# Best practices for writing scientific papers
## (focused on experimental studies)

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24/07/25

# Choosing a journal to submit to

- How to make a short list of journals relevant to your research
  - Your advisor gives you a list
  - Look where papers you cited are published
  - Search key terms from your paper on an indexing site (e.g., Scopus) to see where the topic is published often and recently
  - Follow specific researchers in your field (e.g., on academia.edu or researchgate) to see where they're publishing
- How to choose from the short list
  - To make sure your research topic is **relevant** to the journal, read the scope for the journals on your list and check their recent publications
  - Compare the **impact** factors, but be skeptical of pay-to-publish journals
  - Look up the editors for the journals to see if their research is related to yours and check their reputation (where do they work, how much have they published, etc.)
  - Check the turn-around time from submission to publication, especially if you're in a time crunch to publish
  - Talk to your colleagues working on similar research topics about their experiences with various journals

# Scientific paper writing is NOT creative writing

- People do **not read** the paper **in order** like a book or article
  - Most people read the title, then the abstract, then look at the figures, and finally maybe read the text ☾ allocate your time/effort mostly on the **figures** and **abstract**!
  - Many readers are looking for **specific information** to cite from your paper ☾ make it easy for them to find the corresponding terms and sections throughout your paper
    - Use consistent terminology so a reader can ctrl+F to the sections of interest
    - Use upside-down writing: start a paragraph with your main claim/evaluation, so a reader skimming your paper knows what sections to read (more on this in next slide)
- Use lots of **spoilers**
  - No one should be surprised by your hypothesis; it should fall out logically from the background information you present in the Introduction
  - No one should be surprised by your claims in the Discussion (or Conclusion); they should be hinted at in the Introduction and well-supported by the Results

# Upside-down writing*

- Make your main claim/evaluation in the **first** sentence of a paragraph and then justify it in the rest of the paragraph
- Many writers start a paragraph with an objective fact and build up their case to end with the main claim/evaluation
- This is most relevant to the Introduction and Discussion but can also be applied to the other sections of the paper

## Before

There is a strict format and structure to writing scientific papers. Key terms are also similar to code variables. Thus, writing clear scientific papers is like writing code.

## After

Writing clear scientific papers is like writing code. There is a strict format and structure. Key terms are similar to code variables.

*Term coined by Lena Ting

# Like code, be **consistent** with paper structure and terminology

- Match the order of presentation of topics
  - Start by ordering the figures. This will set up the order of topics (e.g., a, b, and then c).
  - Present these topics in the same order in ALL sections of the text (Introduction, Methods, Results, Discussion).
- Coding analogies
  - Introduction and Discussion sections: first paragraph is the main program, each sub-paragraph is a sub-function

Writing clear scientific papers is like writing code. There is a strict format and structure. Key terms are similar to code variables. — main

Scientific papers have a stereotypical structure that is consistent across topics. Each section is presented in a set order: Introduction, Methods, Results, and then Discussion. Some journals have a Conclusion section at the end or move Methods to the end. — function 1

Key terms of the paper's topic are presented consistently like code variable names. You should define each term the first time you use it and cite references when appropriate. — function 2

# Chronological steps for writing a paper

1. Finalize your figures (“what” you found)
2. Write the Results
3. Write the Methods (“how” you got the results)
4. Write the Discussion (“why” your results matter)
5. Write the Introduction (“why” you’re doing this work)
6. Write the Abstract
7. Choose a title

# 1. Figures contain all your main claims

- The figures (with captions) should contain the full story of your paper
  - Captions should explain every line, symbol, etc. and describe the main trends
  - Spend a lot of time perfecting each figure: make code in Matlab (e.g., prettyfigs.m) to format your figures before exporting to Adobe Illustrator or other graphical editor to fine-tune line/marker styles
- 1 figure ☾ 1 claim/message
  - Tip: come up with one sentence to describe the main claim of each figure. As you edit the figure, refer back to this sentence and ask yourself if that's what the figure conveys.
- Sketch out the figures you predict **before** you start data collection so you know what your predictions are and what data you need to collect

Claim: robot controller settings result in predicted changes to gait parameters

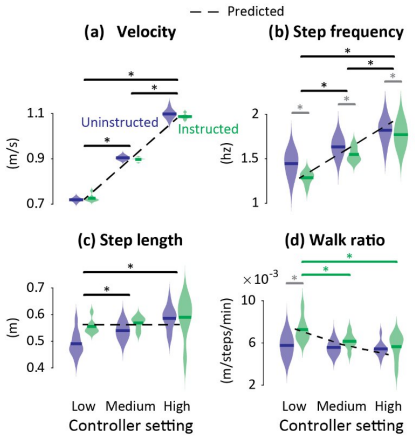
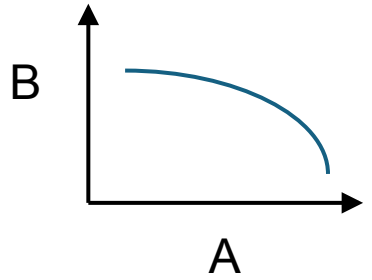


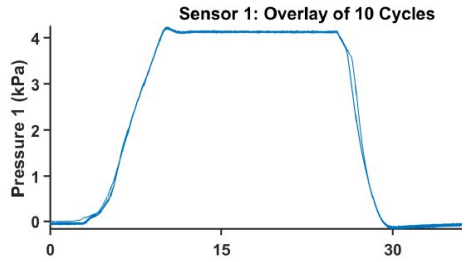

Fig. 2. Gait parameters vs. robot controller setting. Violin plots show means (horizontal lines) and distributions for Uninstructed (blue) and Instructed (green) groups. Dashed line: predicted values for each controller setting. *Significantly different *post hoc* comparisons: black denotes difference between controller settings for both participant groups combined, green denotes difference between controller settings for the Instructed group only, and gray denotes difference between groups at a given controller setting. As predicted, human (a) gait velocity and (b) step frequency increased with controller setting for both groups. (c) Contrary to predictions, step length also increased with controller setting for both groups. (d) As predicted, only the Instructed group changed walk ratio between controller settings. Walk ratio normalized according to methods in [44].

(Wu 2025)

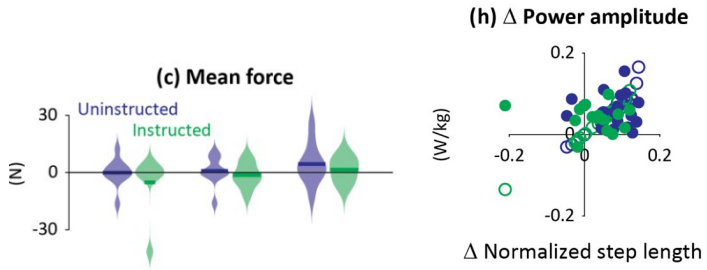


# 1. Figure formatting: **less** is more

- Be consistent across all figures
  - Use the same font sizes, line widths and styles
  - Use the same color codes for the same variables
- Use color and line/marker styles only as needed
  - Use the same color/style if the datasets are similar to each other
  - Use different colors/styles to highlight important differences
- Check all text in figures are readable when you **print** the paper!
- Check figure requirements for your target journal. If not specified, here are some recommendations:
  - Use sans serif fonts for a cleaner look
  - Avoid unnecessary boxes (around plot, legend, etc.) and gridlines
    - E.g., use a single horizontal or vertical line at x = 0 and y = 0 for axis, move axis tick labels to these lines
  - Axes
    - Ticks point outwards
    - 3-5 ticks per axis
    - Use black axes lines instead of default gray ones from Matlab export!
    - Use the output variable name for the title and vertical axis label for the variable's units
  - Line weights: thicker for data, thinner for axes




(van Vlerken, submitted)




(Wu 2025)

Read *The Visual Display of Quantitative Information* by Edward Tufte for more info

# 2. Results describe what the figures show

- Results describe the **trends** (e.g., X increases with Y) and provide **numerical values** for important variables shown in the figures
  - Include numerical values for important quantitative results (e.g., mean and standard deviation for a key metric) so people can easily pull them out and cite your paper
  - Keep this section short!
  - It’s normal for this section to be boring. Few people will read it.
- Include a section on participants
  - Demographic data, number of participants

# 3. Methods explain how results were obtained

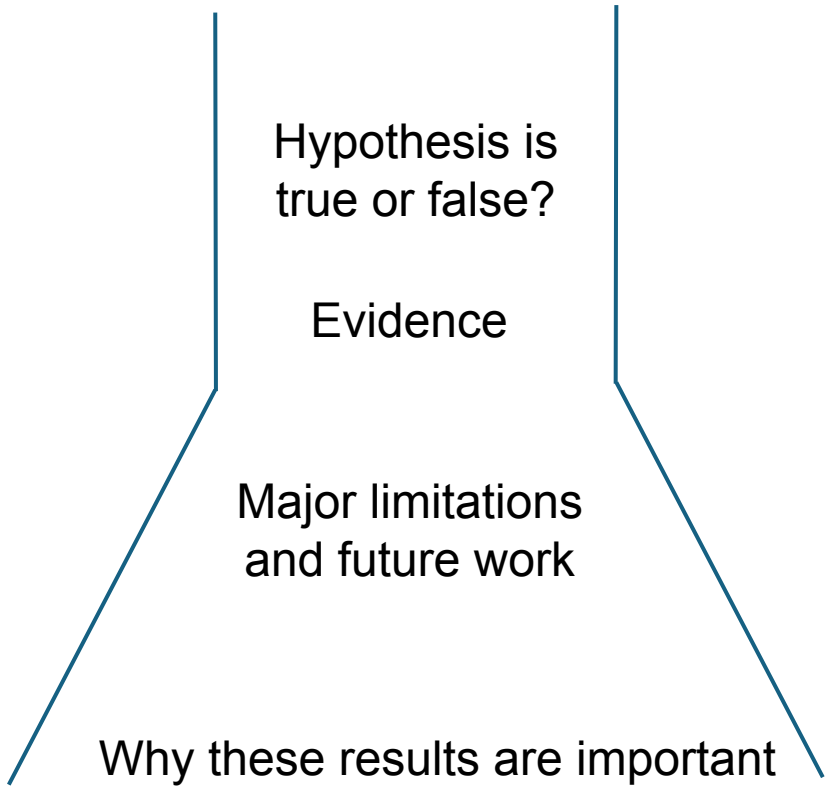
- Goal: include just the right amount of detail
  - Don’t explain everything you did in chronological order, just present what is necessary to explain how the data for the figures and Results section were acquired
  - Expect your reader to be another researcher in your field
  - When in doubt, look at a published paper on a similar topic to see how much detail they included
- Recommendations for level of detail
  - Physical setup
    - Cite the manufacturer name and location for each piece of specialized equipment
    - Include sensor resolution and range
  - Experiment protocol
    - Ethical approval
    - Conditions tested, number of repetitions/trials per condition
    - Sequence of tasks performed
  - Data analysis procedures
    - E.g., Data was filtered at X Hz then averaged across Y conditions
  - Statistical analysis procedures
    - Tests used (e.g., ANOVA), significance criteria (e.g., alpha = 0.05), etc.

# Methods vs. Results vs. Discussion

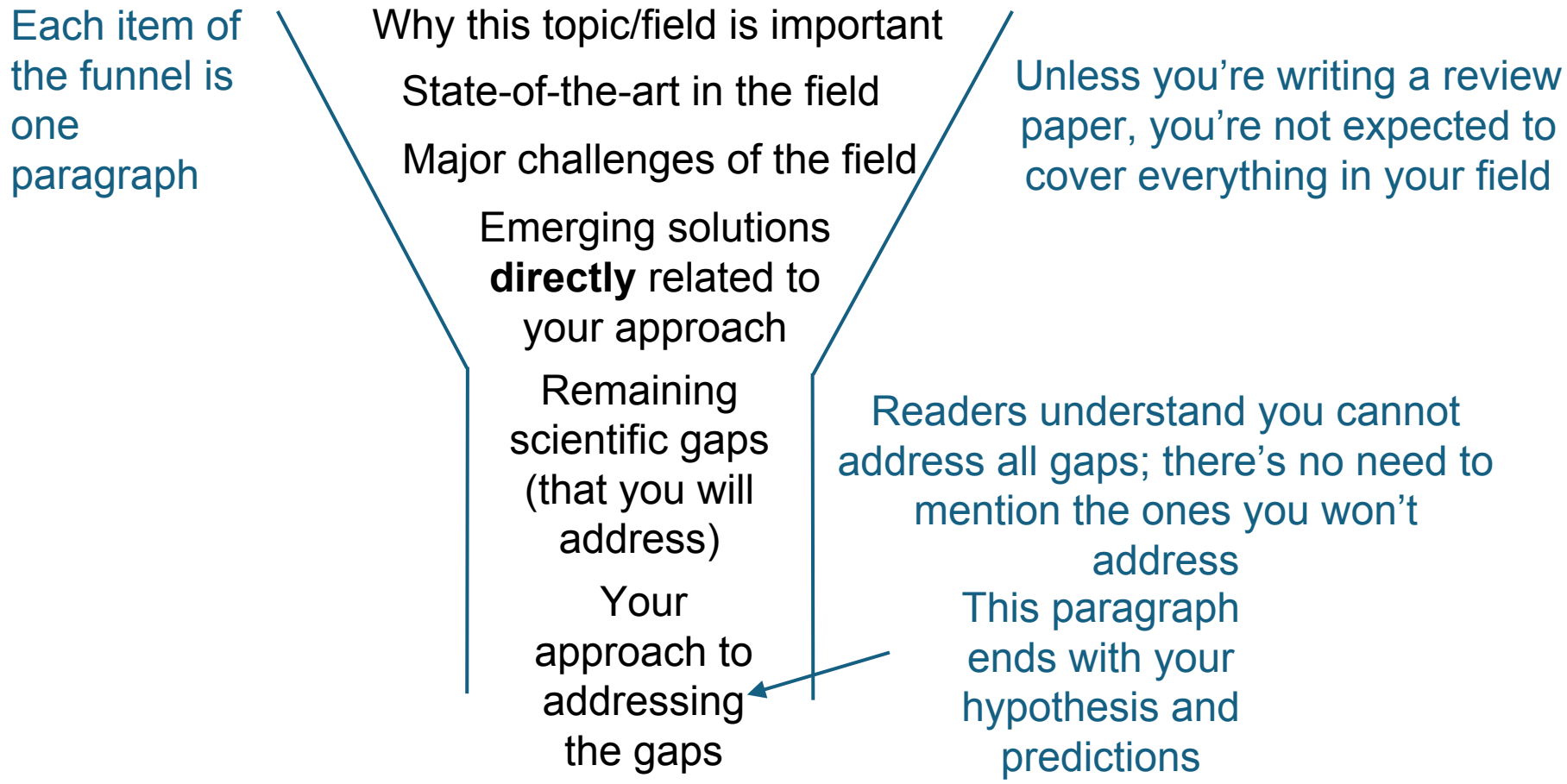
- Methods: **how** you did the work
  - E.g., “X and Y were measured/calculated using Z equipment/method”
- Results: objective, descriptive statements about **what** you found
  - E.g., “Y increases as X increases”
- Discussion: any **interpretation, evaluation, or judgment** about the data
  - E.g., “X causes changes in Y by…”

# 4: Discussion

- First paragraph* is like a reverse funnel
  - Start: if your hypothesis was supported
  - Middle: the major evidence supporting/rejecting the hypothesis and limitations
  - End: impact of your results for the field
  - *This paragraph can also be used instead as the Conclusion
- Use the “main and subfunctions” format and “upside-down” writing
- Spread limitations throughout the Discussion where they apply instead of grouping together as one section
  - Only present the key limitations relevant to your main claims
- Quantitative values not necessary
- DO NOT introduce new data! No figures!



# 5. Introduction is a funnel that justifies **why** you're doing this work



# Hypothesis vs. Prediction

- Hypothesis: a **general principle** that explains an underlying mechanism for why something occurs
  - E.g.: low-force hand interactions influence walking by communicating information that influences human sensorimotor control instead of through direct mechanical propulsion
- Prediction: the criteria by which you will prove your hypothesis; includes **specific** measurable **trends** or **quantities**
  - E.g.,: walking speed will increase with tension force at the hands
  - E.g.,: forces measured at the hands will be lower than that required to propel measured changes to step length

# 6. Abstract: the most important paragraph you will write!

- Include one sentence on:
  - Background for why you're doing this research; you can use the first sentence of the Introduction
  - Your approach to addressing the major research gaps (like a summary of the Methods)
  - What was your hypothesis and whether it was supported
  - Main results supporting/refuting hypothesis with quantities/values: e.g., "metabolic cost was reduced by 20%"
  - Why your results matter; you can use the first sentence of the first paragraph of the Discussion/Conclusion
- Don't include
  - Details on Methods

# 7: Title

- Should reflect your hypothesis and why it matters
- Someone doing a keyword search on relevant topics should find your paper
- Can be cuter as you get more experienced in the field and are more sure that people will read your paper (i.e., puns and jokes)

Let the Force Be With Us:
Dyads Exploit Haptic Coupling for Coordination

# Final thoughts and advice

- Start early but be strategic
  - It's never too early to sketch out your expected figures
  - Your results will determine what your main claims are, which will then narrow the scope of your Introduction, so writing the Introduction too early might be a waste of time
- By the time I'm ready to submit a manuscript, I feel almost physically sick looking at it and never want to see it again
  - It just takes that much time and that many iterations
  - I'm only able to write one high-quality first-author journal paper per year
  - Being thorough will result in a solid paper that requires fewer revisions, allow others to reliably cite it, and ensures your future peace of mind (no retractions!)

# Acknowledgments


- Dr. Lena Ting and the Neuromechanics Lab