A research paper is a report about an experiment. An experiment is an organized, objective way to ask a question. Therefore, a research paper, or empirical paper, is the written report about a question and its answer. Therapists ask questions and look for answers every time they assess and reassess their patients. They ask questions of one person at a time, with the answer specific to that patient. Scientists, however, ask questions of many people at a time, with the answer generalized to the entire population of interest. The research paper describes the question and the reasons for asking it, the population of interest, the method for asking the question, the answer to the question, and the meaning that the answer has for the general population.

Within the past few years the number of empirical papers in the occupational therapy literature has increased. Many therapists have expressed dismay over this trend. They may be unused to reading the empirical literature and may have difficulty understanding scientific papers because these are written in an unfamiliar style. Difficulty in understanding or interpreting empirical papers presents a severe problem. To be well informed, therapists must be able to read the scientific literature upon which their practice is based.

This article is a guide to reading a research paper. It describes the sections of a research paper, each of which gives a different kind of information about the question and answer. These sections include summary material, main text, and ancillary information. Within the main text are introduction, methods, results, and discussion sections. Each section will be described separately, and put in the context of a paper by Steven Heck published in this issue of this journal (see pp. 577-581). The reader should remember that stylistic details vary among journals. For information beyond the scope of this article the reader is referred to style manuals such as the Publication Manual of the American Psychological Association (American Psychological Association, 1983) or published articles such as the paper by Crocker (1977). Issues for the astute reader to keep in mind will be suggested as well.

Summary Material

The summary material usually precedes the text and includes the title and the abstract. The title is a brief statement about the main problem. The abstract expands on the title. In a few sentences, the abstract summarizes the problem or question, the experimental procedure, and the result. Although all scientific writing is supposed to be concise, the abstract may be particularly terse.

The title of Heck's paper is "The Effect of Purposeful Activity on Pain Tolerance." The abstract says,
“Purposeful and nonpurposeful tasks were performed . . . examining the effectiveness of the two types of activity in prolonging tolerance to electrically induced pain. . . . Results indicated that the subjects tolerated pain significantly longer . . . while performing the activity designated as purposeful” (Heck, 1988, p. 577). The astute reader should look for key words and phrases, such as purposeful activity and pain, which tell the central focus of the study and the main findings.

The Text

Introduction

The main body of text is divided into sections such as the introduction, methods, results, and discussion. Usually, these sections are labeled (often, the introductory section is not labeled because its function is obvious). The introduction provides the rationale for the study, the background to the problem under consideration, and a statement of the problem. Published materials relevant to the problem are discussed, including papers, abstracts, books, and government documents. The literature is reviewed critically so that the reader will understand the need for the current experiment or study. The astute reader who is familiar with the field should make sure the author has included all of the literature relevant to the topic. Inclusion of sufficient and appropriate references indicates that the author is familiar with work by other investigators and therefore probably has not replicated an experiment unintentionally. A brief reference list may mean that this is a new area of investigation; replication may mean that the author was not satisfied with the original experiment.

In this case the author appears to have searched the literature thoroughly. He tells us that few studies have addressed his particular topic but mentions the related work on pain control with medical, educational, and psychological treatment. His reason for separating the first four paragraphs of the introduction from the rest of the literature review is unclear since he mentions some of the literature in the introduction. This author is kind to the reader and states, twice, the purpose for the experiment he is reporting. The reason for making this statement at the end of the fourth paragraph is unknown. It might have been better placed at the end of the literature review, with the rest of his explanation of the purpose of the study. Stylistic arguments aside, the astute reader will appreciate reading a succinct statement of the goals and hypotheses of the experiment prior to the Methods section.

Methods Section

The Methods section describes exactly how the study was performed. It may be divided into subsections such as Subjects, Apparatus, and Procedures. Many details are given here so that the reader understands exactly what behavior was studied, and how. These details are important for distinguishing among studies asking related, but different, questions. They are also needed for discriminating among well-planned and poorly planned studies. For example, in the study under review the kind of environment in which the experiment was performed could have affected the results. Therefore, the astute reader should expect some mention of how the experimenter handled, or controlled, that issue or variable. In this case the experimenter used a warm, relatively noise-free room. Similarly, the plan or design, of the study is described in this section. The experimental groups are defined and the experimental treatments, or manipulations, are described. The astute reader should look for explanatory information about each task or experimental condition.

Subjects. The Subjects section describes the participants in the study, known as subjects. The number of subjects is reported, along with relevant characteristics such as age, sex, diagnosis, handedness, or premorbid status. The relevant information varies, of course, depending on the question asked. The method for dividing subjects into groups may be explained here as well. For example, the author of the study on pain says, “Thirty college-age students . . . with a mean age of 20.2 years . . . selected on the basis of the results of a seven-item assessment . . .” (Heck, 1988, p. 578). Later in the article we are told that the subjects were used as their own control subjects. Using the same subject in both the experimental and the control condition is one way to eliminate the possible interfering, or confounding factor of differences in performance under noxious conditions. A design that uses the subject as his or her own control subject is known as a “within-groups” design. The astute reader should look for an adequate description of the subjects and an explanation of how any differences among them were eliminated or controlled. In Heck’s study the within-groups design eliminates differences among subjects. Data from subjects with a ceiling effect were not used; in other words, Heck eliminated subjects whose physiological characteristics were outside the limits of this test. This procedure excluded subjects who were not part of the population of interest.

Test Conditions. In this section Heck describes the procedure for his experimental and control conditions. This information could also have been placed under the Procedures section.

Apparatus. The next section, Apparatus, lists all equipment used in the experiment. Common items, such as a goniometer, may be only mentioned, but unusual or unique items are usually described in de-
ally, an appendix following the main text supplies technical details of a complex apparatus. For example, Heck could have used an appendix to describe his apparatus in greater detail.

Since many readers of this journal may not be familiar with the Cyborg Biolab, which was used to monitor subjects' physiological responses, the author could have described it more completely. He does describe the conditions of the environment and the apparatus used to give electrical stimulation. The range of amplitudes for electrical stimulation might have been reported as well. The author might have wanted to report this information because the astute reader might wonder how the responses of these subjects compared with the findings on the psychophysics of pain perception.

**Procedures.** The Procedures section tells what happened during the course of the experiment. Thus it informs the reader exactly how the question was asked. This section explains the instructions to the subject, the tasks used for each experimental manipulation, or condition, and the methods for collecting data. The astute reader should expect the independent and dependent variables to be defined here as well. The experimental conditions are the independent variables. The data are the information about the dependent variables. Any special characteristics of the experimenters, that is, the people performing the experiment, are mentioned as well. The astute reader should expect to be told the procedures used and the order in which they were performed in sufficient detail to be able to understand exactly what happened to each subject.

For example, in the pain study the independent variables, *purposeful activity and pain*, are defined just prior to the Methods section, also an acceptable place for operational definitions. The dependent variables were duration of tolerance, which is not defined, heart rate, and skin temperature. The Procedures section tells the reader how the dependent variables were measured and how pain threshold was measured. The author also reports how the upper limb was stabilized for optimal functioning of the apparatus. Earlier in the paper the two conditions of the experiment are described.

The procedures for a study should be logical; they should make sense to the reader. When reading about a complicated study the reader may find it helpful to use a simple visual aid, such as the block diagram in Table 1, to assist in understanding the procedures and statistical analyses. Knowing the design of the study helps the reader understand how the data were analyzed. In many experiments the data are described with so-called descriptive statistics such as mean, standard deviation, or standard error. Data from pre- and posttests within each subject may be compared (within-groups comparisons) or data from posttests are compared between groups (between-groups comparisons) by using inferential statistics. These analyses may be mentioned in the Data Analysis section of the Methods section, or in the Results section. The astute reader should look for information about the level of measurement, or kind of scale used, to assess each dependent variable. For example, the identification number of a baseball player represents a nominal scale; grades on a history test represent an ordinal scale; degrees of temperature represent an interval scale (Howell, 1982). The level of measurement determines the appropriate inferential statistic for that dependent measure.

**Results Section**

The Results section describes the outcome of the experiment, sometimes with tables or graphs. In other words, it tells the reader what happened. Descriptive statistics are frequently given in tables. Inferential statistics are used to determine the characteristics of the population of interest from the data collected from the small sample of subjects. Tables, graphs, or equations in the text may be used to express the inferential statistics. Many readers may be disconcerted by these equations, but they are merely shorthand for telling the reader the kind of statistical test used, the result of the test, and the probability that the result occurred by chance.

In the pain study the text might have read, “Subjects tolerated significantly longer periods of pain while performing purposeful activity than while performing nonpurposeful activity, \( t(29) = 2.49, p < .02. \)” In this example, the “*t*” means the data were analyzed with a *t* test for related measures. The “(29)” means the test had 29 degrees of freedom, or 30 subjects. The “2.49” is the value of the test statistic, determined by following a formula and looking up the answer in a table. The test statistic represents the ratio of differences between the groups to measurement error. The “*p*” refers to the probability of making a Type I error, or the probability that the result occurred by chance. The “.02” means that the probability of a Type I error was less than 2%. This author did not actually report the statistical tests in this form, although he could have done so. Instead he provided a statistical table and a figure showing the results. This is also an acceptable style of reporting the results. A *t* test is one of many kinds of inferential statistics. Each has a specific use, depending on the type of data. A description of statistical procedures is beyond the scope of this paper. The reader is referred to any standard statistical text or to a review such as Greenstein’s (1980) article.
In general, the highest acceptable probability that a result occurred by chance is 5%. The statement that a result is statistically significant at \( p < 0.05 \) means that the probability of that event having occurred by chance is less than 5%. If the probability was greater than 5% that the result occurred by chance, it may be said that the result was nonsignificant. The words significant and meaningful are not synonymous in this situation. The experimenter and the reader must decide for themselves if statistically significant data are meaningful. In some instances such differences might not be meaningful. For example in the pain study significantly more subjects might have preferred to read Time magazine than Newsweek. Although such a difference may be meaningful to the sales managers of these publications, this information probably has little relevance to the outcome of the pain experiment. Even without a sophisticated background in statistics, the astute reader should be able to understand the information in the Results section by reading the text carefully and studying the graphs and tables. If the data appear to be totally incomprehensible, the problem may be with the study rather than with the reader.

In this example the data are reported following mathematical transformations. A visual inspection of the graph in Heck's Figure 1 (see p. 580 of this issue) suggests no significant differences between the two conditions on any variable although the \( t \) test showed significant differences for duration of pain tolerance. This apparent discrepancy may be due to the use of transformed data in the graph. The author could have avoided this problem by using a table of the raw data instead. A table can be a useful visual aid for understanding the design of an experiment (see Table 1). Each independent variable should be listed in the columns, and each dependent variable in the rows. The matrix should be filled in with further details as needed. In Heck's study, all subjects were tested under both conditions. Therefore, this is a within-group design. The dependent variables are all measured on an interval scale and presumably do not affect each other. Therefore, the appropriate statistical tests are \( t \) tests for related measures or dependent \( t \) tests, which Heck used.

Figures are also useful visual aids to understanding an experiment. They may include pictures or diagrams of the apparatus as well as graphs of the data. Heck's Figure 1 (see p. 580) is a graph of the transformed data. The astute reader should look for informative labels and titles and error bars indicating the standard errors or standard deviations as well as the mean data. The reader should also look for obvious symbols of different parameters, such as the circles and squares used by Heck. Finally, the reader should look for an explanatory legend.

### Discussion Section

In the Discussion the author talks about the results in the context of the material presented in the Introduction. In the Results section the answer to the question is given. The meaning of the result is explained in the Discussion. The reader should think about the logic of the arguments presented and consider the issues related to the original problem. Criticisms or shortcomings may be mentioned here as well. In discussing the implications of the results to the larger issue, new questions may be mentioned, as a sort of preview of "coming attractions."

In the pain study the author restates the hypothesis succinctly and tells the reader that the data support the hypothesis. Then he tells the reader the broader implications of his findings. He also notes some subjective observations, which augment and support his data, and which may lead to further studies. At the end of this section the author notes that data on peripheral skin temperature were "not statistically significant" (Heck, 1988, p. 000). Since he took the time to mention this point, it is likely that he thought these data were meaningful, even though they were not statistically significant at the .05 level. The astute reader will note that a problem arises in some papers when the author discusses statistically nonsignificant results as if they were significant. Implying meaning to data that may reflect chance differences is misleading because it suggests meaning where none can be found. Heck's comment that these data suggest a need for future research is reasonable; the comment indicates that he does not draw unsupported conclusions from the data. The astute reader should be wary of authors who do draw such conclusions.

### Ancillary Material

Most ancillary material is found following the main text. The list of references includes all publications and other material cited in the text. The author's

### Table 1

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<th>Independent Variable</th>
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<th>Control Task</th>
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name, the publication title, and the publication date and place are provided. Enough information is provided for the reader to identify the source and refer to it if necessary. Other ancillary materials may include an appendix with additional technical information, dates for submission and acceptance of the paper to tell the reader how current the paper is, information about the author, and acknowledgments. Information about the author, usually given at the beginning of the paper, includes his name, professional affiliation, professional or academic credentials, and sometimes his address. This information can be a clue to the author’s qualifications for writing the paper and tells the reader where to contact the author to request further information or a reprint of the paper. If the paper has more than one author, the principal author’s address will be listed (unless a corresponding author other than the principal author has been designated). Authors are listed either in alphabetical order or in order of importance of each person’s contribution to the project (this journal, like most, lists authors in order of importance). An exception to that rule is the case of a series of papers with several authors. In that situation each contributor may be given the first authorship on one paper, or the director of the laboratory where the research was performed may be given the last authorship consistently. Finally, acknowledgments are used to thank organizations who provided support and individuals who provided special technical assistance.

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References


