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PROBLEMS OF THEORY AND MEASUREMENT IN SOCIAL SCIENCE
A CONCEPTUAL OUTLINE©

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I. THE NATURE OF SCIENCE.

A. GENERAL CONSIDERATIONS.

1. <u>The Chief function of the scientist</u> (Camilleri, 170):
    Creation of a systematic theory of a domain of fact and providing empirical support for the theory.

2. <u>The scientific enterprise</u> (Lachman, p. 113); This consists of:

    a. The observation of objects and events and,

    b. The use of mathematical and natural linguistic symbols, along with the rules for their manipulation, to represent these sensory experiences, in order to,

        (1. Organize what is observed into some comprehensible order and,

        (2. By proper symbolic manipulation, to arrive at a representation of what has not yet been observed.

    c. A "model" includes the commentary that accompanies the theoretical undertakings in "b".

3. <u>General aim of science</u> (Torgerson, p. 1):

a. Science aims to establish general principles by means of which the empirical phenomena can be explained, accounted for, and Predicted.

b. In carrying out this objective, science concerns itself with gathering and comparing data in order to establish the relationships (correlations, equations and theories) that are the goal of inquiry.

c. Measurement enables the tool of mathematics to be applied to the science.

B. NOSOLOGY, EXPLICATION AND THE FUNCTIONS OF CONCEPTS.

1. <u>The importance of taxonomy</u> (Eysenck, 1952, p.34):

a. Taxonomy lies at the root of scientific progress. Until taxonomic problems are solved in at least a preliminary way, scientific progress towards answering more complex problems is barred.

b. Measurement is essential to science, but before we can measure we must know what it is we want to measure.

c. Qualitative or taxonomic discovery must precede quantitative measurement.

2. <u>The place of explication</u> (Torgerson, p.8)

a. Initially, scientific constructs are not far removed from common-sense or pre scientific conceptions (especially in the behavioral sciences).

b. Though there is a great deal of common-sense meaning attached to them, the meaning is not specified precisely.

c. It is necessary to transform these inexact concepts into ones which can be specified precisely.

d. The formulation of a rule of correspondence relating the pre-scientific concept to observable data is an explication of the original concept. (operational specification).

e. Often, the problem of establishing a rule of correspondence for relating a construct to observable data amounts to the problem of devising rules for the measurement of the construct.

f. There exist certain connections between the technical terms of empirical science and the vocabulary of everyday experience. With the development of more precise means of observation, both direct and indirect, and the accumulation of more adequate data, science modifies its concepts. The scientific meaning of the concepts in terms of their definition and use become quite different from the same aspects of these terms when used in everyday language. (Doby, p. 30-31)

3. The functions of concepts (Doby, pp. 24-27)

a. Psychological functions:

(1. The scientific concept enables one to conceive of phenomena which cannot be seen or directly perceived (it enables one to circumvent problems of perceptual experience).

(2. The content of the scientific concept which is abstracted out of the mass of particulars may become the object of separate investigation and study.

(3. Because of the verbal or symbolic nature of the concept, it may become the experience of others (to the extent of the communality of the symbols) and this makes possible collective or serial activity in scientific procedure.

(4. The scientific concept makes possible the unity and systematic nature of science by linking together the particular elements and ideas in a pattern.

b. Scientific functions:

(1. Concepts guide research by providing a point of departure or point of view.

(2. Concepts are tools; i.e., they liberate and direct activity with varying degrees of effectiveness, depending upon the validity of the concept.

(3. Once the concept has been formulated and used in connection with one type of problem, new problems and procedures can be deduced which transcend the immediate problems which the concept was set up to solve.

C. STRUCTURAL AND METRICAL LAWS OF NATURE. (Allport)

1. According to Allport (1954) the history of psychological schools and theories can be viewed as a record of attempts to deal with the problem of structure and its laws.

2. There are two reasons for the failure to solve this problem:

   a. The most general reason is the fact that the problem has not been approached in its own right. (Allport, 1954, p. 284)

      (1. It has been assumed that there is no general structural problem--the means are already at hand for explaining each specific structure by the traditional methods of scientific logic.

      (2. It is assumed that, since every event must have some cause, the logic of causality should be able to explain the structuring of events.

      (3. The fact that no explanation has been found is assumed to be due to the fact that the right cause has not been found.

   b. The second reason is that there is a tendency to believe that the laws which state covariations and thresholds of measurable quantities should be able to show that each element of a phenomenon gets placed in the proper spatial position at the exact time and sequence required for its characteristic structuring. (p. 285).

3. Natural laws have been usually considered to be of one type --quantitative.

   a. The precise expression of a natural law is assumed to be in the form of quantitative, mensurational propositions and the seeming differences in kinds of laws are due to the fact that they are not stated in precise enough form.

   b. Allport proposes that there are <u>two types of natural laws</u>:

      (1. <u>Mensurational</u> - laws which relate to quantities or dimensions and their relationships in phenomena.

      (2. <u>Structural</u> - laws which deal with the structure of nature. This type of law requires terms other than those of quantity (they are not reducible to derivable from) quantitative statements).

   c. The two types of law are not separate in their operation but must be studied and formulated separately. The elements of the structural model will be type-patternings of "ongoings" and "events" . (Allport, 1955, p . 621)

4. Structures:

a. Structures are neither random, endlessly varied, inexplicable, nor amenable only to quantitative laws.

b. There exists a unique structural law.

c. This law is completely general in nature and it must be conceived in terms that do not depend upon laws of quantities (There is a general "homology" between all natural systems) (Allport, 1955, pp. 622-623)

5. Events:

a. There are always dimensions that are associated with an event as i t occurs .

b. However, the quantitative laws cannot describe the event itself; they can only assume it.

c. Quantitative laws deal with continuously varying quantities and their relationships. An event is defined as an encounter (point) and is discontinuous: it either does or does not occur.

d. An event, although a part of nature and capable of objective observation, does not really belong in the realm of variable or dimensional considerations. (Allport, 1955, p. 624) [The application of mathematics is therefore not dependent solely upon the amount or degree of measurement of the science. Non quantitative mathematics such as topology and graph theory (Lewin, 1936 & 1951; Harary and Norman) are precise and rigorous, yet not quantitative.]

D. CRITERIA FOR THE EVALUATION OF A SCIENCE

1. Intersubjective testability:

a. The knowledge claims must be in principle capable of test. The possibility must exist for qualified individuals to test the claims.

b. This requirement excludes absolute subjectivity. Zener has challenged the criterion of inter-observer agreement as being necessary.

(1. If one assumes that there are events called phenomenal which exist in the world, then this criterion would exclude a certain class of natural events from scientific study.

(2. There is the possibility, in principle, of transcending the difficulties raised by inter-individual verifiability in reports of private experience.

(3. Since science seeks to formulate systems of functional interrelationships (laws) between certain characteristics of events and their relevant conditions, the "objectivity" required by science means only that

under given specifiable and manipulable conditions, repeatable events (experiences) can be shown to occur.

(4. Whether or not we can directly check the individual occurrence of a particular experience becomes of only minor importance if the experience uniformly recurs under adequately specifiable conditions

2. Reliability:

   a. The degree to which the scientific assertions are supported by available evidence.

   b. This involves the degree of confirmation: confirmability means at least incomplete and/or indirect verifiability or refutability.

3. Definiteness and precision: the reduction of vagueness to a minimum.

4. Coherence: the degree of logical ordering of concepts; the amount of interrelation between theoretical entities.

5. Scope or comprehensiveness: the degree to which the theory adequately deals with the empirical domain to which it refers.

6. Correlational vs theoretical sciences (Torgerson, p. 1-2)

   a. Correlational - a science that consists largely of statements describing the degree of relationship among more or less directly observable variables.

   b. Theoretical - a science that derives, accounts for, or explains the relationships from principles that are not immediately given but lie beyond straight empirical knowledge.

E. CHARACTERISTICS OF SCIENCE.

1. Empirical:

   a. The dichotomy of analytic and synthetic statements is one of the cornerstones of modern logical empiricism (Feigl, 1956, p. 6)

   b. A given formula or sentence which relates two or more concepts n the scientific network may be construed as either analytic (definitional) or synthetic (factual) depending on the interpretation of the rest of the system. This makes the meaning of given symbols systematically ambiguous, but in each single one of the alternative reconstructions the meaning of the symbols is completely fixed. (Feigl, 1956, p. 10)

c. The formal aspect of scientific theory consists of statements of fact in propositional form connected by explicit rules. (Camilleri, p. 171)

(1. The rules provide an objective, communicable means of operating on some of these propositions to produce additional propositions or theorems.

(2. The formal truth of a theorem rests on the demonstration that it has been generated by a correct application of the rules of inference.

d. The empirical aspect of scientific theory consists of interpreting the formal aspect by means of a set of coordinating definitions which are the rules for identifying the empirical referents of the theorems. (Camilleri, p. 171) The empirical truth of a theorem is the degree of correspondence of its interpreted assertion with the observed state of affairs.

2. <u>Propositional</u>: (Francis, 1954 a, pp. 6-7)

a. Science deals with propositions about things rather than with things themselves.

b. The fundamental scientific act involves a choice between alternative propositions according to rules which determine which choices are available.

3. <u>Logical</u>:

a. Syntactics refers to the formal disciplines of logic, mathematics and syntax, where the relations among signs are abstracted from the relations of signs to objects or to the users or interpreters of signs. (Stevens, pp. 2-3)

b. Although syntactics is independent of science, science is not independent of the logic involved. (Francis, 1954a, p. 7)

c. When a conclusion regarding the acceptability of some proposition (or set of propositions) is reached the justification for the conclusion involves demonstrating that the argument follows the rules of inference. Syntactics determines the structure of scientific argument (Francis, 1954a, p. 7)

4. <u>Operational</u>:

a. Semantics refers to the rules that relate signs to objects. (Stevens, p. 3)

(1. Terms have applicability to objects or events when the semantical rules governing their use satisfy operational criteria.

(2. The sentences or formulas created by combining these semantically significant terms into propositions are empirically significant (have truth value) when their assertions are confirmable by means of concrete operations.

b. The empiricist criterion of factual meaningfulness (Feigl, 1956, P. 14-5)

(1. The three blades to Occam's razor:

(a. Formal simplicity: this criterion is applicable whenever the factual content of two systems is identical.

(b. Inductive simplicity (factual parsimony): This criterion is used when two theories differ in factual content, the theory with fewer assumptions being preferred.

(c. Factual meaningfulness: this criterion is directed at hypotheses which are logically incapable of confirmation or discomfirmation.

(2. The early position of logical positivism of direct and complete verifiability has been liberalized to do justice to the inferential (inductive) character of practically all knowledge claims.

(3. The necessary condition for factual meaningfulness is confirmability-in-principle (for statements) and logical connectibility with the terms of a suitably chosen observation basis (for concepts).

5. <u>Public</u>:

a. Pragmatics refers to the relation of signs to the scientists. It involves how the scientist as a behaving being uses signs and how signs influence his behavior. (Stevens, p. 4)

b. "Intellectual honesty" is fundamental to science. In order to use the research of fellow scientists the person must believe in the validity of the report of the research. (Francis, 1954a, p. 19)

c. Due to the propositional form of science, science is symbolic.

(1. Through consensus on the symbols utilized in a science, the objects studied by a scientist may be so well represented as to allow another scientist, who does not observe the original objects himself, to judge the correctness of the inferences drawn.

(2. This allows for replication of the study.

6. <u>Problem-solving</u>:

a. The aims of pure (as opposed to applied) science:

(1. Description - this involves giving an account of the facts as they are. The singular statement is the basic unit of description (the form of the statements differentiate description from explanation and prediction).

(2. Explanation - this involves the accounting for the descriptions in terms of the theory involved. The attempt is to account for a maximum of data with a minimum of basic concepts and principles. It still refers to the facts as they are.

(3. Prediction - this is similar to explanation except that the facts have yet to be observed.

b. A problem is present when some observations exist which need explanation. (Francis, 1954a, p. 8)

(1. A problem is general and belongs to "pure science."

(2. A "difficulty" is specific, referring to a unique set of observations and belongs to "applied science."

(3. The hypothesis (or set of hypotheses) is the proposed solution to the problem.

(4. The correctness of the statement of the problem is crucial. The conception of the problem gives rise to the hypotheses to be tested and the hypotheses in turn indicate which data are needed to satisfy the test.

7. <u>Abstract</u>:

a. The propositions of the theory refer to all instances of the phenomena to which they are linked by the coordinating definitions (Camilleri, p. 171)

(1. The universes to which the propositions refer are always infinite and hence conceptual.

(2. The coordinating definitions must not contain time or place specifications, except as these factors are variables in the system.

b. With the development of a theory, scientific propositions move away from the specific time-and-space statements to more general ones. Although some empirical reference is always necessary, a general scientific theory is highly abstract. (Francis, 1954a, p. 9)

8. <u>Systematic</u>: (Eysenck, 1952, pp. 16-17)

a. Science results in the organization of facts originally seen as fragmentary.

b. Organization is achieved by the discovery of connections when one fact is related to another.

c. The isolated facts are fitted together into an orderly arrangement which yields a system.

d. A set of elements exhibits order (and therefore becomes a system) when, given the properties of some of the members of the set, the properties of other members of the set (or at least some of them) are determined.

e. This determination is due to the relation that orders the set and is not a property of the elements regarded as a class.

f. Science is not concerned with facts per se but with ordered facts. What is important is the type of order rather than the elements that are ordered.

g. Science has its origin in the attempt to co-ordinate the facts of experience, but in the discovery of the appropriate type of order, it passes to the consideration of a different order of facts.

h. Ultimately the explanation of facts is to be found in their organization into a system.

i. With increasing abstraction, science incorporates uniformities among the generalizations themselves. (Francis, 1954a, p. 9).

9. On-going.

a. Any piece of research is imbedded in the intellectual heritage the science and does not stand or fall by itself. (Francis, 1954a, p. 9)

b. The basic character of science is the eternal attempt to go beyond what is regarded scientifically accessible at any specific time. To proceed beyond the limitations of a given level of knowledge the researcher has to break down methodological taboos which condemn as "unscientific" or "illogical" the very methods or concepts which later on prove to be basic for the next major progress. (Lewin, 1949, p. 275)

F. PROBLEMS OF INDUCTION. (Feigl, 1956, pp. 31-33)

1. No matter how strong or weak the uniformities are in the world, the procedure of normal induction is the only methodical procedure which can be proved deductively to be able to disclose such uniformities.

According to Carnap there is a continuum of inductive rules (of definitions of degree of confirmation) and Reichenback's rule of induction is one element. The rules all share the following feature: If the world has some degree of order at all, predictions made according to any one of the inductive rules will in the long run (in the limit) not only converge with the others, but can be shown (deductively) to be the only type of predictions that utilize evidence methodically and are capable of anticipating that order of nature. (p. 29)

2. The world as it is appraised through the guidance of the principle of induction, seems to contain many independencies (non uniformity, disorder) in addition to some dependencies (uniformity, order of various types, e.g., causal and statistical).

3. The various inductive methods (Fisher's maximum likelihood, Reichenback's rule of induction, and Carnap's definition of degree of confirmation c*), while differing in technical points, yield in the long run equal results and are therefore different versions of the same basic idea.

4. This basic idea is this: If we wish for a method of generalization or of individual predictive inference that utilizes evidence and yields (at least in the limit) unique results, then the "normal" method (or methods) of induction are distinct from any "perverse" ones which are either insensitive to accumulating evidence - and therefore not self-corrective - or else lack the uniqueness that is characteristic of the methods of simplest generalization or of maximum likelihood.

5. The specific problem of determining the most adequate value for the limiting frequency of some statistical phenomenon may be solved in two ways:

   a. The statistical ratios found for the specifiable aspects under operationally identifiable conditions may be directly generalized.

   b. A theory may be constructed which involves assumptions regarding statistical distributions. The observed data will have a maximum likelihood (non-perverse) in the light of the assumed theoretical model.

6. It is necessary to assume that the available samples are representative when testing the correctness of a specific estimate of a limit of relative frequency. It is an empirical problem whether or not the sample is "actually" representative and if it is not the method should eventually show this.

7. Instead of postulating a general principle of uniformity of nature, it is more defensible to retain the sound core of that principle, either by absorbing it (a la Carnap) in a definition of inductive probability or more explicitly by formulating it (a la Reichenback) in terms of a rule of procedure (as a feature of the policy of induction).

G. THE STEPS IN (IDEALIZED) SCIENTIFIC RESEARCH. (Francis, 1954a, pp. 12-16)

1. <u>Selection of the problem area</u>: This is a function of the person's academic socialization process.

2. <u>Acquaintance with current theory and knowledge in the area</u>:

3. <u>Definition of the problem</u>: stating a problem in such a way as to permit a solution is a most difficult task. It is critical to subsequent research for only as the problem is clearly apprehended is there a possibility for the development of an adequate theory.

4. <u>Development of hypotheses</u>: The hypothesis is a possible solution of the problem. If correctly considered the hypothesis tells what data should be gathered.

5. Development of the formal argument: one must prove that the hypothesis is true and does in fact solve the problem. It must be decided how the hypothesis is to be tested, what data are needed and what alternatives exist. It must be decided what the argument will be in the face of each of the possible alternative findings.

6. Delineation of the source of data: the hypothesis tells what data are needed and the structure of the argument tells what form they should be in.

7. Creation of the instrument: The task is to develop an instrument which will result in the desired data in the desired form which will allow a rigorous conclusion as to the truth of the hypothesis and, if it is true, whether it solves the problem.

8. Writing a "dummy argument": This is to discover flaws in the argument.

9. Pretest of the instrument, and possible revision: This determines whether or not the instrument gives the data what is needed.

10. Formal acquisition of data:

11. Analysis of the data:

12. Formal write-up of conclusions reached: Usually this is in the form of an argument.

II. THE NATURE OF THEORY

A. APPROACHES TO THEORY CONSTRUCTION

1. Three theoretical orientations: (Meissner, p. 66-67)

   a. Correlationalism - (naive operationalism) stress is placed on rigorous operationalism and completeness of definition and the elimination of surplus meaning and overtones of existential reference of concepts and hypotheses.

   b. Conventionalism - is similar to correlationalism except in the use of the postulational method as opposed to mere correlations.

   c. Constructuralism - the value of the construct is stressed, and surplus meaning is accepted as fruitful and desirable. Theoretical constructs involve existential reference (in some sense) and it is recognized that operational definition is never really complete.

2. <u>Two forms of logical reconstruction of empirical science</u> (Feigl, 1956, pp. 20-22)

a. <u>Ideal science</u> - this involves the idea of a unitary nomologial net. The concepts designating observables are connected with the concepts designating unobservables by lawful connections.

b. <u>Actual science</u> - There is a sharp distinction between theoretical and observational language.

(1. The reconstruction is in terms of partially interpreted postulate systems.

(2. Coordinating definitions or semantic designation-rules connect the (undefined primitive or defined complex) concepts of the uninterpreted postulate system with the concepts of the observation language.

(3. The meanings of the observation terms are either (a) taken as they are found in the natural language of common life or (b) introduced by explicit or conditional (operational, reduction-sentence) definitions.

(4. There is at best a probabilistic or confirmatory relation between the observation terms and the corresponding terms of theoretical language.

(5. This is partly due to the usually complex causal or statistical relations between the theoretically posited magnitudes and the indicator variables of the instruments of observation or measurement.

(6. In practically all measurement situations there are obfuscating ("nuisance") variables which interfere with the direct assessment of the theoretical laws relating basic variables.

(7. In regard to the observer there is the complexity and/or the statistical character of the relations between

(a) the physical stimulus situation (extradermal),

(b) The central brain process of the observer,

(c) And the ensuing responses of the observer.

(8. As long as the obfuscating variables in these domains are neither adequately known, nor sufficiently controllable, the confirmation of theories proceeds implicitly with the "promissory note" that the anomalies, irregularities, or apparent exceptions will be accounted for when more is known about the domain.

3. <u>Construct validation</u> (Chronbach and Meehl, pp. 187-192)

a. An instrument is believed to reflect a particular construct to which certain meanings are attached.

b. The proposed interpretation generates specific testable hypotheses.

c. The nomological net is the interlocking system of laws which constitute a theory.

d. The laws may be probabilistic (statistical) or deterministic.

e. The laws may relate:

(1. Observable properties or quantities to each other;

(2. Theoretical constructs to observables, or

(3. Theoretical constructs to each other.

f. A necessary condition for a construct to be scientifically admissible:

(1. It must occur in a nomological net.

(2. At least some of the laws of the net must involve observables.

g. Admissible constructs may be remote from observation:

(1. A long derivation chain may intervene between the laws which implicitly define the construct and the derived laws relating observables to each other.

(2. The laws involving observables permit prediction.

(3. The construct is not reduced to the observations but only combined with other constructs in the net to generate predictions .

h. The explication of a construct involves either elaborating the nomological network in which it occurs, or increasing the definiteness of the components, or both.

i. An enrichment of the net (adding a construct or relation) is justified when:

(1. It generates laws that are confirmed by observation or

(2. It reduced the number of laws required to predict the same observations.

j. When the theory implies incorrect observation statements there is a certain freedom in selecting where to modify the network, due to the logical structure of the net.

(1. This freedom is not of complete arbitrariness because there are inductive considerations which make it better to modify certain parts of the net than others.

(2. Strictly speaking, any theory can be maintained against any finite body of evidence by the addition of suitable ad hoc hypotheses.

(3. The <u>ad hoc</u> hypotheses are then tested more directly or tested by entering the portions of the observation base not overlapping with the portions used to derive the hypotheses. On this basis an inductive decision concerning the theory is facilitated.

k. Operations which are qualitatively different, measure the same thing if their position in the net connect them to the same construct.

(1. The amount of confidence in this identification depends on the amount of inductive support for the regions of the net involved.

(2. Direct observational comparison of the two operations is not necessary. The intra-network proof indicating that the two operations yield estimates of the same network-defined quantity is sufficient.

l. Construct validation requires that:

(1. The net make some contact with observation.

(2. The net exhibit explicit steps of inference.

(3. There be a rigorous (though probabilistic) chain of inference in order to establish an instrument as a measure of a construct.

m. The network goes beyond the data in the sense that it seeks to characterize behavior facets which belong to an observable but as yet only partially sampled domain. Predictions are generated about the unsampled regions of the domain.

n. Ideally the postulates jointly entail the theorems.

(1. Some of the theorems are coordinated to the observation base.

(2. The system constitutes an implicit definition of the theoretical primitives.

(3. The coordination of the system to observables gives the theoretical primitives indirect empirical meaning.

o. In the behavioral sciences the laws and the net are vague.

(1. However, at least a sketch of the net is available.

(2. This vague, incomplete network gives the constructs whatever meaning they do have.

(3. If there is not at least a sketch of the network nothing intelligible can be said about the construct.

p. Since the meaning of constructs is set forth by stating the laws in which they occur, the incomplete knowledge of the laws produces a vagueness in the constructs.

4. <u>The interpretative and telescopic procedures in the construction of an empirical system</u>. (Koch, p. 20-21)

a. <u>Interpretative procedure</u>:

(1. The investigator believes that an already developed formal (uninterpreted) system may serve as a tool for ordering the domain of data.

(2. Through coordinating definitions certain constructs of the domain are related to terms of the postulate set of the formal system.

(3. If the formal system is isomorphic with the empirical domain every theorem deducible from the system will hold for the domain.

(4. The interpretation of the postulate set will increase in likelihood of correctness directly with experimental verification of the theorems.

b. <u>Telescopic procedure</u>:

(1. Unfortunately the isomorphic relationship rarely obtains.

(2. The theoretician is forced to proceed telescopically by a progressive and simultaneous elaboration of the formal and empirical aspects.

(3. The interpretation of some formal system as an explicit step in the process of theory building is dispensed with.

5. Two procedures for developing a theory (Campbell, pp. 300-301)

a. There is usually some hypothetical idea, the propositions concerning which cannot be proved or disproved empirically.

(1. Also a theory always asserts and means (designates) something which cannot be interpreted in terms of empirical operations.

(2. However, the theory is more satisfactory the more completely the hypothetical ideas in it can be empirically tested.

(3. Therefore when a theory containing such undetermined ideas is presented and appears to be true, efforts are directed to determine as many as possible of the undetermined ideas still remaining in it.

b. This determination of the hypothetical ideas is done in two ways:

(1. By adding new propositions to the hypothesis (i.e., stating new relations between hypothetical ideas).

(a. The hypothesis contains the real meaning of the theory and contains the analogy which gives the theory its value.

(b. A change in the hypothesis involves a change in the essence of a theory and makes it in some degree a new

(c. If a change in the hypothesis is necessary in order to explain or predict some new law then the original theory was not quite complete and satisfactory.

(2. By adding new propositions to the dictionary (i.e., stating new relations between hypothetical ideas and measurable concepts).

(a. The dictionary uses the analogy and the propositions in it are usually suggested by the analogy, but it adds nothing to the analogy.

(b. Since the addition to the dictionary does not involve a change in the essence of a theory then, if a new law can be deduced by the theory by an addition to the dictionary, that law has been predicted by the theory.

(c. The explanation of a new law and the determination of one more hypothetical idea by addition to the dictionary is thus a convincing confirmation of the theory.

6. <u>Closure, completeness and process laws</u>: (Brodbeck, 1958, pp. 8-16)

a. To make a prediction about a system from a theory, there must be added to the theory a set of statements about the state of the system at some specified time (we must know which concepts are or are not exemplified by the system at that time).

b. Prediction in the behavioral sciences is difficult because they lack closure and completeness.

(1. <u>Closure</u>: the referents of the terms of the theory interact only among themselves and with nothing else at the time and within the geographical area considered.

(2. <u>Completeness</u>: none of the variables that in fact do make a difference have been omitted from the expressions of the theory.

c. <u>Process Law</u>: the values of any one variable at any time can be determined by means of the laws from the values of all the others at any other time. Nothing that happens at any other time or place than those being considered affects the behavior of the properties with which the theory is concerned, or, at least, we can take account of these outside influences in our predictions and computations.

d. To know the conditions for closure of social science systems we must first know all the relevant variables (the theory being applied to the system must be complete). The conditions for closure will settle themselves if we know all the relevant variables.

7. <u>The criterion of systematic import</u>: (Camilleri, p. 177)

a. <u>Present research practices in social science</u>:

(1. There is a search for reliable empirical generalizations which must be included as propositions within any theory

(2. The significance level of the finding is often used as a criterion for determining whether a relationship between variables "exist" and so whether there is anything to eventually theorize about.

b. The more fruitful approach: construction and verification of systematic theory:

(1. In the development of systematic theory, the purpose of research is not primarily to determine the empirical adequacy of a particular hypothesis. It is rather to test the coordinated formal system that produced the hypothesis as a theorem.

(2. The systematic import of an empirical result means that the empirical truth of the particular hypotheses the researcher checks upon is valuable chiefly for its instrumental use in determining what should be done with the deductive system by which the hypothesis was produced.

(3. Often research is undertaken not to test a theory but to extend it, to determine its scope of applicability or to enlarge this scope by modifying the theory.

(4. To test a theory means that there is some conception of how the theory is to be treated as a result of the test.

(5. The alternative courses of action dependent upon the results of empirical investigation are alternative steps in the process of theory construction and not the acceptance or rejection of a particular formulation.

B. STRUCTURE OF THEORY.

1. A theory is a logically connected set of propositions. There are two general types of propositions. (Campbell, 290-3, 299-300)

a. "Hypothesis" - this contains statements about some collection of ideas which are characteristic of the theory. The propositions composing it are incapable of proof or disproof by themselves. They must be significant but taken apart from the other part of the theory ("dictionary") they appear arbitrary. They provide a definition by postulate of the ideas which are characteristic of the hypothesis.

b. "Dictionary" - this contains statements of the relation between the ideas of the "Hypothesis" and some other ideas of a different nature.

(1. The ideas which are related by means of the dictionary to the ideas of the hypothesis are such that something is known about them apart from the theory.

(2. It must be possible to determine, apart from knowledge of the theory, whether certain propositions involving these ideas are true or false.

(3. The dictionary relates some of these propositions of which the truth or falsity is known to certain propositions involving the hypothetical ideas. This is done by stating that if the first set of propositions is true then the second set

(4. In scientific theories the ideas connected by means of the dictionary to the hypothetical ideas are always concepts, i.e., collections of fundamental judgments related in laws by uniform association.

(5. The propositions involving these ideas, of which the truth or falsity is known, are always laws.

(6. "Concepts" are defined as those ideas involved in a theory which are not hypothetical ideas. Concepts depend on laws for their validity. All true propositions concerning the concepts are laws.

c. The theory is said to be true if propositions deduced from the hypothesis concerning the hypothetical ideas imply (according to the dictionary) true propositions concerning the concepts, (i.e., laws).

d. A theory is said to explain a law if the law is implied by the propositions concerning the hypothetical ideas.

e. A theory is not a law in that it cannot be proved by direct empirical test while all laws are at least capable of being disproved by empirical test (though they may not always be capable of being proved).

2. <u>The postulational technique</u>. (Koch; pp. 17-18)
There are two main parts:

a. <u>The formal system</u>: This consists of:

(1. A <u>Postulate set</u> involving implicit definitions. A postulate is defined as a sentence which is asserted for the purpose of exploring its consequences.

(2. A group of <u>explicit definitions</u> of certain concepts appearing in the postulates. These are rules stating that certain symbols may be substituted for other symbols occurring in the postulates.

(3. <u>Rules of inference</u> which state how to proceed from one sentence to another in making derivations.

(4. <u>Theorems</u> which are the sentences that are derivable from the postulates and the explicit definitions by the aid of the rules of inference.

b. The empirical system. This is the formal system interpreted with empirical data. The interpretation consists of correlating a term with some factual reference to some terms of the postulate set. A term has factual reference when there is a rule correlating it to some observable state of affairs.

3. The concept of law.

a. A law applies only to true statements. (Hempel and Oppenheim, p. 337)

b. Law-like sentences: a sentence is law-like if it has all the characteristics of a general law with the possible exception of truth. (Hempel and Oppenheim, p. 238) Every law is a law-like sentence but not conversely.

(1. The standard form of a law-like sentence is the universal conditional: If a certain set of conditions is realized, then another specified set of conditions is realized also. The conditional form is not considered essential for a law-like sentence while the universal character is held indispensable. (Hempel and Oppenheim, p. 338)

(2. Fundamental and derivative laws (Hempel and Oppenheim, p. 339-45)

(a. A fundamental law-like sentence is of universal form and contains no individual constants (purely universal).

(b. A Derivative law-like sentence is (1) of universal form and not equivalent to a singular sentence (essentially universal) and (2) derivable from a set of fundamental law-like sentences.

c. Typology of laws (Feigl, 1953, p. 409)

(1. Types of laws:

(a. Deterministic - strict and precise predictability of individual events or of some of their aspects. A "law of strictly universal form" is a statement to the effect that in all cases satisfying certain antecedent conditions an event of a specified kind will occur. (Hempel, 1959, pp. 275-276)

(b. Statistical - predictability on the basis of stable frequency-ratios or according to strict laws governing frequency distributions. A "law of statistical form" asserts that the probability for the antecedent conditions to be accompanied by an event of a specified kind has some specific value. (Hempel, 1959, p. 276)

(2. <u>Forms of laws</u>:

(a. <u>Qualitative</u>.

(b. Semi<u>-quantitative (topological)</u> - the relations of "equal" and "greater then" are defined (ordinal type relations).

(c. <u>Fully quantitative (metrical)</u> - the relations of "equality of intervals", "zero-point", and "units", in addition to topological ordering, are defined.

(3. <u>Domains of application</u>:

(a. <u>Temporal (sequential)</u> - the most common form of scientific law.

(b. <u>Coexistential (simultaneous)</u> - the regular co-presence of certain characteristics or regular concomitances in changes of such properties.

(4. <u>Levels of application</u>:

(a. <u>Macro ("molar")</u>

(b. <u>Micro ("molecular")</u>

This distinction is relative. There may be as many levels as it is methodologically fruitful to distinguish.

C. DEFINITIONS, OPERATIONISM (AND REDUCTION SENTENCES)

1. <u>The nature and purpose of definitions</u> (Feigl, 1949a, p. 499-501)

a. Definition involves the specification or delimitation of the meaning of a term or symbol. It is a statement of the rule concerning the use of a term or symbol.

b. The situations where the need for definition arises:

(1. Uncertainty as to what a term or symbol means if it means anything (obscurity).

(2. There exists a plurality of meanings of a term (ambiguity) removed by multiple definition.

(3. The term or symbol is used so vaguely that a definition giving it greater precision is demanded.

(4. The term or symbol, though defined clearly, unambiguously, and precisely in some respects, is to be given a place in a wider context and thereby enriched in meaning.

(5. A situation in research calls for the coining of a new term as an abbreviatory convenience for more complex aggregations of terms either already in use or so aggregated for the first time (this latter condition arises particularly in the context of the discovery of new elements or relationships in the subject-matter of research).

c. The adult and sane use of common language is on the whole sufficiently definite to permit communication and intelligibility as regards terms representing things and their observable properties. Doubt as to meaningfulness or as to precise meaning arises usually: (1). regarding higher-order constructs (occurring in any science which organizes its subject-matter by means of constructs beyond the level of observable-property predicates); (2). and/or terms of fairly clear subjective meaning but lacking sufficient determination for successful intersubjective testability.

2. <u>Types of definitions</u> (Koch, p. 22)

a. <u>Implicit definitions</u> - these delineate the properties assigned to a term by the postulate set in which it is embedded and state the functional relationships connecting terms.

b. <u>Explicit definitions</u> - these are rules of substitution which permit the replacement of any occurrence of a given term in the postulate set by any other; certain symbols may be substituted for other symbols.

c. <u>Coordinating definitions</u> - these correlate empirical constructs with formal terms in the Postulate set.

d. <u>Operational definitions</u> - these correlate the constructs to some set of observables.

3. <u>Constitutive and epistemic definitions</u> (Trogerson, pp. 4-5)

a. Constitutive definitions express the interrelation of two or more constructs and the interrelation can be thought of as a definition of any one of the constructs in terms of the others Constructs that have one (or preferably more) constitutive definition(s) possess theoretical or <u>systematic import</u>.

b. Operational or epistemic definitions relate constructs directly to observable data.

c. In order to be useful, all constructs must possess constitutive meaning; they take part in the formation of laws and theories. However it is not necessary that all constructs possess a direct operational definition. Only a sufficient number in any system need be operationally defined.

4. <u>Operationism</u>.

a. The essence of the operationist emphasis is the formulation of criteria of scientific meaningfulness and fruitfulness for concepts and of criteria of validity for factual statements. (Feigl, 1949a, p. 498)

b. Operational analysis assists the decision as to whether a given term has factual reference in the way it is used. If the term does have factual reference, operational analysis seeks to show precisely what that factual reference is, in terms, ultimately, of the data of direct observation. (Feigl, 1949a, p. 501)

c. Operationism wisely understood and applied must take account and render account of the level of precision, completeness, and fruitfulness reached at the given stage of concept formation. (Feigl, 1949a, p. 506).

d. Concepts which are to be of value to the factual sciences must be definable by operations which are: (Feigl, 1949a, p. 508)

(1. Logically consistent.

(2. Sufficiently definite (if possible, quantitatively precise).

(3. Empirically rooted by procedural and (finally) ostensive links with the observable.

(4. Naturally and (preferably) technically possible.

(5. Intersubjective and repeatable.

(6. Aimed at the creation of concepts which will function in laws or theories of greater predictiveness.

5. <u>Reduction sentences</u>. (Carnap 1953)

a. There are two methods of introducing a new term into the language of science: (p. 59-60)

(1. Definition - this is the appropriate form if the meaning of the new term is to be fixed once and for all.

(2. Reduction method - this is the appropriate method if the meaning of the term is determined at the present time for some cases only, leaving its further determination for other cases to decisions which are made step by step on the basis of empirical knowledge which is to be obtained in the future. A set of reduction pairs is only a partial determination of the meaning and can therefore not be replaced by a definition. Only if by adding more and more reduction pairs a stage is reached in which all cases are determined may the form of a definition be used.

b. The form of a bilateral reduction sentence for 'Qx':

(1. $Cx \supset (Qx \equiv Ex)$. The empirical results E provide evidence for the construct Q. This implies that Q is defined only under the conditions C.

(2. Therefore, Q is open to different and supplementary operational criteria and different reduction sentences in different E contexts.

(3. The definition of Q is only partial in terms of the correspondence rules linking Q to E. Therefore, if E is confirmed under C the presence of Q is only probable.

(4. Theoretical terms (Q's) are not explicitly defined in observational language. They are introduced by postulate and to that extent are not completely determined. Therefore, the use of reduction sentences does not affect the problem of the meaning and definition of theoretical terms (as conceived by Carnap.)

D. CONCEPTS AND THEIR FORMATION.

1. <u>Types of concept formation in science</u> (Hempel, 1952, pp. 50-74)

a. <u>Classification</u>

(1. A classification of the objects in a given domain D is effected by laying down a set of two or more criteria such that every element of D satisfies exactly one of those criteria.

(a. Each criterion determines the class of all objects in D which satisfy the criterion.

(b. If each object in D satisfies exactly one of the criteria then the classes thus determined are mutually exclusive and jointly exhaustive of D. (p. 51)

(2. When at least one of the conditions of exclusiveness and exhaustiveness are not a logical consequence of the determining criteria, but occur as a matter of empirical fact, then the classificatory concepts have some measure of systematic import for there is implied an empirical law.

(3. <u>Natural and artificial classification</u>: in natural classifications the determining characteristics are associated, universally or in a high percentage of all cases, with other characteristics, of which they are logically independent. (p. 53)

(a. The distinction between natural and artificial classification becomes a matter of the degree of systematic import of the defining characteristics.

(b. The extent to which a proposed classification is systematically fruitful and natural is an empirical problem.

(4. <u>The transition to comparative and quantitative concepts</u>: (p. 54)

(a. A classificatory concept represents a characteristic which any object in the domain under consideration must either have or lack. If its meaning is precise, it divides the domain into two mutually exclusive classes.

(b. Concepts of this kind are used largely (though not exclusively) for the description of observational findings and for the formulation of initial empirical generalizations.

(c. With the development of more subtle and theoretically fruitful conceptual apparatus, classificatory concepts tend to be replaced by others which make it possible to deal with characteristics capable of gradations.

b. <u>Comparative concepts and nonmetrical orders</u>.

(1. A comparative concept with the domain of application, D, is introduced by specifying criteria of the relations coincidence, C, and precedence, P, for the elements of D in regard to the characteristic to be represented by the concept. C and P arrange the elements of D in a quasi-serial order (i.e., in an array that is serial except that several elements may occupy the same place in it.)

(2. The conditions which C and P must meet: (x, y, z are elements of D)

(a. C is transitive: if xCy and yCz then xCz.

(b. C is symmetric: if xCy then yCz.

(c. C is reflexive: xCx.

(d. P is transitive: if xPy and yPz then xPz.

(e. P is C-irreflexive: if xCy then x not-Py.

(f. P is C-connected: if x not-Cy then either xPy or yPx.

(3. Conditions 'e' and 'f' require that any two elements of D must be comparable in regard to the attribute under consideration. (pp. 59-60)

c. Quantitative or metrical concepts.

(1. These concepts attribute to each item in their domain of applicability a certain real number which is the (scalar) quantity for that item (the value is a single number). There are also other metrical concepts whose values consist of a set of several numbers (e.g., vectors).

(2. Fundamental measurement: no prior metrical scales are presupposed. Two steps are involved: (p. 58)

(a. The specification of a comparative concept which determines a nonmetrical order: and

(b. The metrization of that order by the introduction of numerical values.

(3. Derived measurement: scalar quantities which are determined by other metrical concept(s). The determination of a metrical scale is by means of criteria which presuppose at least one previous scale of measurement. (pp. 69-70)

(a. Derived measurement by stipulation consists in defining a "new" quantity by means of other quantities already available.

(b. Derived measurement by law does not introduce a "new" quantity but rather is an alternative way of measuring one that has been previously introduced. This is accomplished by the discovery of some law which represents the magnitude in question as a mathematical function of other quantities, for which methods of measurement have already been determined.

(4. The rules of fundamental measurement determine the value of a metrical concept only for objects of a certain range, constituting and domain D. The rules for the fundamental measurement of the metrical concept do not completely define the concept; i.e. they do not determine the value of the concept for every possible case of its theoretically meaningful application. (pp. 71-73)

(a. To give an interpretation to the metrical concept outside of the original domain D, an extension of these rules is necessary.

(b. Combining the methods of derived measurement by law and stipulation is an important type of procedure for the extension of the rules of measurement for a given metrical concept.

(c. In practice, the empirical generalizations or "laws" formed on the basis of a given scale and using a given metrical concept often hold only approximately and there may be considerable deviations from it, particularly at the extremes of the ordinal scale.

(d. In such cases the original scale of measurement for the given magnitude may be discarded altogether in favor of a more comprehensive scale of indirect measurement.

(e. Considerations of theoretical import and systematic simplicity govern the gradual development of the rules for the measurement of many metrical concepts in the more advanced branches of science.

(f. Frequently there is a complex interplay between the development of theoretical knowledge in a discipline and the criteria used for the interpretation of its metrical terms.

2. <u>Constructed or ideal types</u> (Martindale and McKinney)

a. <u>Definitions</u>.

(1. <u>Weber</u>: (Martindale, pp. 68-69)

(a. The ideal type is formed by the accentuation of one or more points of view and by the synthesis of a great many diffuse, discrete, transient, concrete individual phenomena which are arranged into a unified analytical construct on the basis of the accentuated view points.

(b. The type contains both conceptual and observational materials.

(c. The relationships between the conceptual and observational materials meet the criteria of:

[1. <u>Objective possibility</u> - the conceptual form must represent an empirically possible state of affairs, i.e., it should not contradict any of the known laws of nature.

[2. <u>Adequate causation</u> - the items should be "adequate" in terms of the causal laws of science.

(d. The weighting of determinants of social phenomena (Nagel, 1953). A and B are two adequately specified factors upon which the occurrence of a phenomenon C is supposed to depend in some fashion. One can say that "A is a more important determinant of C than B" when:

[1. A &B both necessary for C.

Variations in B are infrequent.
Variations in A are frequent with consequent variations in C.

[2. A &B both necessary for C.

C varies more with a variation in A than with an equal proportional variation in B.

[3. A &B not both necessary for C.

C occurs with A &Y or B &Z.
A &Y occurs relatively more often than B &Z

[4. A &B not both necessary for C.

C occurs more frequently with A & not-B than with B & not-A.

[5. A &B both necessary for C.

A is a fundamental theoretical construct of theory T
T accounts for C with the help of B; B is necessary to account for C.
T also accounts for other phenomena than C; without reference to B.
The range of phenomena to which T, and therefore A, is applicable is greater than the range to which B is applicable.

(2. <u>McKinney</u>.

(a. The constructed type arranges concrete data so that they may be described in terms which make them comparable.

(b. It is a devised system of characteristics (criteria) that is useful as a basis of understanding empirical reality.

(c. It is a construct made up of abstracted elements and formed into a unified conceptual pattern with an intensification of one or more aspects of concrete reality.

(d. When the type is formulated as "objectively probable" (sic) it throws actual structures or courses of action into a comparative light.

(e. It serves as a basis for comparison and potential measurement of concrete occurrences.

(f. It isolates the behavior that is theoretically significant.

(3. <u>Martindale</u>. (pp. 58-9)
The ideal type is a device intended to institute comparison as precise as the stage of the theory and the precision of the instruments will allow. The theory determines the kind of ideal types developed in comparative procedure.

b. <u>Hempel's discussion</u> (Martindale, pp. 85-88)

(1. The typological concepts used in the social sciences tend to use a logic of properties of classes and therefore they are incapable of adequately dealing with relations and quantitative concepts.

(2. Hempel's classification of types on the basis of their methodological functions.

(a. Classificatory types: these represent the logic of properties and attributes and are not well adapted to the study of quantities and relations. They tend to be supplanted by formulations in statistical terms.

(b. Extreme (polar) types: to function properly they must set up criteria for comparisons of more or less. They are discarded as soon as operational criteria are found for proper judgment of amount in a continuum.

(c. Idealized models: Idealized models representing interpreted theories are legitimate and valuable; the model is deduced from general principles. Ideal types are illegitimate models because the type is usually intuitive rather than theoretical and often addressed to an only vaguely specified body of data.

c. The use of ideal type in comparisons. (Martindale, pp. 87-88)

(1. The type is developed to allow the most precise comparison possible for the level of adequacy of the science.

(2. The type is not compared with an actual state of affairs (as McKinney implies) but the type isolates the dimensions on which comparison of two or more actual states of affairs is critical.

(3. The degree to which the relations involved in the type are intuitive seriously limits the extent to which generalization is possible.

(4. Any given ideal type is destined to be surpassed but they will be employed as long as a science relies upon the comparative method.

E. THE "SURPLUS MEANING" OF THEORETICAL TERMS.

1. <u>Hypothetical constructs and intervening variables</u> (MacCorquodale and Meehl, pp. 605-606, 610)

a. <u>Intervening variable</u> (IV):

(1. The IV contains, in its complete statement for all purposes of theory and prediction, no words which are not definable, either explicitly or by reduction sentences, in terms of the empirical variables.

(2. The validity of empirical laws involving only observables constitutes both the necessary and sufficient conditions for the validity of the laws involving the IV.

(3. The quantitative expression of the IV can be obtained without mediate inference by suitable groupings of terms in the quantitative empirical laws.

(4. The IV involves no hypothesis as to the existence of nonobserved entities or the occurrence of unobserved processes.

b <u>Hypothetical construct</u> (HC):

(1. The HC involves terms which are not wholly reducible to empirical terms.

(2. The truth of the empirical laws involved is a necessary but not sufficient condition for the truth of the HC inasmuch as it contains surplus meaning.

(3. The quantitative expression of the HC can not be obtained simply by grouping empirical terms and functions.

(4. The HC refers to processes or entities that are not directly observed (although they need not be in principle unobservable).

2. Existential hypotheses (Feigl, 1950)

a. Typology of hypotheses: (p. 42-43)

Hypotheses in the form of laws relating:	Type	Hypotheses in the form of singular statements asserting:
Two directly observable properties (magnitudes).	A	Directly testable states of affairs.
Directly observable to indirectly testable properties (magnitudes).	B	Indirectly testable states of affairs.
Two indirectly testable properties (magnitudes).	C	

b. The existential hypothesis and HC are in principle only indirectly confirmable.

(1. Strict logical equivalence between indirectly and directly confirmable statements is precluded.

(2. Therefore, indirectly confirmable statements must involve some sort of surplus meaning. Surplus meaning is any meaning contained in a concept which is beyond that stated in its definition or the laws relating it to other concepts.

c. Confirmatory evidence does not add existential meaning in any significant sense, since the relation of evidence to the hypothesis is a logical one. The postulates of the theory entail the theorems, and a sub-set of the theorems are the observation laws. Since the theorems flow from the postulates, and not conversely, the truth of the postulates is supported by, not clinched by, observation. (Meissner, p. 60)

d. The content of the HC or any constructed model is not totally determined by the results of measurement and observation. It is possible that something more will be contributed either in terms of the real structure under investigation or in terms of the constructive process. (Meissner, p. 60)

(1. A proposition or set of propositions is not the same thing as another set to which they are logically equivalent and which are implied by them for they may differ in "meaning", i.e., the ideas which are called to mind when the proposition is asserted. (Campbell, p. 300)

(2. A theory is valuable, and is a theory in any sense important for science, only if it evokes ideas which are not contained in the laws which it explains. (Campbell, p. 300)

(3. It is in this respect that theories differ fundamentally from laws. Laws mean nothing but what they assert. (Campbell, p. 300)

(4. Surplus meaning is essential to theory for there is always an indeterminate range of factual content implicit in any significant concept. (Meissner, p. 58) (see I.E.7.a. on page nine of this paper)

3. Semantic (empirical) realism (Feigl, 1950, p. 48)

a. The surplus meaning consists in the factual reference of the constructs employed in laws and hypotheses which deal with indirectly testable properties (Types B and C).

b. The distinction is between:

(1. Epistemic reduction (i.e., the evidential basis) and

(2. The semantical relation of designation (i.e. reference).

c. The explication of designation and reference can be achieved only through the construction of an appropriate semantic metalanguage.

F. MODELS AND FORMAL IDENTITIES.

1. Types of formal identity. (Miller, p. 520

a. Isomorphy - a formal identity between two conceptual systems.

b. Homology - a formal identity between two real systems.

c. Model - a formal identity between a conceptual and a real system.

2. Theory and model (Lachman, p. 114)

a. Model includes the commentary accompanying the use of mathematical and/or linguistic symbols, along with the rules of their manipulation, to represent the data, organize this data, and by proper deduction, to predict data not used in the development of the theory.

b. The model is a separate system from a theory (structurally independent).

c. The model (consisting of a separate system) brings to bear an external organization of ideas, laws, or relationships upon the hypothetical propositions of a theory or the phenomena it encompasses.

d. This external organization contributes to the construction, application and interpretation of the theory.

3. Functions of models (Lachman, pp. 114-117)

a. Models provide modes of representation (construction):

(1. A model constituting a separately organized system, furnishes a new system of representation for the phenomena.

(2. Attributes and meanings of the model are transferred from their initial context of usage to the new setting.

(3. The application of unprecedented modes of representation is executed on two levels:

(a. The directly observable objects and events are thought about in the new and unusual fashion prescribed by the model.

(b. The hypothetical concepts and postulates of the theory are conceived in novel modes.

b. Models function as sources for rules of inference (application):

(1. The model signifies the rules by which the theoretical concepts (some of which have been empirically coordinated) are manipulated to arrive at new relations.

(2. Two types of rules may be distinguished:

(a. Specific inference rules provided by certain equations in the model.

(b. Supplementary textual commentary which prescribes the manner in which the theoretical concepts are to be connected (implicit definitions).

c. Models interpret the calculus and theoretical concepts.

(1. In theories with inference rules primarily adopted from a formal calculus, the formal model may be supplemented with one or more additional models which serve to interpret and make intelligible the inference rules employed.

(2. Modular interpretation:

(a. Renders intelligible formulae and concepts,

(b. Shows how to apply the theory and

(c. Suggests procedures for extending the use of individual parameters as well as the theory as a whole.

d. Models provide pictorial visualization.

(1. The pictorial model may be decisive in the initial phase of theory construction.

(2. A model providing only visual representation serves at best didactically and may mislead the theorist.

4. Criteria for evaluating a model (Lachman, pp. 126-127)

a. Deployability.

(1. The degree to which the concepts of the model in their primary context of usage can be successfully applied to the new setting.

(2. Deployability is an attribute of the set of relationships or meanings contained in the model that are employed in formulating the logical propositions of the theory.

b. Scope.

(1. The range of phenomena to which the model is applicable. The number or extent of facts and data that may be derived by the use of the model.

(2. Scope refers to the empirical derivatives of a theory which are generated with the aid of a model.

(3. Generally, the more a model is deployed the greater will by the scope of the theory, but the scope of applicability implies nothing about the deployability of the model.

c. Precision. The degree to which the consequences of a theory are unequivocally derived through the application of the inference rules provided by the model.

5. The model and reality.

a. In practice, science assumes an external world independent of the observer (pragmatic realism). As a consequence, there arises discourse concerning the relationship between the models and constructs of science and the phenomena they refer to.

b. Since a successful model enables predictions concerning the domain it refers to the model is sometimes assumed to be a literal description of reality.

c. This view is unwarranted since several models can serve the same class of events equally well and also a single model can function in behalf of independent classes of events. (Lachman, p. 128)

d. The model is a changeable representation (a research tool) which can be replaced or reformulated in terms of subsequent results. Discrepancies between the conceptual and real system result in revisions of the model in regard to the semantic rules or syntax for the purpose of achieving a better fit between the conceptual and real systems. (Meissner, p. 67)

e. The model is a partial and limited analogy.

(1. It expresses certain aspects of the real system.

(2. The relation between the conceptual and real system is mediated through a set of:

(a. Selective processes,

(b. Measurement techniques and

(c. Methodological procedures.

(3. In this mediation process, allowance is made for both:

(a. The normative status of the real system and

(b. The event guided (but not event determined) constructive activity of the scientist. (Meissner, p. 67)

6. <u>Determinant vs statistical systems</u>.

a. Many of the systems of nature are not systems at all but aggregates, i.e., systems without structure. There is a continuum of degree of structure:

System:	Aggregate:
(1. Structured interaction of elements.	No consistent interaction of elements ("randomness").
(2. General laws of the interaction can be formed.	No general laws of the interaction can be formed.
(3. Theory can be formulated about the system (elements plus interaction).	No theory can be formed of the interaction.

b. The degree to which a system is structured (i.e., is a system) determines its generalizability.

(1. Some statistical structures are scientifically important but are not systems. They have some constant properties on the macro level of analysis (compared with the interacting elements).

(2. The interactions of the elements are complex but the sum of the interactions somehow give lawful macro relations which are much simpler than the micro relations.

(3. In any bounded system, when a very large number of events of the same general sort occur over a very short period of time, an average of the effects of these events may turn out to have stable over-all properties. The elements must be very numerous and small relative to the means of measurement. The macro stability is a result of the statistical properties involved in the large number rather than a function of determinantness.

G. DESCRIPTION, EXPLANATION, PREDICTION, CAUSE AND REDUCTION.

1. Explanation and prediction.

a. Explanation as a process is a procedure of inference. The explanation of a set of facts is the required set of premises in the deductions. Explanation is the inductive-deductive or hypothetico-deductive derivation of more specific (ultimately descriptive) propositions from more general assumptions (laws, hypotheses, theoretical postulates) in conjunction with other descriptive propositions. (Feigl, 1949b, p. 510-511)

b. Description involves singular statements representing fully specific facts, events or situations as more or less immediately observable. (Feigl, 1949b, p. 511)

c. Explanation is relative in two regards:

(1. Any given explanation proceeds from premises which, although possibly capable of further explanation, are assumed or taken for granted in the given case.

(2. The explanatory premises are relative to the confirming evidence and therefore subject to revision.

d. The formal structure of prediction and adequate explanation is the same: (Hempel and Oppenhiem, pp. 322-323)

(1. The difference between them is of a pragmatic character. If the empirical phenomenon has occurred, and a suitable set of statements of antecedent conditions and general laws is provided afterwards, then this is an explanation of the phenomena. If the statements of the antecedent conditions and laws is provided prior to the occurrence of the phenomena, then it is prediction.

(2. An explanation is not fully adequate unless the statements of antecedent conditions and general laws could have served as a basis for prediction.

(3. It is this potential predictive force that gives scientific explanation its importance.

e. <u>Prediction and explanation in social science</u>. Watkins believes that the two processes should be separated when one is dealing with the social sciences for two reasons:

(1. The social sciences often have only an explanation sketch. Such a sketch consists of a more or less vague indication of the laws and initial conditions considered as relevant, and it needs "filling out" in order to turn into a full-fledged explanation. This filling-out requires further research for which the sketch suggests the direction. (Hempel 1949, p. 465)

(2. Even when a full-fledged explanation of an event is available there is difficulty in predicting similar events because they will occur in a system which is not isolated from the influence of factors which cannot be ascertained before hand. (Watkins, p. 723) [This says in effect that the system is not complete (see p. 15, number 6) and may actually reduce to the first reason.

f. <u>The formal structure of explanation (prediction)</u>. (Hempel and Oppenheim, pp. 321-322)

(1. <u>Schema</u>:

$C_1, C_2, \ldots C_k$ Statements of antecedent conditions.

↙ Explanans

$L_1, L_2, \ldots L_r$ General Laws.

Logical Deduction → E Description of the empirical phenomenon to be explained. Explanandum

(2. <u>Conditions of adequacy</u> of the constituents of an explanation:

(a. The explanandum must be a logical consequence of the explanans.

(b. The explanans must contain general laws, and these must actually be required for the derivation of the explanandum.

(c. The explanans must be capable (at least in principle) of empirical test.

(d. The sentences constituting the explanans must be true.

g. Cause. (Feigl, 1953, pp. 408-410)

(1. The clarified concept of causation is defined in terms of predictability according to a set of laws.

(2. The phase: "A is the cause of B" means "The more the actual condition A' approximates the ideal condition A, the more the actual effect B' will approximate the ideal effect B."

2. Levels of explanation.

a. The empirical laws which function as premises in the deductive derivation of strictly descriptive conclusions may in turn become the conclusions of a super-ordinated deductive derivation from higher theoretical assumptions. The highest level of theoretical abstraction at any given stage of theoretical research (ideally) simply covers all relevant and available descriptive data. (Feigl, 1949b, p. 511-512)

(1. Description: simple account of individual facts or events (data) as more or less immediately observable.

(2. Empirical laws: Functional relationships between relatively directly observable (or measurable) magnitudes.

(3. Theories, 1 st. order: Sets of assumptions using higher-order constructs (results of abstraction and inference. A deeper interpretation of the facts as rendered on the Empirical Law-level.)

(4. Theories, nth order: More penetrating interpretation and higher order constructs.

b. Explanation within vs explanation of a theory. (Brodbeck, 1959, pp. 395-396).

(1. Within a theory, the theorems are explained by deriving them from other laws, the axioms of the theory. The axioms themselves are not explained by the theory, but are the statements which do the explaining.

(2. If the axioms of one theory are derivable from the laws of the second theory, then we have an explanation of the first theory.

(3. The reduction of one theory to another therefore explains the former in terms of the latter. For this to be possible, a logical bridge between the two theories must be constructed which connects the referents of the concepts of the two areas. [see p. 34, #c]

3. Emergence.

a. Emergence with respect to the occurrence of characteristic c in an object O: (Hempel and Oppenheim, p. 336) The occurrence of a characteristic c in an object O is emergent relative to a theory T, a part relation Pt (composition rule), and a class of attributes A if that occurrence cannot be deduced by means of T from a characterization of the Pt-parts of O with respect to all the attributes in class A.

b. Emergence with respect to a characteristic c (rather than to an occurrence): (Hempel and Oppenheim, p. 336) A characteristic c is emergent relative to T, Pt and A if its occurrence in any object is emergent in the above sense.

c. Explanatory emergence: (Brodbeck, 1958, pp. 6, 19-20)
The laws of the whole are not derivable from (reducible to) laws about the behavior of the parts, including composition laws about the parts.
This involves any breakdown of a theory with composition laws at a certain level of complexity. The issue is an empirical one of whether or not a given theory is adequate for a given domain of facts.

d. Descriptive emergence: (Brodbeck, 1958, pp. 2, 6, 19-20)
The occurrence of a property (attribute) of a whole which is not definable in terms of either the parts or the relations between the parts or both. This is a matter of the criterion of meaningfulness.

4. Reduction.

a. Isomorphism and model (Brodbeck, 1959, pp. 374, 380) Isomorphism means the similarity between a "thing" and a model (the distinction is different from Miller's in that the model need not be conceptual and the "thing" natural, see II.F.l.)

Isomorphism requires two conditions:

(1. There must be a one-to-one correspondence between the elements (concepts/ terms) of the model and the "thing" of which it is the model. This correspondence must be explicitly stated.

(2. The relations between the elements-concepts of the model and "thing" must be preserved - structural similarity.

b. <u>Models as isomorphic theories</u> (Brodbeck, 1959, pp. 379-380, 392)

(1. Two theories are isomorphic (structurally similar) when their laws have the same form and one theory can be said to be a model for the other.

(2. One area can be a fruitful model for another only if corresponding concepts can be found and if at least some of the laws connecting the concepts of the model also can be shown to connect their corresponding concepts.

(3. The fact that all or some of the laws of one area have the same form as those of another need not signify anything about any connection between the two areas.

c. <u>Types of connections between two empirical theories</u> (Brodbeck, 1959, pp. 393-398)

(1. <u>Identification</u> of one set of phenomena with another.

(a. <u>Three conditions are necessary for identification</u>:

[1. The laws must have the same form.

[2. The constants in the laws must have the same values.

[3. The empirical concepts must be interchangeable.

(b. If the above three conditions obtain then the two theories are only two different ways of conceiving of the same phenomena.

(c. If the basic terms or each theory are interchangeable, knowledge in one area is also knowledge in the other.

(2. <u>Reduction via cross-connection laws</u>. (see p. 33, number 2.b)

(a. Here one area is reduced to (explained by) another by means of empirical cross-connection laws.

(b. The interchangability of empirical concepts (condition 3) does not obtain and so the two areas are not two different ways of talking of the same phenomena.

(c. The laws of theory A in conjunction with the crossconnection laws entail the laws of theory B.

(d. The cross-connection laws form a logical bridge between the two theories by connecting the referents of the concepts of the two areas.

(3. <u>Reduction via definition</u>.

(a. The problem of concern is the possibility of reduction of a social science dealing with group behavior to a social science dealing with individual behavior.

(b. <u>Group property</u> (Brodbeck, 1958, p. 2) A property is a group property when the property is attributed to a group collectively, so that the group itself is logically the subject of the proposition, rather than distributively where each and every member of the group could logically be the subject of the proposition.

(c. <u>Undefinable descriptive group property</u> (Brodbeck, 1958, pp. 3, 6) Attributes of groups which can be directly observed but which cannot be defined in terms referring to either the behavior of the individuals constituting the group or the relations obtaining among them or both.

(d. There is a class of terms used in social science which are not statistical in intent but which have yet to be defined in terms of individual behavior. The source of error is due to the imprecision (but not of measurement) in the definition of the terms. (Brodbeck, 1958, p. 4-5)

(e. <u>Methodological individualism</u>. An understanding of a complex social situation is always derived from a knowledge of the dispositions, beliefs, and relationships of individuals. Its overt characteristics may be established empirically, but they are only explained by being shown to be the resultants of individual activities. (Watkins, p. 732)

Two meanings of methodological individualism (Brodbeck, 1958, p.6)

[1. Denial of descriptive emergence (see II.G.3.d) There are no undefinable group properties.

[2. Denial of explanatory emergence. (see II.G.3.c) The laws of the group sciences are in principle reducible to those about individuals.

(f. Composition laws and group behavior.

[1. Group concepts refer to complex patterns of descriptive, empirical relations among individuals.

[2. The study of the behavior of these complexes results in macro-scopic laws which are different from laws about individual behavior. Both terms of a sociological law may refer to congeries of individuals exemplifying descriptive relations. The law states that whenever a group has one set of relational attributes it also has the other. (Brodbeck, 1958, p. 16)

[3. The definition of group concepts in terms of patterns of individual behavior is not sufficient for the reduction of sociology to psychology. There must be laws within the theory of individual behavior stating how individuals in the group interact with each other to give the resultant behavior of the group - composition laws. (Brodbeck, 1959, p. 397)

[4. Even if sociological laws are derivable from psychological laws, the two areas are not identified. There need not be any similarity between behavior of a complex and the behavior of the elements of the complex. The basic terms of the two areas are different and these terms are not defined within the theory. They are concepts in terms of which all other concepts of the theory are defined.

[a. In sociological theory the basic terms refer to complex patterns - groups.
[b. In psychological theory the basic terms refer to the elements of the complexes - the behavior of the individual members of the group.

[5. These basic terms referring to complexes and members are not interchangeable.

[a. The (composition) laws of psychology are about the member's interaction with each other.

[b. The sociological laws are about resultant behavior of groups and the two kinds of laws need not have the same form. (Brodbeck, 1959, p. 397)

[6. If reduction is possible, then the basic group terms of sociology will be defined terms in psychological theory. That is, if psychological composition laws about the elements exist. then the sociological laws are derivable as theorems from the composition laws and the definitions of the group concepts. (Brodbeck, 1959, pp. 397-398)

(g. <u>The possibility of explanatory emergence</u> (Brodbeck, 1958, p. 19)

[1. Since the composition laws are empirical generalizations the predictions made for a system of a certain level of complexity might be proven false. There are three possible general reasons for this:

[2. There are no laws of human behavior when a certain level of complexity is reached. This involves a breakdown of the composition law <u>and</u> determinism.

[3. A different composition laws concerning the behavior of individuals in groups is needed after a certain level of complexity is reached.

[a. The law is of different form and/or

[b. The law contains variables which begin to be operative only after the population reaches a given magnitude.

[4. Even though group behavior is itself lawful there is no composition rule from which it can be predicted.

(h. <u>Social science using only group concepts and variables</u>: (Brodbeck 1958, pp. 21-22).

[1. Since a process theory (see p. 15, 6.c.) is logically possible with any kind of variables a class of group concepts and laws may form a complete set of relevant variables for a social process. There might be a set of macroscopic laws permitting the prediction of the values of the group variables at all times from its state at any given time.

[a. This possibility is implausible because the change in the social process probably does not depend only upon group or macroscopic units.

[b. There is considerable variability among people and some people have more effect on society than others.

[c. If this variability among individuals makes sufficient difference, then the laws have to take the occurrence of a particular kind of individual into account. Therefore the complete set of variables will not be all macroscopic.

[2. Since complete knowledge with group variables alone is unlikely there is the possibility that approximate laws can be stated using only group variables. The composition laws from which the behavior or some groups may be predicted may be of such complexity and difficulty that it is more feasible to look for whatever imperfect connections

III. MEASUREMENT, PROBABILITY, AND STATISTICS.

A. MEASUREMENT.

1. <u>Measurement and concept formation</u>.

a. Measurement is one aspect of the general problem of concept formation (see: I.B. and II.D.l.)

b. Torgerson (p.2,9-10) and Hempel (1952, pp. 56-7) equate the rigor and maturity of a science to the degree to which satisfactory measurement of the important variables has been achieved and view such measurement as preceding real theoretical development.

c. It is my view (following Allport, 1954, 1955) that this orientation is too narrow and consideration must also be given to the rigor of conceptualization of structure (see I.C.) To this end use of non-metrical mathematics is used to handle the structural variables (e.g. topology, graph theory, matrix algebra for analyzing sociometric structures, etc., see. Glanzer and Glaser).

d. Measurement is only a facet of the general problem of definition of variables and their explication (see I.B.l & 2.) Indeed, prior to any attempt at measurement is the search for, and definition and explication of, concepts and dimensions of the science. (Eysenck, 1952)

e. <u>Factor analysis as a method for finding fundamental concepts</u>. (Eysenck, 1953)

(1. Factor analysis is one aspect of the "analysis of inter- dependence" (as opposed to the "analysis of dependence") and more specifically involves "component analysis." (i.e., delimitation of the variables involved in the study). (p. 105)

(2. <u>There are four main interpretations of a "factor"</u>: (pp. 106-8)

(a. <u>Descriptive statistic</u>: A factor is a condensed statement of (linear) relationships obtaining between a set of variables which can be used mathematically to stand for these variables. (the factor is an IV, II.E.l.)

(b. <u>Suggest hypotheses</u>: A factor is a condensed statement of (linear) relationships obtaining between a set of variables, suggestive of hitherto undiscovered causal relationships.

(c. <u>Hypothesis testing</u>: A factor is a condensed statement of (linear) relations obtaining between a set of variables which is in agreement with prediction based on theoretical analysis.

(d. <u>Cause</u>: A factor is a hypothetical causal influence underlying and determining the observed relationships between a set of variables. (the factor is an HC)

(3. <u>Methods of determining the causal status of factors</u>: (p. 110)

(a. Comparing the results of factor analysis with independent knowledge of the conditions responsible for the results in situations where the causal relations are relatively well understood.

(b. The simultaneous change of scores on all the tests defining a factor when the hypothetical basis of thatfactor is experimentally altered.

(c. When a test has been given to a sufficiently large sample of identical and fraternal twins, it is possible to calculate an index of hereditary determination. A factor can have a higher index value than any of the constituent tests when this factor is based on some definite, underlying biological function which is itself inherited.

(d. Methods logically identical with factor analysis, though less rigorous, have been used to deal with problems in the study of interdependence, (informal taxonomy)

(4. Implications of causality require rotation into simple structure (descriptive parsimony): Thurstone. (p. 112)

(a. Treat the test domain as if its communality is due to a small number of isolable causes.

(b. The best way of isolating and measuring these causes is by purification, i.e., by selection of tests whose variance is due only one or two causes and not to all at once.

(c. This gives a clear-cut differentiation and separation of factors and, at the same time, provides proof for the usefulness of the original assumption by the very possibility of such a selection.

2. <u>The question of what is measured</u>.

a. Torgerson (p.9) distinguishes two types of constructs in science:

(1. <u>Systems</u>: this includes the objects, things, and events of ordinary experience (Allport's "events").

(2. <u>Properties</u>: these are the observable aspects or characteristics of the empirical world; aspects or characteristics of systems; the observables. It is the properties that are measured and not the systems themselves. Measurement is one way of defining a property but not all properties are measurable (exist in degrees).

b. Russell, Campbell and Torgerson define measurement in terms of assignment of numbers to properties and this is the traditional approach to measurement. Steven's definition is broader in that measurement is the assignment of numerals to objects or events and also to aspects of objects or events (Stevens, p. 23) [This aspect Torgerson overlooks in his discussion and criticism of Stevens' approach and concentrates on Stevens' desire to include the naming process as a form of measurement.]

c. Cattell's covariance cube: (Suchman and Francis, p. 126-127)

(1. People held constant and situations and variables vary:

(a. O-technique: study the scalability of situations for a population of variables. The concern is with the ordering of situations based upon the arrangement of variables in the situation.

(b. P-technique: study the scalability of variables for a population of situations. The concern is with the ordering of variables based on the measurement of these variables in different situation.

(2. Situations held constant and people and variables vary:

(a. Q-technique: Study the scalability of people for a population of variables. Given a population of people who respond to a series of items, we attempt to determine the dimensionality of the items and then to rank the people according to this dimension.

(b. R-technique: study the scalability of a population of variables for a collection of people. The order of the different variables or objects is determined for a given group of people.

(3. Variables held constant and people and situations vary:

(a. S-technique: study the scalability of people according to some variable for a population of situations.

(b. T-technique: study the scalability of situations on a given variable for a population of people.

3. Advantages of measurement over classification: (Hempel, 1952, pp. 56-57) (see II.D.l)

a. Descriptive advantages:

(1. Descriptive flexibility and subtlety: differentiation among instances which are lumped together in a given classification. The descriptive subtlety of a given classificatory schema may be increased by the construction of narrower subclasses but the number of distinctions is limited and each subdivision requires the introduction of new terms for the various classes to be distinguished.

(2. Description of relations: the characterization of several items by means of a quantitative concept shows their relative position in the order represented by the concept.

b. Explanatory advantages:

(1. Formation of laws: greater descriptive flexibility allows for more precise formulation of general laws relating different constructs.

(2. Use of mathematics: the introduction of metrical terms makes possible the application of the concepts and theories of higher mathematics: general laws can be expressed in the form of functional relationships between different quantities. [see III.A.l.a to d. for the use of non-metrical mathematics.]

4. The definition and nature of measurement

a. The usual definition of measurement involves properties; the measurement of a property involves the assignment of numbers to represent the property. (Torgerson, p. 14).

b. The problem of what is measurement reduces to the question of what rules are used by which the numerals are assigned. If it is possible to point to a consistent set of rules then there is measurement of some form involved. (Stevens, p. 29)

(1. For unidimensional attributes the measurement problem is that of developing procedures which enable one to assign a number to each quantity of the attribute in such as way that certain relations between the numbers reflect analogous relations between the quantities. The attribute is conceived as a one-dimensional continuum where assigning numbers is analogous to specification of the position of points on a straight line. (Torgerson, p. 37)

(2. For attributes whose quantities form a multidimensional series the measurement problem is to develop procedures to assign a set of numbers to each quantity so that the numbers, when considered in terms of a specified geometrical system, reflect relations among the various quantities. The number of numbers assigned corresponds to the dimensionality of the attribute. The attribute corresponds to an n-dimensional space and the quantity to a point in that space. The process of assigning sets of numbers corresponds to locating the points in the multidimensional space, in terms of a set of relations between the points as specified by the particular geometrical model. (Torgerson, pp. 37-38)

(a. The process of assigning numbers to represent quantities of the attribute is much the same whether they are uni- or multi-dimensional attributes.

(b. The meaning of the numbers assigned to the elements of the model is specified by the model.

(c. Rules of correspondence are established, relating elements and properties of the model to observable data thus converting the formal model into a theory.

(d. If the theory is verified, numbers are assigned to the quantities of the multidimensional attribute as specified by the theory.

(e. Thus a multidimensional attribute is scaled.

c. Measurement is possible only because of the isomorphism between certain characteristics of the number system involved and the relations between various quantities (instances) of the property to be measured. (Stevens, pp. 1-2, Torgerson, pp. 14-15) The procedure is to assign numbers in such a way as to reflect the one-to-one correspondence between the characteristics of the numbers and the corresponding relations between the quantities.

5. <u>Types of scales and features of the real number series</u>. (Torgerson)

a. There are <u>three important features of he real number series</u>: (p. 15)

(1. <u>Order</u>: numbers are ordered.

(2. <u>Distance</u>: the differences between numbers are ordered.

(3. <u>Origin</u>: the series has a unique origin indicated by the number "zero". The difference between any pair of numbers containing zero as one member is the number of the other member.

b. <u>Types of scales</u>:

(1. <u>Nominal</u>: This "scale" is the most unrestricted assignment of numerals (none of the three features of the real number series are interpreted). The numerals can either identify individuals (the statistic is the number of cases) or classes where the members of a class are assigned the same numeral, (the statistics used are the mode and contingency methods). (Stevens, pp. 25-26) For Torgerson, order is invariably involved in measurement and so the nominal "scale" is excluded. The scale types are distinguished according to how much information about the property the numbers represent (the way the scales reflect the characteristics of the number series). (Torgerson, pp. 15, 22)

(2. <u>Ordinal</u> (no distance or natural origin): Numbers are assigned to the instances of the property so that the order of the numbers corresponds to the order of the magnitude of the instances. Any order preserving (monotonic) transformation will do. (Statistics: the means and standard deviations computed are in error to the extent that the successive intervals on the scale are unequal. Type O correlations interpreted only as a test for a hypothesis about order, Type I

correlation is an estimate of the product-moment correlation and assumes an underlying interval scale and bivariate normal distribution, median, percentiles). (Torgerson, pp. 16, 19; Stevens, pp. 24, 26-27)

(3. Ordinal with natural origin (no distance): the number "zero" is assigned to the zero amount (absence) of the property. Any monotonic-increasing transformation of numbers which leaves the origin unchanged may be used. (Torgerson, pp. 16,19)

(4. (Equal) interval (distance but no natural origin): the order of the numbers corresponds to the order of the magnitudes of the amounts of the property and also the size of the difference between pairs of numbers corresponds to the distance (in some sense) between the corresponding pairs of amounts of the property. Any linear transformation involving the multiplication of a positive number and the addition of a finite number can be used. (Statistics: Mean, standard deviation, product moment correlation.) (Torgerson, pp. 16, 19-20)

(5. Ratio (equal interval with natural origin): the numbers assigned to the instances correspond to the distances of the instances from the natural origin of the property. Any transformation involving the multiplication of a positive number can be used. (Statistics: geometric mean, coefficient of variation) (Stevens, pp. 24, 28; Torgerson, pp. 16, 20-21)

6. Types of measurement and measurement in social science.

a. Fundamental and derived measurement (see II.D.l.c) The different types of measurement have to do with the manner in which meaning is attributed in a particular scale to the characteristics of order. distance and origin. (Torgerson, p. 21)

(1. Derived measurement by laws: The characteristics of the real number series possess theoretical meaning directly and operational meaning only indirectly through the measurement of other variables. (Torgerson, p. 22)

(2. Derived measurement by stipulation: The indices and indicants possess only operational meaning initially. Measurement by fiat (or stipulation in less emotional terms) depends on certain presumed relationships between observations and the concept of interest. (Torgerson, p. 22)

(3. Fundamental measurement: There exist laws which relate the various quantities of the construct to each other and also there is a means by which numbers can be assigned according to natural laws to represent the property, but the means does not presuppose measurement of any

other variables. A construct measured fundamentally possesses both operational and theoretical meaning of and by itself. (Torgerson, p. 22).

b. <u>Indicants and measurement in social science</u>.

(1. The difference between an indicant and a measure involves the level of logical coherence of the theory which defines the relationship between constructs connected with data (events) and those connected with other constructs only (theoretical constructs). The operationally defined construct is an indicant (or index) when there is only a <u>presumed</u> relation (usually monotonic) between the indicant and the underlying phenomenon. At worst there may only be a positive correlation of unknown magnitude which is <u>presumed</u> to exist. The indicant has a precisely defined (operational) relation to events but its relation to other theoretically defined constructs is only presumed. An operationally defined construct is a measure when it becomes a scaled value of the phenomenon (event) itself. The distinction between indicant and measure disappears when the quantitative relation between the indicant and the event-property of interest becomes specified. The indicant can then be calibrated and used to measure the phenomenon at issue. (Stevens, pp. 47-48; Torgerson, pp. 7-8)

(2. Any particular scale may be a mixture of different kinds of measurement. In the social sciences, the order may be determined fundamentally while the intervals are stipulated.

(3. The type of measurement for a given scale may change when we move from the domain of phenomenon on which it was originally based. (see II.D.l.c. (4.)

(4. Because there is a lack in the social sciences of a previously established theoretical system which would allow meaningful introduction of new concepts by the process of derived measurement by law, one is forced to use measurement either by stipulation (fiat) or by a fundamental process, or by some combination of the two. (Torgerson, p. 23)

(5. <u>Problems in measurement by stipulation</u>: (Trogerson, pp. 23-25)

(a. This type of measurement depends heavily on the intuitions of the theorist. Logically it is similar to derived measurement by law except that the law is "in the theorist's head and in a vague condition."

(b. The procedure is as follows:

[1. One or more observable properties are selected which on apriori grounds are felt to be related to the concept of interest.

[2. A measure of the observable property itself or of a simple or weighted sum of several such observable properties is taken as the indicant of the concept of interest.

[3. The major difficulty in this type of procedure is the large number of ways in which such scales can be constructed.

[4. Since there are so many possibilities, and since the scales come so cheap, the confidence in any particular explication of this type is low.

[5. As a result the theorist rejects the explication rather than the theory when there is lack of agreement between results and theoretical prediction.

(c. Solution of the problem by fundamental measurement.

[1. When the science is in such a theoretically loose state, then the development of procedures for the fundamental measurement of important constructs is most crucial.

[2. A great deal of arbitrariness is thereby removed for concepts explicated in this way begin with a certain amount of theoretical significance.

[3. The numbers assigned to particular quantities reflect the operation of empirical laws.

[4. Fundamental measurement is an example of the process of construction and verification of theories.

[5. The particular scale type is considered to be a formal model. If the rules of interpretation are laid down which connect the model to observable data, the model becomes a theory and therefore is subject to empirical test.

c. <u>Fundamental measurement</u> (Torgerson, pp. 25-35)

<u>There are two approaches to the construction of a scale by a fundamental process</u>:

(1. <u>Direct test of the postulates of the measurement model</u>.

(a. For the <u>ordinal scale model</u> (assuming that correspondence rules have been developed relating the model to the observable data) the transitivity requirements of the relations of C and P can be tested directly (see II.D.l.b). Whether the transitivity requirements do or do not fit the data depends on the existence of natural laws. If the requirements hold then the attribute is measurable fundamentally on an ordinal scale.

(b. <u>For interval and ratio scale models</u>, the relation of "o" (combinatorial relation specifying the manner in which two quantities may be combined such that the combination is a new quantity of the same kind) is directly interpreted.

(2. <u>Test of theorems based on derivations from the postulates of the model</u>.

(a. For the <u>ordinal scale model</u> derivative test is necessary when some of the quantities cannot be directly compared with some of those remaining.

[1. When there are two subsets of elements such that any element from one subset can be directly compared with any element from the other subset but no two elements from the same subset can be compared directly with each other.

[2. Given n elements in one subset and N in the other then only nN of the (n f N) (N f n - 1) possible relations can be observed directly.

[3. However if the measurable property behaves in the manner specified by the ordinal scale model the remaining relations can be deduced.

(b. For <u>interval and ratio scale models</u> "ratios" and the relation of "distance" are measured derivatively. The conditions which must be obeyed by quantities so that a scale based on the distance relation and ratio relation can be constructed are:

[1. Establish a quasi serial order of the quantities under consideration (see II.D.l.b.)

[2. From the formal model (real number system) certain propositions concerning the properties of differences between real numbers are deduced.

[3. Certain propositions concerning the behavior of ratios of real numbers are deduced also.

[4. The differences and/or ratios are given empirical interpretation in terms of distances between quantities and/or ratios of quantities.

[5. Experimental test is made to determine whether the distances between quantities behave in the same manner as the differences between real numbers and/or whether the ratios between quantities behave in the same manner as ratios between numbers.

[6. If the test of distance is positive, numbers can be assigned to the quantities so that the order of the numbers corresponds to the order of the quantities and also the relative size of the distances between numbers assigned to the quantities.

[7. If ratios have been interpreted, numbers can be assigned with the additional restriction that the ratio of one quantity to another corresponds to the ratio of the numbers assigned to the quantities.

[8. If distance only is interpreted, then numbers can be assigned to two different quantities arbitrarily and the rest are determined. Fundamental scales based on distance and order are interval scales.

[9. If, in addition, testable hypotheses concerning ratios are verified, or if distances from a natural origin are interpreted in some other manner, then only one number can be arbitrarily assigned to one quantity and the rest are determined. The scale is a ratio scale (fundamentally derived)

7. <u>Classification of scaling methods</u> (Torgerson, pp. 41-60)

Torgerson's classification is based primarily on differences in the allocation of the variability of the responses.

a. <u>The subject-centered approach</u>.

(1. The systematic variation in reactions of the subjects to the stimuli is attributes to individual differences in the subjects.

(2. The purpose is to scale subjects who are assigned values, whereas the stimuli are considered as replications.

(3. Changing the number of stimuli from the same stimulus population at random has no effect on procedure or results other than the usual sampling fluctuations.

(4. It is necessary to control the effects of the secondary sources of variation so stimuli and responses are selected that tend to emphasize the individual differences between subjects.

(5. This approach is typically used in mental testing. Likert technique in attitude measurement is also subject centered. Subjects respond to each item on the basis of the extent to which they are willing to endorse it. The subjects only receive scores and the stimuli are selected to increase individual differences with respect to the attitude continuum.

(6. The subject approach has not led to much development of scaling methods and the applications are mostly examples of measurement by stipulation. The field of mental testing is based on this type of measurement.

b. <u>The stimulus-centered (judgment) approach</u>.

(1. The systematic variation in the responses of the subjects to the stimuli is attributed to differences in the stimuli with respect to a designated attribute.

(2. The purpose is to scale stimuli which are alone assigned scale values and subjects are considered as replications.

(3. It is necessary to control the effects of the secondary sources of variation. Therefore the task set minimizes inter-individual differences. A homogeneous group of subjects may be selected or the same subjects may be used over many trials.

(4. In attitude measurement the method of equal appearing and successive intervals is an example. The task set for the judges minimizes

variation due to their own position with respect to the attitude. Items alone receive scale values.

(5. The subject is to evaluate the stimuli with respect to some designated attribute. The subject responds to the stimulus with respect to its relation among other stimuli in a defined continuum.

(6. <u>The determination of order</u>:

(a. The definition of the class of stimuli is independent of whether or not the attribute forms a scale. The class of stimuli which possesses the attribute is defined as those stimuli which for any pair, either one precedes the other, or they coincide with respect to the attribute. Any stimulus for which this is not true is not a member of the class .

(b. The attribute is specified and the relations of C and P are different for each attribute. The rule of interpretation allows for direct empirical determination of the relation between any two stimuli in the class and also involves specification of the attribute under consideration.

[1. The relations of C and P are interpreted directly in terms of the proportion of times one stimulus is judged to have more of the attribute than another.

[2. Practical problems arise in the ordering of a stimulus series with respect to the attribute when the stimuli are very close together or when the attribute is not clearly defined.

[3. This is especially true if repeated independent judgments of each stimulus or stimulus combination cannot be made.

[4. In most situations the ordinal characteristics of the stimuli are known beforehand.

[5. In the ambiguous situations the criterion for order is based on the proportion of times any stimulus is designated as possessing more of the attribute than any other stimulus.

[6. Since there is only a single proportion for each pair of stimuli then, by definition C is Symmetric and reflexive and P is C-irreflexive and C-connected. (see II.D.l.b.)

(c. When the requirements of transitivity are not satisfied the attribute does not form an ordinal scale.

(d. Techniques used are paired comparisons, ranking, single-stimulus rating, and sorting into successive intervals. Only paired comparisons does not force transitivity on the data and consequently only it can test the hypothesis of transitivity.

(7. The unidimensional judgment methods can be differentiated on the basis of the rationale used in obtaining a unit of measurement (in the construction a scale with interval or ratio properties).

(a. <u>Quantitative-judgment methods</u>: Here the unit is obtained directly from quantitative judgments of the stimuli with respect to the attribute. The task requires more than just the ability to differentiate stimuli on the basis of their order. The subject must indicate directly relationships the distances and/or ratios between the stimuli. The quantitative-judgment methods can be subdivided according to how much more than mere knowledge of the ordinal characteristics of the stimuli is required of the subject.

[1. <u>Equisection methods</u>: This requires the least of the subject. It is assumed that the subject can equate sense distances - make ordinal judgments of sense distances.

[2. <u>Fractionation methods</u>:

[a. It is assumed that either the subject can directly report the ratio of the amounts of the attribute associated with two stimuli or can adjust or select a stimulus which bears a given ratio to a second stimulus.

[b. <u>Requirements</u>:

{1. The subject is able to perceive and report directly the ratio of two stimulus magnitudes.

{2. There is an absolute zero which remains fixed.

{3. The problem of unit used does not enter and so the task requires that much less of the subject.

[3. Subjective-estimate methods: This requires the most of the subject.

[a. It is assumed that the subject can rate, sort or arrange members of the stimulus series in such a manner that the ratios of differences between the numbers assigned to the stimuli are equal to the ratios of the distances separating the stimuli on the underlying continuum.

[b. It might be further assumed that the ratios of the numbers are equal to the ratios of the distances of the corresponding stimuli from a natural origin.

[c. <u>Requirements</u>:

{1. The subject is able to perceive directly the position of each stimulus on the underlying continuum.

{2. Although the origin and unit in which the judgments are expressed may be arbitrary for a given experiment, they must remain constant throughout the experiment.

[b. <u>Variability-judgment methods</u>: Here the variability of the judgments with respect to the stimulus or stimulus combination is used to derive a unit of measurement. The task requires that the subjects only be able to differentiate stimuli on the basis of order.

{1. <u>Achieving equality of units (intervals) by arbitrary transformation of ranked data</u>.

{a. It is assumed that the distribution of scale values of the stimulus series is normal on the underlying continuum.

{b. This is used most in situations where the stimuli are individuals or their products.

{c. Given the assumption of the normal distribution of stimuli, the only necessary operations to determine scale values with equal-interval properties are those sufficient to determine the order of the stimuli.

{d. Once the stimuli are ordered, values are assigned so that the stimuli project a normal distribution on the attribute.

{e. Any other distribution could be assumed and the assumption of normality is a convenience.

{2. <u>Achieving equality of intervals by use of the definition of the equality of just noticeable difference (jnd)</u>.

{a. Assuming this definition of equal intervals, it is possible to obtain scales with equalinterval properties for practically any attribute with respect to which subjects can differentiate stimuli.

{b. The difficulty is that there are no criteria to determine when to accept the definition. The idea of equality of jnd's is reasonable and has proved useful in certain situations.

{3. <u>Thurstone methods - the equality of intervals is an empirical matter</u>.

{a. The validity of the theoretical model is subject to statistical test.

{b. An equal-interval scale will be obtained only in those situations where the behavior of the subject can in fact be accounted for by the equations derived from the theoretical model.

c. <u>The response approach</u>.

(1. The systematic variation in the responses of the subjects to the stimuli is attributed to both variation in the subjects and the stimuli.

(2. The purpose is to scale both stimuli and subjects.

(3. The sources of variation are both used and so there is no secondary variation to be controlled.

(4. In attitude measurement the Guttman scale analysis is an example. The task is similar to the Likert technique but the attempt is to order both subjects and items with respect to the attitude continuum and both are assigned values.

(5. The subject is to respond to a stimulus on the basis of the position of the stimulus in relation to the subject's own position with respect to the attribute.

(6. <u>The determination of order</u>:

(a. There are two classes of elements - subjects and stimuli. There is no way of defining the class of elements independent of whether or not the attribute forms a scale and hence additional procedures are needed to specify the classes of elements. The data pertain to relations between elements of one subclass and those of the other subclass.

(b. The attribute is not specified and so additional factors must determine the nature of the attribute. There is no direct interpretation of the relations P and C with respect to the attribute for <u>all</u> pairs of elements in the class and hence a direct and complete test of the primitive postulates for order cannot be made. The different response methods handle the problem of order by various derivative procedures. (see III.A.6.c. (1.) (b.) 1.)

(c. When the requirements of transitivity are not satisfied by the data there are different interpretations of the reason for the failure and these can lead to different subsequent steps. Possible interpretations:

[1. Although the responses are all generated by a single property, this property cannot be represented by an ordinal scale.

[2. The property could be represented by an ordinal scale if there were a better rule of correspondence.

[3. The property could be represented by an ordinal scale if there were a better way of specifying the class of stimuli and/or subjects.

(7. The response methods can be further differentiated on the basis of two different aspects: (a). the provision for, or treatment of, error or unsystematic variance (deterministic vs probabilistic models) and (b). the nature of the task required (categorical vs comparative response.)

(a. <u>Deterministic model</u>: there is no provision for any error or unsystematic variance - all the variations in the responses of subjects to stimuli are accounted for by the positions of the subjects and those of the stimuli. Even though the formal model itself does not fit the data exactly, it may serve as an approximation and indices can be developed which indicate how good an approximation it is.

(b. <u>Probabilistic model</u>: Here variation above that provided for by the parameters of the stimuli and subjects can be accounted for in the formal model itself. Statistical tests of goodness of fit can be applied.

(c. <u>Categorical response</u>: Single stimulus, "irrelative task" ("agree-disagree", "pass-fail")

(d. <u>Comparative response</u>: Relative, choice. Two or more stimuli are compared and then ordered in some sense.

(e. There results a typology of four types of response methods:

[1. Deterministic-categorical response.

[2. Deterministic-comparative response.

[3. Probabilistic-categorical response.

[4. Probabilistic-comparative response.

8. <u>Psychophysics</u> (Stevens. pp. 30-42)

a. Psychophysics, broadly conceived, is the study of the responses of subjects to stimulating configurations.

b. The problems of psychophysics: the general problem is the definition of the stimulus - a complete definition of the stimulus for a given response involves the specification of all the transformations of the environment (both internal and external) that leave the response invariant. There are seven sub-problems:

(1. <u>Absolute thresholds</u>.

(a. The threshold is the value that divides the continuum of stimuli into two classes: those to which the subject responds and those to which he does not.

(b. The problem is to define the properties and limits of the two classes of stimuli.

(c. The solution involves the problem of invariance: for any given attribute, the combinations of stimulus values which will produce the threshold cut are determined .

(d. Ordinarily the threshold is not invariant over time and so the threshold value of a stimulus is "trapped" by statistical devices for interpolating in the gap between stimuli that are definitely below threshold and stimuli definitely above. The threshold is an arbitrary point within a range of variability.

(2. <u>Differential thresholds (jnd)</u>.

(a. The problem is to locate on the continuum of stimulus increments the point that divides the increments into two classes: those to which the subject responds and those to which he does not.

(b. Since the problem of variability over time obtains, sampling techniques and interpolation must be used again.

(3. <u>The determination of equality</u>.
The problem is to determine alternative stimulus configurations for which some attribute of a response remains invariant.

(4. <u>The determination of order</u>.

(a. This is a problem whenever there is a heterogeneous collection of stimuli having no obvious physical dimension that orders the stimuli in monotonic relation to the response.

(b. Rank ordering is used when the attribute connected with a group of stimuli is not a single-valued function of some measurable dimension of the stimuli. One determines the different stimuli which produce a set of responses that can be set in serial order.

(5. Equal intervals
The problem is to determine which stimuli produce a set of responses successively equidistant on the scale of some attribute.

(6. Equal ratios.
The problem is to determine which stimuli produce a set of responses which bear constant ratios to one another on a scale of some attribute.

(7. Stimulus rating.
The problem is to determine with what accuracy (validity) and precision (reliability) a subject can estimate the "true" value of a stimulus. This involves the utilization of a subjective impression to predict the result that would be obtained by an objective measurement (if such is available).

B. PROBABILITY AND STATISTICS IN RESEARCH.

1. Meanings of the term "probability". (Stevens, p. 45)

a. Degree of belief - what an individual is willing to wager.

b. Degree of confirmation - (see I.F.) the likelihood that an empirical statement is true.

c. Apriori probability - this is based on the "principle of indifference" which states that if there is no means of choosing among several alternatives then they are regarded as being equally probable.

d. Relative frequency - the probability of an event is the relative frequency of its occurrence in a large sample of similar events.

2. Problems in the definition of randomness.

a. The concept of randomness has meaning only in relation to the observer. If two observers look for different kinds of pattern they are bound to disagree upon the series which they call random. (Brown, p. 105)

b. The application of the theorems of the probability calculus to empirical data require randomness of the events.

c. The problem involves formulating a satisfactory formal definition of "randomness". von Mises attempted to formulate a mathematical theory of probability using a rigorous definition of the concept of randomness. The core of his theory is as follows:

(1. It is possible to speak about probabilities only in reference to a properly defined collective. (von Mises, p. 38)

(2. A collective is a mass phenomena or an unlimited sequence of observations which fulfill the following two conditions:

(a. The relative frequencies of particular attributes of single elements of the collective tend to fixed limits.

(b. These fixed limits are not affected by any place selection; that is, if the relative frequency of some particular attribute not in the original (but selected according to some fixed rule) is calculated, then it is necessary that the relative frequency so calculated should tend to the same limit as it does in the original collective. (von Mises, p. 38).

<u>Place selection</u> involves the application of a formula by which elements occupying certain positions in the original sequence are selected and retained while others are discarded. The formula must make the number of retained elements infinite and it must ignore the attributes of the elements selected. (von Mises, p. 128)

(3. Condition '(b.' is the <u>principle of randomness</u>. The randomness axiom requires that in a concrete case, when a collective is subjected to a certain place selection, the limiting values of the relative frequencies remain unaffected by this selection. (von Mises, p. 139)

(4. The probability of an attribute within the given collective is defined as the limiting value of the relative frequency of the attribute which is assumed to be independent of any place selection. (von Mises p. 38)

d. The objections to this formulation involve its use of the concepts of "limit" and "infinity".

(1. Usually, these concepts refer only to series for which there are formal rules of construction and since a random series by definition can not have such rules it has been doubted that either one can be given any meaning in this situation.

(2. Various attempts have been made to overcome this difficulty by distinguishing between different types of irregularity and by proposing conditions of irregularity whose consistency can be established. (Nagel, 1955, p. 375)

(3. Copeland and Wald have proved that "Given an arbitrary distribution and an arbitrary enumerable set of place selections, it is possible to define a collective...in which the relative frequencies of particular attributes tend to the limits prescribed by the given distribution and this is not affected by any of the place selections included in the given set". (von Mises, p. 144)

(4. By suitably relativizing the selection of subseries in von Mises' definition to certain very general classes of selections, the logical difficulties can be obviated, while at the same time the consequent restrictions upon those theorems do not seriously impair their general validity. (Nagel, 1955, p. 375)

e. <u>Primary and secondary randomness</u> (Brown, p. 49-50)

(1. <u>Primary randomness - unpredictability</u>:

(a. Within the framework of possibilities being considered, the subject cannot be sure either of the occurrence or non-occurrence of the event.

(b. The only relevant criterion is that the subject is able to guess.

(c. The concept only applies to an event which is yet to happen.

(d. It is only applicable to classes of events in so far as it is applicable to each member of the class as an individual.

(2. <u>Secondary randomness - disorderliness</u>: The concept is applicable only to series of events or observations when the series are themselves taken as units. In this sense a random series is a series with no discernible pattern.

f. Brown believes that there is a dilemma because unpredictability and disorderliness are ultimately incompatible: (Brown, pp. 56)

(1. The knowledge of the limits of disorderliness is incompatible with a guarantee of unpredictability for the person possessing this knowledge.

(2. To give practical interpretation of probability theory for scientific purposes, unpredictability of molecular events must be assumed.

(3. When this occurs the random series contains limitless possibilities of predictable repetition.

(4. When one of the possibilities in the random series begins to be realized, it is stopped. Each event in a series that is called random is supposed to be independent of the events which have gone before it. In the method of producing the series success is dependent upon a very careful watch on what has gone before, with subsequent modification of what is to come. (Brown, p. 100)

(5. The concept of randomness becomes less satisfactory (instead of more) in the consideration of longer series and in a series of infinite length the concept becomes contradictory (in an infinite series the impossible will certainly happen).

g. The ideal randomness presupposed by probability theory is not realized completely. (Nagel, 1957, p. 158)

(1. Although the elements of a sample are selected in random order, i.e., exhibit no discernible pattern of arrangement of a certain kind, it does not follow that they exhibit no pattern of arrangement of some other kind.

(2. It is self contradictory to suppose that a class of elements has no order whatsoever.

(3. The conception of an "absolutely haphazard" series of events is logically absurd.

(4. Therefore the randomness of a sample is always relative to some specified set of patterns and given time enough some determinate order of arrangement or bias is bound to be discovered in any finite class of events.

3. <u>Intrinsic use of probability</u>: Probabilistic vs deterministic theories.

a. A <u>deterministic theory</u> has only propositions, at all levels within the hierarchy of deduction, which express universal relationships. (Camilleri, p. 171)

b. A <u>probabilistic theory</u> contains at least one highest level proposition which expresses a probability relationship between some classes of the elements referred to by the theory. (Camilleri, p. 171)

(1. Probability statements can be inferred only from probability statements and so, if they appear at all in a theory, they must appear at a highest level.

(2. When probability propositions are so incorporated in a theory, they express a fundamental property of the phenomena to which they refer and to remove this type of proposition involves reconceptualization of the phenomena. The probability statement is intrinsic to the theory.

c. <u>Empirical implications of deterministic and probabilistic hypotheses</u>. (Camilleri, p. 175)

(1. Any hypothesis, when tested empirically, makes assertions about the specific situation being observed.

(2. If the hypothesis is of deterministic form it can be completely falsified but not proved true. The observation of a predicted result is only consistent with the hypothesis but is not logical proof that the hypothesis is true since the hypothesis refers to all instances of the given kind whereas only one or some of them have been observed.

(3. If the hypothesis is of probabilistic (statistical) form it can be neither formally refuted or formally proved. (Any result is formally consistent with the hypothesis and none is formally inconsistent with it).

(a. A statistical hypothesis asserts something about the proportion of an infinite collection of samples or elements that are of each possible sample type, but nothing about the order in which they will exist.

(b. All that a statistical hypothesis implies about any particular sample is that it be one of the logically possible ones. but not which one.

(c. If statistical hypotheses are to be admitted as scientific propositions, they can be made empirically responsible only by a logically arbitrary decision to regard certain empirical results as consistent and confirming and to regard other empirical results as contradictory and disconfirming.

(d. This is done even though all the empirical results are logically consistent with the hypotheses.

(e. The problem becomes one of finding some reasonable plan for determining which results shall be considered contradictory and which consistent and of justifying that plan with respect to scientific objectives.

4. Use of probability in auxiliary statistical hypotheses. (theory of measurement error, sampling and randomization)

a. Theory of observation errors. (Camilleri, p. 174)

(1. Any test of a theory requires the specification of conditions under which certain results are expected.

(2. Observation enters into the testing situation at two points: the empirical determination of the specified conditions and hypothesized results.

(3. The task of verification is complicated by the fact that the act of making observations may introduce errors into the testing setting. A hypothesis may be mistakenly rejected or accepted because of error introduced either in the empirical certification of the conditions or of the results or both.

(4. The errors of observation are as much phenomena to be explained as the events to which they are connected.

(5. The explanation of errors is done in the same manner as the explanation of other phenomena - by the formulation and verification of propositions about the errors.

(6. The theory of errors is auxiliary to the substantive theory of primary concern

b. Sampling from finite, existent populations. (Camilleri, p. 172)

(1. The mathematical theory of sampling from finite populations does not require any assumptions about the population sampled except that it remain fixed (or change predictably) during the course of the study.

(2. Given the existence of a population and access to it, samples can be drawn from it by a method that produces sampling distributions with predictable characteristics. On the basis of this, statements can be made about the population by inspecting the sample. In so doing there is the possibility of two types of error when estimating population parameters: accepting an incorrect value or rejecting a correct value.

(3. Since the sample is finite and existent it is possible to avoid sampling by making a complete inspection of the population.

(4. It is necessary to know the scientific relevance of the population and to understand how to use the information obtained by the complete inspection (if it were done) in order to see the scientific relevance of a sample from the population

(5. A statement of fact about the population is a proposition deducible from a theory, i.e., a hypothesis.

(a. The elements to which the hypothesis refers are designated by the coordinating definitions.

(b. Therefore, the finite, existent population is interpreted as a collection of instances of the kind referred to by the coordinating definitions.

(c. The characteristics of the population are therefore evidence for or against the hypothesis.

(d. Without some theoretical context and without suitably generalized coordinating definitions the hypothesis about the population has no great scientific relevance; it is merely a descriptive statement.

(6. <u>Problems in random (probability) sampling</u>.

(a. The scope of the induction provided by sampling is limited to the finite set of elements upon which the sampling procedure was employed.

(b. However, the universes to which the propositions of a theory refer are infinite and hence conceptual (see I.E.7.a.) and there is no procedure for selecting a probability sample from this infinite hypothetical universe specified by the coordinating definitions.

(c. In order to extend the scope of the sample based induction to the hypothetical universe, it is necessary to postulate explicitly the specific relation between the existent elements (from which the sample was drawn) and the hypothetical universe.

(d. The nature of the theory determines whether a probability sampling scheme is required in choosing cases to observe. This is so because the connection between the existent elements and the hypothetical universe is a matter of postulation.

[1. For a deterministic theory (see, III.B.3.a.) the primary concern is choosing cases which have appropriate values of the independent variables specified by the theory. There is no need for probability sampling because there is no need to know the proportionate representation of cases having those values.

[2. For a probabilistic theory (see III.B.3.b.) concern is with:

[a. Choosing cases which have appropriate values of the independent variables specified by the theory and;

[b. The proportionate representation o- the cases having these values. This provides sample values of the probabilities at issue.

[3. Therefore, in a probabilistic theory it is necessary to postulate a statistical relationship between the existing cases and the hypothetical universe. By virtue of this postulate, a complete inspection of the existing cases is interpreted as a probability sample of the hypothetical universe (and a probability sample of the existing cases is therefore a probability sample of the hypothetical universe but of smaller size).

(7. <u>The practical choice between probability sampling and "judgment sampling"</u>

(a. Since the usual practice in social research is not to obtain true probability samples but to use "convenience" samples (use the subjects that are available) it is better to use "judgment" sampling.

(b. Convenience samples are unsatisfactory from both the standpoint of representation of variables and the standpoint of the representation of population.

(c. Judgment sampling involves choosing cases so as to obtain the right combinations of variable values.

(d. This procedure will facilitate the replication of studies by keeping the sample size within reasonable limits and by explicitly stating the conditions that will make the studies comparable.

c. <u>The use of probability in the control of variables in research</u>.

(1. <u>The nature and logic of experiment</u>. (Francis, 1954b.)

(a. In contrast with other research methods, the experiment is characterized by a maximum of control over the various variables involved in the test of a hypothesis. The goal is to vary only the critical (theoretically relevant) variables and control (or hold constant in some sense) the other variables which are not being tested in the present experiment (pp. 101-102)

(b. The identity between the temporal sequence of knowledge and the logical sequence of the argument gives rise to the power of the experiment as a scientific test of a hypothesis.

(c. Necessary and sufficient conditions: (Francis, 1954b, p. 103)

"A" denotes the antecedent-independent-conditions.
"-A" denotes their absence.
"C" denotes the consequent-results-conditions.
"-C" denotes their absence.

[1. Necessary conditions: the consequent occurs only when the antecedent occurs (the antecedent is necessary for the occurrence of the consequent)

	A	-A
C		0
-C		

The joint outcome C and -A has no members.

[2. Sufficient conditions: while the antecedent will "produce" the consequent, other things may also.

	A	-A
C		
-C	0	

The joint outcome -C and A has no members.

[3. Necessary and sufficient conditions: the joint outcomes of both C & -A and -C & A have no members.

	A	-A
C		0
-C	0	

(d. The critical issue in experimentation is how to secure sufficient control over the relevant variables to insure the identity between the temporal sequence of knowledge and the logical sequence of the argument. (Francis, 1954b, p. 102)

(2. Control of variables.

(a. Holding constant: if the potentially interfering factors are subject to direct manipulation one may equalize the variables across treatment groups. This reduces the complexity of the design and clarifies the statement of relationships which can be made. (Francis, 1954b, p. 110)

(b. Matching for factors: if the direct manipulation of some variables is not feasible the variables may be matched either in terms of the experimental groups or in terms of individual members in the different groups (the latter is more rigorous but also more costly and time consuming). (Francis, 1954b, p. 110)

(c. Randomization: this is employed when the possibility for holding variables constant or for matching them is no longer feasible.

(3. Randomization. (Camilleri, pp. 173-174)

(a. In order to apply Mill's methods of experimental inquiry, to discover the causes of a phenomenon or to prove that a particular factor is the cause of a phenomenon, it is necessary to assume, a priori, that all possible causes are known and examinable.

(b. Fisher denies the possibility of an exhaustive enumeration of the possibly effective factors and proposes an argument, based on the act of random allocation of treatments to subjects, to account for the effects of all relevant factors which might be present in the experimental situation.

(c. According to Camilleri, it is the pattern of treatment which is randomly selected from all possible patterns of treatment, and the treatment is applied to the subjects. [Usually there is more than one treatment and they are selected on theoretical grounds. The subjects are then randomly allocated to the different treatment conditions.]

(d. The Fisherian experiment involves a particular theoretical conception which is not appropriate to all phenomena.

[1. The scope of the generalization due to the act of randomization is only to subjects and experimental conditions like those used in the original experiment.

[2. If the identifying characteristics of the subjects and the conditions are not provided then it is not known where to apply the conclusions of the experiment.

[3. The scope of the generalization can be increased by choosing subjects randomly from the existent population of subjects [what ever that means] and by choosing environmental conditions from an existent population of these . [Ditto] However, the generalization from these samples will only apply to these finite, existent populations.

[4. Predictions to situations other than the sampled existent ones must be made on other grounds and this requires the explicit specification of conditions.

[5. This amounts to the assertion of a probabilistic theory which is to be verified by the experimentation.

(e. Experiments which rely heavily (largely) on the act of randomization to control the effects of relevant variables are very vulnerable to Brown's criticisms of Psi experiments ("pure guessing experiments").

5. <u>The use of probability in induction and tests of significance</u>.

a. <u>Inductive probability</u>. (Camilleri, p. 175) (see pp. 9-10/F.)

(1. The process of verification is regarded as probabilistic because of the empirical uncertainty arising from errors of observation and sampling variation, the presence of intrinsic probabilistic hypotheses, and because no scientific hypothesis can be absolutely verified.

(2. Inductive probability is appropriate to the verification of any type of hypothesis.

(3. The probability-of-hypothesis conception is an expression of an attitude toward induction to the effect that the verification of any hypothesis is always provisional and depends upon future observation.

(4. Inductive probability also expresses the idea that hypotheses are more or less likely to be refuted in the future depending upon the degree of verification in the past.

(5. Carnap's "Continuum of inductive methods" is an attempt to encompass and quantify all possible inductive methods. (Carnap, 1952)

b. <u>The test of statistical significance</u>.

(1. <u>Appropriate uses of the tests of significance</u>.

(a. The tests for statistical significance prescribed by probability theory are valid only if the data in the samples used as a basis for inference have been in a random manner. (Nagel, 1957, pp. 155-156)

(b. The empirical invalidity of a test of statistical significance is demonstrated if either of the following conditions appear:

[1. Statistically significant deviations appear with remarkable inconsistency or;

[2. Statistically insignificant deviations appear with remarkable consistency.

(2. <u>Probability values vs replication: The case of Psi research</u>. (Brown)

(a. The scientific status of psi depends, at bottom, on probability calculations; that is, psi factors are only revealed in statistically significant deviations from mean chance expectation.

(b. The p-value of a particular outcome is doubly arbitrary: (Brown, pp. 37-38)

[1. The level of the significant p-value is an arbitrary choice, and also

[2. The p-value itself depends upon what kind of bias is being considered (see III.B.2.a.)

(c. <u>The tendency to diminution of scientific knowledge in the absence of further experimentation or confirmation</u>. (Brown, pp. 106-108)

[1. Any experimental result involving a significance test can be vitiated by the discovery of a pattern in the original standard (random) series.

[2. Initially the results have the form of validity which statistical results in general possess: each probability is assessed on the assumption that there is no relevant bias-patterns in the standard series used.

[3. With the passage of time, the data are examined more closely and eventually some kinds of patterning in the original standard series will be found which had passed unnoticed.

[4. Left to itself, the world of science slowly diminishes as each result classed as scientific has to be reclassed as anecdotal or historical. In the absence of further research, all science eventually becomes history.

[5. Consequently, it is only by experimental replication (using different standards) that scientific knowledge is kept alive.

(d. The difference between a single experiment and a series of experiments is: (Brown P. 108)

[1. A single experiment is likely to become anecdotal more quickly.

[2. The series of experiments is not exempt. To find a pattern common to all the standards so far used is only a matter of time. Once it is found the whole series, like the single experiment, becomes anecdotal.

(e. Highly significant scientific results will turn into miracles (occurrences which are very improbable, wave low p-values) only if they never (or hardly ever) happen again. (Brown, pp. 109-110)

[1. Psychical research results resemble this pattern. Here results of great significance are obtained and this significance has sometimes been built up over moderately long periods of time. But the end is always the same: the results fall off to insignificance, never to recover.

[2. In ordinary scientific endeavor an experiment which is highly significant, i.e., has a low p-value, will be expected, upon replication, to again yield as significant or possibly even more significant result if improvement in control has occurred.

[3. The trouble with psychical research results is that their repeatability never turns out to be a function of their significance. In fact the lower the significance the more likely it is to be replicated showing a similar p-value.

(f. <u>Randomizers and significance levels</u>. (Brown, pp. 111,133-4)

[1. A chance machine left running without disturbance will produce results which are as significantly biased as desired.

[2. In practice the machine is not set to work without intervention but feed-back is employed from the observer to prevent an excess of the patterns the observer i s interested in

[3. In this situation, significant patterns can build up only as long as they remain unnoticed.

[4. In psi experiments the scores are considered to be evidence for psi on the basis of their high significance level. However, results of equal or greater significance in randomized data are not so considered. It is simpler to consider both sets of results as evidence of the inapplicability of probability theory in this realm.

[5. Any valid experiment which is designed to look for a tendency which does not exist must degenerate into a pure probability experiment by its own experimental logic. This is the meaning of the null hypothesis.

[6. In an ordinary scientific experiment there is likely to be some sort of inherent bias greater than any bias in the randomizing agent against which the experimental bias (trend) is compared.

[7. If this is so, the inherent bias of the experiment will show itself in an increasingly significant and demonstrably repeatable deviation in matching scores.

(3. <u>The null-hypothesis test of significance in the scientific enterprise</u>.

(a. The theory of statistical inference, while still a probabilistic policy of induction, avoids the idea of the probability of a hypothesis and concerns itself with the probability of a correct <u>decision</u> regarding a hypothesis tested. (Camilleri, pp. 175-176)

(b. The rationale of the test of significance. (Camilleri, p. 176)

[1. If a rule is adopted to accept (or reject) a statistical hypothesis whenever certain of the logically possible results occur, and

[2. If the hypothesis is tested over and over again indefinitely and is evaluated each time by this rule, then

[3. The correct decision should be made in a predictable proportion of the tests, provided the hypothesis i s in fact true.

(c. <u>Criticism of the test of significance</u>.

[1. The probability of error is a hypothetical construct referring to a hypothetical population of tests.

[a. The empirical interpretation given to this idea is that any desired level of accuracy in deciding the truth of a hypothesis can be obtained by testing the hypothesis over and over again indefinitely.

[b. This amounts to a commitment to test the same hypothesis forever, regardless of the previous outcomes.

[c. The decision to reject (or not) a hypothesis has no consequence for future behavior with regard to the hypothesis.

[d. This is absurd and not in fact what scientists do.

[2. The primary aim of a scientific experiment is not to precipitate decisions, but to make an appropriate adjustment in the degree to which one believes the hypothesis or hypotheses being tested. (Rozeboom, p. 420) Acceptance or rejection of a hypothesis is a cognitive process (a degree of belief) which, if rational, is not a matter of choice but is determined by how likely it is that the hypothesis is true given the evidence. (Rozeboom, p. 423)

[3. While the scientist as a person must make decisions, science is a systematized body of (probable) knowledge, not an accumulation of decisions. The end product of a scientific investigation is a degree of confidence in some set of propositions, which constitutes a basis for decisions. (Rozeboom, p. 423)

[4. The null-hypothesis significance test ignores completely the utilities of the various decision outcomes (i.e., accepting a true hypothesis, accepting a false hypothesis, rejecting a true hypothesis, rejecting a false hypothesis). Therefore the test procedure is not even adequate as a decision procedure. One must know both the probability of the hypothesis under the data available and the utilities of the decision outcomes. (Rozeboom, p. 423)

[5. The test unrealistically limits the significance of an experimental outcome to two alternatives: confirmation or disconfirmation of the null-hypothesis.

[a. The transition from confirmation to disconfirmation as a function of the data is discontinuous (an arbitrarily small difference in the value of the test statistic can change its significance). (Rozeboom, p. 423)

[b. The point at which the transition occurs is entirely arbitrary and is not a logical consequence of the theory of statistical inference. (Camilleri, p. 176)

[6. The test method necessitates one hypothesis being favored over all the others even though they may be equally reasonable. In the classical theory of inverse probability all hypotheses are treated on par, each receiving a weight which reflects the credibility of that hypothesis on grounds other than the data being assessed.

(d. <u>The way out</u>.

[1. For Camilleri, it lies in theory building or applying the criterion of systematic import to the research results. (see II.A.7.)

[2. For Rozeboom, it lies in the more sophisticated use of inductive probability. The scientist is fundamentally and inescapably committed to an explicit concern with the problem of inverse probability. What he wants to know is how plausible his hypotheses are and he is interested in the probability ascribed by a hypothesis to an observed outcome only to the extent he is able to reason backwards to the likelihood of the hypothesis, given this outcome. (Rozeboom, p. 422)

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