Independent Work Guide: Neuroscience

The Discipline of Neuroscience

Neuroscience is a broad interdisciplinary field designed to investigate the brain and other parts of the nervous system at multiple levels of analysis. The field requires rigorous preparation in basic science. Students in this discipline are expected to understand the basic principles and approaches of modern neuroscience. The major provides an opportunity for serious study of molecular, cellular, developmental, and systems neuroscience as it interfaces with cognitive and behavioral research. Gaining knowledge in these areas will prepare juniors and seniors for their independent work, which is an important component of the Neuroscience major. Junior and Senior independent work is an experimental, computational and/or theoretical study of a topic selected and researched by the student and their faculty adviser.

Goals

During the Fall semester of junior year, students participate in tutorials led by postdoctoral fellows. The goal of these tutorials is to learn how to read, critically evaluate, and write about recent research articles in the field of neuroscience. During this semester as well, students are assigned to faculty advisers and begin discussions about the Spring semester junior independent work. During the Spring of the junior year, the goals are to gain knowledge in relevant literature and learn to formulate hypotheses, design projects, and integrate relevant background literature into concrete plans for independent research projects. The ultimate goal of the Spring semester junior independent work is to write a research proposal describing the work you will carry out for the senior thesis. The goals of senior independent work are an extension of the work done during the junior year. Students will continue to develop their research projects and bring them to conclusion with either empirical, computational, or theoretical study. Students will learn how to design a study to fill a knowledge gap in the field, to carry out a line of inquiry using methods

that are appropriate to the scientific question, to critically evaluate their findings, and to integrate those findings into the larger literature on the topic. The senior thesis will be a written work of scholarship that adds new knowledge to the field of Neuroscience. Students will also learn how to communicate their research projects and findings orally.

Evaluation

NEU independent work grading

The Spring JP grade is determined by the PNI faculty adviser. Because it is larger in scope and involves an oral exam, the senior thesis grade is determined by two PNI faculty members, the student's adviser and the second reader assigned by the NEU DUS. These grades are averaged to obtain a grade for the written component of the Senior Thesis. The student will receive written comments from both readers. The Senior oral examination is scheduled to occur at the end of the Senior year. The exam consists of an oral presentation that the student will give to the two faculty members (the student's adviser and second reader) who graded the student's Senior Thesis. The examination normally lasts 20-25 minutes. It begins with the student presenting a 10-minute summary of their thesis. The student is then asked questions about the thesis by the two faculty members, who determine the grade based on the strength of the presentation and the student's responses to questions.

Grading Categories for Spring JP and Senior Thesis

Outstanding (A+)

The student has presented innovative insights, well-supported by scholarly research, which adds to the knowledge base of the field. The research meets criteria to be either fundable by a granting agency (in the case of the Spring JP) or published in a peer- reviewed scientific journal (in the case of the senior thesis).

Excellent (A range)

The student has excelled in some way. There is evidence of independent thinking and an attempt to investigate new ideas. The student has clearly framed the research question and organized the relevant material to support it. The student analyzes the primary scientific literature in a critical manner. Appropriate methodological design and statistical analyses are proposed in the case of the Spring JP or used in the case

of the senior thesis, and any data presented are interpreted and discussed thoughtfully. The presentation of the material is clear.

Very Good (B range)

The student covers relevant material and shows evidence of some independent thinking, but lacks thorough synthesis, entirely clear writing, or presentation.

Fully Passing (C range)

The student covers relevant material, which is clearly described. However, the student does not demonstrate independent thinking in synthesizing the material or in interpreting it.

Minimally Passing (D)

The student reviewed some of the recommended material or completed some portion of an empirical proposal or study. No independent thinking is obvious.

Not passing (F)

The student did not submit the independent work or submitted poor quality work that satisfies none of the expectations.

Process

Students who intend to major in NEU prepare for independent work by taking core courses in Neuroscience, including the required introductory NEU courses, as well as statistics, and mathematical tools in NEU. Students also prepare for independent work during the Fall JP tutorials which provide intensive training in reading, analyzing, and writing about the primary literature in Neuroscience. Also during the Fall semester of Junior year, students begin to read the literature relevant to their adviser's research area in order to both deepen and broaden their understanding of the field. Students doing experimental and computational work will sometimes work directly with graduate students, postdoctoral fellows, and laboratory staff members to gain methodological proficiency. Successful students are typically those that communicate with their adviser

about expectations early on and throughout the process.

Advising

Students have the following two options for finding a Neuroscience adviser for independent study: 1) NEU students may reach out to faculty on their own and inquire about research opportunities. Once an advising arrangement is agreed upon between the faculty member and student, the NEU DUS is notified and the advising arrangement is set; 2) NEU students who do not make their own advising arrangements fill out an extensive survey about their research interests at the start of the Junior academic year, and on the basis of that information and faculty availability, the NEU DUS makes adviser assignments. Most students begin interacting with their adviser no later than the middle of the Fall semester of Junior year, begin discussing plans for independent work, and attending faculty adviser lab meetings. Work on the Spring JP starts no later than the beginning of the Spring semester. Students should anticipate spending about 10 hours a week on their independent study work, and should stay in contact with their faculty adviser and/or laboratory mentor. Many NEU majors continue to work on their independent projects over the summer between Junior and Senior years. During the Senior year, students interact with their faculty advisers frequently and provide drafts of their written work at time intervals arranged between the student and the adviser.

Style, structure, and format

Spring junior paper research proposal format:

The proposal part (for both experimental and the non-experimental JPs) should be no more than 15 pages in length, double spaced, and be structured as follows:

Abstract, **200 words** (often the last thing you write, but the first thing that the reader will see in the final document)

- Include a brief summary of the topic & significance
- Set up the question or hypothesis you are researching
- Provide a concise road map of how you plan to make progress
- Cover all of the main points of your proposal
- Abstracts typically do not have references
- Should stand alone as an effective summary for the proposal

Background and Significance, ~2-3 pages

- Provide the reader with insight into the significance of the research – explain why the reader should care about your research.
- Identify the key findings that have led to the current line of inquiry. Become proficient with the major databases for finding relevant papers (Web of Science, BIOSIS, PubMed, Scopus, and Google Scholar).
- Provide an overview of the relevant primary literature – give the reader enough information to understand the problem your research addresses.
- Synthesize the material to make an accurate, original and comprehensive contribution – tell an interesting "story" providing the logical flow of the science – not necessarily the chronological order of the findings.

An important criterion for evaluating the Background and Significance concerns the Scholarship:

- Reference each fact presented with the primary source, not a review. The citation is typically included at the end of a sentence; however sometimes citations appear within a sentence.
- Rely on recent reviews to point the reader to a more extensive source of information about a field. The style of citation is the same as for a primary literature citation; however the citation should be proceeded by, "reviewed in…", or "… and the references therein".

Specific Aims **–** ~half a page (often written first and revised throughout)

- Include a very brief summary of the topic and significance (one or two sentences). State the question or hypothesis you are researching.
- Write each specific aim followed by a brief description of how you plan to achieve the goal. The 3 specific aims section includes what you intend to

accomplish, followed by a short paragraph with the general outline of the experimental plan.
- The specific aims should be concise, thorough, explicit and clear.
- The aims should summarize the goals and a reasonable and carefully thought out research plan.

Detailed Description of the Proposed Research, ~7-10 pages

This is the main part of your proposal where you provide the rationale and experimental procedures for each of your Specific Aims. If you've already done some experimental work related to your proposal, then you would include analyses of the data in the appropriate section.

- Break the proposal into sections reflecting each of your Specific Aims
- Explain "why" you are proposing each aim followed by "how" you are going to accomplish the aim.
- Write for a scientist not familiar with your research so that the rationale and experimental methods are widely accessible.
- Include a general description of the methods that will be used.
- For each experiment describe the specific controls that will be needed to evaluate whether the experiment is providing meaningful data.
- For each experiment describe the expected outcomes and how they would be interpreted. Discuss potential problems, alternative strategies, and benchmarks for success.

References

- At least 10 primary sources
- Only list articles that you cite in the document
- Detail each citation in the end in the reference section
- Use the format of a published journal
- Learn to use RefWorks or Endnote (both are free and the library gives tutorials)

Senior thesis formats

Neuroscience at Princeton is a broad and interdisciplinary field so there are several acceptable formats that can be followed to generate a successful senior

thesis. The basic formats are described below. *It is important to check with your adviser about which format (and topic) you will be researching.*

There are three basic senior thesis formats: 1) an experimental thesis; 2) a computational thesis; and 3) a theoretical thesis. Another option is to combine the first two formats into an experimental/computational thesis.

1. Experimental thesis research

You will work both independently and under supervision to plan and conduct experiments to advance scientific knowledge, with attention to proper controls. You will be expected to analyze and interpret critically the results of experiments, to use the conclusions of individual experiments to plan and revise subsequent experiments and to integrate your knowledge from all sources.

2. Computational thesis research

You will work both independently and with the input of your adviser to carry out hypothesis-driven research culminating in the construction of a computational model that addresses some set of empirical data, cognitive processes, and/or neural mechanisms. Alternatively, a data analysis-oriented project might include new analyses and/or meta-analysis of previously acquired data.

3. Theoretical thesis research

You will work both independently and with the input of your adviser to carry out research in the service of developing a theoretical synthesis of the existing literature with the generation and presentation of new conceptual ideas.

GENERAL GUIDELINES

There are no set requirements for style or length of the senior thesis. Below are some suggestions you can use as a guide. *It is most important to check with your adviser about any questions regarding how to organize your write-up.*

Experimental and/or Computational theses

These typically have 4 chapters: introduction, methods, results, and discussion.

Introduction

The Introduction includes a comprehensive review of the relevant scientific literature that forms the rationale for your project. At the end of the introduction, you should clearly state what research question your senior thesis sought to answer.

Methods

In the methods section, you should describe how the research project was carried out with enough detail so that others could repeat the study, whether the methods were experimental, computational or both. As you prepare to write this section, it is helpful to consult the methods sections in research articles closely related to your project, to get an idea of the level of detail. Be certain that you look at the methods in supplemental materials if you are consulting a journal that contains abbreviated methods in the main text.

Results

In the results section, you should describe your findings (experimental data and/or computational results) clearly and in detail, including any statistical analyses to support your findings. Include figures and tables showing your findings in this section.

Discussion

In this section, you should discuss how your findings fit with the published literature. Are they consistent with previous findings or were the results unexpected? If so, discuss reasons why discrepancies might have arisen. After you have discussed your findings and any limitations in your methods, discuss ways that new studies might help to clarify and inform your scientific question further. Summary figures can be included in the Discussion.

Theoretical thesis

For non-laboratory thesis work that involves a theoretical synthesis of the existing literature with the generation and presentation of new conceptual ideas, the write-up should include an introduction, a discussion and several intermediate chapters that clearly articulate your theoretical ideas and/or interpretations of existing data, and any predictions that they make. *It is important to check in with your adviser about this before you get started writing.*

A NOTE ON FIGURES

All figures should be placed at the appropriate location in the text. Each figure should include a legend that describes the figure. For data figures, statistics and n sizes should be included in the legend. In the case where figures are adapted from published papers, make certain to indicate this in the legend

A NOTE ON CITATIONS

A critical component of any scholarly work is the appropriate citation of published papers. Wherever possible, cite primary research articles. There is no set requirement for the format of references, but you should be consistent with your format throughout the reference list. Check with your adviser to get a recommendation about a journal style to follow.

A NOTE ON GENERAL FORMATTING

It is recommended to use 11 or 12 point font, 1 inch margins and 1.5 line spacing. Number the pages and include a table of contents page. Check with your adviser about any formatting preferences.

RE-USE OF JUNIOR PAPER MATERIAL

Since the senior thesis typically follows the research proposal put forth as the spring junior paper, it often makes sense to re-use material from the junior paper. If that is the case, you must either

1. Cite your junior paper (and list in the bibliography) as you would any other paper

OR

2. Make a note in the relevant section of text with the following form: “This section contains text that is based closely on, or identical to, text found in my junior paper."

Funding

Students who wish to obtain funding for their independent work should contact the office of undergraduate research. PNI also offers some funding for senior thesis research, which can be applied for through SAFE.

Timeline

Junior Year Fall:

Enroll in and take Fall JP tutorial (enrollment is administered by PNI, not the registrar. You will receive an email about this at the beginning of the Fall term.

Fill out NEU research interest survey and match with an adviser (or notify DUS about your faculty adviser arrangement).

Meet with your adviser and begin to attend lab meetings by the end of October

Junior Year Spring:

Work with your faculty adviser and lab members to formulate independent research plan.

Apply for research funding for senior thesis work, including to stay on campus and work in a lab during the summer.

Write the Spring JP, receive feedback from your adviser, revise, and submit by the May deadline (TBD).

Senior Year Fall:

Carry out senior thesis project.

Meet with your adviser and lab members regularly to discuss progress and trouble shoot any problems.

Senior Year Spring:

Write drafts of the senior thesis, submit them to your adviser. Receive feedback and revise accordingly.

Submit senior thesis through the NEU independent work portal by the April deadline (TBD).

Prepare for senior oral exam. Organize material, make slides, and practice.

Present your senior thesis at your oral exam (scheduled in May).

Additional Resources

During the Fall JP tutorial, students meet and receive instruction from the Behavioral Sciences librarian, Meghan Testerman (mtesterman@princeton.edu). After this time, she will continue to serve as an available resource for students who need help accessing scholarly material through the library system.

Students can also seek help with writing through the writing center, which offers boot camps and 1:1 peer support for students.

Note: While these additional resources are available and students may find them helpful, they should not be used as a substitute for interaction with the faculty adviser and lab members, who can provide important information about relevant literature and provide feedback on written drafts.