listening paradigm". Proc Natl Acad Sci U S A. **113**(50):14444-14449
- Seth, A. K. (2009). "Explanatory correlates of consciousness: Theoretical and computational challenges." Cognitive Computation **1**(1): 50-63.

Web resource

<http://integratedinformationtheory.org/>

LECTURE 6**Consciousness and cortical plasticity**

Prof. Jamie Ward

The functional specialisations of different cortical regions are relatively fixed. This is often considered to be particularly true of sensory and motor regions of the brain because their functions are 'anchored' by their peripheral inputs (e.g. from the sense organs) and outputs. However, there are important exceptions to this general trend that have significant implications for our understanding of consciousness. For example, it is possible to redirect visual inputs (from the eyes) to the auditory cortex of animals. To give another example, in blind humans the 'visual' cortex is used for hearing and touch. In these 'rewired' brains, does the conscious experience reside with the brain region (e.g. the visual region gives rise to visual experiences whatever its input) or reside with the function (e.g. the visual region will give rise to auditory experiences if it carries out auditory functions)? The philosophers Hurley and Noe (2003) refer to these two positions as cortical dominance and cortical deference respectively, and there appears to be examples of both in the literature. For example, synaesthesia and referred phantom limb sensations appear to be examples of cortical dominance (e.g. the colour region gives rise to colour experiences even if they are elicited by sounds). Sensory-substitution devices may be an example of cortical deference. The issue of how these two different accounts can both be true (depending on the circumstances) will be discussed in the seminar.

Essential Reading

- Gray, J. (2003). "How are qualia coupled to functions?" *Trends Cogn Sci* **7**(5): 192-194.
- Noe, A. and S. Hurley (2003). "The deferential brain in action: Response to Jeffrey Gray." *Trends Cogn Sci* **7**(5): 195-196.

Recommended Reading

- Ramachandran, V. S. and W. Hirstein (1998). "The perception of phantom limbs. The D. O. Hebb lecture." *Brain* **121** (Pt 9): 1603-1630.
- Ward, J. and P. Meijer (2010). "Visual experiences in the blind induced by an auditory sensory substitution device." *Conscious Cogn* **19**(1): 492-500.

Scholarpedia

<http://www.scholarpedia.org/article/Synaesthesia>

LECTURE 7**Consciousness and the predictive brain**

Prof. Anil Seth

A new theory is taking hold in neuroscience. It is the theory that the brain is essentially a hypothesis-testing mechanism, which is continuously trying to minimize the discrepancy (or 'prediction error' between its sensory inputs and its own emerging models of the causes of these inputs. Put simply, the idea is that our conscious perceptions are just the brain's 'best guess' of the causes of its sensory signals: a fantasy that (sometimes) coincides with reality. The theory has deep roots, going back (at least) to Helmholtz's notion of perception as 'unconscious inference' and taking in Richard Gregory's idea of perceptual 'hypothesis-testing' on the way. Today, concepts like the Bayesian brain and the 'free energy principle' are increasingly dominant within neuroscience and cognitive science. This lecture will introduce these basic and powerful ideas and explore what they can tell us about the brain basis of consciousness.

Essential Reading

- Clark, A (2013). "Whatever next? Predictive brains, situated agents, and the future of cognitive science." Behavioural and Brain Sciences **36**(3):181-204 [read at least the first few sections]
- Melloni, L. et al. (2011). "Expectations change the signatures and timing of electrophysiological correlates of perceptual awareness." Journal of Neuroscience, **31**(4): 1386-96.

Recommended Reading

- Clark, A. (2016). "Surfing Uncertainty". Oxford University Press
- Hohwy, J. (2013) "The Predictive Mind". Oxford University Press
- Muckli, L. et al (2014). "Contextual feedback to superficial layers of V1". Current Biology **25**(20):2690-95.
- Otten, M., Pinto, Y., Paffen, C.L.E., Seth, A.K., Kanai, R. (2016) "The Uniformity Illusion: Central stimuli can determine peripheral perception" Psychological Science
- Pinto, Y., et al. (2015). "Expectations accelerate entry of visual stimuli into awareness". Journal of Vision **15**(8):13
- Seth, A.K. (2014). "A predictive processing theory of sensorimotor contingencies: Explaining the puzzle of perceptual presence, and its absence in synaesthesia". Cognitive Neuroscience **5**(2): 97-118.
- Sherman, M.T., Kanai, R., Seth, A.K., and VanRullen, R. (2016). "Rhythmic influence of top-down perceptual priors in the phase of ongoing occipital alpha oscillations." Journal of Cognitive Neuroscience **28**(9):1318-30

LECTURE 8**Interoceptive awareness**

Dr. Charlotte Rae

The internal state of the body is proposed as the primary reference for a sense of self. The coordinated regulation of internal bodily state is arguably the basis for motivations; correspondingly, motivationally significant sensations from the body are viewed as fundamental to emotional processes. Interoception describes the central representation of such information, and interoceptive sensitivity refers to the ability of an individual to gain declarative conscious access to such sensations. A basic logic is that enhanced interoceptive sensitivity is an indicator of better representations of bodily sensations which would predict, from peripheral theories of emotions, more intense affective experiences in that individual compared to those with more impoverished interoceptive ability.

Damasio's somatic marker theory argued that our rational thoughts and conscious decision-making are heavily and implicitly influenced by interoceptive processes (ultimately representing the unconscious representation of prior motivational experience) yet saw the same information as the basis to emotions and defined the core self. Craig has a broad, but also exclusive, definition of interoception, proposing a labelled line for such neural information flow that leads to preferential access to certain aspects of conscious affect. He has extended this logic to propose that conscious awareness and coherence, even of the passage of time, is grounded on such as representations within the brain. In this teaching session, we will explore such ideas, evidence and their implications.

Essential Reading

- Craig, A. D. (2010). "The sentient self." Brain Structure and Function **214**: 563-577
- Damasio, A. and H. Damasio (2006). "Minding the body." Daedalus: 15-22.
- Katkin, E. S., S. Wiens, et al. (2001). "Nonconscious fear conditioning, visceral perception, and the development of gut feelings." Psychol Sci **12**(5): 366-370.

Recommended Reading

- Craig, A. D. (2009). "How do you feel--now? The anterior insula and human awareness." Nat Rev Neurosci **10**(1): 59-70
- Critchley, H. D., S. Wiens, et al. (2004). "Neural systems supporting interoceptive awareness." Nat Neurosci **7**(2): 189-195.
- Garfinkel, S.N., Critchley, H. D. (2016). "Threat and the body: how the heart supports fear processing" Trends Cogn Sci **20** (1): 34-46.
- Parvizi, J. and A. Damasio (2001). "Consciousness and the brainstem." Cognition **79**(1-2): 135-160.
- Sanchez-Vives, M. V. and M. Slater (2005). "From presence to consciousness through virtual reality." Nat Rev Neurosci **6**(4): 332-339.

LECTURE 9**Consciousness of body and self**

Prof. Anil Seth

This lecture will discuss the distinction between consciousness and self-consciousness, and ask the question, what IS a self? We will describe some philosophical perspectives challenges the very idea of the existence of a self. We will then discuss relevant experimental evidence, for example the artificial induction of “out-of-body” or “autoscopic” experiences. We will then turn to challenging and controversial experiments that address the linked topics of agency, volition, intention, and free will. Finally, we will ask whether there are ‘default’ modes of brain activity pertaining to awareness of the self, as opposed to awareness of the environment.

Essential Reading

- Lenggenhager, B., T. Tadi, et al. (2007). "Video ergo sum: manipulating bodily self-consciousness." Science **317**(5841): 1096-1099.
- Seth, A.K. (2013). "Interoceptive inference, emotion, and the embodied self". Trends Cogn Sci. **17**(11): 565-73.

Recommended Reading

- Blanke, O., Slater, M., & Serion, A. (2015). "Behavioral, neural, and computational principles of bodily self-consciousness". Neuron **88**(1):145-66.
- Brugger, P., & Lengennhagger B. (2014). "The bodily self and its disorders: neurological psychological, and social aspects." Curr Opin Neurol **27**(6): 644-652.
- Haggard, P. (2008). "Human volition: towards a neuroscience of will." Nat Rev Neurosci **9**(12): 934-946.
- Petkova, V. I. and H. H. Ehrsson (2008). "If I were you: perceptual illusion of body swapping." PLoS One **3**(12): e3832.
- Seth, A.K. and Friston, K.J. (2016). "Active interoceptive inference and the emotional brain. Philosophical Transactions of the Royal Society B: Biological Sciences

Scholarpedia

http://www.scholarpedia.org/article/Self_models

LECTURE 10**Psychiatric disturbances of consciousness**

Dr. Jim Parkinson

In this session we will consider the degree to which mental illnesses can be construed as disorders of consciousness. All psychiatric disorders involve disturbances of subjective experience: indeed it is usually these disturbances that are the essence of the presenting problem. Does this help us delineate 'mental illness' as a category apart from other illness? The 'consciousness thesis' of Stephens and Graham will be briefly discussed as an example of a theoretical view which explicitly posits psychiatric illnesses as disorders of consciousness. We will also examine the phenomenology of schizophrenia, a common and severe psychotic illness, and consider whether reformulating schizophrenia as a consciousness disorder may be helpful. Finally, we will examine the phenomenology of depersonalization disorder, a relatively little-studied condition in which there is a pervasive disturbance of self-experience in the absence of psychotic phenomena.

Essential Reading

- Medford, N., Sierra, M., et al. (2005). "Understanding and treating depersonalization disorder". Adv. Psych. Treat. **11**:92-100.
- Sass, L., & Parnas, J. (2003). "Schizophrenia, consciousness, and the self". Schizophrenia Bulletin. **29**(3):427-444.

Recommended Reading

- Fletcher, P.C., and C.D. Frith (2009) "Perceiving is believing: a Bayesian approach to explaining the positive symptoms of schizophrenia". Nature Reviews Neuroscience **10**(1):45-58.
- Phillips, M. L., N. Medford, et al. (2001). "Depersonalization disorder: thinking without feeling." Psychiatry Res **108**(3): 145-160
- Stephan, K.E. and C. Mathys (2014). "Computational approaches to psychiatry". Curr. Opin. Nbiol. **25**:85-92.

LECTURE 11**Animal consciousness and its evolution**

Dr. Daniel Bor or Prof. Anil Seth

How widespread is consciousness among other animals? And how do we go about assessing whether other animals are conscious and by how much? How similar is a chimpanzee mind to a human mind? Do birds have anything like conscious experiences? This lecture will first discuss behavioural approaches to answering these questions, including assessing the ability of other animals to learn in ways the lecture series has suggested are important for consciousness. Also covered will be an assessment of how animals might report on their own level of awareness, for instance by using binocular rivalry paradigms and animal analogs of blindsight. Various problems with the behavioural approach will be discussed. The second part of the lecture will cover possible neurophysiological approaches to assessing animal consciousness, including comparing parts of human neuroanatomy known to be associated with consciousness with the neuroanatomy of other species. Also discussed will be ways of measuring the level of animal consciousness dynamically, for instance by using an information integration approach. Finally, we'll discuss the possible evolution and purpose of consciousness, and whether conscious machines are possible.

Essential Reading

- Cowey, A. and P. Stoerig (1995). "Blindsight in monkeys." Nature **373**(6511): 247-249.
- Edelman, D. B. and A. K. Seth (2009). "Animal consciousness: a synthetic approach." Trends Neurosci **32**(9): 476-484.

Recommended Reading

- Butler, A. B. (2008). "Evolution of brains, cognition, and consciousness." Brain Res Bull **75**(2-4): 442-449.
- Edelman, D. B., Baars, B.J. and Seth, A.K. (2005). "Identifying the hallmarks of consciousness in non-mammalian species." Consciousness and Cognition **14**(1): 169-187.
- Logothetis, N. K. (1998). "Single units and conscious vision." Philos Trans R Soc Lond B Biol Sci **353**(1377): 1801-1818
- Merker, B. (2005). "The liabilities of mobility: a selection pressure for the transition to consciousness in animal evolution." Conscious Cogn **14**(1): 89-114.
- Nesher, M. et al. (2014). "Self-recognition mechanism between skin and suckers prevents octopus arms from interfering with each other". Current Biology **24**:1271-75.
- Northoff, G. and J. Panksepp (2008). "The trans-species concept of self and the subcortical-cortical midline system." Trends Cogn Sci **12**(7): 259-264.
- Seth, A. K., B. J. Baars, and Edelman, D.B.. (2005). "Criteria for consciousness in humans and other mammals." Consciousness and Cognition **14**(1): 119-139.
- Seth, A. K. (2016). "Aliens on Earth: Octopus consciousness?" In *Aliens*, ed. J. Al-Khalili. Profile Books.
- van Swinderen, B. (2005). "The remote roots of consciousness in fruit-fly selective attention?" Bioessays **27**(3): 321-330.