Opinionated Principles for Scientific Writing

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GENERAL PRINCIPLES

Scientific writing does not have to be boring

- "There is no form of prose more difficult to understand and more tedious to read than the average scientific paper." -- Francis Crick, *The Astonishing Hypothesis*
- If doing science were as boring as most scientific writing, none of us would bother
- Scientific writing is telling a story, albeit a story strongly buttressed by data.
- We are taught to write in third person passive voice using lots of jargon with no emotion. No interesting story is told this way: "One piece of fruit from the *Malus domestica* tree, which was suggested to have contained 12 mol./cm^3 of cyanide, was eaten by Snow White."
- Good storytelling involves some breaking of the rules (but not so much that traditionalists are outraged).
- Although we are taught that every intro has to end with a hypothesis and hypotheses are expected to be proven, the reality of science is that much is discovered by serendipity. It should be perfectly acceptable to acknowledge such serendipity and surprising results as such.

Goals of Writing

1. "Publish or perish"
2. Develop a good reputation

- In academia, we tend to emphasize the number of papers; however, the quality and the reception of the papers is also important and is often underemphasized
- For example, granting agencies may consider other factors (e.g., in the "Greatest Hits" section of a grant) such as citation counts
- The number of people who read and cite your papers depends on how well you communicate your ideas and their importance
- "Every profession is sales": In science, you are selling your ideas and your reputation

Learning to write is learning to edit yourself

- Many students do a brain dump, edit it once and call it done, expecting the advisor to clean it up
- You should be giving your advisor work that you feel you've put your best effort into, not some half-baked writing that you've been too lazy to improve yourself
- Good writers edit themselves repeatedly, ad nauseum
- Keep editing yourself until you can't see any changes, your changes make it worse, or the thing is due
- Editing often works best when done after a hiatus
    - I often leave the piece overnight and edit it again the next morning
    - I find I catch more of my mistakes on a paper hardcopy than on the screen
- Don't always start editing at the beginning or the beginning is perfect and the end is lousy

- Sometimes reading your writing aloud to yourself can reveal awkward passages

Macro vs. micro level

- "forest vs. trees"
- Macro level
  - "forest"
  - thesis evaluation calls it "content"
  - are the experiments good and appropriate
  - do the ideas flow logically and smoothly
- Micro level
  - "trees"
  - thesis evaluation calls it "form"
  - do sentences flow logically and smoothly
  - is grammar correct
  - is writing concise and easily digestible

Get Macro in place before Micro

- There's no point having a perfect sentence if you end up cutting the whole paragraph or section
- The hardest part of editing is dealing with macro before micro
- Make an outline and discuss it with your advisor before you start writing prose (particularly if you are bad at micro-writing)
- Make sure your advisor is good with the macro before perfecting the micro

Start writing a paper with the results

- I like Tutis Vilis's approach of starting to decide how to write a paper by beginning with the figures.
- Start by preparing a set of figures (they don't have to be perfect) that illustrate what's going on in the data
- Plan your figures to tell the story
- You can write a methods section and parts of the intro before you know the results but the results and discussion sections hinge on the story and the spin
- A good way to write a paper is Methods-Figures-Results-Intro-Discussion-Abstract

Write in "trickle-down" newspaper style;

- Newspaper articles start with the key info and then get into the details
  - Headline (e.g., Gunman Opens fire at college)
  - 1st part – take home message (A gunman opened fire at a Montreal college yesterday)
  - 2nd part – major details (e.g., One woman died, several in critical condition; Gunman was Kimveer Gill)
  - 3rd part – medium details (e.g., Gill was a Goth loner who posted on vampirefreaks web site)
  - 4th part – minor details (e.g., Gill bought guns legally through a gun club; College is closed till Monday)
- Your writing (esp. Methods and Result sections) should often follow this pattern. Put the important stuff first and the details later.

- Reader should be able to stop at any point having extracted the most important details

Corollary: Alice Tarnava's first sentence rule

- The first sentence of every paragraph should tell you what the paragraph is about
- You should be able to (mostly) understand a paper by reading only the first sentence of every paragraph

Don't be overconstrained by traditional format

- Unfortunately experimental psychology courses teach you to follow fixed formulae for writing
    - For example, Conventional Wisdom says the Methods section must consist of subheadings like Participants, Apparatus, Stimuli, Procedure
- Journals are being less rigourous about this than they used to be
    - Example: Many high-profile journals are going with Intro-Results-Discussion-Detailed Methods order rather than traditional Intro-Methods-Results-Discussion order
- I believe this reflects a growing emphasis on readability

Know your audience

- One of the first things to think about as you write is who your audience will be
- This is particularly important for things like scholarship applications
- If you are submitting an experiment proposal, you will write it differently from your advisory committee than the OGS scholarship committee where the readers may be professors from other fields
- When writing your thesis, be aware

Corollary: Know the journal (also see Choosing a Journal section below)

- For journal articles, decide where you want to submit the manuscript before starting to write it and notify your colleagues who are editing it

Know how people read

- Your readers are time-pressed academics, not vacationers on a beach
- Most are going to read things as quickly as possible to get the gist
- A few are going to read things carefully and critically
- Your reader may be reading long pieces in short bursts
    - e.g., your thesis committee members may read a chapter or two of your thesis at one time, with long interruptions
- Your reader may be frequently interrupted
    - e.g., a surprising number of things get read on airplanes and your reader may be disrupted by crying babies or flight attendants selling duty free goods every 10 min
- Don't overestimate your reader's attention span
    - e.g., don't assume that while reading experiment 4 of your thesis, they remember what you did in experiment 1
- Some repetition is good (but don't overdue it)
- Your reader should be able to get the basics of your article by

    - reading the abstract
    - skimming the intro
    - reading the intro-methods transition
    - looking at the figures
    - skimming the discussion
- See my advice, "How to Read a Journal Article"

Use direct subject-verb relationships, including the active voice where appropriate

- Many students think that indirect phrasing sounds more scientific but it's just boring and cumbersome
- Most scientists are taught to write in the passive voice to sound more objective but it too can be cumbersome
- Again, throw Conventional Wisdom out the door and aim for readability
- It sounds less egotistical to use "we" than "I"; however, in a thesis, "I" is expected to have done the work
- Examples
    - Bad: "It was determined that the activation was higher in Condition A than B"
    - Okay: "We determined that the activation was higher in Condition A than B"
    - Better: "The activation was higher in Condition A than B"
    - Better: "Condition A generated higher activation than Condition B"

Dealing with writer's block

- You are going to have bad brain-dead days where you can't write a Post-it note, let alone a thesis
- That's okay if it happens occasionally. If it happens all the time, it suggests problems with writing and you have to bite the bullet and begin

"The way to do things is to begin"
"How do you eat an elephant?" "One bite at a time."

- Don't just sit down and stare hopelessly at a blank screen waiting for divine intervention
- There's no big secret to writing: Start it. Continue it. Finish it. Edit it. Edit it more. Edit it more still.
- If you can't write a hard part, work on an easy part (e.g., Methods)
- Start with an outline. Fill it out a bit. Fill it out more. Keep going.
- Make yourself start writing for an hour. When you get on a roll, keep going till you burn out

Transition words and linking phrases are very important

- Some students miss the transitions when going from an outline to prose
- Connect ideas, not points
    - Bad: Ren and Stimpy (1992) found X. Pi and Pu (2000) proposed Y→Z. Pinky and Brain (2001) found Z.
    - Better: Based on the finding of X (Ren & Stimpy, 1992), Y was thought to cause Z (Pi & Pu, 2000), a finding that was indeed confirmed (Pinky & Brain, 2001).

- There are a wide range of transition words/phrases that can convey relationships between ideas
    - **Caveats**: However, but, nevertheless
    - **Cause and Effect**: Therefore, then, consequently, if… then
    - **Support**: In addition, furthermore, moreover, also, indeed
    - **Contrasts**: In contrast, whereas
    - **Summary**: In sum, in conclusion, to summarize
    - **Examples**: For example, for instance

SECTION-SPECIFIC ADVICE

Methods sections

- Two goals of a methods section
    1. Convey the gist of the experiment to the casual reader well enough that they can understand the results section
    2. Provide the details for the aficionado in your field who might want to replicate or extend your study
- Sometimes you can't explain your apparatus until you know what the goal and procedures are
- Most people don't give a flying ^%$# about the retinal angle of your stimuli, the type of computer you used to present your stimuli, or the time to echo in an imaging experiment (unless these things are particularly unusual for a given study). However, someone who wants to replicate or extend your experiment might. Make these secondary points.

Results Section

- Figures are the most important part of a research project
- The data are objective, the interpretation is subjective
    - Good scientists evaluate the figures themselves and don't just read the interpretation
- They should tell the story visually. Your reader should not have to do any more reading than necessary to understand your figure
- Wherever possible, put key information (e.g, legend) in the picture rather than in the figure legend
- Stats are excruciatingly boring. Don't force the reader to read any more stats than necessary
- Summarize the take home message in the first sentence of a paragraph. Support that statement with stats
- Where appropriate, put dense information into a table rather than into text.
- When preparing your figures, especially the final versions once the paper is accepted, think about how the image will appear on the printed copy in the journal (aspect ratio, font sizes, etc.)
    - Be aware that journals typically squeeze figures into smaller spaces than you think they should

Introduction

- "Who knows, who cares, why bother?"
- You want to lead the reader to the conclusion that your experiment answers the most logical next question in an area of research
- In a journal article, you want to convey enough of the background to motivate your research question. However, do not add extraneous information… leave subtler stuff till the discussion
- In a thesis, you may be expected to provide a more comprehensive overview of your research topic
- Two possible approaches
  1. Spell out your question, then outline the logic behind it, then summarize it again
  2. Walk the reader through the background, then lead up to your question
- I like to end the introduction with a paragraph or two that summarizes the question, the brief method, and sometimes the hypotheses
- Be sure to convey why the experiment is interesting and informative

Discussion

- "The discussion is the part of the paper where the writer got tired of thinking"
- This is the part of the paper where you want to end with a bang not a whimper
- Now that you know the answer to your question, what does it mean?
- Begin with a summary of the main results
- Put the sexiest and most important stuff up front
- Consider discussing
  - your interpretation of the data and conclusions from it
  - the relationship with previous data
  - the caveats of your conclusions
  - remaining questions, future directions
  - a final summary of the take home message

THESIS-SPECIFIC ADVICE

- Profs differ on their views of what a thesis should be. The old school believes a thesis should be a comprehensive and erudite exposition that demonstrates mastery of the entire literature and the research. Many in the younger generation more pragmatic and realize that it may not be strategic to spend an undue amount of time on a document that is only likely to be read by a handful of people. Hence many universities have moved to thesis formats based on publishable manuscripts. Typically an Honours or Master's thesis consists of one publishable manuscript and a PhD consists of three publishable manuscripts, bracketing between a general introduction and a general discussion.
- The only people who are likely to read your thesis are your thesis committee members (and even then, it's not guaranteed. My graduate advisor's corrections ended on p. 7 of 99). The most widely read thesis at Harvard is the Unabomber's. Ergo, unless you're planning to become a terrorist (in which case, why are you doing a thesis?), you only need to satisfy your committee and yourself.

- Like many pieces of writing a thesis should be "as long as it needs to be and no longer." No one on your committee wants to read a 200 page thesis. Really, they don't. One hundred pages is lots. If you want to do a comprehensive review of a field, consider writing a publishable review article so you get some "real credit" for the work.

CHOOSING A JOURNAL

- Should you submit to *Nature* (Impact Factor = 30), *Experimental Brain Research* (Impact Factor = 2.1), or *Perceptual and Motor Skills* (which some suggest has a "negative impact factor" – if you have to publish there it damages your reputation)?
- In addition to considering impact factors, consider where a paper will have its greatest impact. I once published a visual psychophysics paper in a high impact neuroscience journal, but then realized it would have probably had better recognition (e.g., citation counts) had it been published in a visual psychophysics journal.
- A publication in a high impact journal can win you much respect and boost your career; however, the odds are against you and there are significant costs to submitting to high impact journals if you are unsuccessful, which you are likely to be.
- In addition to the obvious costs to you (e.g., the time it takes to format a manuscript for a particular journal, the time you waste waiting for reviews) and your advisor (e.g., the time for editing manuscripts), the biggest cost is your mental energy. The journal review process can be onerous even for lower impact journals and if you run through the gauntlet of high impact journals, you are more likely to suffer "*manuscript fatigue*". This is a phenomenon where you get so frustrated, you never want to look at a paper again so you end up "file-drawering" it, dragging your feet on it, or sending it to a lower tier journal just to get done with it. Save some of your energy for a battle you're more likely than not to win.
- My own rule of thumb is to judge a suitable journal and try for one step above (e.g., if I think a paper is worthy of *Journal of Neurophysiology*, I may shoot a bit higher for *Journal of Neuroscience*, but not *Nature Neuroscience*).
- There are also costs to the system. Editors and reviewers are overburdened and unnecessary submissions waste time and energy. If you follow my advice that scientists should give approximately the same number of reviews as they get, consider whether the submission has a good enough shot at getting in that you would be willing to do three extra reviews yourself. If you submit everything to the top journals, there is also a risk that the editors will stop taking you seriously.
- Even the very best scientists with the very best letterhead typically publish less than 10% of their best work in top journals. Consider whether your submission is in the top 10-20% of your research.
- All that said, it is worth shooting high when you really believe in a paper. If you have a paper that you genuinely feel is worthwhile, a handful of colleagues agrees, and you're willing to try your luck, then go for it.
- If you shoot for a sexy journal, you have to have a sexy punchline and you have to tell a compelling story. Sometimes this can force you to take a stronger position than what you really believe and that can be dangerous.

- Many sexy journals will allow presubmission enquiries, where you can send an abstract and they will tell you whether they would be likely to send it out for review. While this can be valuable, it's still no guarantee.