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Siu L. Chow
Department of Psychology, University of Regina, Canada
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Contents

Summary

The impetus of psychological research is the inability of psychologists to accommodate new phenomena or problems with their existing knowledge. Conducting research is a formal and systematic exercise for the following reasons. First, conceptual skills are deployed to propose a theory for the to-be-explained phenomenon. Second, deductive logic is used to derive the research hypotheses from the theory. This is possible only if the theory is sufficiently specific. Third, researchers collect data systematically according to a plan or design. Fourth, the inductive rule that underlies the experimental design makes it possible to exclude some potential interpretations of the data. Fifth, appropriate statistical procedures are used to tabulate and analyze the data. Lastly, deductive logic is used to draw the theoretical conclusion. In short, the success of the research process depends on a confluence of conceptual, meta-theoretical, methodological, and statistical skills.

For various reasons, psychologists may emphasize some of the six aforementioned reasons at the expense of the other issues. Consequently, psychologists use a wide array of research methods. This sometimes gives the impression of fundamental methodological differences among psychologists. While this is not necessarily undesirable, it is hoped that the discussion of the meta-theoretical and philosophical issues serves to set the methodological disagreements among psychologists in the proper context. For example, before considering whether empirical research should be driven atheoretically by data or be guided conceptually by theory, it may be helpful to examine first whether or not there is "pure" observation. At the same time, realizing that all observations are theory-dependent, should we conclude that no objectivity is possible, particularly when psychologists appeal to the incorporeal entity, the mind? Before attempting to answer the question as to whether or not the mind can be reduced to the brain, we may find it necessary to see how cognitive psychologists study unobservable hypothetical structures or processes like perception, memory, intelligence, motives, and the like.

Explanations are qualitative in the sense that psychological phenomena are explained in terms of hypothetical mechanisms to which theoretical properties are attributed. Are psychologists being inconsistent when they insist on using statistics or psychometric tests? How is it possible to use

quantitative data as evidential support for qualitative theories? How do psychologists generalize from their data that are collected in an artificial setting to real-life phenomena? What is the rationale of experimentation in psychological research? How can psychologists assess their research?

1. Introduction

Conducting research differs from informal gathering of information in that researchers collect data systematically so as to answer a well-defined question. The research is systematic if data are collected in strict accordance with a predetermined plan or design. The question is well defined if it originates from an unambiguous theoretical statement. These requirements seem reasonable for studying tangible and durable phenomena (e.g. a floating vessel). However, they would seem at first blush impossible for psychologists to conduct research in view of the following challenges.

First, much of what interests psychologists is not observable in the way physical objects like chairs and cars are tangible. To skeptics, the incorporeal nature of mental phenomena (e.g. memory, drives, thinking, etc.) precludes them from being observed or measured. This, in turn, renders it impossible to study them systematically. Second, individual human beings are unique and unpredictable in a way physical objects are not. It would seem inappropriate to strive for general statements, let alone functional laws or explanatory theories that apply to all human beings without exception. Third, unlike inanimate objects whose nature is relatively durable, psychological phenomena are colored by fleeting wants, desires, fears, and the like. Is it possible to study inconstant phenomena systematically and objectively? Fourth, while it may be possible to study a complex object bit by separate bit if the object is the sum of its components, this analytical approach is inappropriate for psychology because individual character has a unity that is more than the sum of its parts. For example, taking away Smith's motives (if it were possible), psychologists are no longer studying Smith. Conversely, it is not meaningful to talk about Smith without taking into account Smith's motives. Fifth, human affairs are value laden. Can, or should, psychological research be objective?

This introduction to the research methods used in psychology begins with how the confluence of psychologists' conceptual, logical, meta-theoretical, theoretical, and statistical skills serves to ensure that research data are collected systematically to answer well-defined questions. Next is a summary of the multiplicity of research methods at the disposal of psychologists. The philosophical and methodological assumptions underlying the aforementioned reservations about psychological research are considered before the discussion of how research findings are assessed. The discussion concludes with an affirmation of the primacy and importance of theoretical considerations.

2. The Confluence of Issues from Different Domains

A description of various skills implicated in conducting research provides the backdrop for subsequent discussion of various philosophical and methodological issues implicated in psychological research. It is also essential for understanding why psychologists do things the way they do.

2.1. Conceptual Issues

Psychologists begin a research project when confronted with a phenomenon that cannot be readily accommodated by the existing conceptual scheme. For example, why does the normally reserved Joe become an ardent activist who participates in protests? Why do drivers sometimes "see" the red traffic light after they are half a block past the intersection (see *Experimentation in Psychology--Rationale, Concepts and Issues)*? The first step in conducting research is the conceptual task of coming up with a conjecture that makes sense of the to-be-understood phenomenon. Note that the phenomenon exists before the research, and that the research is about an explanation of the phenomenon, not the phenomenon itself (for a discussion of the analogous distinction between the

interpretation of test scores and the test scores themselves in *The Construction and Use of Psychological Tests and Measures*).

In Psychologist A's view, Joe's new found activism is the expression of his previously suppressed aggressiveness. However, Psychologist B considers the change as a sign that Joe has overcome a crippling inhibition. Can the two explanations be true at the same time? Which one is correct if they are incompatible? At the same time, both may be incorrect. For example, Joe's change may be brought about by a newly acquired insight into social policies. It is a sophisticated conceptual task to design appropriate research to sort out these questions.

Psychologist C may suggest that Joe's previous reserve was, in fact, aloofness, which camouflaged Joe's aggressiveness. Such a stance raises the conceptual issue as to how it is possible that aggressiveness can account for two apparently unrelated, if not opposite, phenomena (aloofness and activism). A related conceptual issue is whether or not aggressiveness would be evoked to explain Joe's reserve had his demeanor been characterized as shy instead of aloof. That is, the direction of the research depends on how the phenomenon is conceptualized in the first place.

Native speakers of a language are not necessarily good at explaining what makes an utterance grammatical in the native language. This is because the ability to analyze and talk about natural language is a meta-linguistic skill different from the ability to use the language. Likewise, a different conceptual skill is required to explicate or analyze the rationale of psychological research, namely, a familiarity with some logical rules and relationships, as well as some methodological issues.

2.2. Logical Rules and Relationships

Psychologists dispute whether a scientific psychology is deductive or inductive. In contrast, satirizing some psychologists' scientific aspiration as mere scientism (an exaggerated faith in the propriety or efficacy of applying the methods used in the physical sciences to the social sciences and humanities), some psychologists suggest that adductive rules be used in psychological theorizing. This sets in high relief the need to clarify the role of logic in psychological research. In fact, researchers have to use deduction, induction, and adduction, albeit for different purposes at different stages of the research. Moreover, researchers have to be well versed in three logical relations.

2.2.1. Deductive Logic

Deductive logic consists of rules that make it possible to derive a valid conclusion from a set of premises. Of particular interest are the four conditional syllogistic paradigms (or argument forms) shown in Table 1. The modus tollens argument form may be used to introduce the terms necessary for subsequent discussion.

Table 1. Four conditional syllogistic arguments whose major premise is a conditional proposition

1	Modus tollens ("denying the consequent"): Major premise: If A is true, then B is found. Minor premise: –B (B is not found). Conclusion: A is definitely not true.
2	Affirming the consequent: Major premise: If A is true, then B is found. Minor premise: B (B is found). Conclusion: A's truth-value is indeterminate.
3	Modus ponens ("affirming the antecedent"): Major premise: If A is true, then B is found. Minor premise: A (A is true).

	Conclusion: B is definitely true.
4	Denying the antecedent: Major premise: If A is true, then B is found. Minor premise: –A (A is not true). Conclusion: B's truth-value is indeterminate.

Consider the meanings of "truth-value" and "categorical proposition" with reference to [E1] and [E2]:
[E1]: An automobile has four wheels.
[E2]: If Theory T is true, then Implication I is true.
If what is described in [E1] is indeed the case, E1's truth-value is true. If what [E1] describes is not the case, [E1] has "false" as its truth-value. [E1] is a categorical proposition in the sense that its truth-value is determined solely by what it says without referring to any other proposition. This is not the case with [E2], which has three components: the two categorical propositions, "Theory T is true" and "Implication I is true," and the logical operator "If . . . then . . ."
The operator "If . . . then . . ." stipulates the logical operations that are permissible on the antecedent and consequent. [E2] is a conditional proposition in the sense that its truth-value is contingent on the truth-values of its antecedent and consequent. The proposition that follows "If" is the antecedent, whereas the proposition that follows "then" is the consequent of the conditional proposition. As may be seen from Table 2, the conditional proposition is false only when it has a true antecedent and a false consequent.

Table 2. The truth-value of the conditional proposition

Truth-value of antecedent "A is true"	**Truth-value of consequent "B is found"**	**Truth-value of the conditional proposition "If A is true, then B is found"**
True	True	True
True	False	False
False	True	True
False	False	True

An argument is a syllogism if it is made up of three propositions such that the first two (called the "major premise" and "minor premise," respectively) form the basis for deriving the third one (the conclusion). A conditional syllogism is one whose major premise is a conditional proposition. The inferential foundation of empirical research is the conditional syllogism.
As may be seen from Table 1, the categorical proposition used as the minor premise of the conditional syllogism may affirm or deny the truth of the antecedent or consequent. Such a state of affairs gives rise to four argument forms. The modus tollens form says that denying the truth of the consequent warrants concluding that the antecedent is false. The modus ponens form says that affirming the truth of the antecedent justifies accepting the consequent as true. No definite conclusion can be drawn when the consequent is affirmed or when the antecedent is denied (see *Quasi-Experimentation*)**.**

2.2.2. Graphical Representation of the Conditional Syllogisms

A graphical representation may be used to overcome the counter-intuitive feel of the "affirming the consequent" and "denying the antecedent" paradigms. For the purpose of the present exposition, "If

T, then I" means that all members of T are members of I. This is represented in Figure 1 by placing the smaller oval T inside the larger oval I. The area outside oval T is –T. By the same token, the area outside oval I is –I. The elements x, y, and z represent particular members of T, I, and –I, respectively. The four syllogistic argument forms shown in Table 1 may now be explicated as shown in Figure 1.

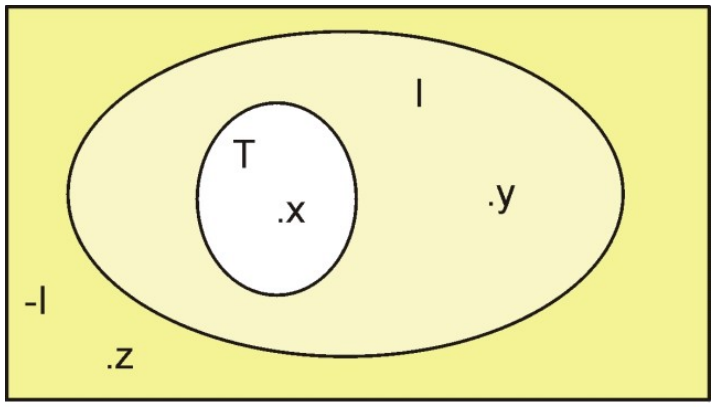

Figure 1. A Venn diagram illustrating the four conditional syllogistic argument forms

In terms of Figure 1, to assert –I is to say that there is an element that is not a member of I. This is the assertion of the minor premise of the modus tollens argument form. Such an element may either be y or z. As both y and z are outside oval T, neither of them can be a member of T. This shows why denying I (i.e. asserting –I) warrants the –T conclusion in the modus tollens paradigm.

To say that I is true, amounts to saying that there is an element that is a member of I. Both x and y fill the bill. However, while x is member of T, y is not. In other words, knowing that there is a member of I does not warrant the conclusion that there is a member of T. Hence, affirming the consequent leaves indeterminate the truth-value of the antecedent of the conditional proposition.

The modus ponens rule may be explicated in like manner. Being a member of T, x is also a member of I by virtue of the inclusion of T in I. Hence, if T is true, I is true. Although neither y nor z is a member of T (i.e. –T), y is nonetheless a member of I. Consequently, knowing that there is an element that is not a member of T is not informative as to its membership in I. Hence, denying the antecedent of "If T, then I" leaves the truth-value of I indeterminate.

2.2.3. Inductive Logic

The proposition "All X are Y" is a universal (or general) proposition in the sense that it makes an assertion about **all** tokens of X, namely, that they are all members of Y. In contrast, "Some X are Y" is a particular statement that asserts that only some tokens of X are members of Y. The function of inductive logic is commonly understood as a means that enables us to leap from the particular proposition to its universal counterpart. For example, having seen white swans without exception in the past, the budding naturalist may conclude (albeit incorrectly) that "All swans are white." That is, induction in such a view is generalization on the basis of enumeration. However, this commonly held view is unsatisfactory.

For example, what is the minimal number of white swans that warrants the generalization? Psychologists actually use more sophisticated inductive rules to reduce ambiguities in their explanation of data (see *Experimentation in Psychology--Rationale, Concepts, and Issues)*.

2.2.4. Three Logical Relationships

References are often made in theoretical discussions to one of three logical relationships between two variables or between a variable and a phenomenon: (a) the necessary condition, (b) the sufficient condition, and (c) the necessary and sufficient condition. Each of them (particularly the necessary and sufficient condition) at various times has been identified with the causal agent.

Z is the necessary condition for E if, in the absence of Z, E cannot occur. Suppose that Z refers to studying conscientiously and E stands for passing the examination. Suppose that students who do not study conscientiously do not pass the examination. In such an event, studying conscientiously is the necessary condition for passing the examination.

W is the sufficient condition for Y when Y always occurs in the presence of W. An example may be the observation that whenever an individual gives birth, the individual is always a female. That is, Y refers to being a female, and W stands for giving birth. (However, as will be seen in *Section 2.2.5. Formal Rules and Relationships in Theoretical Discussion*, giving birth is not the sufficient condition for being a female.)

Variable A is the necessary and sufficient condition for Event B if (a) Event B cannot occur in the absence of Variable A, and (b) Event B occurs whenever Variable A is present. Suppose that A refers to water, and B stands for the flourishing garden. In the presence of plenty of sunshine and good soil, water is the necessary and sufficient condition for the flourishing garden.

2.2.5. Formal Rules and Relationships in Theoretical Discussion

The logical rules and relationships described are applicable to all subject matters. This shows that logic and substantive issues belong to different domains. Specifically, knowing that water is the necessary and sufficient condition for the garden to flourish is to become knowledgeable of a formal relationship between water, sunshine, soil quality, and plant growth. There still remains the substantive question as to why water bears such a relationship to plant growth, given sunshine and a good soil. It follows that the necessary and sufficient condition cannot be identified with the cause. Similarly, neither a sufficient nor a necessary condition should be so identified. A logical relation is simply not a causal relationship.

The seahorse's breeding method is unusual because it is the males who give birth. Hence, it is incorrect to say that being a mother is a sufficient condition for being a female. This counter example shows that the "induction by enumeration" procedure is an unsatisfactory means for establishing knowledge. It takes only one negative example to give the lie to the putative sufficient relationship between motherhood and being a female.

Likewise, the four conditional syllogisms are formal rules. Indicative of their having no substantive import is the fact that they are used in the same way, regardless of what T and I represent or how T and I are obtained. This does not pose any problem for logicians because they do not have to consider what T or I says or why Propositions T and I have the implicative relationship entailed in "If T, then I." Nor have they to explain why the minor premise is I or –I. Nonetheless, the logical relations and four conditional syllogistic argument forms are implicated in theoretical discussion (see *Quasi-Experimentation).*

2.3. Meta-Theoretical Issues

Psychologists use conditional syllogisms to assess the relationship between the theory, the experimental hypothesis, and research data (see *Experimentation in Psychology--Rationale, Concepts, and Issues)*. Consequently, psychologists have to specify the substantive meanings of A and B when "If A, then B" is used as the major premise. Deriving implications of this sort depends on having an unambiguous theory to begin with, as well as on the psychologists' theoretical sophistication.

2.3.1. Criteria of Falsification

Reference is made to the well definedness of the research question. Such a question is based on a testable statement that, in turn, is an implication of the to-be-corroborated theory. The meaning of "well definedness" may be explicated as follows. Suppose that there are four theories about atmospheric events: T_1, T_2, T_3, and T_4. Further suppose that, in the context of a particular geographical locale, they imply I1, I2, I3, and I4, respectively:

It will rain	[I1]
It will rain tomorrow, given the right conditions	[I2]
It will rain on April 1, 2020	[I3]
There will be 2.5 cm of rain on April 1, 2020	[I4]

Theory T_3 implies [I3] in the sense that T_3 cannot be true if [I3] is not true. Although the common practice is to say that [I3] is a "prediction" of T_3, it is more correct to say that [I3] is a theoretical prescription of T_3 because [I3] is not a forecast of an event in the future. Instead, [I3] instructs researchers to declare that T_3 is not tenable if [I3] is not observed. It is in this sense that an implication of the theory is a criterion of rejection or falsification of the theory.

Suppose that there is 1 cm of rain on April 1, 2020. This leads to the rejection of T_4, but not T_3. For this reason, [I4] is a superior criterion of rejection to [I3] because it is more stringent by virtue of its being more specific. This is the consequence of T_4 being formulated better theoretically than T_3. Nonetheless, both [I3] and [I4] are well-defined statements because they stipulate specific, unambiguous criteria for rejecting a theory. This is not the case with [I2] or [I1].

In the absence of an independent index for the caveat "given the right conditions," [I2] is true by definition (and, hence, circular). That it does not rain may mean that the right conditions are absent. On the other hand, the right conditions must be present when it rains. At the same time, it is not possible to say that [I1] is false because of its imprecision. In short, statements like [I1] and [I2] cannot be used as criteria of rejection in theory corroboration. What this says about theoretical considerations is that theories like T_1 and T_2 that give rise to the likes of [I1] and [I2] as implications, respectively, are not testable theories. Theoretical sophistication is required to avoid entertaining non-testable theories.

2.3.2. Falsification versus Verification

To recapitulate, the corroboration of Theory T consists of the following sequence of events. Psychologists identify an implication of T (i.e. I), and use "If Theory T, then Implication I" as the major premise. Implication I consists of a stipulation of (a) the test conditions and procedure, and (b) the data (D) necessary for the tenability of Theory T (the theoretical prescription that T is not tenable if D does not match I). The outcome of the research (D) supplies the minor premise of the conditional syllogism implicated in the theoretical inference.

Psychologists have to use the "affirming the consequent" argument form when D is like I (i.e. I is obtained). The truth-value of Theory T is indeterminate under such circumstances. This is the reason why psychologists cannot claim to have proved a theory even when the expected data are obtained. In the event that D is unlike I (i.e. "–I" represents that I is not obtained), modus tollens dictates that the research conclusion be the rejection of the theory represented by T.

It seems disconcerting that (a) psychologists can never prove a theory because the truth-value of the theory remains indeterminate regardless of the frequency with which the consequent is affirmed, and (b) one negative outcome leads to the abandonment of the theory.

We can rest assured that the indeterminate conclusion based on affirming the consequent does not render impossible psychological research, because the lack of absolute certainty does not mean futility. At the same time, the discomfiture brought about by not being able to prove a theory is more apparent than real because there is an alternative to verification as the means to establish a theory's tenability. Psychologists may adopt the falsification route instead. That is, the theory

corroboration process consists of a concerted effort to refute the theory. Psychologists' confidence in the theory increases as more and more deliberate and rigorous attempts to falsify the theory fail. Such a concerted effort assumes the form of a series of theoretically informed and interrelated investigations. They are collectively called "converging operations" because they converge on the theory's tentative tenability if none is rejected. Important to objectivity is the fact that diverse investigators (who may not share the same faith in the theory at the beginning) contribute to the converging operations.

2.4. Methodological Issues

Research methods available to psychologists fall into three categories: non-experimental, experimental, and quasi-experimental. They are distinguished by the extent to which three types of controls are present. Note that none of these controls means constraining the research participants. Instead, a control is a means to exclude an alternative explanation of research data. Specifically, a valid comparison baseline is a control. For example, in order for psychologists to assert that the new and old methods of teaching produce different results, the minimal requirement is to measure student performance in an identical manner under comparable conditions after teaching students with the two methods. The important point is that setting up controls in the experiment does not mean shaping subjects' behavior (see *Experimentation in Psychology--Rationale, Concepts, and Issues)*.

If psychologists do not provide any recognized control in the empirical study, they are conducting a non-experimental investigation. When all theoretically informed controls are present in the empirical study, psychologists are conducting an experiment. If, for various reasons, at least one control is not instituted, psychologists are conducting a quasi-experiment.

The choice between the three types of research methods depends on the meta-theoretical assumptions and theoretical foundation of the research. Psychologists who use non-experimental methods have to decide on a research plan and to choose the measuring instrument (see *Interviewing and Observation* and *The Construction and Use of Psychological Tests and Measures)*. Experimental psychologists have to choose an appropriate experimental design, the experimental task, and the dependent variable as well as determine the type or amount of training provided for the subjects before data collection (see *Experimentation in Psychology--Ratinale, Concepts, and Issues)*. Applied psychologists conducting quasi-experiments have to choose an appropriate design and the outcome measure (see *Quasi-Experimentation)*. Ideally and regardless of the choice of research methods, psychologists have to decide on the data analysis procedures before commencing the research.

In cases where quantitative information is deemed irrelevant, psychologists would have to decide on how to deal with the narrative data collected from open-ended interview questions. The choice of the method of text analysis is an important consideration for dealing with narrative data (e.g. the classical or pragmatic content analysis or the grounded theory, etc.).

2.5. Statistical Issues

For most psychologists, statistics is an essential research tool whose utility differs in different types of research. Psychometricians use correlation to establish the validity and reliability of psychometric tests. Two main issues in extracting the factors from among a set of correlations coefficients are (a) the number of factors to be extracted, and (b) the nature of the rotation required in extracting the factors (e.g. oblique, orthogonal, or any other means). The type of validity used in substantiating the factors thus extracted (construct validity, performance validity, etc.) may influence the construction of the items of the test. The nature of the test items, in turn, may determine the type of reliability to be ascertained (see *The Construction and Use of Psychological Tests and Measures)*.

The correlation and regression coefficients are also used in path analysis and structural equations. These two methods are assumed by many psychologists to be the statistical means of ascertaining causal relations among a set of variables. However, "cause" is not used in its vernacular sense in this context. Instead, by "causal," path analysts have in mind a functional relationship identified in the path diagram.

The most frequently used statistical procedures are various significance tests (e.g. the χ^2 test, *t*-test, *F*-test, etc.). They are procedures used to test whether or not it is warranted to rule out chance influences on the data collected in different conditions. The essence of these decision rules is that any test statistic is deemed too unlikely to be explainable in terms of chance influences if its associated probability is α or smaller than α. The most commonly used value for α is 0.05 (see *Statistics and Its Role in Psychological Research)*.

Hence, a crucial consideration for psychological researchers is choosing an appropriate statistical procedure. This decision should be made with reference to the design of the study, the level of measurement used, and the statistical question being asked. For example, the dependent and independent *t*-tests are used in conjunction with the related-sample and independent-sample, one-factor two-level designs, respectively, when the data are at the interval or ratio scale. The non-parametric Wilcoxon test and Mann-Whitney U test, respectively, should be used when ordinal data are collected from two related samples and independent samples.

Despite their critical role in empirical research, a litany of complaints about significance tests has accumulated since the 1960s. This general dissatisfaction with significance tests was important in the formation of the Task Force on Statistical Inference by the American Psychological Association. The more ardent critics of significance tests even advocate prohibiting their use. However, the criticisms are deconstructionist (see *Statistics and Its Role in Psychological Research)*. Specifically, no critics have taken into account the fact that the probability basis of significance tests is the sampling distribution of the test statistic. The criticisms are contentious because they owe their impetus to a failure to distinguish (a) between statistical and non-statistical concerns, and (b) between concepts at different levels of abstraction (for a discussion of the appropriateness of using the standard error of measurement in estimating test reliability see *The Construction and Use of Psychological Tests and Measures)*.

3. An Overview of Research Methods

Not only do psychologists have three types of research methods from which to choose, they also have multiple options within each type of method. An overview of the research methods, particularly those subsumed under "non-experiment," commonly used in psychological research may be found in Figure 2.

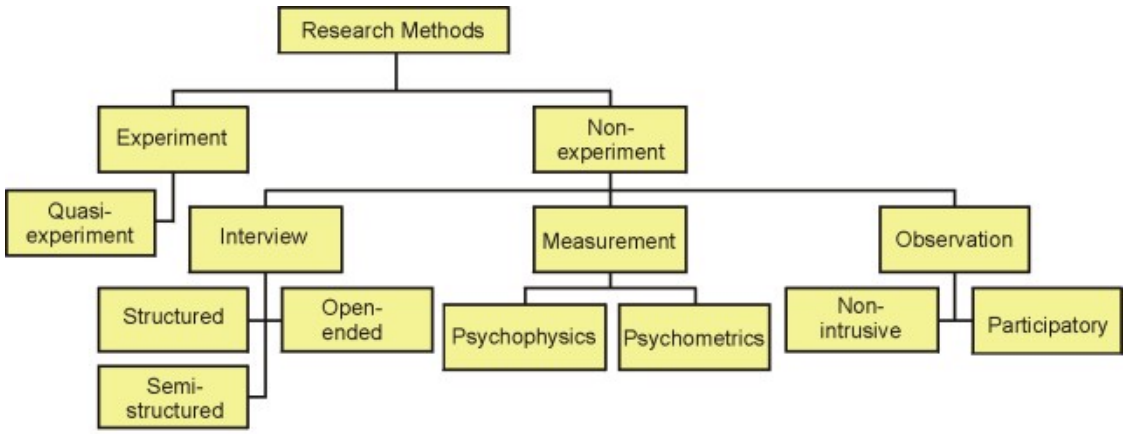

Figure 2. Methods in Psychological Research

3.1. Methodological Evolution

Note that research methods in psychology are related in the sense that they are all means of soliciting information about human nature from human participants. As a matter of fact, all methods originate from introspection in which individuals are asked to describe as accurately as possible what goes on in their minds when sensations or experiences of pains and emotions occur. The difficulties with introspection became obvious when it was found that research participants had to be trained extensively before data could be collected. Apart from being time consuming, the picture obtained from very specialized participants may not be germane to obtaining an account of human experience in general. Moreover, it is not possible to tell whether the introspective accounts thus collected are accurate.

The need to collect objective, quantitative data about actual sensations efficiently and without being beholden to the subjects' articulateness led to the development of the classical psychophysical methods (e.g. the method of limits). With some additional assumptions, the new (and presumably more direct) psychophysical method (sensory scaling and inter-modality scaling) was introduced.

There is another dissatisfaction with introspection. Although interesting, an individual's introspective account of sensations or emotions may not be relevant to researchers' concerns. Hence, it seems necessary to provide a directive for subjects as to what to report. This is the beginning of the unstructured interview with open-ended questions. Before long, it is realized that there is the issue of comparability when more than one interviewee participates in the investigation with the unstructured format. For example, how can interviewers ensure that the same questions are asked in the same way of all interviewees? Moreover, the fruitfulness of this method depends too much on the interviewees' articulateness. The issue of comparability may be dealt with by determining the exact set of to-be-used questions before the interview. The difficulty with differential articulateness among interviewees may be overcome if all interviewees are given the same set of response options. These solutions give rise to the structured interview. When the structured interview is conducted in written form, researchers are using a questionnaire.

Crucial to experimentation are well-defined theories, from which research questions and experimental hypotheses are deduced. This derivation process is not unlike the development of formal proofs in mathematics. However, mathematicians do simulations when the model on which they work does not permit any formal derivation. Alternatively, simulations may be used when the derivation is too complicated. The same situation arises in psychological research. Psychologists appeal to computer simulations when it is difficult, if not impossible, to derive experimental hypotheses. This brief account shows that the multiplicity of research methods is partly the result of

how research methods evolve when researchers are confronted with difficulties with the current method.

3.2. Non-Experimental Methods

Any research without a valid comparison baseline is a non-experimental study. As may be recalled from Figure 2, there are many non-experimental methods: interview, observation, measurement, or the formalistic simulation method.

3.2.1. Interview and Related Methods

The interview is used to solicit information by talking to participants (called "interviewees"). No predetermined question is used in the unstructured interview with open-ended questions, and interviewees determine the depth and the manner of the answers. In contrast, the interviewers ask interviewees a set of predetermined questions in a specific order in the structured interview. Moreover, interviewees are given specific instructions as to how to answer the questions (e.g. yes-no, agree-disagree, etc.). When the structured interview is administered in printed form, psychologists are administering a questionnaire. Using the questionnaire, psychologists may use a mixture of fixed-option, yes-no, rating-scale, Likert-scale items to collect information. In between the unstructured and structured interviews, interviewers may use the semi-structured format, in which predetermined questions are mixed with open-ended questions. Regardless of which method is used, psychologists may ask direct questions or indirect questions. The projective method is an example of soliciting information by asking indirect, open-ended questions (see Figure 3) (see *Interviewing and Observation)*.

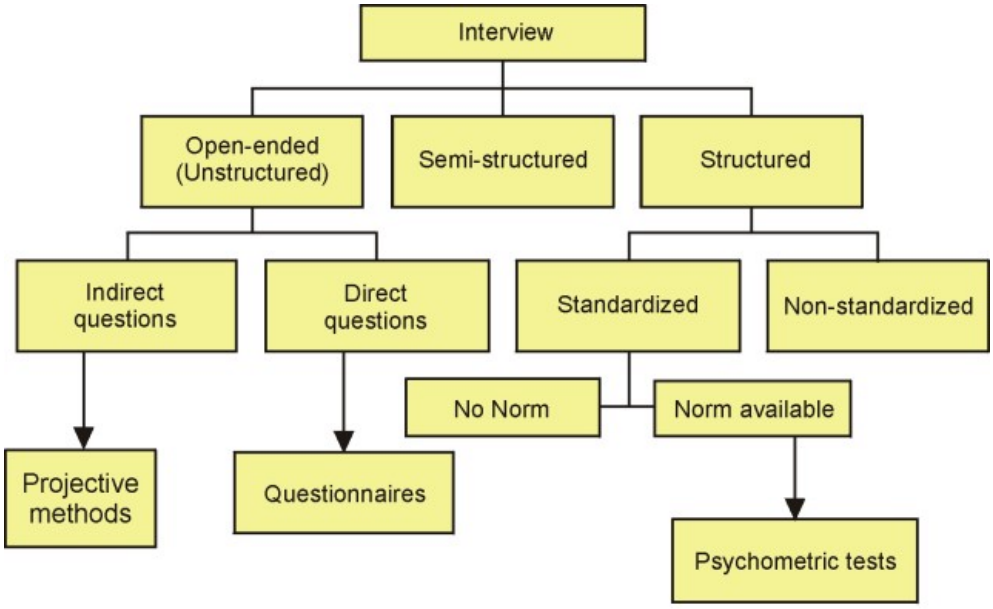

Figure 3. Soliciting information by asking questions

Non-verbal information or information about interpersonal interaction may be collected with one of two methods of observation. Observers adopting the non-intrusive approach would endeavor to be as inconspicuous as possible, and may record observations with the help of a behavioral checklist. Psychologists would role-play in the course of collecting data when the participatory observation method is used. Suppose that the study is about the stresses experienced by medical orderlies. In

carrying out a participatory observation investigation, researchers might work as medical orderlies in order to observe the orderlies (see *Interviewing and Observation)*.

3.2.2. Measurement

To measure behavior is to assign numerical values to observations with reference to a well-defined rule. Observations are invariably measured in experiments. However, measurement data are not necessarily experimental data if they are collected in one condition only. This is because collecting data in one condition means that there is no comparison baseline. It is in this sense that using a psychophysical procedure to establish the absolute or differential threshold is a non-experimental exercise. However, if the psychophysical instrument is used in two conditions that are identical, except for the experimental manipulation, the psychophysical data become experimental data.
A psychometric test is not unlike the printed form of a structured interview or a questionnaire, with the exceptions that (a) the focus is more specific or theoretically more informed, and (b) an attempt is made to establish its reliability and validity. It is used to measure a particular aptitude, attitude, emotion, or personality characteristic. As such, the data it yields are not experimental data in the absence of any comparison data. However, if the psychometric test is used in two conditions, one of which provides baseline data, the data thus obtained qualify as experimental data (see *The Construction and Use of Psychological Tests and Measures)*.

3.2.3. Computer Simulation

Euclidean geometry is a formal system that consists of (a) a minimal number of undefined terms (i.e. terms whose meanings are taken for granted and understood even by someone who is not knowledgeable in Euclidean geometry, such as "length" and "point"), (b) all other terms used in geometry, defined in terms of the undefined terms (e.g. "angle"), (c) a minimal number of logically independent axioms (postulations whose truth is taken for granted), and (d) all geometry propositions being deductively derived from the axioms. The simulation approach to psychological research (e.g. in the study of cognitive activities) shares these characteristics. The simulation method differs from the deductive inference in Euclidean geometry in that the deductive logic in the latter is replaced in the former by procedures that can be implemented with the computer.

3.3. Laboratory Experiments

A discussion of experimentation requires an understanding of the relationship between a variable and its levels. Color is a variable in the sense that it may be identified as black, white, green, and the like. The particular electromagnetic wavelengths used to represent the variable color are its values or levels. Hence, red, yellow, blue are three values of color. Experimenters have to consider four types of variables: independent, control, dependent and extraneous (see *Experimentation in Psychology--Rationale, Concepts, and Issues)*.

3.3.1. Independent Variable

In conducting experiments, psychologists manipulate the independent variable and measure the dependent variable while holding the control variable constant. For example, psychologists manipulate *color* in the experiment when (a) a subset of its values are used (e.g. pink, brown, and beige), and (b) the three colors are used to set up three corresponding test conditions. This variable is called the "independent" variable because the formation of the test conditions is not determined by what the subject does.

3.3.2. Control Variable

Suppose that the experiment is about the effect of color on mood. For theoretical reasons, psychologists may decide to recruit male subjects within a particular age range only. Consequently, the variables gender and age are represented at the same level in the test conditions defined by the three colors in the present example. It is in this sense that experimenters hold constant gender and age. Consequently, gender and age are the control variables of the experiment.

3.3.3. Dependent Variable

Consider the situation in which subjects are required to respond as quickly as possible to a stimulus presented visually. This is the variable of reaction time (i.e. how long it takes subjects to respond). Its exact value on any trial depends on the subjects' readiness, perceptual speed, motor dexterity, and the like. Reaction time is the dependent variable of the experiment.

3.3.4. Extraneous Variable, Confounding Variable, and Control Procedure

The extraneous variables of the experiment are identified by exclusion. Specifically, any variable that is neither the independent nor the dependent nor the control variable is an extraneous variable. Consequently, there are logically an infinite number of extraneous variables. Fortunately, psychologists can eliminate most of them on conceptual or theoretical grounds.
Furthermore, psychologists may also exclude some potential confounding variables with special control procedures such as choosing the appropriate experimental design (the completely randomized, repeated-measures, randomized block or mixed design), randomizing stimulus presentation, counterbalancing, and the like. The sole purpose of these control procedures is to ensure that extraneous variables may justifiably be excluded as potential explanations of the data.

3.3.5. Confounding Variable

A confounding variable is an extraneous variable that varies systematically with the independent variable. For example, forgetting has been explained in terms of subsequent learning interfering with previous learning. Hence, experimenters vary the amount of material to learn in the intervening trials before testing. However, it takes more time to present more to-be-learned items, thereby increasing the delay before initial learning and recall. The delay of testing is a variable that is confounding with *list-length* under such circumstances.
Confounding variables in experimental studies are invariably discovered after the fact. Otherwise, they would have been incorporated in the experimental design either as a control variable or as an additional independent variable. It is quite different when applied psychologists have to collect data *in situ*, where they often have to collect data with the knowledge that there is a confounding variable.

3.4. The Quasi-Experiment

The confounding variable may be used to introduce the quasi-experiment. Suppose that the quasi-experiment is about the effects of color on employees' moods in a department store. Psychologists may not have the luxury of being able to assign subjects randomly to the three color conditions. Instead, pink, beige, and brown are assigned to the cosmetic department, the kitchenware department, and the hardware section, respectively. In such an event, *color* is confounded with the type of clientele. Important to methodology is the fact that the three color conditions differ in more than color. Consequently, any difference in the employees' moods among the three conditions cannot be attributed unambiguously to the difference in color (see *Quasi-Experimentation)*.

It is the presence of confounding variables that distinguishes between experiment and quasi-experiment. There is also the difference in nomenclature. Instead of being discussed in terms of independent and dependent variables, quasi-experimental studies are described in terms of treatment and outcome variables, respectively.

4. Reasons for the Multiplicity of Methods

There are many intertwined reasons for the multiplicity of psychological research methods. To begin with, any psychological phenomenon is open to multiple interpretations that differ in type, complexity, or level of abstraction. For example, hyperactivity may be explained in terms of an unhealthy diet, an improper reinforcement regime, or a central nervous system that is not adequately stimulated. Other reasons for the wide range of research methods are the psychologists' training, meta-theoretical perspective, theoretical orientation, research objective, and vested interests.

4.1. Training and Methodological Preference

Researchers come with diverse backgrounds, ranging from formal disciplines like mathematics to deconstructionist literary criticism. They also bring with them different emphases. For example, while some psychologists emphasize basic research, other psychologists may consider social advocacy important. In addition to injecting new insights into psychological phenomena, these diverse emphases also bring special methodological preferences. For example, psychologists with extensive training in the physical or biological sciences would find the idea of the "constancy of conditions" congenial (manipulating some variables in a consistent fashion while holding other variables constant) (see *Experimentation in Psychology--Rationale, Concepts, and Issues)*. They are more likely to conduct experiments. Cognitive psychologists well versed in computing techniques may find it warranted to run simulations to study mental processes. Psychologists who see human affairs as a dramatic saga are more inclined to collect narrative data by conducting interviews with open-ended questions.

4.2. Meta-Theoretical Perspective

Psychologists use theories to describe or explain mental or behavioral phenomena. This theorization exercise is more abstract than the phenomena themselves. In planning their research or assessing their research data, psychologists have to reflect on methodology or theories. This activity is more abstract than theorizing about psychological phenomena. This higher-level frame of reference is the meta-theory that has implications on the method used in research.

4.2.1. Non-Logical Issues with Logical Nomenclature

There is a meta-theoretical dispute among experimental psychologists as to the primacy of theory or data. Do data come before theory or the other way round? Some psychologists use "deduction" to refer to the view that theories come before data (i.e. the "theory $\rightarrow$ data" sequence), and "induction" to refer to the stance that behavioral laws are to be abstracted from atheoretical data (i.e. the "data $\rightarrow$ law" sequence). The choice between the more structured and the more free-spirited approaches to research (e.g. structured interviews versus open-ended interviews) owes a lot to these two meta-theoretical perspectives. By and large, the "deductive" perspective is more conducive to adopting a better-structured method than is the "inductive" stance.

For example, there is no way to organize the research procedure if the to-be-studied phenomenon is ill defined. Hence, psychologists may opt for using the non-intrusive observation method under such circumstances. Likewise, when confronted with a new client about whom little is known, the open-ended interview seems to be the most suitable option. Adopting this perspective, psychologists would see the primary purpose of research as the collection of data so as to generate a theory. This

is the meta-theoretical impetus of many correlational studies in which a large number of participants are measured on two or more variables, and the research objective is to ascertain the inter-correlations among the variables. It is important to note that "law" in this "induction" perspective refers to these correlations (or functional relations between variables). Hence, there is an emphasis on theory discovery among psychologists who feel that the to-be-studied phenomenon is not well understood (see *The Construction and Use of Psychological Tests and Measures)*.

4.2.2. Atheoretical Experiments versus Theory-Corroboration Experiments

Although all experiments share the same formal structure (the experimental design, the independent, dependent, and control variables, the protocol used to assign subjects to the test conditions, etc.), they may be categorized as "atheoretical" or "theory-corroboration" experiments. This distinction also owes its origin to the two meta-theoretical perspectives. Experimenters in the "induction" tradition (e.g. Skinnerian behaviorists) conduct atheoretical experiments to establish descriptive, functional relationships between variables, whereas experimenters subscribing to "deduction" conduct theory-corroboration experiments (see *Experimentation in Psychology--Rationale, Concepts, and Issues)*.

In terms of their objectives, atheoretical experiments are like correlational studies. That is, the procedure is to measure the same group of subjects on two or more variables, and the objective is to ascertain the inter-correlations among the variables. However, appropriate controls are found in atheoretical experiments, but not in correlational studies.

Adopting the "deduction" perspective, some psychologists conduct experiments to corroborate explanatory theories. An explication of why it is misleading to represent the "deduction" stance by the "theory $\rightarrow$ data" sequence may prove helpful in appreciating the idea of theory corroboration.

Upon encountering Phenomenon P, which cannot be explained in terms of existing knowledge, psychologists propose a tentative theory (Theory T) that, if shown to be tenable, would account for the phenomenon. This is the theory-discovery phase of the research. Theory T is then subjected to rigorous tests in the corroborative phase (by obtaining evidential data, D). However, the discovery and corroboration activities feed on each other. The collection of evidential data, D, depends on what Theory T says. At the same time, additional nuances about Phenomenon P may be discovered in the course of testing the original theory. This necessitates changing the theory. The modified theory requires corroboration anew, a process that may unveil more nuances.

In short, it is more informative and correct to represent the "deduction" stance as the "phenomenon $\rightarrow$ theory $\leftrightarrow$ evidential data" sequence. The double arrow sets in high relief three meta-theoretical points. First, there is a constant interplay between theory discovery and theory corroboration. Second, a distinction need be made between the original phenomenon for which the explanatory theory is proposed and the research data that provide the evidential support for, or the criterion for rejection of, the theory. Third, research deals with how psychologists theorize about phenomena, not the psychological phenomena themselves.

4.2.3. Adductive Inference

Psychologists entertaining the "data $\rightarrow$ law" meta-theoretical perspective may differ among themselves as to how the theory-discovery process is carried out. For example, those who subscribe to the induction by enumeration approach would insist on collecting similar data (e.g. observing the same thing in similar conditions or similar things in identical conditions). Replicability is crucial, and the emphasis is on the frequency of replication. The inductive conclusion is assumed to be stronger the more often replication is obtained.

At the same time, there is an alternative school of thought within the "induction" perspective that may best be understood by referring to a practice adopted in historical research. Historians abstract explanatory theories about events in the past. However, they do not treat their task as a matter of looking for some recurrent characteristics among similar events. Instead, historians use the method

of adduction. That is, they look at different aspects of the event, collect information from diverse sources, and utilize disparate information that may collectively inform them of an explanatory account of the event.
Under the influence of literary criticisms, psychologists of the social constructionist persuasion would find the adduction approach more congenial. Moreover, they may treat psychological phenomena as dramas or "texts." Consequently, not only would they conduct unstructured interviews with open-ended questions, they may also collect observation data or utilize archival materials. Text analysis becomes an integral part of psychological research (e.g. context analysis, the grounded theory, etc.). In some instances, psychological research is not unlike an exercise in hermeneutics.

4.3. Theoretical Orientation

Different psychologists may study the same phenomenon differently because they are committed to some broad theoretical framework or system such as behaviorism, connectionism, or social constructionism. While behaviorists conduct experiments or quasi-experiments, connectionists are more likely to run computer simulations. Psychologists who subscribe to social constructionism may be less inclined to consider experimentation than those who subscribe to connectionism. The theoretical orientation has such an effect because it determines the level of analysis adopted by the psychologists.
Consider the case of the psychology of language. One psychologist may be interested in linguistic development, whereas another's concern is the linguistic competence of adult native speakers of the language. Given the rigid demands of the method, it may not be appropriate, if at all possible, to study experimentally children at the one-word stage of language development. Moreover, the crucial information would be what those children produce spontaneously, as well as the frequencies of certain utterances. Hence, the observation method may be the method to use in research about the neophyte's linguistic performance. On the other hand, some theories of adults' linguistic competence are sophisticated enough to render experimentation possible.
As another example, some psychologists may find language production interesting while their colleagues concentrate on language reception. While it is easy to design experiments for language reception, the same is not true of language production studies. In short, the choice of a research method may be determined by the psychologists' theoretical orientation.

4.4. Research Objective

Psychologists conduct research for various purposes. Those who emphasize the experiential aspect of psychological phenomena may be interested in achieving empathy through understanding participants as unique individuals. Given such an idiographic research emphasis, those psychologists are more inclined to conduct an in-depth interview with open-ended questions. However, interview is too labor-intensive a method to use if the objective is to determine what attitude adults share in general, despite individual differences. Consequently, psychologists may use a theoretically informed questionnaire for such a nomothetic research.
Suppose that the concern is whether there is a link between the two multifaceted variables *life style* and *health*. Crucial to this sort of epidemiological research is the representative nature of the sample, the reliability, and the validity of the measures used. To satisfy such a need, psychometricians' main research concerns are the validity and reliability of psychometric instruments. They rely heavily on statistical procedures other than significance tests (e.g. factor analysis, path analysis, structural equations, etc.) (see *The Construction and Use of Psychological Tests and Measures)*.
Suppose that a psychologist is commissioned to ascertain whether a new method of training improves a worker's output in a particular factory. Note that generality is not a concern in view of the specificity of the research question. Nor is the issue about why there is a change in job

performance. Moreover, the to-be-measured variable is the worker's job performance itself. Given these constraints, it is not possible to institute control procedures like random subject assignment, choosing a theoretically informed experimental task, or dependent variable. Yet, the study would have superficial resemblance to the experiment. Studies of this kind are quasi-experiments.

5. Philosophical Issues

Reference has been made to (a) "induction," the "data → law" approach that produces data-driven generalizations or laws, and (b) "deduction," the "phenomenon → theory ↔ evidential data" stance that gives rise to conceptually driven explanatory theories. Underlying the distinction between data-driven generalizations and conceptually driven theories are several philosophical issues: (i) the nature of the intervening variable, (ii) the reality of unobservable structures or processes, (iii) the validity of using animals as theoretical models or analog, (iv) the lure of reductionism, and (v) the possibility of objectivity if observations are theory dependent.

5.1. Logical Construct versus Hypothetical Construct

Positivist behaviorists subscribe to the "induction" perspective in which a generalization is a statement of the functional relationship between two measurable variables. An example is the generalization that if *x* is a response that is accompanied by a reinforcing stimulus, then *x* is a response that acquires an increment of habit strength. The two variables are the rat's response readiness (dependent variable) and the frequency of reinforcement (independent variable). What it says essentially is that the readiness of the rat's response to the bar is a function of how often it has been followed by reinforcement. There is also a third variable, "habit strength." It is the "intervening variable": an unobservable variable that comes between two measurable variables. Though unobservable, it is not a mental concept in the behaviorists' account. The intervening variable has no substantive role. Even if it is not evoked, the functional relationship between response readiness and the frequency of reinforcement can be adequately described. As the sole function of the intervening variable is to simplify descriptions, it is called a logical construct. The "latent variable" in contemporary psychometric discussion seems to be closer to the hypothetical construct than to the logical construct (see *The Construction and Use of Psychological Tests and Measures)*.

Psychologists who find behaviorists' rejection of mental concepts inadequate are concerned with explaining psychological phenomena in terms of mental concepts. Consequently, intervening variables in research conducted from the "phenomenon → theory ↔ evidential data" perspective have substantive meanings by virtue of their theoretical roles. These unobservable intervening variables are hypothetical structures or mechanisms imbued with theoretical properties (e.g. attention, memory, etc.). Hence, instead of being satisfied with descriptive functional relationships, cognitive psychologists conduct research to corroborate explanatory theories. Corroborating a cognitive theory consists of substantiating the hypothetical structures and processing postulated in the theory.

5.2. The Acceptance of Unobservable Structures or Processes

The onus is on cognitive psychologists to demonstrate the psychological reality of the unobservable hypothetical mechanisms and processes. It helps to recall the following points. First, it is accepted that psychological phenomena exist. Second, psychological theories are proposed to make sense of the psychological phenomena. Third, research is about psychological theories, not the psychological phenomena themselves. Fourth, a psychological theory is substantiated by demonstrating the tenability of the hypothetical mechanisms and processes envisioned in the theory.

An implication of this recapitulation is that if the theory is true (i.e. the hypothetical mechanisms and processes work in exactly the way stipulated in the theory) the consequences of applying the

mental apparatus in a specific context are well defined. That is, although unobservable, these hypothetical mechanisms and processes (hence, "hypothetico") should have tangible consequences ("deductive") if they are to be taken seriously. Hence, the mechanism of conducting research of the "hypothetico-deductive" is to set up the specific context; the tenability of the theory is assessed by comparing the actual consequences of the research manipulations with those stipulated by the theory. The hypothetical mechanisms and processes are falsified if there is no match; the theoretical intervening variables are deemed tenable, albeit tentatively, otherwise. The hypothetical structures and processing are intervening variables in the sense that they come between the observable research manipulations and the tangible consequences.

5.3. The Nature of Psychological Explanation

Psychologists use research findings to foster understanding of psychological phenomena. However, the assessment of their access is complicated by three issues: (a) what constitutes understanding, (b) the logic of explanation, (c) the behaviorists' claim, and (d) the nature of a causal explanation.

5.3.1. Two Dimensions of Understanding

Understanding has two independent dimensions: experiential and conceptual. The experiential dimension is characterized by the "Aha" feeling. Individuals who seek empathic solace would find it acceptable to tune selectively to information that boostered certain emotions. Conceptual understanding, on the other hand, is assessed in terms of objective evidence. Hence, acceptable explanations are couched in non-experiential, non-teleological, and impersonal terms. This explains the general public's dissatisfaction with much of academic psychology. Likewise, those who look for motives behind human behavior would find wanting the non-teleological explanations offered by much of academic psychology.

Conceptual understanding is achieved by extending the current knowledge base through integrating the new information into individuals' preexisting frame of reference. The explanation is made up of the explanandum (the thing to be explained) and the explanans (the element that does the explaining). The understanding is tested, informally or formally, by testing the explanans with the hypothetico-deductive procedure. Understanding is achieved only when the attempt is successful, in other words, when the explanans can be substantiated independently of the explanandum, and the explanandum "makes sense" in view of the explanans.

5.3.2. The Logic of Explanation

During the heyday of positivistic behaviorism, modus ponens was considered the paradigm of explanation, as may seen from panel 1 of Table 3. The explanans consists of the conditional syllogism whose major premise asserts the functional relationship between two variables. The explicit minor premise affirms the antecedent of the major premise. Modus ponens permits affirming what is said in the consequent of the major premise. The phenomenon is deemed explained because it is shown to be the special case of the general functional relationship between the antecedent and consequent of the empirical generalization.

Table 3. Modus ponens as the paradigm of behavioral explanations (panel 1) and modus tollens as the paradigm of explanation in cognitive psychology (panel 2)

Panel 1	**Explanandum**	**Phenomenon**	**Rat R presses the bar readily when it is placed in the Skinner box**
	Explanans	Major	If *x* is a response that is accompanied by a reinforcing stimulus, then *x* is a response that acquires an increment of habit

				strength
			Minor	Rat R's bar-pressing response is accompanied by a reinforcing stimulus
			Suppressed minor	A response that is readily emitted has habit strength
	Explanation		Conclusion	Hence, Rat R's bar-pressing response is readily emitted
Panel 2	**1**	**Explananum**	**Phenomenon**	**Realizing belatedly that one has just driven through a red light**
	2	Explanans		If there is **a very brief visual sensory buffer**, then sensory information about any properly registered visual stimulus may be processed belatedly
	3	Justification of the explanans	Major 1	If sensory information may be processed belatedly, then there is partial-report superiority
	4		Major 2	If there is response bias in partial report, then there is partial-report superiority
	5		Minor	Partial-report superiority is obtained
	6	Explanation of data	Experimental conclusions	The "response bias" explanation can be rejected by virtue of modus tollens. Sensory information may be processed belatedly
	7	Explanation of phenomenon		The sensory information retained in a very brief visual sensory store permits the belated processing of the red light

For the positivistic explanation to work, the major premise of its explanans must be a token of Aristotle's efficient cause in view of the behaviorists' belief that reinforcement shapes behavior. However, in rejecting hypothetical structures and mechanisms, behaviorists cannot answer the Humean skepticism about discovering the efficient cause by atheoretical observation. The Humean argument is that no matter how hard one tries one can never see how one billiard ball causes another billiard ball to move. One observes only the temporal and spatial contiguity of the two billiard balls' movement. Moreover, that the contiguity has been found in the past does not guarantee that it will be observed on the next occasion. The behaviorists' implicit minor premise is not helpful because "habit strength" is simply a logical construct in the sense that it is a merely a re-description of the consequent of the major premise. To be useful, there must be an independent index of "habit strength" other than the rat's response readiness.

A more recent account of psychological explanation is shown in panel 2 of Table 3. Although the appeal is still made to modus ponens, the emphasis is not on the formal relationship between the two variables. Instead, the force of the explanation is based on the theoretical properties of the hypothetical structure described in the antecedent of the major premise (brief visual sensory buffer). Specifically, the explanation works by showing first how the explanandum (i.e. realizing belatedly that one has just driven through a red light) *can be* accounted for if the explanans is tenable. The boldface in row 2 of panel 2 highlights the fact that the explanans is the antecedent of the conditional proposition (a very brief visual sensory buffer), not the entire conditional proposition. The consequent of the conditional proposition (only sensory information about any properly registered visual stimulus may be processed belatedly) is an implication of a theoretical property of the explanans, which is used to make sense of the explanandum (see Appendix 1 of *Experimentation in Psychology--Rationale, Concepts, and Issues)*.

The italicized "*can be*" in the previous paragraph alludes to the second element of the legitimate explanation. *Can be* is used instead of *is* because the explanandum can also be explained by other explanans. Hence, for an explanation to be accepted, it must have evidential support at the same time that its contenders are rejected by the evidence. That is, the explanans is justified only when the theoretical property of the hypothetical structure is substantiated. This theory-corroboration aspect of the explanation may be seen from the two conditional syllogisms depicted in rows 3 through 6 of panel 2.

Rows 3, 5, and 6 make up the conditional syllogism used to substantiate the sensory nature of the very brief visual buffer. Rows 4, 5, and 6 constitute the conditional syllogism used to challenge the sensory nature of the visual buffer in question. That is, the entries in rows 3 and 4 are the major premises of two separate conditional syllogisms. The entry in row 5, supplied by the data of a properly designed experiment, is the minor premise of both syllogisms. The data rejects, by virtue of modus tollens, the syllogism headed by the entry in row 4. Hence, the tentative experimental conclusion is the antecedent of the conditional proposition in row 3, which is an implication of the hypothetical structure, the very brief visual buffer.

5.3.3. Understanding, Causal Explanations, Prediction, and Control

Behavioral psychology owes it attractiveness to the claim that they have understood behavior because they can forecast (hence, can shape) behavior. However, there is neither self-evident nor empirical reason for the behaviorists' practice of defining "understanding" in terms of forecasting or shaping behavior. The behaviorists' explanation is wanting because there is no justification for its explanans. The more serious problem is that behaviorists have misled friends and foes alike when they claim to have identified the efficient cause in their causal statement. Behaviorists' laws are simply functional relationships, not causal statements that have been substantiated.

Aristotle also recognized the material and formal causes. Pouring molten chocolate into the mould of a rabbit results in a piece of chocolate in the form of a rabbit. The shape of the mold is the cause of the shape of the solid chocolate by virtue of its form. This is an example of a formal cause. Various musical notes are produced when a pianist hits different keys. The explanation in terms of an efficient cause is inappropriate because the same striking action is used to produce the different musical notes. The differential musical notes are determined by the properties of the different strings of the piano. This is an example of Aristotle's material cause.

Likewise, the sensory nature of the very brief visual buffer is an example of the material causes. That is, in corroborating the properties of the very brief visual buffer, cognitive psychologists are establishing a formal or material cause of behavior. In other words, understanding may be achieved when an empirically substantiated explanation of a material or formal cause of behavior is appreciated by the individual who seeks understanding. This sort of understanding occurs with or without the "Aha" feeling.

5.4. The Validity of Animal Studies

Behaviorists' psychology owes its empirical basis to studies with animals as experimental subjects. The validity of their assumption depends on the applicability to all species of the functional relationships between observable behavior and environmental variables thus established. The behaviorists' functional laws are true to the extent that "behavior" and "environmental variables" are defined so broadly that the functional relationships become true by definition. For example, a "response" is the behavior that is followed by reinforcement. This definition applies to the rat pressing the bar in the Skinner box and to a student diligently studying when "environmental variable" refers to the presence of a food pellet and passing the examination with high distinction, respectively. However, such success is more apparent than real because, as has been shown, the behaviorists' account does not extend the knowledge base.

Nonetheless, it would be incorrect to dismiss animal studies for the simple reason that behaviorists had oversold their promise. Given the similarity of the cat's and the human visual systems, much about the basic operation of human vision was acquired by using cats as subjects (e.g. the ideas of visual field, the hierarchical organization of the visual system) (see *Animals as Models or Analogs)*.

5.5. The Lure of Reductionism

Units of analysis at various levels of abstraction are implicated in psychological research or discourse. For example, individuals are the units in idiographic research. The emphasis is on individuals' unique past experiences or encounters. Nomothetic researchers use groups of subjects to study constructs or phenomena like intelligence, traits, depression, aggression, motives, memory, and the like. Cognitive psychologists study selected components of memory. Neuropsychologists seek to understand psychological phenomena by studying the functions of various parts of the nervous system or the brain. In like vein, cognitive scientists study the brain with computer simulations in which the units of analysis are the virtual cells and the network of cells. Psychologists with a strong background in the biological sciences may seek understanding by investigating cellular behavior, the effects of chemicals (particularly hormones and proteins) on behavior, or the role of DNA (e.g. the gene that presumably underlies selfish behavior or action). Adopting the historical perspective of idiographic approach, some psychologists currently seek to explain the nomothetic concepts (e.g. human aggression) in evolutionary terms.
The brief survey raises two issues. First, is the individual uniqueness envisioned in idiographic research incompatible with the de-personalized or disembodied intelligence, motives, or memory studied in nomothetic research? Second, can mental processes or human actions ultimately be explained in terms of genes or the juxtaposition of various chemical and electrical activities at the cellular level?

5.5.1. The Compatibility of Idiographic Uniqueness and Nomothetic Constructs

The presumed incompatibility between idiographic uniqueness and nomothetic constructs is more apparent than real. In actual fact, the former cannot be established without the latter. For example, Jane is deemed unique because she differs from her peers in one or more ways (e.g. dress code, hobbies, demeanor, etc.) Any of these differences is predicated on a uniformity or a norm. For instance, Jane may be unique because she wears a red blouse without a belt, whereas all her colleagues wear white blouses with blue belts. An example of uniqueness with reference to a norm is that Jane is taller than 99% of her peers. A subtler example is the case where Jane is unique because she is so erratic that she cannot be expected to behave in the same way twice in the same situation. This case owes its uniqueness to the assumption that unique individuals are nonetheless consistent in their uniqueness. Jane simply departs from this common feature. In short, it is not possible to talk about uniqueness in the absence of commonality. Nomothetic constructs deal with what is true of human nature, despite individual differences.

5.5.2. Reductionism Revisited

It is envisaged in the idiographic research that an individual is an embodied self characterized by a unique combination of incorporeal features. Cognitive psychologists claim to be studying an incorporeal entity, the mind. However, for psychologists who find it difficult to entertain incorporeal entities, the appeal to the tangible chemical and electric activities of the cells, the brain structure, or the central nervous system is very reassuring. This physiological reductionism (the assumption that psychological phenomena can be adequately explained in terms of physiology) is very attractive, given the success of linguistic reductionism of mental terms (the attempt to dismiss mental phenomena by showing that mental concepts are nothing more than a trick the natural

language plays on its users). However, the physiological account becomes less convincing once it is shown that mental terms are more than being just the product of the language game.
The force of the language-game argument is based on the putative invalidity of referential meaning. Specifically, it is argued that terms such as "memory," "thinking," "wish," and the like do not refer to anything real. Instead, they are merely social acts of a particular sort. However, this meaning-as-use view is debatable because social action presupposes meanings. Consider the following example. Speech-act psychologists are correct in saying that "I like it that C is the case" is an act of avowal of satisfaction. However, they are incorrect in saying that "like" does not refer to a particular psychological phenomenon. For example, the same avowal may be expressed with "I am happy that C is the case" or "I have no objection that C is the case." That a particular mode of making the avowal is chosen over other alternatives suggests that the speech act serves more than a mere performative function. It also serves a referential function, namely, to say something about a particular psychological phenomenon.
Stripped of its linguistic sidekick, physiological reductionism is founded on a host of correlations between physiological and behavioral indices. For example, the blood flow or electrical activity in region X in the frontal lobe is expected to change when subjects are given a particular cognitive task to do. Short of any theoretical foundation, data of this sort are no more than correlation data. At best, they demonstrate that the brain or the central nervous system is necessary for psychological phenomena. They cannot give an adequate account of psychological phenomena. For example, how are the differences between envy and jealousy reflected by physiological indices? Moreover, is it possible to identify the psychological phenomenon that gives rise to a particular pattern of physiological indices? How would a pattern of physiological indices represent sympathy?

5.6. The Possibility of Objectivity

Constructionism in literary criticism is the outcome of pushing to the extreme the view that beauty is in the eye of the beholder. To such critics, a literary text does not refer to the reality envisaged by its author. Instead, what the text says depends on what readers can read into it. Adopting such a meta-theoretical position, some psychologists doubt the possibility of having an objective psychology. In their favor, constructionist psychologists may avail themselves of the following evidence.
Consider the situation in which John's demeanor may suggest shyness or aloofness. How he is being treated depends on the initial assessment he receives. Of interest is the fact that someone who is used to social interactions is more inclined to see John as shy, whereas a timid person may see John as aloof. That is, what one sees is the outcome of one's own experience or perspective. Constructionist psychologists may also point out the phenomena of perceptual constancies (e.g. shape constancy, size constancy, etc.) visual illusions (e.g. the Muller-Lyer illusion), as well as the effects of linear perspective on perception. That is, seeing per se is no guarantee of objectivity.
The "theory-dependent observations" view would indeed be fatal to objectivity if there were only one omnibus theory. However, the theory to which experimental data owe their identity is not the to-be-corroborated theory (see *Experimentation in Psychology--Rationale, Concepts, and Issues)*.

6. Some Methodological Issues

It is assumed that readers understand that "validity" means correctness. That concerns about validity are raised often in many contexts indicates that research can be wrong in more than one way. Hence, a distinction is made between the internal validity and external validity of the research (see *Quasi-Experimentation)*.

6.1. Internal Validity

When research results are assessed in terms of the structure and implementation of the research itself, the concern is its internal validity. There are two components to internal validity. First, questions about the appropriateness and correctness of the experimental design or the non-experimental plan are basically about whether recognized alternative interpretations of the data may be excluded. As these questions are answered with reference to the inductive principle underlying the design or plan, this component of internal validity may be called the inductive conclusion validity.

Data from nomothetic studies are tabulated and analyzed with the appropriate statistical procedures. Researchers have to choose the appropriate procedure with reference to (a) the level (or scale) of measurement of the data, (b) the statistical question being asked, and (c) the design of the research. These are questions about the statistical conclusion validity of the research.

6.2. External Validity

There are also two components to the external validity of empirical research: generality and construct or hypothesis validity.

Empirical research is conducted to answer questions about the world. Hence, research data may be assessed as to their range of applicability. The generality of the conclusion of empirical research is the extent to which it can be applied to other settings. It is for this reason that the issue of representativeness becomes important. Representativeness is determined by both the representativeness of the research participants and that of the situation in which data are collected. However, it is important to note that generality is independent of the other component of external validity.

It helps to talk about the second component of external validity separately for psychometric and for quasi-experimental or experimental studies. Consider the psychometric research conducted to establish an instrument for measuring aggression. It is imperative to ascertain that the test measures aggression, not defensiveness or some other phenomenon. To the extent that the test measures aggression, the test has construct validity.

It is a bit different with experimental research. Recall experiments are conducted to corroborate theories (hypothesis), not the phenomena about which the theories are proposed. Hence, the data are different from the to-be-studied phenomenon itself. Nonetheless, the data must be relevant to the hypothesis. For this reason, it is more helpful to talk about the hypothesis validity of the data, that is, the extent to which the data inform about the tenability of the to-be-tested hypothesis (see *Experimentation in Psychology--Rationale, Concepts, and Issues)*.

7. Current Trends in Methodology

Psychologists are very conscious of their methodology, so much so that they constantly question their research approach and develop new methods, particularly statistical methods. One reason is that psychologists have expanded their research interests as a result of (i) involving themselves in conducting studies that are strictly non-psychological (e.g. the epidemiological approach to life-style or “wellness”), and (ii) collaborating with researchers from other disciplines (e.g. education and sociology). The trend in some areas of research is to introduce non-methodological issues into methodological considerations. Two notable examples are ecological and practical validity. These two non-research issues are conflated with methodological issues, much to the detriment of conceptual rigor, hypothesis validity, or conceptual clarity. Consequently, issues about internal validity and external validity seem to have been neglected.

It is easy to show that many psychological investigations, particularly psychological experiments, are artificial. The rhetorical question then asked by the skeptics relates to the usefulness of the data thus obtained. This is the charge that research data collected by experimental psychologists may

lack ecological validity (i.e. people do not behave in the way depicted by the data because the data are not collected in natural or real-life settings). The artificial setting in which experimental data are collected can be defended (see *Experimentation in Psychology--Rationale, Concepts, and Issues*). ffice it to say here that advocates of ecological validity have failed to appreciate the fact that research is about theories (i.e. tentative explanations of phenomena), and not the phenomena themselves.

Much of the contemporary dissatisfaction with using significance tests stems from the desire to use research to inform practical decision making (e.g. whether to use a new method of teaching, a new drug, etc.). While this is a legitimate concern, it should not be conflated with the proper role of statistics. For example, some psychologists advocate using confidence-interval estimate and effect size in addition to, if not in place of, tests of significance. They insist that experimenters should use the sample-size tables envisaged in power analysis to determine the sample size. It is said that *effect size* is more useful than the decision about statistical significance because the *magnitude of the effect* has substantive impact, but not statistical significance. Note the two italicized phrases are not synonymous (see *Experimentation in Psychology--Rationale, Concepts, and Issues* and *Statistics and Its Role in Psychological Research***)**. It can be shown that (i) the tests of significance cannot (and ought not) be replaced, (ii) there are fundamental differences between statistical decision and causal inference, and (iii) statistics cannot be used to reduce conceptual ambiguities in data interpretation.

Glossary

Adductive reasoning: The process of putting forward a theory by looking at different aspects of the event, collecting information from diverse sources, and utilizing disparate information.

Atheoretical research: Research that is not guided by any theoretical perspective.

Categorical proposition: A proposition whose truth-value is assessed on its own.

Conditional proposition: A proposition that has an antecedent and a consequent. The two are linked up by the logical operator "If . . . then." Its truth-value is contingent on the truth-values of its antecedent and consequent.

Consequent: The proposition that comes after "then" of the logical operator "If . . . then" of the conditional proposition.

Control: A control is a means in research to exclude an explanation of the data.

Construct validity: The construct validity of a test is the extent to which it correlates with the behavioral index of the to-be-measured psychological structure or mechanism.

Correlation: The association between two random variables.

Deduction: Some psychologists use "deduction" to represent the "theory $\rightarrow$ data" sequence of research.

Deductive logic: A set of rules that render valid the derivation of a proposition from one or more propositions.

Ecological validity: The extent to which various aspects of the research mimic their counterparts in the real-life phenomenon.

Experiment: Empirical research that has two or more data-collection conditions that are identical in all aspects but one.

Explanandum: The thing to be explained.

Explanans: The explaining element in an explanation.

External validity: The correctness of empirical research assessed in terms of criteria exogenous to the research.

Factor: The statistical term for "variable." The ways in which a factor may be identified are the "levels" of the factor.

Functional relationship: The relationship between two variables expressed as a mathematical function.

Hypothesis validity: The extent to which the theoretical process envisaged in the hypothesis is supported by empirical evidence.

Idiographic research: Research about what is unique about an individual.

Induction: Some psychologists use "induction" to refer to the atheoretical "data → law" view of research.

Inductive logic: Inductive logic consists of rules that permit the exclusion of unwarranted interpretations of the data.

Internal validity: The correctness of empirical research assessed in terms of criteria endogenous to the research itself.

Nomothetic research: Research about the common characteristics of a group.

Proposition: A statement that is capable of being true or false.

Quasi-experiment: Experiment-like research in which at least one recognized control is missing due to logistic or practical constraints.

Reductionism: Reductionism is the meta-theoretical assumption that incorporeal psychological phenomena can be explained with terms used in the physical, biological, or computational sciences.

Reliability: The extent to which the same test will produce comparable results.

Research: Research is the systematic collection of data to answer a well-defined question.

Scientism: An exaggerated faith in the propriety or efficacy of applying the methods used in physical sciences to the social sciences.

Syllogism: An argument made up of two premises and a conclusion.

Theory corroboration: The attempt to assess whether or not a theory is tenable with empirical data collected for that specific purpose.

Truth-value: Whether or not a proposition is true.

Validity: "Validity" is the technical term for the correctness of empirical research. As the research may be correct in more than one way, psychologists are concerned with various types of validity, namely, internal validity, external validity, ecological validity, and practical validity.

Variable: A variable is something that may be identified in more than one way. For example, color as a perceptual category may be represented by white, blue, green, and the like. Hence, *color* is a variable, three of whose representations (called values or levels) are white, blue, and green.

Bibliography

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