Psychology 1454. *Neuroscience Fiction: An Introduction to Cutting Edge Neuroscience through the Lens of Film and Television*
Fall 2022

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Course Summary:
Film and television-shows often capture the cutting edge of science, and they sometimes even anticipate future scientific advances. We'll use examples from film and television as an introduction to several hot topics in the field of neuroscience, such as Mind Control, Mind Reading, Smart Pills, and Brain Machine Interfaces, which are all getting closer to reality. Will neuroscientists ever be able to control a person's thoughts, or to know what a person is thinking? Can taking a pill really awaken untapped brain power? Will you ever be able to drive a car without touching a steering wheel? In this course, we will cover the state of the art and the future of these exciting areas of neuroscience (and entertainment). Because these are not textbook topics, this is an advanced course that will focus on reading and discussing the primary literature. *Prerequisites*: SLS-20 plus either PSY 14 or MCB 80 or permission of instructor. Many previous students have taken the course and done quite well without satisfying the prerequisites, but I include them essentially as a recommendation.

Classes: Thursday 3:00 - 5:00 PM, William James Hall Room 765
Workshops: 1 hour each, days & times to be determined (only 4 or 5 meetings all semester)

Seminar Dates/Topics:

Mind Control (altering & controlling brain states)
Sept. 01 Introduction: taking science fiction seriously
Sept. 08 Remote Control (optogenetics, microstimulation)
Sept. 15 Bionic Minds (brain machine interface)
Sept. 22 This Time with Less Feeling (control of emotion/social behavior, oxcytocin)

Mind Reading (reading brain states)
Sept. 29 Eavesdropping & Lie Detection (sensory decoding/replay, neuro "polygraph")
Oct. 06 Memory Replay (memory decoding)
Oct. 13 **Midterm Exam Due by Midnight (last time zone on earth).**

Memory Modification (modifying the set of possible brain states)
Oct. 20 How Memory Breaks (short-term, long-term, content-specific memory loss)
Oct. 27 Erasing Memories (reconsolidation theory)
Nov. 03 Implanting Memories (inception, artificial hippocampus)

Becoming Limitless
Nov. 10 Cognitive/Neural Enhancement (induced neurogenesis, chemical enhancement)
Nov. 17 Digitize Me (the singularity, transhumanism)
Nov. 24 **Thanksgiving Break**
Dec. 01 AI, Neural Entanglement, & NeuroSciencFiction Projects

Dec. 04 **Final Exam Due by Midnight (last time zone on earth).**

Overview:
This goal of this class is for students to learn how neuroscience concepts depicted in movies (e.g., Mind Control, Memory Erasure) might actually be accomplished in the field of neuroscience, and to present the material in a way that it is ***accessible to anyone, regardless of background expertise***. Each seminar will focus on a particular neuroscience-fiction theme (e.g., Mind Control), and will follow the same basic structure:

- **Movies**. Every class begins with a brief viewing (~10-20 min) of at least two movies, which I've edited down to convey the core neuroscience-fiction plot points. The goal of watching these movies isn't to critique them, but rather to get you to think creatively about the topic.
- **Brainstorms**. We'll use these movies to launch into Breakout sessions where each group will brainstorm a specific neuroscience-fiction topic (e.g., Discuss exactly how a mind control system could be built…what are the requirements/issues/challenges?), and then share their solutions with the full class.
- **Primary Reading**. Finally, we'll discuss two primary readings for the week. In any given week, each student is assigned to be a "primary reader" on one of the two articles. Primary readers help lead the classroom discussion on each paper, explaining the main purpose, methods, findings, raising points of confusion, etc. Because these articles are from the primary neuroscience literature, they can often be very difficult to read through, particularly if you don't have a background in neuroscience. BUT…learning how to read these papers to learn about *cutting edge* research is really the point of the course. This is where we spend the bulk of our time, unpacking the terminology and concepts in these papers, translating them into plain language, in order to make sure everyone understands the key concepts.

Quizzes/Exams:
There is a mid-term exam and a final exam. Sort of. Rather than having marathon exams, you will be given Quiz questions covering the material week-to-week. However, mid-way through the course (Oct. 20) you will be given the opportunity to submit revised responses for Quizzes 1-5 and to answer a few bonus questions. At the end of the course (Dec. 04) you can submit revised responses for Quizzes 6-10, and answer a few bonus questions. This should allow students to improve their responses based on feedback, or to incorporate learning from later in the semester to improve their responses. If you are happy with your original response, you don't have to submit a revised one. Grades on these final, "Locked in" Quiz responses will replace initial quiz grades and count as the mid-term exam and final exam grades.

Workshops:
We will have 4-5, 1-hour workshops (times to-be-determined). **None of the workshop projects are graded, although participation is required.** The goal of the workshop is to teach you some cutting edge neuroscience methods (without the pressure of being graded), and to give you an opportunity to produce your own work of neuroscience fiction. The workshop is divided into two parts: (1) During the first half of the semester, we will do a *mind reading* project, where we will learn to analyze actual human neural data using cutting edge analysis methods. We will work in groups, and each group will turn in a power-point lab report when the project is complete. (2) During the second half of the semester, you will create your own work of neuroscience fiction (in groups or on your own), which could be a short-film (funds and equipment available), a short screenplay, a graphic novel, or any other piece of neuroscience-fiction you can imagine.

Workshop Schedule (days/times TBD, most likely on Fridays):

Week	Workshop Topic
Sep. 22	Introduction to Brain Data & Pattern Analysis
Sept. 29	Introduction to Feature Modeling
Oct. 06	Feature Rating Surveys
Oct. 13	**No Workshop (Midterm week)**
Oct. 20	Brain Models Mind Reading
Oct. 27	NeuroScienceFiction Project Pitch

Collaboration Policy:

No collaboration is allowed *during* Quizzes/Exams, although you are allowed and encouraged to prepare for the Quizzes/Exams in groups. For the workshop projects, you are encouraged to work in groups.

Assigned Reading:

See the following pages for a weekly breakdown of the readings. Each week, you will be a "primary reader" for an empirical article (a paper that reports neuroscience research). As a primary reader, you will be responsible for leading the discussion and explaining the reading to the rest of the group during the seminar. Although you are the primary reader for only one article per week, you are expected to read and know the material from all of the assigned readings (usually 2, sometimes 3 per week).

Grading:

1. **Class participation (34%):** One of the primary goals of the course is for you to be comfortable and confident in your ability to discuss the course topics and readings. But this definitely doesn't mean you need to master the material before we discuss it! Students can contribute to the discussion by helping to explain the material to their classmates, pointing out what was confusing or unclear, or making connections to other material from the course or from outside of the course.
2. **Quiz 1-5 (aka mid-term exam) (33%)**: see Quizzes/Exams section for more details
3. **Quiz 6-10 (aka final exam) (33%)**: see Quizzes/Exams section for more details
4. **Mind-reading Project (0%; but required):** Zero percent? Why? For students without computational neuroscience backgrounds, or who haven't conducted a lot of quantitative research, the mind reading project might seem overwhelming at first. By making this assignment essentially pass/fail, we get to push the cutting edge (legitimately learning to read thoughts from neural signals), and can contribute to the project at whatever level best fits your background (from conceptual down to nitty gritty implementation details if you wish).
5. **Neuroscience-fiction Project (0%; but required):** Zero percent? Seriously? You'll have to trust me here, students in past years have submitted amazing projects, including short-films, websites, graphic novels, screenplay treatments, etc. Because the parameters of this project are so wide open, there's no sensible grading rubric to be applied, and who am I to judge an artist anyway? Although, it is the case that if your grade is borderline, a fabulous Neuroscience-fiction project can bump your grade up.

Readings should be completed **before class** (with the exception of Seminar 1).

Week 01 (Sept. 01): Introduction

No reading before the first class.

Week 02 (Sept. 08): Remote Control (optogenetics)

Optional, But Potentially Helpful Background

1. Williams, S.C.P. & Deisseroth, K. (2013) **Optogenetics.** PNAS. October 2013.

Primary Readings:

1. Anderson, D. J. (2011). Optogenetics, Sex, and Violence in the Brain: Implications for Psychiatry. Biological Psychiatry.
2. Liu, X., Ramirez, S., Pang, P. T., Puryear, C. B., Govindarajan, A., Deisseroth, K., et al. (2012). Optogenetic stimulation of a hippocampal engram activates fear memory recall. *Nature*, *484*(7394), 381-385.

Week 03 (Sept. 15): Bionic Minds

Optional, But Potentially Helpful Background

1. Thakor, N. V. (2013). Translating the brain-machine interface. Science translational medicine, 5(210 210ps17), 1-7.

Primary Readings:

1. Velliste, M., Perel, S., Spalding, M. C., Whitford, A. S., & Schwartz, A. B. (2008). Cortical control of a prosthetic arm for self-feeding. *Neurosurgery*, *63*(2), N8-N9.
2. Raspopovic, S., Capogrosso, M., Petrini, F. M., Bonizzato, M., Rigosa, J., Di Pino, G., ... & Micera, S. (2014). Restoring natural sensory feedback in real-time bidirectional hand prostheses. *Science translational medicine*, *6*(222 222ra19), 1-12.

Week 04 (Sept. 22): This Time with Less Feeling

Optional, But Potentially Helpful Overviews

1. *(Overview of Kosfeld Reading)* Damasio, A. (2005). Brain trust. *Nature*, 435, 571-572.
2. *(Overview of Baumgarter Reading)* Mauricio, R. M. R. D. (2008). Fool me once, shame on you; fool me twice, shame on oxytocin. *Neuron*, *58*(4), 470-471.

Primary Readings:

1. Kosfeld, M., Heinrichs, M., Zak, P. J., Fischbacher, U., & Fehr, E. (2005). Oxytocin increases trust in humans. *Nature*, *435*(7042), 673-676.
2. Baumgartner, T., Heinrichs, M., Vonlanthen, A., Fischbacher, U., & Fehr, E. (2008). Oxytocin shapes the neural circuitry of trust and trust adaptation in humans. *Neuron*, *58*(4), 639-650.

Week 05 (Sept. 29): Eavesdropping & Lie Detection

Primary Readings:

1. Haynes, J. D., & Rees, G. (2006). Decoding mental states from brain activity in humans. *Nature Reviews Neuroscience*, *7*(7), 523-534.
2. Nishimoto, S., Vu, A. T., Naselaris, T., Benjamini, Y., Yu, B., & Gallant, J. L. (2011). Reconstructing visual experiences from brain activity evoked by natural movies. *Current Biology*, *21*(19), 1641-1646.
3. Hasson, U., Nir, Y., Levy, I., Fuhrmann, G., & Malach, R. (2004). Intersubject synchronization of cortical activity during natural vision. *Science*, *303*(5664), 1634-1640.
4. Greene, J. D., & Paxton, J. M. (2009). Patterns of neural activity associated with honest and dishonest moral decisions. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(30), 12506-12511.

Week 06 (Oct. 06): Memory Replay

Primary Readings:

1. Ji, D., & Wilson, M. A. (2007). Coordinated memory replay in the visual cortex and hippocampus during sleep. *Nature Neuroscience*, 10(1), 100-107.
2. Chadwick, M. J., Hassabis, D., Weiskopf, N., & Maguire, E. A. (2010). Decoding Individual Episodic Memory Traces in the Human Hippocampus. *Current Biology*, *20*(6), 544-547.

Week 07 (Oct. 13): Midterm Exam (due by midnight) — No Class

Week 08 (Oct. 20): How Memory Works and Breaks

Optional, But Potentially Helpful Background

1. Tulving, E. (1985). How many memory systems are there? *American Psychologist*, *40*(4), 385-398.

Primary Readings:

2. Verfaellie, M., & O'Connor, M. (2000). A neuropsychological analysis of memory and amnesia. *Seminars in Neurology*, *20*(4), 455-462.

Week 09 (Oct. 27): Erasing Memories

Optional, But Potentially Helpful Background

1. Karim, K. N. (2003). Memory traces unbound. Trends in Neurosciences, 26(2), 65-72.

Primary Readings:

1. Schiller, D., Monfils, M. H., Raio, C. M., Johnson, D. C., LeDoux, J. E., & Phelps, E. A. (2009). Preventing the return of fear in humans using reconsolidation update mechanisms. *Nature*, *463*(7277), 49-53.
2. Cao, X., Wang, H., Mei, B., An, S., Yin, L., Wang, L. P., et al. (2008). Inducible and selective erasure of memories in the mouse brain via chemical-genetic manipulation. Neuron, 60(2), 353-366.

Week 10 (Nov. 03): Memory Implants

Primary Readings:

1. Berger, T. W., Hampson, R. E., Song, D., Goonawardena, A., Marmarelis, V. Z., & Deadwyler, S. A. (2011). A cortical neural prosthesis for restoring and enhancing memory. *Journal of Neural Engineering*, *8*(4), 046017-046017.
2. Garner, A. R., Rowland, D. C., Hwang, S. Y., Baumgaertel, K., Roth, B. L., Kentros, C., et al. (2012). Generation of a synthetic memory trace. *Science*, *335*(6075), 1513-1516.
3. Shibata, K., Watanabe, T., Sasaki, Y., & Kawato, M. (2011). Perceptual Learning Incepted by Decoded fMRI Neurofeedback Without Stimulus Presentation. *Science*, *334*(6061), 1413-1415.

Week 11 (Nov. 10): Limitless

Optional, But Potentially Helpful Background

1. Lynch, G., Palmer, L., & Gall, C. M. (2011). The likelihood of cognitive enhancement. *Pharmacology, Biochemistry, and Behavior*, *99*(2011), 116-129.
2. A Hypothesis About the Role of Adult Neurogenesis in Hippocampal Function. *Physiology* (Bethesda), *19*(5), 253-261.

Primary Readings:

1. Farah, M. J., Haimm, C., Sankoorikal, G., & Chatterjee, A. (2009). When we enhance cognition with Adderall, do we sacrifice creativity? A preliminary study. *Psychopharmacology*, *202*(1-3), 541-547.
2. Sahay, A., Scobie, K. N., Hill, A. S., O'Carroll, C. M., Kheirbek, M. A., Burghardt, N. S., et al. (2011). Increasing adult hippocampal neurogenesis is sufficient to improve pattern separation. *Nature*, *472*(7344), 466-470.
3. Anguera, J. A., Boccanfuso, J., Rintoul, J. L., Al-Hashimi, O., Faraji, F., Janowich, J., ... & Gazzaley, A. (2013). Video game training enhances cognitive control in older adults. *Nature*, *501*(7465), 97-101.

Week 12 (Nov. 17): Digitize Me

Primary Readings:

1. Suchow, J. (2011). NPG's policy on authorship. *Nature*, *477*(7363), 244-244.
2. Tucker, P. (2006). The singularity and human destiny. *The Futurist*, *March-April*, 38-48.
3. Behrens, T. E. J., & Sporns, O. (2012). Human connectomics. *Current Opinion in Neurobiology*, *22*, 144-153.

Week 13 (Nov. 24): Thanksgiving Break — No Class

Week 14 (Dec. 01): AI, Neural Entanglement — Last Class

Primary Readings:

TBD