How to read an empirical paper

Empirical papers are generally organized into these sections: Introduction, Methods, Results, and Discussion. (In some journals, the Methods section is presented at the end of the paper, but we encourage you to read the Methods before the Results). Each section contains very different kinds of information and it is most effective to read each of them with a clear set of goals in mind.

**A note of reading things in order:** While an empirical paper should be written in a way that maximizes clarity, there are often technical details in different sub-sections of a paper that are completely opaque to non-experts in that area of research. It can be frustrating when you do not understand a single sentence of a paragraph, but fortunately, for most papers, a good understanding of the logic and the main arguments of the paper does not depend on a deep understanding of the technical details (i.e., you can understand the arguments of an ERP paper even if you do not understand what kind of electrodes were used in the study or how the data have been pre-processed).

You should try to answer these questions when you are reading:

**Introduction**

- What are the big-picture questions?
  - A good paper starts by explaining what is at stake first. However, at times the big-picture questions are not immediately clear in the introduction. If the authors did not state the big-picture questions explicitly, you should try to come back to this after reading the entire Introduction section.
  - Sometimes the authors talk about a debate with opposing points of view, and the question is implicit.
- What specific question(s) did the authors try to ask in this paper?
  - Authors of empirical papers approach the big picture questions by formulating more specific questions that can be addressed experimentally. You should identify the authors’ arguments for why this is an interesting/reasonable question to ask.
- How does the current study contribute something new compared to what previous studies have accomplished before?
  - Most Introduction sections provide a review of the previous work on related research questions. You should try to identify how the current study can potentially add to our knowledge about such questions.
  - Some possible scenarios:
    - This is a completely new research question that no one has attempted to answer before (this is pretty unusual).
    - Previous findings are difficult to interpret either because there are missing pieces, or because the results are in conflict, or because they are compatible with multiple explanations, etc., so the current experiment is intended to clarify what the previous findings mean.
    - This study is intended to extend previous findings to a new population/environment (e.g., speakers of different languages, children, second language learners).
- What hypotheses did the authors discuss?
  - Hypotheses are about underlying mental processes (e.g., processes involved in sentence comprehension) and are independent of the experimental methods.
Important: Do NOT confuse hypotheses with predictions. Predictions describe the kind of evidence one would observe within a particular experiment if the hypotheses were correct.

Methods

- What is the experimental design?
  - Identify the independent and dependent variables
    - Experiments involve manipulating one or more factors and measuring the effects of such manipulations on observable outcomes. The factors that are manipulated are called “independent variables”, and the outcomes that are measured are “dependent variables”. Each factor has multiple levels, often called conditions.
    - Example: We want to know the effects of temperature on a person’s heart rate. We can manipulate the temperature of the environment (e.g., high vs. low temperature). In this case, temperature of the environment is an independent variable / factor, and it has two levels (high temperature condition and low temperature condition). We can then measure people’s heart rates (a dependent variable) in each condition.
  - Try to draw a table to explain to yourself the experimental design and fill in the boxes with sample items.
    - Describe what a trial would be like in each condition (i.e., what a participant would see/hear in each condition).
    - Example:

<table>
<thead>
<tr>
<th>Plurality</th>
<th>Animacy</th>
<th>Animacy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Animate</td>
<td>Inanimate</td>
</tr>
<tr>
<td>Singular</td>
<td>Cat</td>
<td>Car</td>
</tr>
<tr>
<td>Plural</td>
<td>Cats</td>
<td>Cars</td>
</tr>
</tbody>
</table>

- Sampling from a population
  - How many participants were tested?
  - What are some characteristics of the population of interest?
    - Were they college students/patients/children/infants?
  - How many items per condition did each participant see/hear?
    - Sometimes this is reported directly, but sometimes you need to figure this out from the total number of items and number of conditions.
    - This can differ quite a lot depending on the population you are testing (e.g., while healthy adults can sit through a 2-hour experimental session, you cannot expect the same for infants/toddlers) as well as the experimental methods you are using (e.g., ERP studies tend to require a much larger number of data points than self-paced reading studies).
  - What are the characteristics of the materials?
    - The stimuli across conditions will inevitably be different in many aspects besides those manipulated as the independent variable. For example, when you manipulate the plurality of a noun, e.g., car – cars, you are inevitably also changing the length/spelling of the word.
    - What unintended variation is controlled for? How was it controlled for, i.e., by being held constant or by counterbalancing?
What was the task?
  o Some tasks are more common/simple than others, but at times you need to first understand the task in the experiment before being able to identify where the dependent variables come from (e.g., reaction time to what? how was it measured?)
  o You can usually get the most detailed description of the task in the subsection called “Procedure”, but note that it usually comes after the description of the experimental design and materials

What does each of the hypotheses predict?
  o How do the dependent variables from the experiment (e.g., reaction time) relate to the hypothesized mental processes (e.g., lexical access)?
    ▪ You might find a discussion in the Introduction where the authors explain why the chosen experimental method is appropriate for testing the hypotheses.
  o If an experiment is well-designed, the competing hypotheses should make contrasting predictions. You should try to figure out the predictions yourself, and then compare them to what the authors said the predictions are. Sometimes the authors put this in the Introduction section.
  o Understanding the predictions of the hypotheses is one of the most important steps in understanding an experiment.

Do not get caught up with the “Analysis” subsection. Eventually if you do your own experiment, you will need to figure out how to analyze your data, and as a researcher it is also important to be able to evaluate whether a particular analysis method is suitable for a particular kind of data. But for now we will just be learning about how different kinds of data are typically analyzed without worrying too much about the details.

Results
  ▪ Understand the figures in the paper and link them back to the predictions
  o Results sections are often filled with technical details about the results of the statistical analyses. We will briefly talk about what some of them (e.g., p-values, main effects, interaction effects) means, but for now you should not worry about the details of the statistics.
  o Rather, it is important that you try to understand the descriptions of the result pattern and be able to read the figures to identify whether the results match up with the predictions.

Discussion
  ▪ Before you start reading the discussion, you should first think about what the results mean and how they bear on the research question.
  ▪ The author’s interpretation of the results
    o The authors usually first summarize their findings in the Discussion section.
    o They are usually free to discuss what the findings mean, and you should decide for yourself whether you agree with their interpretation.
    o The authors sometimes discuss questions that arise from their findings, and this can provide interesting insights for future research.