Appendix: How to Read a Journal Article in Cognitive Psychology

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Research in cognitive psychology and cognitive neuroscience is aimed at understanding the workings of the mind/brain. Cognitive processes are those involved in knowing the world, and cognitive scientists are interested in all facets—from sensing and perceiving, to attending and remembering, and on to thinking, reasoning, and solving problems. Language processes are often a central part of the study of cognition, as language is regarded as "the light of the mind." Therefore, processes involved in listening to speech and in reading are frequently studied.

The study of cognition can proceed through use of purely behavioral methods or by methods from cognitive neuroscience. In the first approach, researchers control and manipulate stimulation to the senses and measure behavioral responses, often focusing on the speed of responses or the patterns of errors generated on a task. From these data, they make inferences about the mental processes involved in a task. The cognitive neuroscience approach involves the study of cognitive processes through use of neuroimaging techniques or from studying patients who have suffered various types of brain damage. The patients and people whose brains are scanned are usually given tests much like those in purely behavioral experiments, but interest centers on specifying neural correlates of performance.

As in all sciences, the journal article is the dominant form of communication among researchers in cognitive psychology. Many journals exist to report findings in the fields of cognitive psychology and cognitive neuroscience, and most subscribe to a similar format. The form of scientific journal articles is unlike that of forms of literature you have already experienced as students; journal articles are not like magazine articles, expository essays, short stories, or novels. The one feature in common is that the journal article, like these other forms, is intended to communicate information and tell a story about the research that was conducted.

The purpose of this appendix is to give you advice on how to approach the journal article. We assume that most readers will have had little more than a first course in psychology. Entering the world of scientific literature is, in our experience, rather like embarking on a journey in a foreign country where the language and customs are strange. To be sure, the words in these journal articles may be English, but often the terms (even ones that seem

familiar, like *perceiving* or *paying attention*) are used in ways that take on technical meanings. Scientists, like members of all subcultures, have their own private languages to discuss the phenomena of their fields. You must learn their language for them to communicate with you, or vice versa. The jargon and format of the writing can be daunting.

Journal articles serve many functions and come in many forms. Some journals specialize in papers that review the literature or present theories. Other journals present findings in brief form and are intended for a wider audience than specialists. However, the standard article in most journals is written for specialists. This means that the authors assume quite a bit of knowledge and they will not bother to explain some terms that "everybody" in the field is supposed to know (e.g., between-subjects design, analysis of variance, or double-blind experiment). If some of the articles you read seem hard to follow or assume too much knowledge, it is probably because they were written for another specialist and not for a novice to the field. Most of the articles in the book you are holding were carefully selected by the editors to be appropriate for undergraduate students without much background in the topic. Nonetheless, some terms will be unfamiliar. If the article you are reading has terms that you do not understand, our advice is to look them up or to ask your professor or a graduate student in the field. However, as noted below, you will not necessarily be able to understand every aspect of each paper perfectly if you are just starting out in the field. Concentrate on the main points.

Scientific articles in psychology come in distinct parts, which usually appear in a systematic order. The main purpose of this chapter is to acquaint you with these sections and to let you know what to expect. These parts include the title and authors, the abstract, the introduction, the method, the results, the discussion, and the references. We cover these in the order they appear in a paper, but as you gain experience in the field, you may elect to read the parts of articles in a different order from their arrangement in the paper. For example, if you just want to know the main conclusions, you can usually get these by reading the discussion.

If you are unfamiliar with journal articles, it is important to avoid getting bogged down by details that are difficult for you to understand. Often you do not need to know these details (e.g., the details of some complicated statistical test) in order to understand the main points of the article. Concentrating on the complex details may only interfere with your grasp of the main points in the article (and you probably won't remember the details, anyway). So, keep your eyes on the forest (what are the important points to be gleaned from this article?) and do not let some scraggly trees (what is multiple regression, anyway?) interfere with your overall comprehension of the main thrust of the article.

Title and Authors

A good title should give you an accurate idea as to an article's content. The author who made the most significant contribution (i.e., to the research and writing) is typically listed first, and in a footnote, you can find out where the research was performed.

Abstract

The abstract represents a brief summary of the article. It usually tells what the research was about, what methods were used to study the issue under investigation, and what results were obtained. Finally, the abstract provides a brief assessment of either the practical value or theoretical importance of the findings. If properly written, the abstract entices you into the paper and gives you a framework for understanding it.

Introduction

The introduction specifies the problem to be studied and tells why it is important. A good introduction will have you involved in a fascinating scientific journey, so that by the end you will know the theory guiding the research and the hypotheses that were tested. In addition, the author also reviews the relevant research literature on the topic in the introduction. In citing relevant literature, psychologists put the name of the prior author doing the work right in the text (e.g., Jacoby, 1991), rather than in a footnote.[1] (The reference can be found at the end of the paper.) Depending on how much prior work has been done (and how extensively the authors report it), the introduction may vary in length. By the end of a good introduction, you should be ready (even eager) to learn about the methods, results and conclusions that will be delivered in the remaining sections.

Method

The *method* section describes exactly how the experimenter conducted the study, and it should contain enough information so that another researcher could replicate the work. Although it is sometimes printed in smaller type to conserve space, it is still a critical part of the article, because it tells how the researchers approached the problem and what they did. Knowing the method is essential if you want to completely understand results of an experiment and form your own interpretation of them.

The method section is usually divided into subsections that cover the participants (or subjects), the design of the experiment, the apparatus or materials, and the procedure that the participants experienced. The *participant* or *subject* section tells how many people (or animals) were studied, how they were selected and assigned to conditions (at random or by specified criteria), and who they were (college undergraduates taking introductory psychology, paid volunteers obtained by a newspaper ad, patients undergoing a certain medical procedure, etc.). Depending on the nature of the study, more or less detail may be provided. For example, in studies of aging it is typical to give quite a bit of detail about ages, education, and other characteristics of the group of people being tested.

The *design* section provides a crisp description of the conditions that will be involved. For example, in an experiment on remembering, it might be that old, middle-aged, and young subjects were asked to study pictures, words (i.e., the names of the pictures), or both types of material simultaneously. Thus, the design would be described as a 3 (age: young, middle, or old) × 3 (materials: pictures, words, or pictures + words) design. The dependent variable would be the number of items recalled on the memory test. The idea for the design section is to present the logic of the experiment concisely. The design just described has two independent variables or "factors" (age and type of material) with three levels of each factor. Recall that independent variables in experiments are those that the experimenters manipulate and dependent variables are the measures of behavior that are taken. The design section typically specifies the independent and dependent variables used.

The *apparatus* subsection of the method section describes any equipment used to test the subjects. This section might include such details as the model number of a computer or the resolution of a viewing apparatus. This section is referred to as the *materials* section when questionnaires, written or videotaped sketches, and similar means are used to test subjects. If they are long, lists of special materials may be placed in an appendix section,

[1] Footnotes are used for asides, like this one, or to qualify the point under discussion with new information. However, in psychology (unlike some fields) they are not used for primary references. Footnotes are generally discouraged, but some authors cannot live without them.

usually set in smaller type, or placed on the Internet with an address provided. (The difficulty with this last practice is that the website may become unavailable as technologies change.)

The *procedure* section explains what happened to subjects in relatively great detail, so that the experimental techniques could be replicated. Therefore, the critical features must be clearly enumerated. Many "failures to replicate" past work often hinge on factors that were not well specified in the original procedure but that are discovered, after much later work, to have been critical. The procedure section should include instructions subjects received, the timing of events, the responses participants were required to make, the number of trials or events experienced, and so on. When you read the procedure, it is often helpful to imagine being a subject in the experiment to form an intuitive understanding of the task and the demands that were placed upon the participant.

Results

The results section tells the outcome obtained in the research. It is unusual to find raw data or individual subjects' scores reported in a journal article; instead, descriptive statistics are presented that summarize the data. Typical descriptive statistics are the mean of a distribution of scores, reflecting a central tendency or "average" score, and some measure of variance (the standard deviation or standard error of the mean) about the mean value. Inferential statistics provide the probability that the observed differences between the various experimental conditions could have been produced by random, or chance, factors. Statistically significant results are those that are judged unlikely to have occurred by chance; they are said to be reliable, which means that they can probably be replicated. This information helps both the researcher and the reader determine how confident to be that the independent variable(s) produced a change in the dependant variable. Both kinds of statistics are important to help psychologists understand the outcome of an experiment.

Either *tables* or *graphs* may be used to describe and summarize data. In the typical *table*, such as Table A.1, data appear under various headings. The experiment required students to answer one of three types of questions about words they saw one at a time. Questions given before each word directed attention to simple perceptual features (Is the word in uppercase letters?), to what it sounded like (Does the word rhyme with *chair*?), or to its meaning (Does the word refer to a type of animal?). If the word to be judged were BEAR, then the answer to any of the questions would have been *yes*. In actuality, half the time the presented word required a *yes* response and half the time it required a *no* response. After subjects had answered a question for each of the words, they were given a recognition memory test.

Before you look at the data, you should first read the title of the table. The title should be explicit enough to tell you what type of data appears in the table. The title of Table A.1 tells you that it contains information about recognition of the words as a function of the questions that people were asked about the words. Sometimes you will also find a note at the bottom of the table, which is used to give more specific information about the data than is provided in the title. Next, you should examine the headings and subheadings carefully. These will tell you about the conditions or variables that are relevant to the data in the table. Across the top of Table A.1 is the Question Type, with three subheadings and columns representing the three types (Case, Rhyme, and Category). On the side are the responses people made to each question (*Yes* or *No*).

TABLE A.1. Mean Proportion of Words Recognized, as a Function of Question Type at Study (Case, Rhyme, or Semantic) and Response Type ("Yes" or "No").

	Question Type		
Response Type	**Case**	**Rhyme**	**Category**
Yes	.42	.65	.90
No	.37	.50	.65

Note. Adapted from Craik and Tulving (1975, Experiment 9).

The data in the table show that the type of question asked had a powerful effect on probability of recognition, with category questions leading to better retention of words than the rhyme questions, which in turn produced better recognition than the case questions. This main effect is a replication of a result that has been well documented in the memory literature: items encoded with respect to meaning were better remembered than those encoded with respect to their surface features (the levels of processing effect; Craik & Tulving, 1975). Further, although the effect of type of question occurred with both responses, this effect was larger when the answer was *yes* than when it was *no*. This pattern represents an interaction between the two variables. That is, the effect of one independent variable (question type) on the dependent variable (recognition performance) depended on the other independent variable (response type). In these data, the levels of processing effect was greater for *yes* than for *no* responses.

Tables are useful to present numerous data points from various conditions. *Graphs* or *figures* are very effective ways of highlighting important aspects of the data and of showing trends. In Figure A.1, we have graphed the data from Table A.1 that we just discussed. The mean proportion of recognized items is represented on the vertical axis, or *ordinate*. On the horizontal axis, also called the *x-axis* or the *abscissa*, are the six question/answer conditions (that is, three questions to which there could be two answers). On the vertical axis (the *y-axis* or the ordinate), the proportion of items recognized is represented. Nearly all figures from any type of psychological research have a scale of the dependent variable (what is measured) on the ordinate. In figures from experiments, the independent variable (what is manipulated) is on the abscissa. In correlational research, where an independent variable is not manipulated, there is a dependent variable on both the ordinate and the abscissa. (If you have trouble remembering which axis is the ordinate and which is the abscissa, a good mnemonic or memory aid is that your mouth moves in the appropriate direction when you say the words: it widens side to side when you say *abscissa* and lengthens up and down when you say *ordinate*.)

Be sure to examine the labels on the ordinate and the abscissa so you know what data are plotted in the figure. In Figure A.1, the heights of the bars tell you the proportion of items recognized in each condition. The main effect of question type is represented by the fact that the bars increase from left to right, as the question was varied. Also, there is an effect of response type, so that words that required a *yes* response are generally better recognized than are those that required a *no* response. The interaction between these two independent variables can be seen by the fact that the difference between the *yes* and *no* bars varies from one question type to the next.

Figure A.1 is a bar graph, and the data from an experiment are plotted as bars when the levels of the independent variable are not given in a measurable dimension. That is, the conditions here are qualitatively different and have different names, but they cannot be ordered on a quantitative dimension. A different way to plot data is shown in Figure A.2. The data appear as points (triangles) connected by lines. A function like this is drawn when the independent variable is on a measurable dimension, so that an ordering of the measures is possible. In Figure A.2, the graph represents the effect of study time (shown on the abscissa) on correct recall of words from a list (measured on the ordinate). Greater time to study each item (i.e., slower presentation rates) results in greater recall.

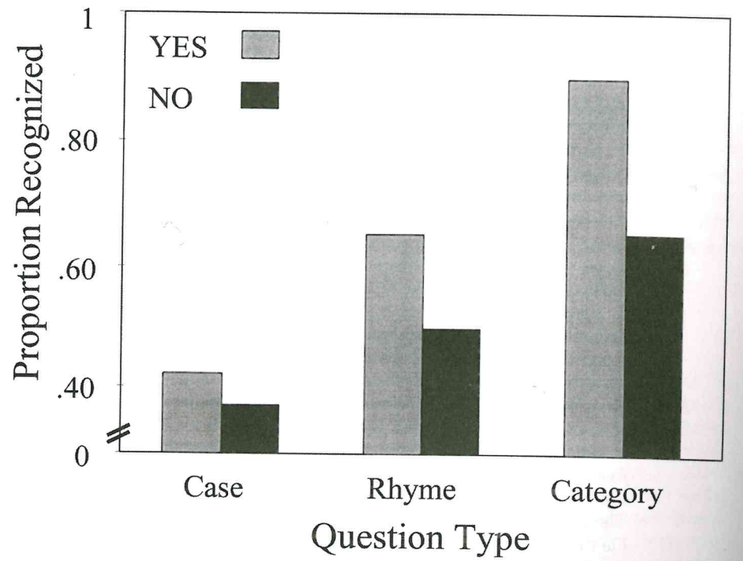

FIGURE A.1 ■ Mean proportion of items recognized for each of the three question types in Craik and Tulving (1975, Experiment 9). The dependent variable (mean proportion of recognized items) is on the ordinate, or vertical axis, and one independent variable (question type) is on the abscissa, or horizontal axis. The other independent variable (response type) is represented by the different colored bars, as specified in the upper-left hand key. Note how the main effect of each independent variable, and their interaction, can be seen from the figure.

When you are trying to understand the data in a figure, be sure that you pay close attention to the scale of the dependant variable on the ordinate. Sometimes the scale can be misleading: An exaggerated scale with widely spaced numbers will tend to make differences appear more impressive, and a scale with numbers jammed close together will tend to make differences appear smaller. To see how this works, look back to Figure A.2. Here we put breaks along the ordinate so that the scale could be widely spaced from .60 to .80, thereby exaggerating the differences in the data to highlight the effect of study time on recall. However, if we had simply allowed the scale to range from 0 to 1, as in Figure A.3, one gets a much different impression from the data. Here the differences among the conditions are not emphasized as much, and a casual glance might lead to the conclusion that the manipulation was not nearly as effective as it appeared in Figure A.2. However, exactly the same data are accurately plotted in both figures.

Both of these graphing techniques are common, and you should always look carefully to see what the scale is in a graph. But which way of graphing the results is right? In a sense, both are, because both can be argued to portray matters accurately. However, if statistical tests have shown a difference to exist between the three conditions, then Figure A.2 would more accurately capture the relation between measures and show up the differences obtained. With experimental data, it is more important to determine whether a difference is statistically reliable than to determine whether the difference appears large when graphed,

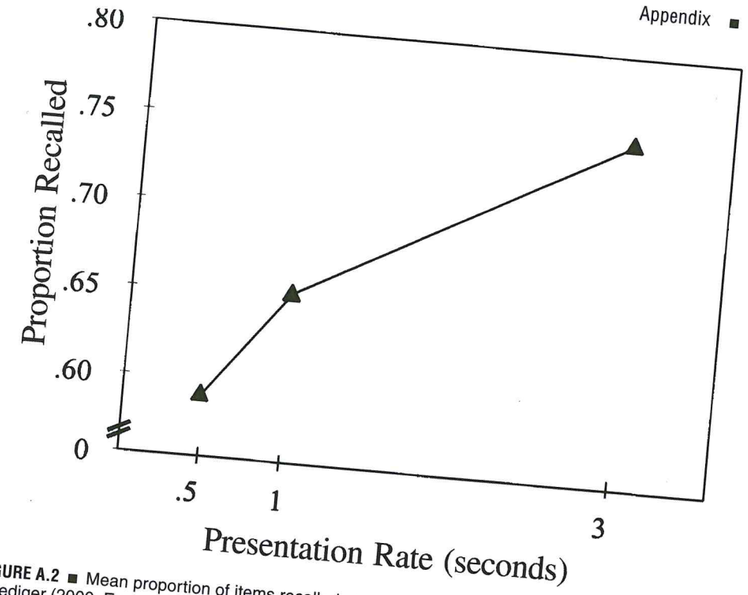

FIGURE A.2 ■ Mean proportion of items recalled at each of the three presentation rates in Gallo and Roediger (2000, Experiment 2). Slowing presentation rate appears to result in a dramatic increase in recall.

because whether a result appears large or small depends on the scale of the dependent variable on the ordinate.

Inferential statistics permit the assessment of whether differences that appear between conditions are the result of the experimental manipulations as opposed to unknown or chance factors. Inferential statistics about the data appear in such statements as "F (4, 60) = 2.03, MSe = 3.40, $p < .05$." This means that the odds for obtaining by chance an F-statistic at least as large as 2.03 would be less than 5% if the experiments were repeated (that's the $p < .05$ part of the reporting of the statistical test). That is, if the experiment were conducted 100 times, the direction of difference in the results should be the same in at least 95 out of the 100 repetitions. You do not necessarily need to know a lot about the statistical tests to survive as a consumer of the research being reported. By convention, results that meet the .05 level of confidence are deemed statistically significant; if you see $p < .05$ that means there is less than a 1 in 20 probability that these results occurred by chance, a good indicator that they are reliable.

Discussion

The discussion section is often the most creative part of an article. At the beginning of the section, the author will typically provide a concise statement of the outcome of the experiment, summarizing the results. Then the author will go on to draw theoretical or practical implications from the results and to relate them to the rest of the literature on this topic. How do these results change what we know about the topic at hand? How do these results fit in with past results? Besides answering these sorts of questions, the author may go on to

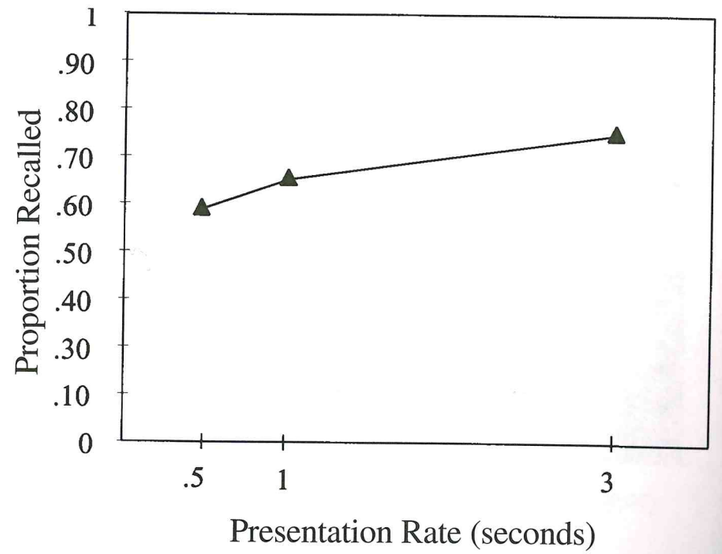

FIGURE A.3 ■ Data from Figure A.2 that have been plotted using the full range (from 0 to 1) of the dependent variable. Note that although the data are the same as in Figure A.2, the effects of presentation rate on recall do not appear to be as "dramatic" in this figure, due to the change of scale.

describe future research that might be useful in answering questions that are left unresolved by the current research.

References

References are found at the end of the article, and include only those articles that are cited in the text. This is different from a bibliography, which includes as many relevant citations as feasible. In contrast to journals in other disciplines, psychology journals list full titles of referenced articles. This practice helps to tell the reader what the article is about, making this section a valuable guide for related information. Furthermore, the references in an article can also be used as a good starting place to find out more about the topic. The cited articles usually refer to the most recently published works in the area before the current one you are reading, as well as including the most important previous publications.

Checklist for the Critical Reader

In this section, we offer some hints that have helped us to become better consumers of the information presented in psychological journals. Keep this checklist handy as you read through the journal articles included in this book. Although many of the points should seem redundant to you by now, going through them will help you identify which sections you may not be reading as effectively as possible, and will sharpen your skills at extracting the critical pieces of information from these sections.

Introduction

1. *What is the author's goal?* The introduction explains the reasons behind the research and reviews the earlier literature on the phenomena of interest. If one or more theories are related to the research, the introduction gives the predictions the theories make. As with scientists in other areas, psychologists do not necessarily agree as to the underlying mechanisms and theoretical interpretations of behavior. The author may present a particular theory that he or she thinks provides a useful explanation of behavior. Although the author may present more than one theory in the introduction, he or she will proceed later on to demonstrate that they do not all help equally to predict and explain the obtained results. Try to figure out which of the several theories the author believes and which are slated for subsequent rejection.
2. *What hypothesis will be tested in the experiment?* The answer to this should be obvious and stated directly within the introduction section.
3. *If I had to design an experiment to test this hypothesis, what would I do?* This is the key question for the introduction. You must try to answer this *before* continuing on the method section of the article. Many experiments are done within the context of a systematic investigation of behavior to test and support a particular theoretical framework developed by the author. If the author has any skill as a wordsmith, once you have finished the method section, you are likely to agree with the method that the author has advocated in the article. A clever author will plant the seeds to this answer in the introduction itself; this practice makes it harder for you to state a method independently. Write down your ideas for testing the hypothesis.

Method

Compare your answer to question 3 with the method used by the author. They probably will differ, if you have not peeked. Now answer questions 4a-c.

4a. *Is my proposed method better than the author's?* Regardless of who has the better method, you or the author, this forced comparison will make you think about the method section critically, instead of passively accepting it.

4b. *Does the author's method actually test the hypothesis?* The hypothesis is sometimes an early casualty, disappearing between the introduction and the methods sections. Always check that the method used is adequate and relevant to the hypothesis at hand.

4c. *What are the independent, dependent, and control variables?* This is an obvious question and can be answered quickly. Listing the variables helps you avoid passive reading of the methods section. After you have resolved differences between your proposed method and the author's, answer the next question.

5. *Using the participants, apparatus, materials, and procedures described by the author, what results would I predict for this experiment?* You must answer this on your own before reading the results section. Think about the procedure of the experiment, and how the different processes involved in the task would have influenced your performance had you been a participant. State your prediction in terms of the hypothesis and the independent and dependent variables. You may find it impossible to predict a single outcome. This is not really a problem, because the author probably also had more than one prediction originally. He or she may have done some preliminary investigations to narrow down possible outcomes; alternatively, he or she may have been surprised by the results and had to rethink the introduction

TABLE A.2. Questions for Critical Readers

Introduction	
1.	What is the author's goal?
2.	What hypothesis will be tested in the experiment?
3.	If I had to design an experiment to test this hypothesis, what would I do?
Method	
4a.	Is my proposed method better than the author's?
4b.	Does the author's method actually test the hypothesis?
4c.	What are the independent, dependent, and control variables?
5.	Using the participants, apparatus, materials, and procedures described by the author, what results would I predict for this experiment?
Results	
6.	How did the author analyze the data?
7.	Did I expect the obtained results?
8a.	How would I interpret these results?
8b.	What applications and implications would I draw from my interpretation of the results?
Discussion	
9a.	Does my interpretation, or the author's, best represent the data?
9b.	Do I or does the author offer the most cogent discussion of the applications and implications of the results?
10.	Am I being too critical?

once the results were in. Draw a rough sketch illustrating the most likely outcomes you have predicted.

Results

6. *How did the author analyze the data?* Although you may not be totally comfortable with statistics yet, a good exercise is to note how the author presented and analyzed the data. Note *which* conditions are being compared and *why*. Data from experiments never come out exactly as anticipated, and authors will often focus on presenting data that they feel are important to convey their main point, while downplaying other data. Do try to understand the author's point of view, but also try to form your own impression about the data as a whole. Are there some unexplained puzzles in the results that the author overlooks?
7. *Did I expect the obtained results?* If not, then you will reach one of two conclusions: either your prediction was wrong, or the results are hard to believe. Perhaps the method the author selected was inappropriate and did not adequately test the stated hypotheses or introduced sources of uncontrolled variance. Or perhaps these results would not be obtained again if the experiment were repeated. Still, even if you did not expect the results, the author obtained them and clearly believes them. Also, if the editors selected the paper for this book of readings, the results are probably considered important to the field.

8a. *How would I interpret these results?*

8b. *What applications and implications would I draw from my interpretation of the results?* Try to answer these questions on your own, before reading the discussion.

Discussion

The discussion section includes the author's interpretation of the data in the form of conclusions. A good discussion section brings the reader full circle in that it provides a narrative response to the questions posed in the introduction. In addition, the author expands on his or her conclusions by offering insight regarding the applications and implications of the experimental results.

As a critical reader, you have constructed your own interpretation of the results. Compare the merits of your interpretation with the merits of the author's. Which one do you prefer? Answer questions 9a and 9b to help you critically assess yours and the author's interpretation of the results.

9a. *Does my interpretation or the author's best represent the data?* Because authors are allowed more latitude in the discussion section than in other sections, it is conceivable that an author has drawn conclusions that may not be warranted by the data. In other cases, authors draw conclusions that are largely appropriate but may proceed to extend these conclusions beyond what the data can support. The latter situation typically occurs when a researcher fails to recognize the limitations of the dependent variable. Still, the author has doubtless thought longer and harder than you have about the problem. Think critically about issues, but don't become nihilistic and believe nothing from what you read.

9b. *Do I or does the author offer the most cogent discussion of the applications and implications of the results?* This question is secondary to the question posed in 9a. Nonetheless, a researcher's responsibilities extend beyond that of conducting a tightly controlled experiment. He or she must also consider the rationale and theory that underlie the research. The extent to which an author identifies applications and implications of the results contributes to the overall integrity of the research process.

10. *Am I being too critical?* Although critical evaluation of a particular set of findings is an important element of science, it is equally important to be willing to accept new ideas and discoveries. Keep in mind that, with practice, anyone should be able to find problems or limitations of a particular piece of research. Only the best scientists are capable of acknowledging these limitations while, at the same time, recognizing the novel contributions an article may offer. The research glass may be mostly full, so you shouldn't necessarily see it as partly empty.

Authors' Note

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REFERENCES

Craik, F. I. M., & Tulving, E. (1975). Depth of processing and the recognition of words in episodic memory. *Journal of Expermental Psychology: General, 104,* 268–294.

Gallo, D. A., & Roediger, H. L., III. (2000). *Variability among word lists in eliciting false memories: The roles of associative activation and decision processes.* Manuscript in preparation.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory & Language, 30,* 513–541.