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# WRITING AND REWRITING FOR SCIENTIFIC COMMUNICATION



# Contents

<i>1</i>	<i>Introduction</i>	<i>5</i>
	<i>1.1 Readings for the workshop</i>	<i>6</i>
	<i>1.2 Workshop schedule</i>	<i>8</i>
<i>2</i>	<i>Day 1: Sentences</i>	<i>11</i>
<i>3</i>	<i>Day 2: Openings</i>	<i>15</i>
<i>4</i>	<i>Day 3: Paragraphs</i>	<i>19</i>
<i>5</i>	<i>Day 4: Arguments</i>	<i>21</i>
<i>6</i>	<i>Day 5: Words</i>	<i>23</i>
<i>7</i>	<i>Wrap-up</i>	<i>25</i>



I

## Introduction

Welcome to our one-week writing workshop! This workshop is meant for students who are working on a manuscript that they plan to submit for peer review at a scientific journal. We'll be focusing on how to structure and rewrite your manuscript to make it clearer and easier to read.

There are a number of things that are important that we won't cover here:

1. **Grammar and usage.** These are both very important, and you'll want these to be impeccable when you submit your manuscript. However, there are loads of resources and courses for this, and while I often see cases where students haven't mastered this yet, I don't think it's hard to find the resources to learn these. Also, at least through your graduate career, you will almost always have co-authors, including a senior author (typically the head of your research group). Grammar and usage problems are easy to fix quickly when your senior author edits your paper. The things we will cover here take more time and work.
2. **Doing a literature review.** This is an art of its own. It's very important for your manuscript to use good examples from the literature to set up why your study is important and to put what you find in the context of previously published studies. If you are pursuing a graduate degree, you will need to explore the literature enough to understand the current state of science in your field and how your work fits into the field. With certain types of manuscripts, like commentaries and reviews, the whole manuscript might be a synthesis and exploration of the literature. Ideally, you will have done quite a bit of work to explore and get examples from the literature by the time we do this workshop, as this will provide some of the raw material for your manuscript. However, we will only tangentially discuss how to explore and review the literature. This will be in the context of building and presenting arguments in your manuscript, as evidence from the literature will often be needed to do this, particularly in the Introduction and Discussion.
3. **Creating effective figures and tables.** This is also extremely important. At worst, bad figures and tables can make a manuscript look unprofessional.

If they do, then a reviewer may worry that the research presented in the study is similarly sloppy or poorly done. Figures and tables are the best chance to immediately engage a reader, and they'll often stick with the reader, if they're good, much longer than the text. They also serve double-duty, as you'll use them in presentations you make about the research. Finally, a really good figure or table encourages the reader to explore the results from the research deeply, and start looking for patterns or trends that suggest ideas for next steps for the research area. Manuscripts are more likely to get cited, and to have a higher impact on your field, if readers leave the paper with ideas of research they want to do to take the next steps. There are some excellent resources for learning how to design and create figures and tables. I particularly like books by Edward Tufte and Howard Wainer. There are also a number of books on visualization that are specific to a programming language, like R or Python.

4. **How to get words on paper.** Our focus will be on improving and revising a manuscript once you've already got some stuff down on paper. We won't talk much about how to get the stuff down in the first place. There are some good books on the topic of writing initial drafts. Different writers have different styles for this. Some will work very hard on the first draft, so that rewriting doesn't need to be extensive. I tend to start by writing a lot, but all of it pretty messy, and then wrangling and editing that raw material into a more solid draft. I usually do lots of rounds of drafts, first moving big parts around to form the larger structure of the paper and to see where there are holes that need more evidence or support. Then, in later drafts, my editing process involves drilling down to make the writing clearer and easier to read. In this workshop we'll focus on the work involved with the later stages of editing. If you'd like to learn more about tips and techniques for earlier stages, where the focus is generating your starting material, I like the books of Peter Elbow. Stephen King's *On Writing* is also great, particularly in inspiring you to get something down even when you're discouraged (by bad reviews or by how big the task seems, for example).

Click on the **Next** button (or navigate using the links at the top of the page) to continue.

## 1.1 Readings for the workshop

We will be reading and trying out the ideas from several books for this workshop. They all have connections to Joseph Williams *Style* book, which has gone through several editions (and titles) since it was first published in the 1980s.

There are a lot of good writing books out there, but this is by far my favorite. I regularly pick it back up when I am editing manuscripts, particularly when I have a section of a draft that I am struggling to write clearly. What I like about it is that it focuses on how we can edit our writing to make it easier

for readers to read and understand. It bases its advice on how readers process information as they read, and it gives advice that is easy to use to diagnose problems and fix them.

I cannot overstate how important it is to edit your scientific manuscript until it can be read easily (and feel “quick” to read) and until it is hard to misunderstand. You are moving into work where you will be the expert in the room. You will know your very specific topic better than all but a handful of people in the world, and often better than the editor and reviewers for your manuscript. You are teaching through your manuscript, and the text must be clear for readers to learn what you’ve learned.

Also, scientific papers are hard work to read, even when they are written beautifully. As the reader, you must work to understand the science and statistical methods that were used to generate results for the paper. Your mind works hard to integrate the paper’s results with what you know from other papers in the field. If the writer does not make the writing clear and easy to read, it can feel impossible to read the paper, because your brain can’t simultaneously try to figure out what the writer was trying to say and what the science in the paper is saying. You have worked hard on your science. It’s worth the effort to edit your manuscript until you remove all overhead and make the writing easy to read.

Most people, even senior scientists, write first drafts that are a drag to read. Even if all the information is there, it’s a lot of work to mentally extract it, and it’s often hard to follow along with the arguments and explanations. It’s fine for your early drafts to be like that. It’s not good for the submitted manuscript to still feel so heavy.

The examples in *Style* are mainly from academic writing, although not specifically from scientific manuscripts or manuscripts meant for peer review. Fortunately, two other writers have taken Williams’s ideas and illustrated how they work in scientific writing. Further, they give some tips specific to scientific writing, including how to plan and structure certain sections—like the Introduction and Discussion. These are the second and third books on the list.

The fourth book in the list includes a section on arguments. We often don’t think of scientific writing as argumentative, but it really is. You will need to convince readers that your study is important, that it advances the science. Then you’ll need to not just present your results, but provide an interpretation for those results. You will need to walk your readers through why those interpretations are reasonable and appropriate. While many students come into graduate school with a reasonable mastery of grammar, they often present their arguments in a way that is scattered and diffuse. Often, when I am editing manuscripts with first authors who are students, much of the editing process is related to finding and fleshing out their arguments. We won’t be able to go deeply into rhetoric in this workshop, but we will cover the basics of building arguments in your writing based on the advice in this book.

The full list of books for the workshop is:

1. *Style: The Basics of Clarity and Grace (2nd edition)* by Joseph Williams. (This edition is no longer in print. I prefer the earlier editions, which are shorter. There tend to always be used copies available on Amazon. There also seems to be a pdf of an early edition version available online that you can use before your print edition arrives.)
2. *Writing Science in Plain English* by Anne E. Greene.
3. *Writing Science* by Joshua Schimel
4. *The Craft of Research (4th edition)* by Wayne C. Booth, Gregory C. Colomb, Joseph M. Williams, Joseph Bizup, and William T. FitzGerald.

We will also use three published articles as examples. None of these are traditional research articles, but rather cover a range of commentary/editorial-style articles. All three should be available either directly online or through CSU. Please let me know if you have any problem accessing any of these articles.

1. Gall, Melanie, Kevin A. Borden, and Susan L. Cutter. "When do losses count? Six fallacies of natural hazards loss data." *Bulletin of the American Meteorological Society* 90.6 (2009): 799-810.
2. Cheplygina, Veronika, et al. "Ten simple rules for getting started on Twitter as a scientist." *PLoS Computational Biology* 16.2 (2020): e1007513-e1007513.
3. Schwartz, Sharon. "The fallacy of the ecological fallacy: the potential misuse of a concept and the consequences." *American Journal of Public Health* 84.5 (1994): 819-824.

I have picked these papers because they all provide important ideas and advice, and they all have some strong writing. In particular, they have a clear overarching structure and state and defend their arguments well. Also, like most published papers (mine included), they include examples where sentences or paragraphs could be edited to be easier to read and harder to misunderstand. They therefore provide some nice examples of both the good and the bad (none get into "the ugly", but you won't have to look too far in the scientific literature to find some that do), and so we can see that even very good papers have room for further editing and try our hand at doing that.

## 1.2 Workshop schedule

Each day of the week, we will focus on a different topic.

Schedule:

- **Day 1:** Sentences
- **Day 2:** Openings
- **Day 3:** Paragraphs
- **Day 4:** Arguments
- **Day 5:** Words



You can navigate to the material for each day through the table of contents links above.



## 2

### *Day 1: Sentences*

We will cover several different techniques for editing and rewriting your manuscript, and they will target different parts (e.g., Introduction, Results) or levels (e.g., paragraphs, sentences) of your manuscript. Some will take a lot of mental work and editing to put in place. We will start, however, with some techniques that are easy to do, and make a huge difference in how easy your manuscript is to read, but that are underused in science. These techniques focus on editing at the sentence level.

To learn these techniques, you will be reading several chapters of the Joseph Williams book (*Style*). If you haven't received that one yet, you can find link to an online scan of an earlier version (like the one I've sent you) [here](#).

The techniques are revisited in the other books I sent, all of which are built on the ideas that *Style* presents. I'll include some suggestions for additional readings from some of the other books, and you can use that if you feel like you haven't mastered the ideas yet from reading the *Style* chapters (or if you're so excited about them you want to see more examples!). If you'd like examples from scientific writing, you can find them in the suggested additional reading from *Writing Science in Plain English* and *Writing Science*.

#### **1. Read Chapter 1 from *Style*.**

This first chapter sets up Joseph Williams's goals and philosophy for the book, and it captures nicely what we'll be trying to do through our workshop this week. Notice in particular that we won't be focusing on "correct" or grammatical writing, but instead on editing to make things easier for our readers.

#### **2. Exercise: Read and rank the three example papers**

In the Introduction, I've included links to three papers that we'll use as examples, in addition to working with your own manuscripts. Read these three papers and rank them (1 as best to 3 as worst) in terms of: (1) how easy you found it to read; (2) how much you enjoyed reading it; (3) how much you learned by reading it.

### 3. Read Chapter 2 from *Style*.

This chapter explains how you can think of sentences in terms of characters and their actions, and how you can diagnose if a sentence is not divided into subject and verb in a way that highlights these elements. While it may seem that this idea would be more important in fiction, this chapter provides examples of how it can clarify sentences in academic writing.

*Additional reading.* If you would like more information on the ideas in this chapter of *Style*, you can also check out Chapter 3 from *Writing Science in Plain English* and Chapter 17.2 from *The Craft of Research*.

### 4. Identify the characters in the example papers.

In the three example papers, re-read the Introductions. List three to five main characters in the Introduction of each paper, using the explanation of “main characters” that Joseph Williams provides in Chapter 2 of *Style*. Remember that, in some cases, characters can be concepts.

Next, identify the characters in the following sentence:

“The use of the ecological fallacy to explain the discrepancy between individual and ecological correlations may have unintended consequences.” Schwartz, 1994

Try to rewrite the sentence to conform with the first two principles of clear writing (p. 21 of the online version of *Style*).

Do the same with the following sentence (it may help to replace the semi-colon with a period and diagnose / fix the resulting two sentences separately):

“For these reasons, using Twitter appropriately can be more than just a social media activity; it can be a real career incubator in which researchers can develop their professional circles, launch new research projects and get helped by the community at various stages of the projects.” Cheplygina et al., 2020

### 5. Identify the characters in a paragraph of your manuscript.

Pick a paragraph of your manuscript. List three to five main characters in that paragraph. In the sentences in these paragraphs, are the main characters the subjects of the sentences? Are there any examples where the action is in abstract nouns (e.g., knowledge, determination) rather than in verbs (e.g., know, determine)?

Pick one sentence of this paragraph. Rewrite it two ways. First, rewrite it in a way that violates the first two principles of clear writing (p. 21 of the online version of *Style*) and then in a way that conforms with these principles.

Next, read through the full paragraph and try to diagnose every sentence that is problematic, from this perspective. Use the following advice from the *Style* book:

“A quick method is simply to run a line under the first five or six words of every sentence. If you find that (1) you have to go more than six or seven words into a sentence to get past the subject to the verb and (2) the subject of the sentence is not one of your characters, take a hard look at that sentence; its characters and actions probably do not align with subjects and verbs.”

If you do not find any in this paragraph, look through other paragraphs in your manuscript. Write down up to three sentences that you find, and we'll work together to diagnose if they do indeed have this problem and, if so, fix them.

## 6. Identify and replace nominalizations.

In Chapter 2 of *Style*, Joseph Williams defines *nominalizations* and explains how they can confound clarity in a sentence. Identify any nominalizations in the following sentence:

"We begin with a description of the validity framework and the definition of key terms." Schwartz, 1994

Rewrite the sentence without any nominalizations.

Next, find three sentences from your own manuscript with nominalizations. There are some tips in the section in Chapter 2 on "Looking for Nominalizations". Write these down, and then try rewriting them to remove the nominalizations.

## 7. Editing sentences in a paragraph.

Using all the techniques from Chapter 2, diagnose problems in the following paragraph and rewrite it:

"Natural hazard losses exhibit an upward trend over time. This is a function of increases in wealth and population but is also attributed to better loss accounting in recent years. The escalating pattern of hazard losses is therefore partially an artifact of advances in reporting losses, but how much or how little this effect contributes to the skyrocketing losses in comparison to effects of population growth and increasing wealth in high hazard areas is unclear." Gall et al., 2009

**All the following steps are things for you to try after our workshop meeting on "Sentences".**

## 8. Read Chapter 3 from *Style*.

This chapter takes the next step—it starts considering how sentences fit within a paragraph, and how ordering the information in the sentence can help the flow across the paragraph.

*Additional reading.* If you would like more information on the ideas in this chapter of *Style*, you can also check out Chapter 7 from *Writing Science in Plain English*, Chapter 12 in *Writing Science*, and Chapter 17.3 from *The Craft of Research*.

## 9. Identify topics in a paragraph of your manuscript.

Pick a paragraph of your manuscript. Identify all the topics in the paragraph. Is there a consistent topic string, as defined in Chapter 3 of *Style*? Are your topics visible? Revise your paragraph based on this diagnosis.

Next, read through all the paragraphs in your manuscript. Highlight the topics throughout. Are there certain sections where it looks like the topics might not be very visible, or where there may be too many topics in a paragraph?

**10. Read Chapter 4 from *Style*.**

This chapter discusses strategies for ending sentences, to emphasize the point you want to emphasize. This chapter is helpful, but you'll get more immediate mileage from mastering the content in Chapters 2 and 3. For now, read through this chapter so you can mull it over, but I don't have any exercises for you based on it.

# 3

## Day 2: Openings

On Day 1, we focused on mechanics rather than content. Today, we'll talk about content, focusing on your Introduction. I usually find this section the hardest to write, and I'll often put it off until last. You need to draw in your reader and convince him or her that the rest of the paper is worth reading (and, for a research article, that the science was worth doing). If a reviewer is going to hate your paper, he or she often decides by the end of the Introduction (based on review comments I've gotten for past papers). And while the other reviewers won't decide that they love it by that point, they can be convinced that they are in reasonably good hands, and that you are competent in the area and familiar with the field and open problems in it.

*Writing Science* discusses the job of an Introduction in a scientific paper, and how an Introduction can fail. For today's meeting, you'll be reading through several chapters in this book, evaluating whether and how the Introductions in the three example papers do their job, thinking about how to frame the Introduction for your manuscript.

### 1. **Summarize your manuscript.**

In 2–3 sentences, describe what your manuscript covers.

In 2–3 more sentences, explain why your manuscript is important in advancing science in your field.

### 2. **Read Chapter 4 of *Writing Science*.**

This chapter explains common story structures, and how they can be applied to scientific writing. Near the end of this chapter (section 4.3), it presents the key components of a paper's Introduction, Methods, Results, and Discussion.

### 3. **Identify key Introduction components in an example paper.**

Re-read the Introductions of the example papers by Cheplygina et al. and Schwartz. Try to identify the following components in the Introduction:

- What is the larger problem that the paper will be tackling?

- What is the relevant context for that problem?
- What are the key characters?
- What background information is given to help the reader understand the specific work in the paper?
- What is the “challenge” (“the specific hypotheses/questions/goals of the current work”)?

Go through each of these two Introductions and use three different colors to highlight elements that you think are part of the Opening, the Background, and the Challenge, based on how those parts are explained in this chapter. (You will be reading other chapters today that go deeper into these ideas, so you may come back and revise your answers based on your later reading.)

#### 4. **Read Chapter 5 of Writing Science.**

This chapter covers the very first part of the Introduction, which the author calls the “Opening”.

#### 5. **Diagnose the Opening for an example paper.**

Re-read the first paragraph of the Schwartz paper. Based on this paragraph, who do you think is the intended audience for the paper? What is the larger issue the paper will address? Do you think that they are properly “advertising” what they will later cover in the paper?

#### 6. **Define Opening components for your paper.**

Write down the following for your own manuscript:

- What is the target audience? Is it broad / interdisciplinary or targeted to researchers in a certain field?
- What is the larger issue that the manuscript will address? In writing this, be sure to be clear about the scope with which the manuscript will cover this issue.
- What are a few elements of the issue that are interesting but that your manuscript will **not** address?

#### 7. **Revise the Opening for your manuscript.**

Take a look at the first paragraph of your Introduction in the context of your answers to the questions in the previous prompt. Does your Opening need the whole paragraph, or just the first sentence or two? Does this first paragraph include any signals to clarify what audience you expect for the manuscript? Does the paragraph give readers clues on the larger issue that the manuscript will address? Does the paragraph “overpromise”, indicating that the manuscript will cover a larger scope than it does?

Write a revised version of your first paragraph where you address any limitations of your previous draft of your Opening.

**All the following steps are things for you to try after our workshop meeting on “Openings”.**



**8. Read Chapters 6 and 7 of *Writing Science*.**

Chapter 6 covers how to move from the Opening of your Introduction to the Challenge that you present before moving into other parts of your paper. Chapter 7 discusses how to end an Introduction with a “Challenge,” motivating everything you present in the rest of the manuscript.

**9. Evaluate the Funnel and Challenge of example papers.**

Re-read the Introductions for the three example papers. Find and write down the text in each paper that presents the Challenge of the paper.

Next, re-read the Introduction of the Gall et al. paper. How does the Introduction funnel the readers from the Opening to the Challenge at the end of the Introduction? What background information does it give readers to help them understand and appreciate the Challenge? What examples do they use from the literature to convince readers that their Challenge is important?

**10. Define the Challenge of your manuscript.**

In 1–2 sentences, write the Challenge of your manuscript.

Look at the draft of your Introduction. Is this Challenge clear in the text? If so, is it at the end of the Introduction, or somewhere else?

Write down three pieces of background information that you think it is critical for your reader to know to believe that your manuscript’s Challenge is important. Draft a paragraph one each of these explaining and presenting the background information to readers.

Write down two examples that you think might help readers understand why your Challenge is important. Draft a few sentences presenting each of these examples.

Revise your Introduction to integrate your drafted material on the background and examples.

**11. Read Chapters 8 and 9 of *Writing Science*.**

These next two chapters move into advice on writing the body of the manuscript (the “Action”, which often includes Methods and Results) and the “Resolution” (typically the Discussion). Think about what you’re hoping to achieve through these later parts of your manuscript.



# 4

## *Day 3: Paragraphs*

Today, we'll be moving back from content to mechanics. Today, we'll talk about editing for clarity at a different level, the level of paragraphs. We will look at how we can move around text in a paragraph to make it easier for a reader to quickly understand what they should get out of a paragraph and to easily follow ideas in the paragraph.



5

## *Day 4: Arguments*

**Literate programming.**



6

## *Day 5: Words*

The `ggplot2` framework is a





# 7

## Wrap-up

If you're doing it right, you will continue working to improve your writing your whole career. We can only cover a bit in one week. Here are some tips for things to do to continue:

1. **Read a lot.** Ultimately, you will have to read a lot of journal articles in your field to internalize the style of your field. By “style” here, I mean things like what the Introduction normally covers (and in what depth), how limitations of the study are discussed, how much detail should be included in the Methods, and how materials are split between the main text and the Supplemental Online Material for manuscripts. As a student, you will need to read a lot anyway to become familiar with the literature. In later stages of your career, you will read a lot (of varying quality) through service roles, like as a peer reviewer. At all stages, you will learn more about what works and what doesn't, what's expected and what isn't, in your field if you read a lot of journal articles in that field.
2. **Find some favorite authors.** For environmental epidemiology, one of my favorite authors is Ben Armstrong. He can explain very complex methodological approaches very clearly. For R programming, I love reading things that have been written by Jenny Bryan and Richie Cotton.
3. **Work on grammar and usage or find a good copyeditor.**
4. **Try out writing groups and sessions.**
5. **Explore brainstorming, planning, and organizing tools for writing.**
6. **Learn LaTeX.**
7. **Find your favorite text editor and learn to use it well.**
8. **Learn more about rhetoric.**