RESEARCH GUIDE

PLANNING AND CONDUCTING SUCCESSFUL RESEARCH

PREPARED BY:

BERTALAN DUDAS MD

DIRECTOR OF RESEARCH
L E C O M

MAJOR RESEARCH CATEGORIES

Basic (fundamental or pure) research:

1. Primary objective is the advancement of knowledge and the theoretical understanding of the relations among variables (see statistics).
2. Exploratory and often driven by the researcher's curiosity, interest or hunch.
3. Conducted without a practical end in mind (although it can have unexpected results that point to practical applications)
4. The terms "basic" or "fundamental" research indicate that, through theory generation, basic research provides the foundation for further, often applied research.
5. Because there is no guarantee of short-term practical gain, researchers often find it difficult to obtain funding for basic research.
6. Basic research asks questions such as: which aspects of genomes explain organismal complexity?

Applied (clinical) research:

1. Intend to solve specific, practical questions; its primary aim is not to gain knowledge for its own sake.
2. Exploratory but often it is descriptive.
3. Characteristically done on the basis of basic research.
4. Often the research is carried out by academic or industrial institutions. More often an academic instituion such as a university will have a specific applied research program funded by an industrial partner.
5. Applied research asks questions such as: what is the most efficient and effective vaccine against influenza?

There are many instances when the distinction between basic and applied research is not clear. It is not unusual for researchers to present their project in such a light as to "slot" it into either applied or basic research, depending on the requirements of the funding sources. The question of genetic codes is a good example. Unraveling it for the sake of knowledge alone would be basic research – but what, for example, if knowledge of it also has the benefit of making it possible to alter the code so as to make a plant commercially viable? Some say that the difference between basic and applied research lies in the time span between research and reasonably foreseeable practical applications.

Exploratory research: a new problem can be structured and identified

Constructive research: a (new) solution to a problem can be developed.

Empirical research: empirical evidence on the feasibility of an existing solution to a problem can be provided.

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RESEARCH FUNDING

Most funding for scientific research comes from two major sources: **corporations** (through research and development departments) and **government** (primarily through universities and in some cases through military contractors). Many senior researchers (such as group leaders) spend more than a trivial amount of their time applying for grants for research funds. These grants are necessary not only for researchers to carry out their research but as a source of merit. Some faculty positions require that the holder has received grants from certain institutions, such as the US National Institutes of Health (NIH). Government-sponsored grants (e.g. from the NIH, the National Health Service in Britain or any of the European research councils) generally have a high status.

RESEARCH METHODS

Experiment

This method is one in which a researcher manipulates a variable (anything that can vary) under highly controlled conditions to see if this produces (causes) any changes in a second variable.

The variable, or variables, that the researcher manipulates is called the independent variable while the second variable, the one measured for changes, is called the dependent variable. Independent variables are sometimes referred to as antecedent (preceding) conditions.

All scientific disciplines use this method because they are interested in understanding the laws (cause-and-effect relationships) of nature. The power of the experimental method derives from the fact that it allows researchers to detect cause-and-effect relationships.

However, a major limitation is that this method can only be used when it is practical and ethical for the researcher to manipulate the antecedent conditions. A second limitation to this method is that experimental studies are usually done in the highly controlled setting of the laboratory. These conditions are artificial and may not reflect what really happens in the less controlled and infinitely more complex real world.

Natural observation

In the naturalistic observation method the researcher very carefully observes and records some behavior or phenomenon, sometimes over a prolonged period, in its natural setting. The major strength of this method is that it allows researchers to observe behavior in the setting in which it normally occurs rather than the artificial and limited setting of the laboratory.

The main limitation of this method is that this is a descriptive method, not an explanatory one. That is, without the controlled conditions of the laboratory, conclusions about cause-and-effect relationships cannot be drawn. This method can also take a great amount of time.

Case study

This method is also a nonexperimental, descriptive type of study. It involves an in-depth descriptive record, kept by an outside observer, of an individual or group of individuals. In the natural sciences case studies might involve in-depth studies of a particular animal or group of

animals or some detailed investigation of a particular physical phenomenon. Case studies are also useful when researchers cannot, for practical or ethical reasons, do experimental studies.
Case studies also involve only a single individual or just a few and therefore may not be representative of the general group or population.

Correlation

Correlation is classified as a nonexperimental, descriptive method. Although correlation is often described as a method of research in its own right, it is really more of a mathematical technique for summarizing data, it is a statistical tool. A correlational study is one designed to determine the degree and direction of relationship between two or more variables or measures of behavior.
Correlation also can be used as a basis for prediction. For instance, if we know that two variables are highly correlated, say +.85, we can predict the value of one by knowing the value of the other. Suppose that SAT scores and college GPAs (grade point average) correlate at +.85. Knowing this, college admission officials can predict a student's grades in college, with a fair degree of accuracy, if they know that student's SAT scores.
The greatest limitation of correlation, that it only shows that two variables are related in a systematic way, but it does not prove nor disprove that the relationship is a cause-and-effect relationship. Only the experimental method can do that.

Survey

The survey, another type of non experimental, descriptive study, does not involve direct observation by a researcher. Rather, inferences about behavior are made from data collected via interviews or questionnaires. Interviews or questionnaires commonly include an assortment of forced-choice questions (e.g. True-False) or open-ended questions (e.g. short answer essay) to which subjects are asked to respond. Surveys are particularly useful when researchers are interested in collecting data on aspects of behavior that are difficult to observe directly and when it is desirable to sample a large number of subjects. The major limitation of the survey method is that it relies on a self-report method of data collection. Intentional deception, poor memory, or misunderstanding of the question can all contribute to inaccuracies in the data.

RESEARCH DESIGN

1. **Selecting a topic**
   a. Prime motivator: your interest
   b. Secondary motivator: interest of your target audience
   c. Time: can it be realistically done?
2. **Literature search**
   a. Originality: avoiding duplication what is already published
   b. Try to determine whether or not data in those reports are valid, outdated, etc.
3. **Research team:** set up a team for solving the problem
4. **Authorship:** determine the authorship prior to the research (very important)

THE RESEARCH PROCESS

1. **<u>Define a question</u>** - state the problem or purpose of the study clearly and concisely
2. **<u>Hypothesis</u>** – giving a tentative explanation for the facts to be tested
3. **<u>Study design</u>**
   a. Good planning is essential to strong design
   b. Originality
   c. Mastering the terminology appropriate to the study design (e.g., incidence, prevalence, sensitivity, specificity)
   d. Selection of the optimal study design for research
      - Basic science research – select the technique carefully
      - Educational research – sample size and statistical approach is essential
      - Clinical research (see appendix)
         i. Randomized controlled trials – excellent for proving causation
         ii. Case-control study
         iii. Cohort studies
         iv. Cross-sectional studies – snapshot of a problem at a specific point in time; prevalence studies
         v. Ecological study
         vi. Case and case series reports
         vii. Meta-analysis
   e. Minimizing bias
      - Bias – "systematic error introduced into sampling or testing by selecting or encouraging one outcome or answer over others (Webster's)."
      - Research specific types of bias and epidemiologic methods for your particular study design and topic
      - Selection bias – to avoid choose a random sample from a stable population and get adequate follow-up
      - Response bias – respondents differ systematically from non-respondents
      - Information, or measurement, bias – systematic difference among the measurements recorded in different study groups.
      - If bias occurs, try to measure its effects and adjust your statistics accordingly.
      - Use randomization and blinding to minimize bias
   f. Designing a short but comprehensive data collection form
      - Ask experienced researcher to critique your form
      - Conduct a pilot test of your form
      - Test for reliability and validity.
   g. Determining eligibility for the study – group should be a homogeneous as possible - define criteria for inclusion and exclusion – must be clearly objective.
   h. Protection of the patient confidentiality.
   i. End points and outcome
      - Choose the optimal unit of analysis before your start your data collection
      - Anticipate extraneous variables that could distort you data
      - Use your literature search to identify variables that could affect your data

- Distinguish between independent and dependent variables; record outcome with several variables
- Choose variables that can be quantified; measure variables as precisely as possible

j. Determining sample size needed to produce good statistical results or definitively answer the research question

k. Preparation for the statistical analysis
   - Consider how to measure each of your variables
   - Organize your variables into logical groups
   - Establish a valid control group (if needed)
   - Determine a length of follow-up (if needed)

4. **Data collection**
   a. Obtain and carefully record your findings
   b. Periodically monitor progress of the study to assure that protocol is being followed and data are complete and accurate
   c. Monitor for potential problems and needs for revision of elements of the study design
   d. Build your database with statistical analysis in mind
   e. Clean and freeze data in advance of analysis

5. **Analyzing and interpreting the data** – keep an open mind and let the data reveal the truth
   a. Univariate analysis – "characterized or depending upon only one random variable (Webster's)."
   b. Multivariate analysis – "having or involving a number of independent mathematical or statistical variables (Webster's)."

6. **Conclusion and revising of hypothesis** - A common misunderstanding is that by this method a hypothesis can be proven. Instead, by these methods no hypothesis can be proven, rather a hypothesis may only be disproven. A hypothesis can survive several rounds of scientific testing and be widely thought of as true (or better, predictive), but this is not the same as it having been proven. It would be better to say that the hypothesis has yet to be disproven. A useful hypothesis allows prediction and within the accuracy of observation of the time, the prediction will be verified. As the accuracy of observation improves with time, the hypothesis may no longer provide an accurate prediction. In this case a new hypothesis will arise to challenge the old and to the extent that the new hypothesis makes more accurate predictions than the old, will supplant it.

WRITING THE PAPER

1. **<u>Initial design</u> -** Avoid compartmentalizing your research – publishing your results in many small papers can minimize the impact of your research
2. **<u>Title</u>** – short, easy to understand, concise and gives accurate idea to the content of the entire paper
3. **<u>Abstract</u>** – the gateway of your paper, be sure it is well written – many scientist will read the abstract initially and decide if your paper is interesting enough
    a. Demonstrate that your findings are important and study was carefully done
    b. State your objectives clearly and concisely
    c. Try to avoid having the same sentences in your abstract and in the body of the paper
    d. Keep it short but do not exclude key information – briefly state your findings
4. **<u>Introduction</u>**
    a. Go right to the essence of the problem or premise of the article in order to focus the reader's attention
    b. Provide adequate background information; use the literature to enhance your introduction
    c. Define terms used in the title, as needed
    d. Describe the purpose of your paper clearly and concisely
5. **<u>Methods</u>**
    a. Provide ample details and organize in a meaningful way
    b. Describe all aspects of the study design and how the data were collected
    c. Describe data collection in detail (who, what, when, where, how, why?)
    d. Define all your variables
    e. Statistical analysis – make this easy to understand and define what is statistically significant and provide reproducible details of the statistical methods used in the data analysis
6. **<u>Results</u>**
    a. Present your results with confidence and provide your data in natural order
    b. Begin with the major positive findings; give negative findings at the end of the results section
    c. Present statistical information using statistical terms appropriately
    d. Be sure that this section is comprehensive and convincing
    e. Acknowledge any problems with data (e.g., small sample size, limited follow-up time, etc.)
    f. Present data for similar variables consistently
    g. Use well-designed tables, graphs, flow charts, histograms, and figures; be sure to cite and summarize these in the text
        - Simple and self-explanatory and not a repetition of the written text
        - Use consistent formats; clearly define all terms
        - Provide units for each variable
        - Include clearly written legends for each figure
    h. Present adverse outcomes perceptively
7. **<u>Discussion</u>**
    a. Begin with your most important point
    b. Confine the discussion to your results and comparison of your results with other data in the published literature

c. Provide practical information and emphasize any new information that your results provide
d. Keep the discussion focused; avoid lengthy rambling discussions
e. Discuss the implications of your findings
f. Consider other explanations for your results, if appropriate
g. Discuss any limitations of your study

8. **Conclusions**
   a. Conclusions should be clear and strong
   b. Be sure that your conclusions are fully supported by the results presented
   c. Limit conclusions to boundaries of the study presented
   d. Describe any further research that should be considered, if applicable
9. **References**
   a. Use full-length articles from peer-reviewed journals; you may also use articles accepted for publication but not yet in print ("in press")
   b. Make sure that all required information is complete and accurate
   c. Limit list to key citations; appropriate, recent or review references; do not use a long bibliography
   d. Appropriately cite references throughout the paper
   e. Refer to reference guidelines for targeted journal

PUBLISHING THE PAPER

1. Selecting a journal – choose the journal most appropriate to the content and reader interest of your study or topic
2. Consider the journal with the higher impact factor
3. Read and follow the "Guidelines for Authors" of the target journal
4. Be sure you understand issues of copyright; get permission to use copyrighted material, if necessary
5. Organize all of your materials into a manuscript for submission
   a. Cover letter
   b. Title page
   c. Abstract and key words
   d. Text of paper (introduction, materials and methods, results, discussion, conclusions)
   e. Acknowledgements
   f. References
   g. Tables and figures
   h. Figure legends
6. Proofread your manuscript several times
   a. Edit, edit, edit; pay attention to detail
   b. Minimize jargon
   c. Check grammar, syntax and punctuation
   d. Delete redundant or excess words and sentences; revise for clarity and brevity
   e. Remember to number your pages in sequence
   f. Recheck all of your calculations

g. Know when and how to use trade names

7. Request an internal review of the paper from an experienced researcher prior to submission
8. Work with reviewers and editors to correct any problems or deficiencies
9. Most common deficiencies encountered (in order of frequency):
   a. Poor presentation
   b. Weak discussion
   c. Lack of originality
   d. Poor methods
   e. Inappropriate statistical analysis
   f. Inadequate results
   g. Weak conclusion

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APPENDIX: STUDY DESIGN FOR CLINICAL RESEARCH

1. **<u>Randomized controlled trial (RCT): the highest quality clinical study</u>**

Required features:

- It has a treatment group. These people receive the therapy under study.
- It has a control group. These people are as similar as possible to those in the treatment group except they do not get the experimental treatment. Instead, they may receive the standard treatment or a placebo (such as a pill with no active ingredient).
- Subjects are randomly assigned. Neither subjects nor researchers get to choose who goes in which group. Assignment is determined by chance, such as by tossing a coin or having a computer randomly assign the volunteers.

Optional features:

- It is double blinded: Neither patients nor researchers know who is in which group. Blinding greatly boosts a study's quality. But blinding is not always possible—one example of this would be a study that compares patients who've had surgery with those who have not.
- It has a large sample size (number of subjects).
- Subjects are followed for a long time.

Disadvantages:

- Expensive - must be funded with large grants from government or industry
- Time consuming
- Some cases RCT is not possible. For example, it would be highly unethical to expose a group of people to anthrax.

2. **Case-control study:**
    - The study looks backwards.
    - It compares people who already have a certain disease with a group of similar people without the disease to look for links between the disease and past events.
    - For example, researchers might compare the foods eaten by cruise ship passengers who got food poisoning and those who didn't.

3. **Cohort study:**
    - The study looks forward.
    - It starts with people who've been exposed to a certain risk factor and other people who haven't and sees what happens to them later.
    - For example, a study might follow women who've used hormones and those who haven't to track and compare rates of cancer development.

4. **Cross-sectional study:** looks at a single point in time. Examples include surveying people with diabetes to see how many take aspirin and comparing rates of arthritis in overweight and lean people.

5. **Ecological study:** compares rates of diseases in different populations—for example, cavity rates in towns with different levels of fluoride in their water.

6. **Case and case-series reports:** provide the weakest evidence. They describe the experiences of one patient (case report) or a few patients (case-series report). For example, when AIDS first appeared, so did case reports describing seriously ill patients with a puzzling cluster of symptoms.

7. **Meta-analysis:** does not actually involve treatment or observation of subjects. Instead, the scientist searches the medical literature for similar studies and pools the results. In effect, a meta-analysis creates a study with a large sample size. A meta-analysis, however, is only as good as the studies it includes.

Literature:

Wikipedia
Webster's Dictionary
North Central Regional Educational Laboratory
Maricopa Center for Learning and Instruction