Critical Periods in Brain Development and Behavior
PSYC UN3481
4 points

Fall, 2020

Where/When
Thursdays 10:10am-12pm
Virtual (Zoom)

Instructor
Dr. Sarah Canetta (ses2119@cumc.columbia.edu)

Office Hours
By appointment, via Zoom

Prerequisites
This course is open to advanced undergraduate students who have taken UN1010 (Mind, Brain, & Behavior) or an equivalent introductory course in neuroscience or cognitive psychology. Instructor permission is required prior to registration.

Bulletin Description
The majority of our mental capacities—ranging from basic sensory functions to more advanced social, emotional and cognitive capabilities—take many years to develop and are highly influenced by environmental signals encountered during particular developmental ‘critical periods’. In this seminar we will explore examples of these periods across diverse brain systems and behaviors, ranging from vision and audition to social, emotional and cognitive development, by considering each example in the context of human brain function and behavior as well as at the level of more detailed neurobiological mechanisms underlying these changes elucidated by studies using non-human animal systems.

Course Description
Unlike many systems of the body, which are largely mature at birth, the human brain continues to undergo massive developmental maturation throughout childhood and adolescence. Likewise, our mental capacities undergo extensive postnatal development and maturation. This is true both for basic senses such as sight, hearing, taste and touch and for advanced social, emotional and cognitive capabilities such as theory of mind, social and emotional regulation, memory, language and abstract reasoning. We now understand that the neural development underlying the acquisition of many of these capabilities is highly regulated by environmental signals that help prepare the brain to respond to the experiences most likely to be encountered later in life. Importantly, we have also learned that the brain is frequently most receptive to these signals during specific developmental windows.

The term ‘critical periods’ has been coined to denote developmental windows in which each brain system is most plastic or malleable, and after which change to the circuitry and the behavior it subserves is more difficult, if not impossible. In this course, we will explore this idea of critical periods. We will begin by introducing what they are and why they might exist. We will subsequently explore examples of these periods across diverse brain systems and behaviors, ranging from vision and audition to social, emotional and cognitive development. We will consider each example in the context of human brain function and
behavior as well as at the level of more detailed neurobiological mechanisms underlying these changes elucidated by studies using non-human animal systems. We will conclude by examining how our understanding of critical period mechanisms is enabling the possibility of reopening plasticity later in life.

This course is a weekly seminar, with each meeting divided into a brief introductory lecture followed by a student presentation and discussion of weekly assigned readings. Grading will be based on attendance and general participation (25%), a weekly reading response posted to Courseworks (25%), a presentation of a piece of primary literature required for one session (25%) and an 8-10-page final paper (25%) in which each student is expected to explore one topic from the semester that has peaked their interest in more depth. Details on all of these elements are given below.

**Role in the Psychology Curriculum**
This course is designed to give advanced undergraduates a deeper understanding of the principles and mechanisms underlying critical periods in the development of different facets of behavior and corresponding neural circuitry. It is designed particularly for seniors majoring in Psychology or Neuroscience & Behavior and for students participating in the Post-Baccalaureate Certificate program in Psychology. These students will have priority in registration, followed by junior majors, followed by non-majors. The course fulfills the following degree requirements:

- For the Neuroscience & Behavior major, this course fulfills the fifth Psychology requirement for “one advanced seminar from a list approved by the Psychology Department advisor to the program.”
- For the Psychology major or concentration in Columbia College and in the School of General Studies and for the Psychology Post-Baccalaureate Certificate program, this course meets the Group II (Psychobiology & Neuroscience) distribution requirement.
- For Psychology Post-Baccalaureate students and for Psychology majors, this course will fulfill the seminar requirement.
- For the Barnard Psychology major, this course might fulfill the senior seminar requirement.

**Requirements/Grading**

*Attendance and Participation:* A large portion of each class will be devoted to discussion of the day’s topic and the associated primary literature. Therefore, it is crucial that everyone come prepared having reviewed the required readings PRIOR to class, as well as having considered them in light of the learning objectives I have outlined in the syllabus for that seminar meeting. Attendance and participation are required and will count towards 25% of the final grade. Good participation will reflect both thoughtful listening to other students’ comments as well as consistent contribution to the day’s discussion. Discussion contributions should reflect that the student has reviewed the readings prior to class. One absence is permitted, but must be communicated to the instructor prior to the beginning of class or it will be considered unexcused.

*Weekly Reading Response:* In order to stimulate discussion, a thoughtful response to the weekly readings is required. This response should be between ½ to 1 page in length and submitted prior to the start of class. Thoughtful responses, including those that comment on or critique the week’s primary literature or compare and contrast the topic with another topic from the course, will receive full credit and count towards 25% of the final grade. Feedback will be provided on the first response to help guide students towards what is expected in this regard.

*Presentation:* Beginning with the second class period, each week one or more students will present a primary literature article assigned as part of that week’s reading. During the class, the student presentations will follow the mini introductory lecture to the day’s topic given by the instructor. The goal
of the presentation will be to provide background and justification for the study, discuss the experimental design (clarifying the methodological details), the results and conclusions, especially with regard to the bigger picture questions being addressed both in the particular class as well as the course as a whole. The student should come prepared with some questions to stimulate discussion on his/her particular article(s) but the instructor will lead the larger class discussion for the day. It is required that all students schedule a time to meet with the instructor at least 2 days prior to their presentation to discuss the article(s). This presentation will count towards 25% of the final grade.

Final Paper: Students are asked to pick a topic from the semester to research and write about in more detail. The final paper should be 8-10 pages in length and contain a minimum of 10 primary source citations (not including reviews). In order to assure that you are on the right track, it is required that you come to class on Thursday, November 12th with an outline of what you plan to write about. At a minimum, this should include a description of the topic or question of interest and two or three primary source articles you are considering as source material. We will discuss our topics as a group and then there will be an opportunity to meet individually with me if you have more questions afterwards. This paper will count towards 25% of the final grade. To give me sufficient time to grade your papers, they must be submitted by midnight on Friday, December 11, 2020.

Additional Class Policies
Conduct: Please keep your video on and mute yourself when you are not participating in the discussion. Although classes will be conducted via Zoom, students should be attentive to class presentation and work to participate as much as possible in the class discussion.

Academic Integrity: Please read and adhere to the policies regarding academic integrity found in Columbia’s Guide to Academic Integrity (http://www.college.columbia.edu/academics/integrity). Remember that you are responsible for presenting your own work in assignments and exams and for attributing others’ ideas where appropriate. If you have any questions about these policies and how to correctly adhere to them, please make an appointment to see me.

Students with Disabilities: If you have special needs and may require specific accommodations with regard to the classroom or assignments, please 1) Make an appointment to see me during the first week of class and 2) Contact the Office of Disability Services in Lerner Hall before the start of the course to register for these accommodations.

Schedule
The following example schedule gives topics to be covered, with identified learning objectives and example readings (subject to change). Although this course will rely on primary source articles and reviews and there is no official course textbook, I may also post relevant sections of background textbook reading on Courseworks prior to each class period.

Week 1. Introduction to Critical Periods, 9/10/2020
Learning Objectives:
- Use early ethological studies (such as Lorenz’s studies of imprinting) to understand the general principles of behavioral critical periods and arrive at a definition of critical periods in the context of brain development and behavior
- Discuss the benefits and drawbacks of critical periods for organism survival
- Understand the concept of neurobiological plasticity and be able to list several ways in which brain plasticity is accomplished
Readings:


Learning Objectives:
- Understand the basic architecture of the visual system
- Be able to list typical developmental milestones in human vision
- Understand that effects of early perturbations in vision on long-term visual functioning
  - Define amblyopia, identify some of its causes and its long-term consequences for visual functioning and current medical practice for treating it

Primary Source Readings:


Reviews:

Optional:

Learning Objectives:
- Review basic architecture of the visual system
- Understand response properties of binocular cells in primary visual cortex
- Use ocular dominance plasticity (ODP) as an example of how the brain and behavior can be shaped by environmental input during critical periods
- Use ODP as an example to understand plasticity mechanisms at work during critical periods

Primary Source Readings:


Reviews:

Learning Objectives:
- Review basic architecture of the visual system
- Use ODP as an example to understand mechanisms that may trigger the opening and closing of critical periods

Primary Source Readings:


Week 5. Critical Periods in Audition – Introduction and Human Studies, 10/8/2020
Learning Objectives:
- Understand the basic architecture of the auditory system
- Be able to list typical developmental milestones in human audition
- Understand that effects of early perturbations in audition on long-term auditory functioning
  o Understand cochlear implant technology, and how the timing of this intervention influences its outcome.
- Define perfect/absolute pitch and describe evidence that this auditory ability may have a critical period

Primary Source Readings:


Reviews:
Whitton JP & Polley DB. Evaluating the Perceptual and Pathophysiological Consequences of Auditory Deprivation in Early Postnatal Life. JARO.

Week 6. Critical Periods for Cross-modal Plasticity During Development – Human and Animal Studies, 10/15/2020

Learning Objectives:
- Understand what is meant by cross-modal plasticity
- Understand how this cross-modal plasticity evolves during development
- Examine evidence for a critical period for cross modal plasticity in humans

Primary Source Readings:


Week 7. Critical Periods for Language – Human Studies, 10/22/2020

Learning Objectives:
- Understand basic neural circuitry contributing to language perception and production
- Be able to describe typical development of the human language system
- Be able to provide evidence for critical periods for acquisition of language phonology and syntax

Primary Source Readings:


Reviews:
**Week 8. Critical Periods for Social and Emotional Development – Human Studies, 10/29/2020**

*Learning Objectives:*
- Understand basic brain systems involved in social and emotional behavior
- Be able to describe typical milestones in human social and emotional development
- Using the Romanian Foster Care studies, describe evidence for a critical period for social and emotional development

*Primary Source Readings:*


*Learning Objectives:*
- Review brain systems involved in social and emotional development
- Using primate studies, describe evidence for some of the environmental factors regulating social and emotional development during critical periods
- Using rodent studies, describe some neurobiological mechanisms by which these early environmental factors may influence brain circuits relating to social and emotional behavior

*Primary Source Readings (Please select three):*


Week 10. Discussion of Paper Topics, 11/12/2020

Week 11. Critical Periods for Exposure to Neuromodulators, 11/19/2020

Learning Objectives:
- Using the example of serotonin, explore how neuromodulator levels influence the development of brain circuitry
- Use the concept of critical periods to understand the paradox of SSRI exposure in terms of conflicting outcomes on emotional behaviors during development versus adulthood

Primary Source Readings:


Week 12. No class 11/26/2020

Week 13. Critical Period Disruption in Psychiatric Disorders Focusing on Schizophrenia, 12/3/2020

Learning Objectives:
- Be able to describe key defining behavioral symptoms of schizophrenia and associated proxy behaviors in mice
- Discuss the evidence that critical period disruption may play a role in changes in brain circuitry related to schizophrenia

Primary Source Readings:

Reviews:
Week 14. Reopening Adult Plasticity – Possibilities and Pitfalls, 12/10/2020

Learning Objectives:
- Compare and contrast brain plasticity during development and in adulthood
- Discuss principles for opening critical periods during development and how they can be applied for the reopening of critical periods in adulthood
- Discuss the possibilities and pitfalls of reopening critical periods in adulthood

Primary Source Readings:

Reviews: