Research reports

Overview of research reports

Results from our experiments do not have much use unless we communicate them to our fellow scientists. This communication will be part of your lab experience. For several of the experiments you will be asked to write a short research report. The purpose is not to provide you with meaningless busy work or another means by which to grade you (although they will be graded). Rather, the research reports serve two main goals. First, they give you an intimate understanding of the widely accepted format of scientific papers. By practicing writing these papers yourself, you will not only prepare yourself for a potential research career, but you will gain a much deeper understanding of how scientific information is presented. Second, they give you practice communicating information clearly and concisely in written form. For each report, we will provide you with feedback designed to improve your future writing.

Your goal is to write each lab report in the form of a short, scientific journal article (hence the name "Research Report"). Consider your audience to be familiar with your field but not with your specific experiments. Write your research report as if the results are truly new. These reports will be graded and commented on to indicate how your writing, reasoning, and presentation can be improved. Please take the comments into account when preparing subsequent reports.

As you develop your paper, pay attention to overall structure. The Introduction starts broad and ends specific; the Discussion starts specific and ends broad. Focus also on how you structure each paragraph. Do not write 1-2 sentence paragraphs. Each paragraph should focus on one key idea that is articulated in the first (topic) sentence, and is elaborated in the rest of the paragraph. Also, work on good transitions between sentences and between paragraphs. A list of commonly used transition words will be given out in class. Aim for an overall length of about 10-12 pages (double-spaced), excluding illustrations. The reports should be printed double-spaced, except for the References. In writing the research report, you should communicate concisely the following four key topics:
The rationale for the experiment (why did you do it?)
The methods that were used (how did you do it?)
The results obtained (what did you find?)
An interpretation of those results (what does this mean?).

Format

You will use a primary research report format, which is standard for presenting new experimental data in scientific journals. Primary research reports consist of the following sections:

Title Page
Abstract
Introduction (Why did you do the experiment? Focus on Context, Focus and Justification)
Methods (How did you do the experiment?)

Results (What did you find?)
Discussion (What do the results imply? Limitations? Next experiments?)
References

Each research report should include these sections (outlined below in more detail). Except for the Title, Author(s), and Affiliation, these sections should be labeled in your research report.

Title Page

This page should include the title of the report, the author (you), and the author's affiliation (your affiliation is your Department and M.I.T.). The title should convey the subject of the report but should be more specific than the title of the assignment. E.g., "Fly Lab" would be too general.

Abstract:

The Abstract should be about 100 words in length, and should be printed double-spaced. Begin the Abstract on a new page. Give a concise summary of the report, including why these experiments are interesting, your hypothesis, a short description of Methods and Results, a brief Discussion. The final line should provide a "big picture" perspective, with possible implications of your work. Use one or two sentences for each topic, but keep the emphasis on the Results. Sentences in the Abstract should not be identical to those in the rest of the report.

Hint: Write your abstract last.

Introduction:

The Introduction should be less than two double-spaced pages. Start by describing the specific research area. Move from the broad background to more narrow concerns. Why should the reader care about this topic? Indicate your understanding of the relevant literature (readings for the lab session and other articles) by summarizing it and by noting how it applies to the particular question(s) you address. Cite the literature correctly (see Citation, below).

State the hypothesis that you tested, or indicate the question that you addressed. If relevant, identify the variables that were manipulated (independent variables) and those that were measured (dependent variables). The hypothesis might be stated in terms of the expected effect of the independent variable on the dependent variable (see Hypothesis, below). Remember that not all hypotheses have to be true or false. For example, the hypothesis "Fly tangential cells prefer stimuli moving at a particular speed on the retina," is not strictly true or false, but is, rather, a lead-in to ask such questions as, "If neurons are tuned to a particular speed, what speed is it? Are all neurons tuned to the same speed?" etc. And you may test more than one hypothesis. Although it is easier to write about one clear hypothesis and perhaps tangents from that hypothesis, this is not a rule. If you do try to test two hypotheses that seem to be distinct, then you should make this clear in your writing.

Once you have established the importance of your area of research and have stated your hypothesis, use the last bit of your introduction to provide a very brief description of the methods you used to test the hypothesis, the findings you obtained, and the most important conclusion you reached. Note: Introductions are written primarily in the present tense.

Hint: After you have written the rest of the report, revise your Introduction.

Methods:

The Methods section should provide enough detail for someone else to replicate your experiment. Clearly describe the techniques used. A figure of your basic set-up may be useful. Emphasize those aspects of your experiment that are critical to the testing of your hypothesis. However, omit descriptions of methods that are not specific to the experiment. Assume that the reader is familiar with the tools of the trade; e.g., there is no need to explain what an oscilloscope is or how to operate an audio amplifier. Methods sections are written primarily in the past tense.

The Methods section is broken down into subsections, each of which has a sub-heading. E.g., :

Animals. Indicate type (give genus and species), number, weight, sex.

Surgical procedures. Include method of anesthesia.

Procedure. Provide an accurate, chronological account of what you did. This section resembles the procedure section of the laboratory handout, but it is written in the past tense. The passive voice is often used to describe Methods.

Analyses. Describe methods used to complex analyze the data, e.g., "The neuronal response functions were estimated by multivariate regression..." For Fly Labs, indicate how the collected voltage data were analyzed to produce the plots and numbers shown in Results.

Results:

Here, you report the findings of your experiment. Like the Methods, the Results may be divided into several subsections. You may find it helpful to use an "inverse pyramid" style, in which you begin a paragraph or subsection by stating the general finding before going on to provide the detailed results. For example,

"Compound action potential (CAP) amplitudes are larger when more stimulation current is applied. Figure 2 shows a graph of CAP peak amplitude as a function of stimulation."

Most illustrations (Tables and figures) are included in the Results section. In fact, one way to think of the Results is as a description of the illustrations. Number illustrations consecutively (separate numbering for Tables and Figures), and be sure to refer to all of them in the text (see section on Illustrations below).

Hint: Start working on the Results by first sketching the figures you plan to make. Choose figures that illustrate the answer to the question that you set out to test. Once you have a set of figures to work with, begin writing the Results.

Discussion:

Start specific, with a brief description of the main results of the experiment and state your main conclusion: is your hypothesis true? Now try to convince the reader that these findings are of interest. What do they imply? The best strategy here is to relate your findings to the existing literature, noting any

similarities or discrepancies. An exhaustive search of the literature is not expected; rather, try to find one or two published papers that overlap with your study. Comment on the significance of your data. The scope here is broader than in the Introduction. Discuss any problems you encountered in conducting the experiment. What might have been done differently? Finally, outline directions for future work along the lines that you have discussed.

References:

Do not become overly concerned with tracking down all possible references. The goal is for you to learn how to cite, not how to do a full literature review. Thus, the assigned and supplemental readings will provide most of your sources. Of course, you are encouraged to find one or two additional sources, and we suggest that you search for them via PubMed maintained by the National Library of Medicine:

http://libraries.mit.edu/pubmed/

Once you have located an article that you would like to read, if it was published in the last five years, you can download it through M.I.T.'s library site:

http://libraries.mit.edu/vera

Courtney Crummett, the BCS Librarian can help you search PubMed to find appropriate references.

MIT Libraries has a resource guide for Citation Management:
http://libguides.mit.edu/references

MIT Libraries also provide access to RefWorks, a citation management tool:
http://libguides.mit.edu/refworks

Most importantly, you should have read the papers you cite.

Every citation in the text of your report (see "in text citation" below) should have a corresponding entry in the list of References. Conversely, do not list anything under References that is not cited in the text. Alphabetize your references according to first author's last name. Use standard abbreviations for journal titles, which should be italicized (e.g., *J. Neurosci).* Single-space the entries and double-space between entries. Do NOT use foot-notes to add reference citations. Use the following citation format:: first author, last name first, then other authors, then year of publication in parentheses, then title of article, then title of journal in italics, then volume number and pages. E.g.,

Andermann, M.L., Ritt, J., Neimark, M. A. and Moore, C. I. (2004) Neural Correlates of Vibrissa Resonance: Band-Pass and Somatotopic Representation of High-Frequency Stimuli. *Neuron* 42:452-463.

Hint: Double check that in-text citations match up with references, with regard to names and years.

In-text citation

Cite the literature by indicating, usually in parentheses, the authors' names and the year of publication. If there are only two authors, both are noted; if there are more than two, note the first author's name and

then write *et al. (et alia,* Latin for "and others"). If you mention the authors by name in your own sentence, simply give the year of publication in parentheses immediately after the authors' names. For example:

Multiple memory systems have been identified in the visual cortex (Desimone *et al.,* 1995). One such system was found to recall vertical movement only (Smith and Brown, 1997). However, Owens and Jones (1998) conclude from their study that a second system may be involved...

Abbreviations
Introduce abbreviations the first time a term is mentioned, and then use the abbreviation consistently throughout the report. The abbreviation is first given in parentheses. For example, "Compound action potential (CAP) was measured by..." Use standard abbreviations when available. Be judicious in choosing which key terms to abbreviate; too many abbreviations cloud the writing.

Illustrations

Illustrations (tables and figures) in scientific texts are not only an accepted format for relaying ideas, they are essential. In the neurosciences, images are crucial to conveying information and ideas. More data can be packed into a single illustration than described in several pages of text. Use illustrations to complement and amplify your main findings, and err on the side of including too many figures rather than too few.

Numbering Figures, Tables and Captions:
Number tables with Roman numerals (I, II, III, IV, etc.) and place number and tide above the table. Don't include long, descriptive captions for tables; instead, use footnotes, but do so sparingly. For statistical analyses, specify the type of test that was performed and the p values. For graphs, include error bars.

Number figures with Arabic numerals (1, 2, 3, etc.); place number and legend below the figure. Make Figures and their legends "stand alone" – i.e., the legend caption should give the reader enough information to understand the figure without referring to the text. For example,

"Figure 1. Effect of chocolate on alertness of M.I.T. students. Amount of chocolate, in grams, consumed per hour was plotted against time spent sleeping in class. Red = women; blue = men."

Note: a graph is considered a figure. Here are there are three types of figures that you may wish to use in your research reports:

Data figures
Primary data should be presented as figures, typically graphs. Also, 2D and 3D images of data surfaces are good if used appropriately. Make sure the graphs are clearly labeled and can be easily understood by reading the caption.

Method figures
In the Method figure, an image is used to make the set-up or approach to data acquisition clear to the reader. Examples of this kind of figure are DiCarlo and Johnson (1999), Figure 1 (shown below), and Andermann *et al.* (2004), Figure lA.

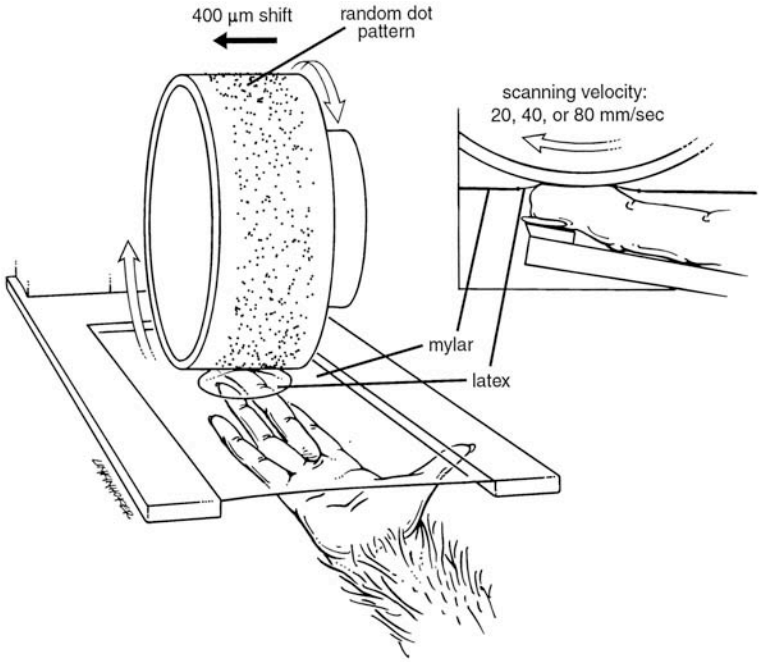

Figure 1. Drum stimulator. The stimulus pattern consisted of a field (28 mm wide × 175 mm long) of randomly distributed, raised dots on a plastic surface, mounted on the surface of a drum, 320 mm in circumference. The dot pattern stimulated the skin through a thin latex sheet positioned over the distal fingerpad that contained the neural RF. The latex intermediate was tethered to a circular aperture in a Mylar sheet supported by a Plexiglas frame. The hand and finger were held fixed from below and the intermediate contacted the fingerpad with a force of 10 gm. The purpose of the intermediate latex sheet was to minimize lateral skin movement caused by tangential, frictional forces between the surface and the skin; as a further precaution, these forces were minimized by lubricating the pattern surface with glycerin. The drum rotated with controlled normal force (30 gm), producing surface pattern motion from proximal to distal over the fingerpad. The scanning velocity was fixed at 20, 40, or 80 mm/sec for each scan through the random dot pattern. After three drum rotations (one at each scanning velocity), the drum was translated by 400 µm along its axis of rotation. The data entering into the RF estimates were derived, on average, from 25 scans at each velocity, which corresponded to 10 mm of translation.

Conceptual figures

The Conceptual figure illustrates a model, theory, or simply a clear way of thinking about what you are reporting on. Examples are DiCarlo and Johnson (1999), Figure 1 and Neimark *et al.* (2003), Figure 1 (shown below) and Figure 8.

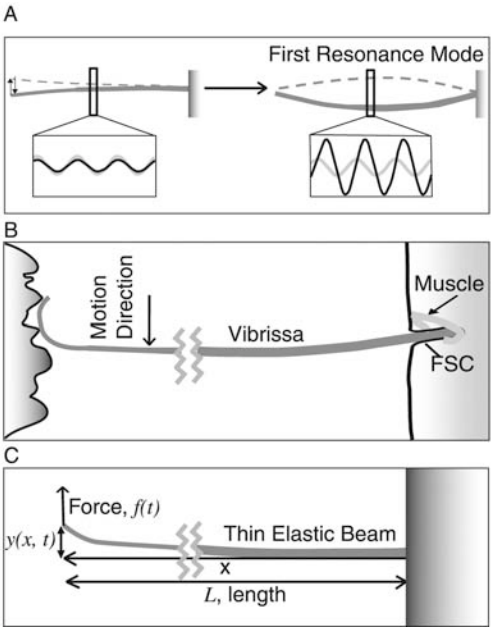

Figure 1. A diagram of a TEB expressing resonance and the vibrissa sweeping past a surface. *A*, Left, When stimulated at frequencies lower than the FRF, TEB motion reflects the amplitude of displacement. Right, When driven at its FRF, a TEB demonstrates a significantly larger amplitude motion at its resonance mode. The increase in motion amplitude at this mode is accompanied by a 90° phase shift. Insets: gray, stimulus wave form; black, TEB motion. *B*, As the vibrissa sweeps past a surface, spatial frequency components in the surface exert a time-varying force on the vibrissa, causing it to deflect at specific temporal frequencies. As with the TEB motion in *A*, this action should induce resonance in the vibrissa. The vibrissa base is secured in the FSC. *C*, A diagram of the axes and directions of motion used in the model.

General points concerning writing

Scientific writing should be, above all, clear. Make sure you proofread your report to eliminate errors of grammar, spelling and usage. If you need help, speak to the writing instructor assigned to the course or make an appointment with a tutor in the Writing Center in the basement of Stata (appointments can be made online).

Second, construct each paragraph around a single idea. Include, usually at the beginning of the paragraph, a topic sentence indicating what that paragraph will cover. For example, if a given paragraph discusses prior studies of vibrissa resonance and the fact that only one previous study was carefully conducted, then the following would be an appropriate topic sentence: "Several prior studies have investigated vibrissa resonance properties, but only the study by Neimark *et al.* (2003) was conducted properly."

Third, provide orienting paragraphs at the end of the Introduction and at the beginning of the Discussion that give the reader a scope of the entire theme of the report. In both cases, state the major findings and their implications. If the idea of topic paragraphs seems redundant-- it is! Redundancy in the service of clarity is not a crime, and in general, you should repeat the main points of the paper several times in different ways.

Clean up your writing by always following the word "this" with a noun, a noun phrase or a gerund to explain what "this" refers to. For example, "We were given a Supplement on style for our research report. This document was helpful." Aim for conciseness.

Research report grading criteria

Each of your research reports will be graded in two overall areas:
1) The quality of the writing (structure of the paper, format, clarity and conciseness of writing)
2) criteria specific to the topic of the report (how well did you address specific topics and questions in the topic area ?)

The total points will be divided roughly in half between these two areas. For each research report, we will provide a worksheet describing the details of these expectations. We will post this worksheet online so that you can review these criteria while you write your papers.

In addition to instructor grading, a writing instructor will evaluate your first research report. She will critique a draft of your first report in depth for style, format and clarity. See the course schedule for submission dates. After her evaluation of this draft, you will have the opportunity to take the commentary and use it to refine the report further before your final submission of this research report. We hope that you will gain invaluable writing style tips from this evaluation that you will be able to use for the subsequent research report and for further writing outside of this course.

9.17 Systems Neuroscience Lab

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