Devin L. Jindrich

HOW TO STRUCTURE A SCIENTIFIC PAPER: SUMMARY

INTRODUCTION		
SECTIONS (Sections delimited by bold/italicized *subheadings* that are *complete, conclusive sentences* directly related to hypotheses. A section can be 1 or more paragraphs.)	**1**	**Importance.** Justify why the research topic is important (e.g. relevant to many people, answering a critical research question, etc.). Identify a **GENERAL** gap in understanding.
	2,3	**The MEASURABLE GAP in understanding. DEFINE** all terms necessary to understand your study. Explain why past discoveries lead to current understanding using **REASONED ARGUMENTS** (DEDUCTIVE and/or INDUCTIVE) and **LOGICAL TRANSITIONS** between ideas. Reference each statement of fact using peer-reviewed, quantitative studies (all references at the **END** of sentences). Laws of physics, mathematical derivations, or reasoned conclusions do not require references. Explain current understanding as a logical progression that uses the **RESULTS** of previous studies as **PREMISES** (i.e. statements of fact) of arguments with **CONCLUSIONS** that identify a **CONFLICT** or a measurable **GAP** in understanding.
	4	**Hypotheses**. Briefly state the **OVERALL GOAL** to fill the general gap in understanding. Explicitly state the **GENERAL** hypotheses. Explicitly state how each **GENERAL** hypothesis directly leads to one or more **MEASURABLE** hypotheses. Explain ALTERNATIVE hypotheses (e.g. that would arise from different assumptions). Briefly preview the specific approach (e.g. experiment) used to test each measurable hypothesis.
METHODS		
SECTION (Sections can have >1 paragraphs if necessary. Use *subheadings* to identify sections.)	**1**	**Study participants**. How many participants enrolled, and why the number of participants was appropriate. Age, sex and other important characteristics of participant population (e.g. mass, anthropometry, etc.), and reasons why the population was appropriate.
	2	**Procedures and Protocols**. Overall **design** of study (cross-sectional, cohort, etc.) and why chosen. Procedures for **group selection** and why. **Treatments** used and why, explained in detail. **Data collection**: measurements employed and why chosen over other measurement methods, where appropriate. Specific **equipment** used and why. **Calibrations** employed and why. **Controls** employed and why. Use a **REASONED** framework that explains why each procedure contributes to testing one or more measurable hypothesis (not a chronology).
	3	**Data Analysis**. How and why collected data were conditioned (e.g. filtered) and reduced. Normalizations employed and why appropriate. Mathematical calculations employed and why (detailed mathematical derivations can be placed in an Appendix). Statistical tests employed and why they were the most appropriate tests.
	4	**Hypothesis test(s)**. The specific criteria (calculations, statistics, and judgments) that will be used to support or reject each measurable hypothesis.
RESULTS		
SECTIONS (Delimited by bold/italicized *subheadings* that are *complete, conclusive sentences* directly related to hypotheses)		**Summary (optional)**. Brief summary of data and conclusions (i.e. hypothesis tests).
		Sub-conclusion Sections. Each section follows a **bold/italicized** subheading concisely stating the **conclusion** of the section using a **complete sentence**. The conclusion should directly relate to a measurable hypothesis (e.g. actually be the conclusion of the hypothesis test). The body of each section defends why the data lead to the conclusion. Structure arguments using deductive and/or inductive **reasoning**. Use **logical transitions** between ideas. Place references to figures and tables **only** at the **END** of sentences. Explicitly state the justification/reasons for rejecting or not rejecting each measurable hypothesis.
DISCUSSION		
SECTION (delimited by bold/italicized *subheadings* that are *complete, conclusive sentences* directly related to hypotheses)	**1**	**Concise summary of the Results**. Explicitly state the **measurable hypotheses** and the conclusion of testing each measurable hypothesis.
	2	**Assumptions** made. Reasons why the assumptions are unlikely to affect the conclusions.
	3	**Limitations** of the methodology or analysis. For each limitation, reasons why the limitations are **unlikely** to affect the conclusions of the study.
	4,5	**Supporting general hypotheses and/or generating new hypotheses**. Explain how the results change to our understanding. Explain how each result (e.g. measurable hypothesis test) is **CONSISTENT** or **CONFLICT** with existing understanding (previous studies). If the results are consistent with past findings, explain how the results **strengthen** our confidence in general hypotheses. Hill's criteria (Reproducibilty, Diversity, Plausibility, Strength, Temporality, Specificity, Dose-response,etc.) can be useful for organizing and grouping arguments. Explain why **conflicts** with previous understanding lead to **novel, testable, general and measurable hypotheses**.
	6	**Implications** of the study. Why the findings are important. Potential contributions to current or future research. Potential applications (e.g. to clinical practice, injury prevention, technology development, public policy, etc.)

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SUGGESTED STEPS FOR PERFORMING A SCIENTIFIC STUDY AND WRITING A SCIENTIFIC PAPER (listed chronologically)

1) Perform a literature search to gain a comprehensive understanding of a particular field or problem
2) Identify a specific gap in understanding that is important to fill
3) Find (in the literature) or create a General Hypothesis that, when tested, will help fill the gap in understanding
4) Create several Measurable Hypotheses that:
    a. Make specific predictions that are distinct from alternative hypotheses
    b. You can cleanly test based on your capabilities and constraints
    c. Directly help to test the General Hypothesis
5) Design an experiment that allows you to test the Measurable Hypotheses. To Design an experiment:
    a. Select the overall study design (prospective, retrospective, cross-sectional, longitudinal, cohort, etc.)
    b. Select an appropriate subject population (animal or human, age, sex, traits or experiences, etc.)
    c. Select appropriate controls (control for individual differences, environment, bias, artifact, etc.)
    d. Design specific procedures and protocols, including necessary calibrations. Use objective, quantitative (not qualitative) research methods and measurements whenever possible
    e. If experiments involve humans, write down the specific instructions that you will uniformly provide to all participants
    f. Design specific data analysis to perform, including data normalization and reduction
    g. Determine the specific criteria that you will use to test your measurable hypotheses. Establish reasonable conditions for rejecting hypotheses or null hypotheses
    h. Design the statistical tests necessary to make comparisons. Statistical design may involve selection of parametric vs. non-parametric statistics, choice of specific statistical tests, and power analysis
6) Perform the experiment as thoroughly and consistently as possible. Collect quantitative data
7) Normalize, Reduce, and Analyze collected data. Perform planned statistical tests
8) Use the preponderance of the data and the outcomes of the statistical tests to make conclusions about the measurable hypotheses. Each measurable hypothesis can be either
    a. Rejected (if the data are clearly inconsistent with the predictions of the hypothesis)
    b. Not Rejected/"Supported" (if the data are clearly consistent with the predictions of the hypothesis)
    c. (note that hypotheses CANNOT be "accepted" or "proven." Do not use this terminology)
9) Assess the strength of your conclusions based on assumptions and limitations of your study. Consider and discuss limitations associated with every aspect of hypothesis generation and selection, study design, data analysis, and reasoning
10) Relate your specific findings to the conclusions of other studies in the context of General Hypotheses
    a. Identify areas where your findings and findings of other studies are consistent with the predictions of General Hypotheses (supporting the General Hypotheses)
    b. Identify areas where your findings conflict with the predictions of General Hypotheses and the other studies that have been used to support the General Hypotheses (decreasing support of the General Hypotheses and suggesting that new General Hypotheses are needed).
11) Defend overall conclusions about whether to either
    a. Support existing General Hypotheses or
    b. Create NEW General Hypotheses
12) Investigate potential implications and applications of your conclusions to research, technology, clinical practice, policy, etc.

For a written paper, steps 1-4 above should be explained in the INTRODUCTION, step 5 in the METHODS, steps 6-8 in the RESULTS, and steps 9-12 in the DISCUSION.