

SETTING THE SCENE:

BEST PRACTICES FOR WRITING MATERIALS AND METHODS

The Materials and Methods (hereafter “Methods section”) is the section of a research paper that provides the reader with all the information needed to understand your work and how the reported results were produced. Having read the Introduction, the reader already knows why your work is important, so the next step is to connect that section to the experimental design used to address your research questions.

Depending on the type of paper, the Methods section can encompass anything from the parameters of a literature search to the methods employed in a field study to the details of bench work in the lab. The common feature is that the information needs to be presented in a way that is clear and familiar to the reader. It is important to note that the purpose of the Methods section is not just to convey what you did; a thorough and well-organized Methods section reflects your knowledge and understanding of appropriate research techniques and increases the reader’s confidence in your work.

PURPOSE AND STRUCTURE.

The Methods section is easiest to follow when it begins by providing a clear context for the detailed descriptions of the methods and materials used in the study. This context is best achieved by beginning with general characteristics and parameters (e.g., identification of sample sources or populations, descriptions of geographic areas, or characterizations of study participants). A reader who understands the foundation of your experiments will

more easily understand the procedures that follow.

The underlying principle for what information to provide in the Methods section is that the reader should be able to replicate your study. This section must explain the methods used with enough detail to answer any of the reader’s questions about how the study was performed. Because the Methods section is meant to convey how the research was conducted, conforming to the accepted conventions of the field is extremely important.

Generally, the Methods section should assemble familiar concepts and research activities into a logical series of events. Terminology and sentence structure should be consistent within the paper and conform to the conventions of the field, and repetition is accepted or even expected. Because Methods sections often rely on lists of information, consistency - i.e., the presentation of like elements using the same terminology, notation, and sentence structure - is especially important.

WHAT IS MOST IMPORTANT?

Present your information in a way that is clear and familiar to the reader.

The information in the Methods section should follow the order of execution as closely as possible, although similar procedures should be presented together. For example, descriptions of sample or data collection should be described together, even if these are performed at different times or with intervening analysis, because a purely chronological account would mean switching back and forth between procedures.

KEY INFORMATION.

Any procedure described in the Methods section should be included to address a specific question and to yield meaningful information. Hypotheses should be testable and falsifiable, quantities should be measurable and comparable (e.g., by using consistent units), and all influencing factors should be explicitly described or controlled. In short, the key to writing a great Methods section is to include all the relevant information without providing excess or unnecessary detail.

Journals typically provide guidelines on what to include, but certain information should always be provided. All experimental procedures should be mentioned, even if only in a single sentence with a citation of a previous publication, and all human or animal studies should include an ethics statement naming the body that approved the experimental protocol.

NOTATION AND TERMINOLOGY.

Methods should be presented using accepted conventions, terminology, and units so that the reader can focus on the protocols instead of trying to relate the name of a technique to something familiar or trying to convert units to something more recognizable. The common convention is SI units, but because accepted conventions for presenting quantities can vary across fields, you should follow the conventions of your field or a journal's preferences where SI units are not standard.

All the information should be provided in the most easily recognizable form; for example, solutions should be provided as a concentration, not the amount of solute, and centrifugation parameters should be presented not in rpm, as different rotors subject samples to different forces at the same rotor speed, but in units of linear acceleration (typically $\times g$).

EQUIPMENT AND MATERIALS CITATIONS.

Because the reader should be able to replicate our work from the information in the Methods section, any materials, quantities, procedures, and equipment that are essential to the study or that could influence the results should be specified. The guiding principle for determining when to provide specific information and manufacturer citations for the equipment used is when it is integral to a procedure.

For example, the manufacturer of the light microscope used for cell counts does not need to be identified, but the make, model, and manufacturer of an electron microscope should be included; the details about the glassware used to prepare culturing agar can be omitted, but types of flasks should be specified for a study that compares them; and the provider of the sodium chloride used to mix physiological saline is unimportant, but the provider of any experimental grade compounds or pharmaceuticals should be cited.

Furthermore, any equipment that is important enough to mention by name will generally require a manufacturer citation, including location details at the first mention of the manufacturer.

ACQUISITION AND DEFINITION OF THE RESULTS.

The format of the results should be clear from the description of their acquisition, and you should address any potential ambiguity before moving on to present the results themselves.

It should be clear how measurements are taken, how they are processed, and how data are stored. For example, the equipment used to register data, the relevant inclusion/exclusion criteria, and the form of combined data (e.g., means \pm SE) should be presented. Of particular importance is clearly defining any study-specific criteria; for example, if air temperature in a meteorological study is to be classified as cool, intermediate, or warm, then thresholds for these categories should be stated in the Methods section.

STATISTICAL METHODS.

Statistical tests are an integral part of most studies and should be described as thoroughly as any other procedure, usually at the end of the Methods section. Because statistical tests strongly influence the veracity of a study's

findings, their rationale should be presented in enough detail for the reader to evaluate their applicability and use.

In particular, this part of the Methods section should include the specific tests used for the different types of data, what prerequisites (e.g., distribution normality) were tested, what significance or confidence interval levels were used, and which post hoc tests were applied. An additional benefit to thoroughly addressing the statistical methods here is that the statistical criteria will likely not need to be reiterated throughout the Results section.

CONCLUDING STATEMENT.

By its nature, a Methods section is highly factual and does not need to flow or engage the reader like an Introduction or Discussion. Nonetheless, the Methods section is critical in helping a reader fully understand your work. A clear and well-organized Methods section prepares readers for the results of your work and allows them to proceed through the paper without being distracted by questions about the origins of those results.



ABOUT THE AUTHOR

Dr. Bendiksby received a Bachelors in Pharmacology in Scotland, a Neuroscience Cand. Scient. in Norway, and his PhD from Duke University studying visual perception and the cognitive processing of attention and reward in rhesus macaques.



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