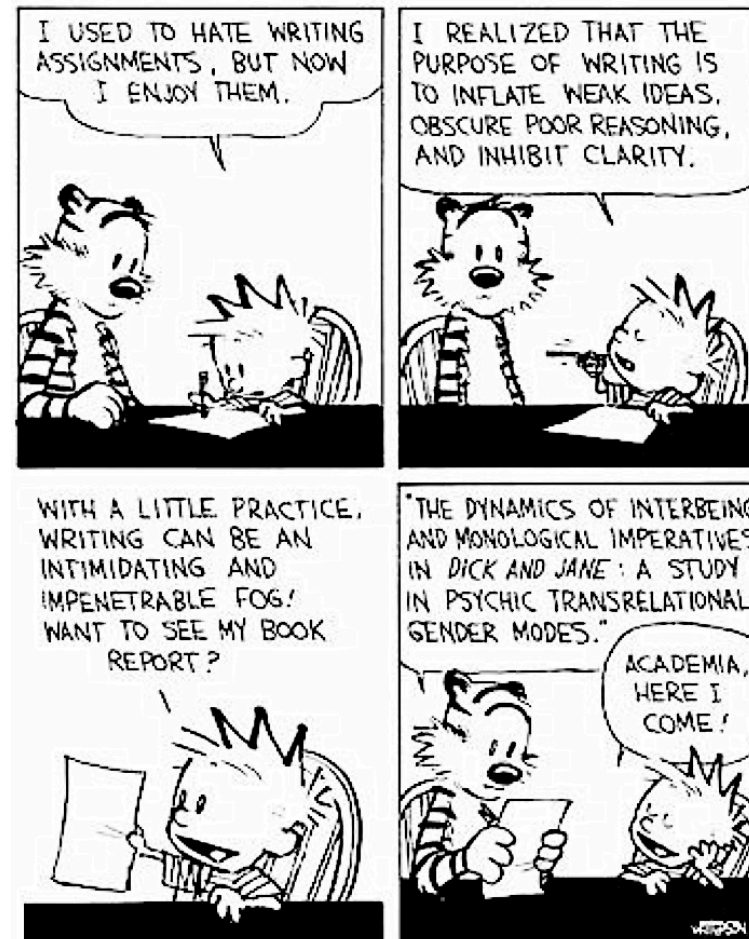


***How to write a good
research/technical
paper/report***

Motivations

Fallacy!

We write papers mainly to impress others, gain recognition and get promoted...



Motivations *(cont'd)*

- For your work to have significant impact, it is essential that you can convey results to your community
- You need to convey your ideas and results to your community / clients
- No research project can truly be considered complete if it does not result in a publication
- Communication of your results contributes to the pool of knowledge within your discipline (and others!) and very often provides information that helps others interpret their own experimental results

Motivations *(cont'd)*

- **A good report is easy to recognise;** its title is precise and informative, its layout and format are well organised, and the binding is easy to handle and opens flat to reveal both text and diagrams
- **Reading a well written report is pleasurable:** the style is accurate, fluent and concise, with headings to indicate the content of each section; the diagrams (non-verbal material such as tables and graphs) are well presented and clearly labelled
- You, the writer, must practice writing and thinking within the structure given in the present slides and learn by example from the writings of others; learning the nuances of this style and format will be enhanced as you read the scientific literature - pay attention to how professional scientists write about their work; you will see improvement in your own scientific writing skills by repeatedly practicing reading, writing and critiquing of other's writing

Outline

- Introduction
- Getting started
- General rules
- Structuring the paper
 - ✓ *The Abstract*
 - ✓ *The Materials / Method / Procedures*
 - ✓ *The Results*
 - ✓ *The Discussion*
 - ✓ *The Conclusions*
- Prose and style
- *Do's and Don'ts*
- Concluding Remarks

Introduction

- There are no absolute rules about the details of report production, because every report must be totally adapted to the needs of its reader
- These slides suggest rules of good report writing, but only because in the field of communication, laws should be generally applied but broken if necessary

For example, one law concerns brevity; if clients have spent thousands of euros to gain access to expert knowledge, it may be inappropriate to reveal it in five pages; they will feel cheated if they receive so little, even if it represents value for money; a longer report will be politically more expedient

- Nevertheless, laws can be broken only on the basis of knowledge!

Getting started



- Order and organize the information you wish to present: scientific writing requires special attention to **order and organization**
- Develop a **list of the major points** to be included in each section, before you begin to write
- **Audience:** who will be reading your paper?
Knowing your audience helps you to decide what information to include -you would write a very different article for a narrow, highly technical, disciplinary journal vs. one that went out to a broad range of disciplines
- The **objectives** of a report identify exactly what information it covers, for whom it is written and why it should be produced; these objectives should be clear to the writer long before the process of writing starts

General rules

- The reader is the most important person
- Keep the report as short as possible
- Organise for the convenience of the report user
- All references should be correct in all details
- The writing should be accurate, concise and unobtrusive
- The right diagram with the right labels should be in the right place for the reader
- Summaries give the whole picture, in miniature
- Reports should be checked for technical errors, typing errors and inconsistency
- The report should look as good as it is

Structuring the paper

- **Title:** *the title of any paper is a key element that advertises its contents; try to be as specific as possible in describing your study/work*
- **Abstract**
- **Introduction**
- **Materials / methods / procedures**
- **Results**
- **Discussion**
- **Conclusions**
- **References**
- **Acknowledgments** (*not usually required*)
- **Appendices** (*used rarely for additional matter that can not be included in the previous sections – long calculations, previous fundamental works, etc.*)

The Abstract

- The abstract is a succinct (one paragraph) summary of the entire paper
- The abstract should briefly describe the question posed in the paper, the methods used to answer this question the results obtained, and the conclusions
- It should be possible to determine the major points of a paper by reading the abstract
- Although it is located at the beginning of the paper, it is easiest to write the abstract after the paper is completed (like the title)

The Materials / Methods / Procedures

The rule of thumb is that methods should be described in sufficient detail to allow another investigator to repeat your experiments; this does not necessarily require an exhaustive description, particularly if you are using methods that have been well-described previously by you or others (appropriate references should be cited in this case)

It is important to include sources of key reagents / raw materials / samples as well as any variations to standard methods that you have instituted; list the used instrumentation and equipment

For people who have trouble getting started with manuscripts, the methods section should be the easiest to write; it is as good place to start!

The Results

This is the heart of the paper!

- It is not necessarily required to describe the experiments in the precise sequence they have been performed; what is important is to provide a logical progression through the experimental design, with some limited interpretation of the data to lead the reader from one concept to the next
- The results section should not, however, contain substantive analysis of the data, nor it is this the place to compare the current findings with others obtained previously by other scientists; it is also important to avoid duplicating information, particularly data, among text, figures or tables, and figure legends

The Results *(cont'd)*

- Any results that include multiple data points that are critical for the reader to evaluate the experiment should be shown in tables or figures
- When referring to a particular table or figure, they should be capitalized (e.g., Table 1, Figure 6, etc.)
- The text of the Results section should be succinct but should provide the reader with a summary of the results of each table or figure
- Not all results deserve a separate table or figure; as a rule of thumb, if there are only a few numerical results or a simple conclusion, describe the results in the text instead of in a table or figure
- Your paper should focus on what worked, not things that did not work

The Results *(cont'd)*

- **Tables and Figures:**
 - ✓ All tables and figures should be put into a contextual framework in the corresponding text
 - ✓ Tables and figures should present information in a format that is easily evaluated by the reader; a good rule of thumb is that it should be possible to figure out the meaning of a Table or Figure without referring to the text
 - ✓ Tables and figures should typically summarize results, not present large amounts of raw data; when possible, the results should provide some way of evaluating the reproducibility or statistical significance of any numbers presented

The Results *(cont'd)*

- ✓ **Tables and Figures** should be sequentially numbered
- ✓ Each table / figure should have a title / caption (shown above the table) that describes the point of the table; for example, *“Table 1. Bacterial strains and plasmids used in this study”*
- ✓ **Captions are one of the most important elements of a good manuscript:** often, a reader will flip through a paper, read the captions, and decide if it is worth the read
- ✓ If necessary to interpret the table / figure, specific descriptions about what a result represents or how the results were obtained can be described in a legend below the table/figure

The Results *(cont'd)*

- ✓ Tables and figures may be printed on separate pages that follow the References section; alternatively, the tables and figures may be integrated into the paper if you are using a page layout program (make sure that there is not a page break in the middle of a table or figure)
- ✓ Do not wrap text around the outside of tables and figures – if the results are important enough to show as a table or figure they should stand out on the page, not be buried in text

The Discussion

- For beginning investigators, the discussion section is often the hardest section of the paper to write
- This is the place to interpret the findings in detail, explore their significance and place them in the context of what has gone before
- The length of the Discussion section should be proportional to the amount of data presented and redundancy between this and the results section should also be avoided wherever possible
- In many cases the Results and Discussion sections can be merged (be careful not to confuse them)
- It is advisable to avoid unduly speculative comments, as well as claims for the primacy of the observations made

The Conclusions

The Conclusions section is written to

- ✓ provide a brief introduction restating the central question of the research
- ✓ display an analysis of fundamental findings
- ✓ underscore the significance /implications of the study

Conclusions (often structured as Summary) have, therefore, to show the essential elements of the whole report, giving sufficient background to make sense to the reader, commenting on the major findings and giving stress to conclusions which are of general importance

A summary gives a general picture of the report for those who want to be reminded of what they have already read, and also for those who will never see - or want to see - the total report

Prose and style

- Your writing should be in complete sentences and easily understood: *your ideas will have little impact, no matter how good the research, if they are not communicated well*
- Always remember that scientific terminology very often has precise meaning: be certain you choose your words correctly and wisely
- It is important to write clearly and concisely: make sure that every paragraph has a clear topic sentence and that the paragraph content supports the topic. The goal is to report your findings and conclusions clearly, and with as few words as necessary. Your audience (other scientists usually) are not interested in flowery prose, they want to know your findings

Prose and style *(cont'd)*

- **Abbreviations:** do not use abbreviations in the text except for units of measure
- **Use Past Tense:** research / technical papers reflect work that has been completed, therefore use the past tense throughout your paper (including the Introduction) when referring to the actual work that you did, including statements about your expectations or hypotheses; use the past tense, as well, when referring to the work of others that you may cite; only experiments that you plan to do in the future should be described in the future tense

Prose and style *(cont'd)*

- **First vs. Third Person:** limit your use of first person construction (i.e., " I (or we) undertook this study): usually it is most acceptable in the Introduction and Discussion sections and then only to a limited extent. Use first person in the methods sparingly if at all and avoid its use in the results. Most text should be written in the third person to avoid sounding like an autobiographical account penned by a narcissistic author; it is better to say "It is possible to .." than to say "One could ...". Writing that uses the impersonal pronoun "one" often seems noncommittal and dry

Prose and style *(cont'd)*

- Give numerical values in statements and avoid ambiguous words (small, large, low, etc.)
- If the values of X and Y are compared, then X and Y must have the same dimensions (avoid "comparing apples to oranges")
- All numerical values that have dimensions must have their units specified
- All units, including those that are named for a person, have a lower-case first letter when written out (ohm, coulomb, ampere, hertz, etc.)
- Units that are named for a person have an upper-case first letter when abbreviated ("kilohertz" is "kHz")
- Only metric prefixes for 10^{+6} or more have an upper-case abbreviation (e.g., M = 10^{+6} , G = 10^{+9} , etc.)
- There should always be one blank space between a number and a unit: "5 kHz", not "5kHz"
- Avoid labelling the axis on a graph or a column in a table as, for example, "volts x 10^{-3} "
- In general, choose a metric prefix that will make the numerical value between 0.1 and 1000 (better between 0 and 10)

Prose and style *(cont'd)*

- Equations are prose and should be punctuated as such; it is common for an equation to function as a clause or sentence: variables and parameters are nouns; the equal sign is equivalent to the verb "is"; operators serve as conjunctions
- Do not embed equations in a line of text: every equation goes on its own line
- Number each equation at the right-hand margin (use the "flush right" command in Word processor); even if it is not necessary to refer to the equation by number in the text, someone may want to refer to the equation in a letter or future publication
- One must identify each of the variables and parameters by name when they first appear (one might be excused for not saying that t is the time, since this is such a standard choice of variable)

Do's

- **Do** try to enlist the help of a native English-speaking colleague to assist with the preparation of your manuscripts if English is not your first language.
- **Do** read your manuscript carefully prior to submission and preferably ask a number of individuals to check the typescript for errors. Familiarity breeds "typo-blindness"!
- **Do** conduct your experiments with a view to their ultimate publication; thus, don't waste too much time with a series of studies with minor variations in design, only to have to go back to make the required number of repetitions of an experiment to allow for statistical analysis
- **Do** state the hypothesis of your study prominently in the introduction section
- **Do** read the instructions (for the manuscript / article / report)!
- **Do** consider starting to prepare your manuscript even before all of the experiments are complete; often, outlining the results section will alert you to gaps in the reasoning and additional experiments that can fill them
- **Do** read other published manuscripts: it is a wonderful way to learn what works (and what doesn't)
- **Do** be willing to accept constructive criticism from trusted colleagues

Don'ts

- Don't rely too heavily on the spell-check feature of your word processor (but do use it!)
- Don't try to impress people by using words most people have never heard of; many published articles are like this and they are poor papers on account of it
- Don't report previous works and results in detail; a reference is enough
- Don't describe well known techniques, procedures and properties
- Don't use colloquial speech, slang, or "childish" words or phrases
- Don't use contractions: for example, "don't" must be "do not" and "isn't" must be "is not", etc.
- Don't use too many subtitles and paragraphs

Concluding Remarks

- Follow the guidelines provided here
- Take every opportunity you can to write technical / scientific manuscripts (and thus get practice and feedback)
- Preparing a good paper takes time; do not expect to throw it together last minute

