Egon Brunswik's research perspectives in relationship to educational knowledge development : historical and metamethodological considerations.

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EGON BRUNSWIK'S RESEARCH PERSPECTIVES IN RELATIONSHIP TO EDUCATIONAL KNOWLEDGE DEVELOPMENT: HISTORICAL AND METAMETHODOLOGICAL CONSIDERATIONS

A Dissertation Presented

by

CANDIDO GENOVART-ROSELLO

Submitted to the Graduate School of the University of Massachusetts in partial fulfillment of the requirements for the degree of DOCTOR OF EDUCATION

September 1975

Major Subject: Educational Psychology
EGON BRUNSWIK'S RESEARCH PERSPECTIVES IN RELATIONSHIP TO EDUCATIONAL KNOWLEDGE DEVELOPMENT: HISTORICAL AND METAMETHODOLOGICAL CONSIDERATIONS

A Dissertation

By

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September 1975
This Dissertation has been possible, thanks to:

Dr. David G. Coffing

Dr. Pedro Alcantara Martinez

The Ford Foundation

My wife
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Psychology as well as education has generally been dealing until now with human beings in a one at a time relationship between individuals and their environment. Many contemporary schools have acknowledged the lack of representativeness this relationship explores. But only a few scientists have tried to change the pattern. One of them was Egon Brunswik (1905–1955) who introduced some new concepts in the Behavioral Sciences. Brunswik's activities were in the fields of ecology, history of science, perception and psychological design.

The major purpose of this study was to analyze Brunswik's new methodological and theoretical approaches to the relationship between the organism and the environment. Three different levels of analysis have been
involved: (1) a comparative level in which the Brunswik approach is compared with other systems; (2) an adaptive level in which the Brunswik approach is translated into present language terms for the sake of a better modern appreciation; and (3) an evaluative level in which the Brunswik approach is weighted in terms of its implication for Philosophy of Science, psychological design and today's problems in education.

The study was organized as follows: (1) an Introductory Chapter that describes the main features of the study approach; (2) a Chapter that describes Brunswik's background and some of his biographical data; (3) a Chapter that considers three leading Brunswik concepts (a) a conceptual framework that is conceived to handle the complexity of behavior without reduction of methodological rigor; (b) the conceptual development of functionalism as a means of studying the dynamic unity of mental phenomena related to the adaption of the organism to its environment; and (c) a comparative analysis of psychological systems. These three leading points are developed within the rubric of the "regional reference;" (4) a Chapter that describes the study of the environment within the framework of probabilistic functionalism which stresses the so-called vicarious functioning in behavioral achievement; (5) a Chapter that studies the nature of the organism and the lens model in which are expressed some of the most important Brunswikian features such as ecological validity, the utilization of cues, and functional validity; (6) a chapter that analyzes Brunswik's main methodological issue, the comparative
value of systematic design versus representative design which followed from Brunswik's concern for the universe of situations in the natural habitat that would need to be considered in order that any study be representative of the probabilistic nature of environmental circumstances of any organism of interest. The last Chapter that evaluates the educational relevance of Brunswik's principles in terms of the basic needs in modern educational research: (a) the lack in education of established relationships with other behavioral sciences, and (b) the need in such fields as teaching, learning, thinking, etc., for a new conception of the metatheoretical analysis, i.e., a metatheory concerned with the development, investigation or description of theory itself.

A critical description of the psychological and educational terms used in this Dissertation is included as Appendix.
CHAPTER I

INTRODUCTION

Statement of the Problem

Psychology as well as education has had a history of dealing with human beings in a restricted way, i.e., in a one at a time relationship between individuals and their environment. All contemporary schools have dealt more or less with the problem of how representative was this relationship. But a few scientists have tried to change the pattern in an intelligent and imaginative manner. One of them was Egon Brunswik (1905-1955) who introduced some new concepts in the Behavioral Sciences. Nevertheless, Brunswik has been poorly understood though it can be argued that his relevant studies in ecology, history of science, perception as well as in the field of experimental design deserve a better knowledge and utilization. It is also important to evaluate whether Brunswik's conceptualizations and methods are suitable for application in the field of Educational Psychology.

Purpose of the study

The work with Brunswik is projected to be on three different levels:
1. **Comparative Analysis Level.** This level makes a comprehensive summarization and analysis of the works and historical background of the Brunswik approach itself as well as its relationship with other related systems.

2. **Adaptive Level.** This level translates into present language Brunswik's terms and concepts as well as ideology. In other words, it is desired to make accessible to current practitioners the main points involved in Brunswik's thought. To help to do this, a vocabulary of psychological and educational terms thought necessary for understanding the contents of the study is presented.

3. **Evaluative Level.** This level makes an analysis of the value and richness of the Brunswik system at least in terms of:
   a. its implications in Philosophy of Science
   b. its implication in psychological design
   c. its potential application into the day to day problems in education.

**Organization of the study**

For fulfilling the described project the work has been organized into

**Chapter I:** Introduction

**Chapter II:** Description of Brunswik's background and some Biographical data.
Chapter III: Considerations and main points implied in Brunswik's probabilistic functionalism.

These include:

a. The study of the following three leading attitudes in Brunswik's system:

1. Brunswik was looking for a conceptual framework which could handle the full complexity of behavior without sacrifice of methodological rigor.

2. Brunswik was convinced that the conceptual developments in psychology showed a gradual and inevitable convergence towards functionalism (the philosophical and psychological doctrine that considers—since William James—mental phenomena in their dynamic unity as a system of functions directed to adapting the organism to its environment).

3. Brunswik thought that such a functionalism is better understood within a comparative analysis of psychological systems.

b. The study of the Psychological systems in terms of the so-called "Regional Reference" in which are also analyzed the following organism-environment relationships:
1. An organism and its surroundings provides the conditions and supports for the organism behavior-causal texture.

2. The environment is divided in "regions." The "regions" can be referred to as either physical features and events which are considered as antecedent conditions in the analysis of behavior or the regions can be considered to represent reactions of the organism and their effects on the environment.

3. The psychological analysis may focus on events located at a "central," "proximal" and "distal" distance from the organism.

c. The study of the Historical Reference:

Brunswik was particularly interested in the argument that the historical development of psychological systems is characterized by an increasing degree of the so-called "distal reference." Brunswik points out that classical psychophysics were concerned with the relationship between proximal stimulation and perceived sensation, the inferred response in the central state of the organism. In the same way introspective analysis of central states was based on the assumption that there exists a strict one-to-one relationship between verbal statements and inner central or peripheral proximal events.
And in a similar way he suggested that the "gestalt" approach distorted this relationship (the central state was treated as a response to the total sensory configuration) as did classical behaviorism that continued to define the stimulus in proximal terms.

For Brunswik, the "distal" reference emerges from two connected studies. On the one side, the studies on perceptual-constancy shows that the organism can maintain a stable perceptual environment in spite of variations in proximal mediation. On the other side, the study of "molar" behaviorism represented mainly by Tolman's work in which the representative features are:

1. A description of behavior not in molecular but in molar terms.
2. All behavior is seen as purposive.
3. The individual learns not sequences of movements but expectation sets.
4. Reinforcement is replaced by the principle of confirmation.

Chapter IV: The study of the environment in the framework of the probabilistic functionalism.

This involves:

1. The parallel analysis of perceptual and behavioral achievement within a unitary conceptual framework.
2. The assessment of the organism's achievements in adjusting to an environment which remains to an important degree unpredictable.
3. An important emphasis on the so-called "vicarious functioning"—the mediation of perceptual and behavioral achievements by multiple and interchangeable processes.

Chapter V: The study of the nature of the organism and of the lens model.

Assessed are:

1. The ecological validity. The presence of a given distal property doesn't imply a specific, predictable pattern of proximal effects. Thus it is not possible with certainty to infer the nature of the distal variable from a specific pattern of proximal stimulation. What defines the ecological validity is the degree of association between a proximal cue and a distal property of the proximal cue with respect to that property.

2. The utilization of cues. Confronted with cues of limited validity the organism is forced to adopt a "probabilistic strategy." To determine this it must make an independent determination of the ecological validity of different proximal cues and insure the real value given to these cues by the organism.
3. **Functional validity.** The relationship between distal variable and perceptual response measures the degree of the organism's perceptual achievement. Thus the degree of attainment can be determined if the stimulus measurement can be correlated with the perceptual responses. This correlation measures the functional validity of the perceptual response.

Chapter VI: Dedicated to the study and analysis of the Brunswik's main methodological issue, namely, the comparative values of the systematic design versus the representative design. Since Brunswik wanted to show the universe of situations, that is, the natural cultural habitat of the organism (Ecology), he needed a sort of design that would cover two different points:

1. It could reflect accurately the probabilistic nature of environmental circumstances.

2. It could exhibit the full measure of the organism ability to cope with environmental contingencies. The classical systematic design manipulates and changes stimulation patterns. The representative design recognizes the probabilistic nature of environment and behavioral laws and attempts to sample reaction to the stimulus pattern across the range of normally expected environmental settings.
Educational Relevance

Chapter VII: Presents some basic generalizations useful in metatheoretical and educational purposes. Some of these generalizations are:

1. Psychological analysis must focus on the organism's achievements in adjusting to its environment.

2. The environmental regularities to which the organism can adjust are probabilistic rather than certain.

3. Perceptual discrimination may be regarded as response patterns of probabilistic cues; it can be argued that in Brunswik's system are implicit some direct points that are directly related with the unity of science as well as with the philosophy of science and that these need some logical order explanation. It can also be argued that in Brunswik's system are valuable frames of reference applicable to educational systems.

This study will attempt to establish that:

1. In education there is a lack of established relationships with other behavioral sciences (Anthropology, Psychology, Biology, etc.);

2. in contemporary educational systems very few useful theories have been developed;
3. that educational research, mostly in new fields, i.e.,
teaching, learning, thinking, etc., should be based on a
new conception of metatheoretical analysis—a metatheory
is a theory concerned with the development, investigation
or description of theory itself—reflecting Brunswikian
consideration.

By revisiting Brunswik’s work (there is only one book on Brunswik’s
system presently available) it is felt that these premises can be examined,
explained and supported and some new approaches to the theoretical basis of
the behavioral sciences can be made.
CHAPTER II
SOME BIOGRAPHICAL DATA ON Egon Brunswik

Egon Brunswik was born in Budapest in 1903. His father was Hungarian and his mother Austrian. His childhood languages were Hungarian and German; thus he was brought up in a bilingual atmosphere.

When he was eight, he was sent to Vienna to be educated at the Theresianische Akademie Empire's Gymnasium. There he received instruction in Science, Classical Literature, Mathematics and History.

After returning from Sweden, where he was sent with his sister to recover from the First World War years, he took courses again at the Theresianische Akademie and finally graduated in 1921.

From 1921 to 1923 he received training at the Vienna Technische Hochschule to become an engineer, passing the state examination at the end of that time.

In 1923, Brunswik made the important decision to study Psychology and entered the University of Vienna. Here he worked under Karl Buhler's¹

¹Karl Buhler was born in Meckesheim (Baden) in 1879, and died in Pasadena (California) in 1963. He worked with Kulpe. He worked as a Professor at Wurzburg, Bonn, Munich, Dresden and Vienna. In 1934, he settled in Los Angeles. Primary fields: Child Psychology, Thought and
direction and was influenced by the "Vienna Circle" of Logical Positivism. Two of his classmates were Paul F. Lazarsfield and the future Nobel Prize-winner Konrad Lorenz.

In 1926 he earned the necessary degree to qualify as a Gymnasium teacher in Mathematics and Physics.

In 1927 Brunswik received his Ph. D. and became Karl Buhler's Assistant at the Psychologische Institut.

The following years were rich in teaching experiences. He worked one year at the Real Gymnasium, several years at Vienna's Pedagogical Institute, and the Vienna Volkshochschule, and from 1931 to 1932 was a Language. Mostly concerned with the non-sensorial nature of language and with the multiplicity of methods that were crowding Psychology. Buhler stressed the necessity for some kind of agreement between the methodology of the natural sciences and the more phenomenological methodology of psychology. Major works: Die Geistige Entwicklung des Kindes, 1929; Die Krise der Psychologie, 1927; Ausdruckstheorie, 1933; Sprachtheorie, 1934.

2 The "Vienna Circle" or "Vienna School" was the Neopositivist and Operationalist group of thinkers led by K. P. Moritz and M. Schlick which maintained that Philosophy had no specific content. Hence by means of Mathematical Logic, Philosophy helped to classify conceptual contradictions in the empirical and experimental sciences and improve their propositional systems. Some of Schlick's followers were R. Carnap, K. Popper, P. Frank, H. Reichenbach and V. Kraft.

See "eclecticism," "empiricism," "operationalism," "physicalism," "proposition" and "reductionism" at Appendix A.
visiting lecturer at Ankara's School of Education in Turkey. Here he managed to establish the first recognized laboratory of Psychology in that country. Back in Vienna in 1934, he was designated "Private-dozent" of the University of Vienna.

In 1935 Brunswik made his first important American contacts. During the 1935-1936 period, he received a Rockefeller Fellowship which he used to do research in Psychology at the University of California, Berkeley. In 1937, aware of the increasing political difficulties in Europe, he returned to Berkeley as Assistant Professor and there he settled permanently.

In 1938 he married Else Frenkel, who had also been familiar with Buhler's Institut in Vienna. Egon and Else Brunswik became American citizens in 1943.

In 1942, suffering from hypertension, Brunswik underwent a sympathectomy, which reduced his blood pressure. However from then on, his health remained delicate and he was forced periodically to limit his social and professional contacts, though his work continued to be as creative as it had always been until his untimely death in 1955.

3 University lecturer in Germany. An appointive rank obtained by a medical or professional student after having served as "Arzliche Approbation." After serving successfully as "Private-dozent," he may, upon recommendation of the faculty, receive the title of a professor.
CHAPTER III

SOME CONSIDERATIONS IMPLIED IN BRUNSWIK'S PROBABILISTIC FUNCTIONALISM

Integration and independence in Scientific Psychology

Brunswik's systematic approach is oriented toward the integration of two basic positions, namely a Methodological physicalism (Morris, 1937; Jorgensen, 1951) and a theoretical functionalism (Allport, 1955; Feigl, 1955; Hilgard, 1955; Prentice, 1956). Favoring both attitudes implies that:

(a) psychological methods are regarded as similar to those used in the development of other sciences. A community of objective methods of observation and measurement form the basic foundation of the so-called unity of science\(^1\) (Carnap, 1938; Neurath, 1938; Hempel, 1952, 1956; Allport, 1955; Wolman, 1970). However, it further implies that

(b) psychology also intends to remain free enough to develop its own body of necessary analytical instruments\(^2\) and theoretical considera-

\(^1\) See also the term "science" in Appendix A.

\(^2\) We regard analysis here as a method of studying phenomena by breaking up the object of study into smaller units, either by physical separation or by thinking separately about the distinguishable parts or qualities of the object. One view of analysis as research into elementary components or as a means of reducing them to simple S – R elements is explained later on in this paper.
Flexibility of behavior processes

The organism's achievement in adjusting to the environment (Brunswik, 1943; Feigl, 1955; Postman, 1955) is the main concern of psychological functionalistic theory. Consequently the success of behavior is sustained by the stability and flexibility of the processes that behavior involves. Some of these processes are in the field of perception, thinking and learning.

Brunswik stresses the value of treating them in a broad ideographic analysis (Windelband, 1894; Allport, 1937; Postman, 1955) and thus eliminating any reductionistic tentation (Nagel, 1935; 1949; Thompson and Braithwaite, 1952; Krech, 1955; Kemeny and Oppenheim, 1956).

Perceptual discrimination and vicarious functioning

Perceptual discrimination (Brunswik, 1937, 1944, 1951, 1956; Allport, 1955) is considered as a response to examples of probabilistic cues. These cues are accumulated and combined by the organism to achieve a correct discrimination, and at the same time are used interchangeably; thus different

3 We understand theory as a general principle, supported by considerable data, proposed as an explanation of a group of phenomena; theory is also a statement of the relations believed to prevail in a comprehensive body of facts. Theories are more solidly supported by evidence than are hypotheses; they are less firmly established than law; and they generally cover a wider range than a single law, which is usually limited to a single kind of relationship. See also "theory" in Appendix A.
examples of cues can lead to the same effects. Similar correspondence occurs when different motor responses result in equivalent behavioral achievement. This property is called vicarious functioning (Feigl, 1955; Hammond, 1955) and is representative of the semierratic character of the environment to which behavior adjusts.  

Psychological prediction

Psychological prediction (Reichenbach, 1938; Mehl, 1954; Beach, 1967) admits the semierratic nature of the environment. Since the organism reacts to events in a probable way, the predictions of behavioral achievement are necessarily probabilistic rather than certain (Brunswik, 1939, 1943, 1951, 1955a, 1955b). This demonstrates that the understanding of empirical examination and discovery comes from the functionalistic emphasis on achievement and the adjustative qualities of behavior.  

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4The concept of vicarious functioning calls for a more detailed explanation. Vicarious functioning can be understood as the substitution of one psychological process for another. One sensory process $S'$ may be substituted for another. $S''$ - equipotentiality--and one response $R_1$ for another $R_2$--equifinality--, so that, in learning, for example, the stimulus situations may differ from that of the practice period, and the response likewise, yet a new relationship can be demonstrated between $S''$ and $R_2$. It has to be distinguished from generalization, either of stimulus or response, in which the stimuli $S'$ and $S''$ and $R_1$ and $R_2$ must belong to the same family and be very similar. In vicarious functioning there need be equivalence only, with no similarity at all.

5Given the multiplicity of meanings of psychological prediction theory some classification is needed. See the term "prediction" in Appendix A.
Perception and reasoning as representative of Brunswik's thought

When Brunswik refers to the utilization of cues, he points out that the organism relies on a process similar to statistical reasoning. In Brunswik's conception of statistical reasoning there is a process akin to Hermann von Helmholtz's (1821-1894) theory of unconscious inference (Helmholtz, 1856; Gruber, 1956; Warren, 1968). Helmholtz believed that perception is a two-stage process. The bases of perception are manifested in the sensations, whose quality and intensity are inborn, and which are conditioned by specific characteristics of the sense organs. Sensations themselves, however, have no significance for space and object perception; they are merely signs that acquire significance only in the course of development by association through

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6 Statistical Psychology is a mathematical-model psychology that has to be distinguished from the use of statistics in designing a conclusion from empirical data. Statistical Psychology is preferred as a systematic attempt to substitute a mathematical model for traditional constructs.

7 As additional information on the study of perception the following paragraph may be important: "... perception has not until recently been a markedly American subject of investigation. ... only after World War II psychologists began to see some functional implications in the study of perception. They began to see how perception is in many cases imbedded in and formed by the activities and purposes and needs of the perceiver. They saw the possibility of throwing light on motivational and personal variables through the study of perception; they even saw perception as a kind of paradigm of all complex behavior" (Prentice, 1956, p. 37).
experience. The acquisition of meaning consists, in Helmholtz's opinion, of judgment processes that may be conscious to begin with but that become automatic, after repeated association, as unconscious inferences which, because of their compulsive character, appear as evident perceptions. Helmholtz thus adopted a distinctly empirical position in the empirism vs. nativism argument in perception theory. However, between Helmholtz and Brunswik's positions there are some comparisons that have to be made in the context of this thesis. The first is Brunswik's assertion that the analysis of perception can be made without any reference to the question of conscious experience. The second is that perceptual inferences—as Helmholtz points out—are not rational but independent of any intellectual influence. And finally, the only possible agreement between both authors is that reasoning and perception lead to a similar goal: the acquisition of knowledge. In Brunswik's words (Brunswik, 1954) the formal characteristic of reasoning furnishes a model—the ratiomorphic model—to which the processes and achievements of perception and thinking can be referred.

Nomothetic—universal laws vs. ideographic—probabilistic laws

Psychological scientific generalizations are necessarily probabilistic because those traits of the ecological environment that can be sensed by the organism are broadly unpredictable (Brunswik, 1943; Allport, 1955; Hilgard, 1962).

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8 For a broader discussion of ecology see Appendix A.
1955; Postman, 1955; Wolman, 1970). On the one hand, universal laws⁹ are the consequence of physical measurements of the environment; on the other hand, the organism cannot control environmental conditions and so enforce these same laws. This does not represent a failure of the law itself, only an acknowledgement of the fact that a wide range of events are not described by universal laws. Hence, physical laws and ecological correlations have a complementary relationship rather than being in opposition.¹⁰ So, while physical laws refer to relationships that have been perceived once

---

⁹A law is a verbal statement supported by such ample evidence as not to be open to doubt unless much further evidence is obtained of the way events of a certain nature consistently and uniformly occur. Note that a natural law is not conceived as controlling events: it simply describes them. Some authors use the term "law" where "generalization" or "principle" would be more appropriate.

¹⁰Though on page the relationship between "environment" and "ecology" is described in the context of Brunswik's work, it is valuable to mention here that "within the realm of facts existing at a given time one can distinguish three areas in which changes are or might be of interest to psychology: 1. The 'life space'; i.e., the person and the psychological environment as it exists for him. We usually have this field in mind if we refer to needs, motivation, mood, goals, anxiety, ideals. 2. A multitude of processes in the physical or social world that do not affect the life space of the individual at that time. 3. A 'boundary zone' of the life space: certain parts of the physical or social world do affect the state of the life space at that time. The process of perception, for instance, is intimately linked with this boundary zone because what is perceived is partly determined by the physical 'stimuli'; i.e., that part of the physical world which affects the sensory organs at that time. Another process located in the boundary zone is the 'execution of an action' (Lewin, 1941, p. 306).
irrelevant conditions have been eliminated, ecological correlations refer to all those relations that exist in the normal conditions of the organism habitat. One clear example of this sort of correlation is shown in Figure 1.

The reductionist position and the mediational mechanism

There is a final problem that has to be treated in relation to Brunswik's theoretical and methodological conceptualizations, namely the so-called mediational mechanism. The traditional theory—usually described in S-R terms expresses the idea that certain stimuli, also called signs in this theory, do not directly initiate instrumental behavior but activate an intervening process that is connected in a complex systematic way with many action systems. Mediational analysis, though, refers to specific chains of events leading from stimulus to response. To some extent, mediational positions

11 Habitat refers to the entire geographical environment of an organism at a certain stage of its development. The habitat consists of inanimate and animate environmental factors. Environment is a collective term for all the influences impinging on an organism. For a more accurate explanation of the term see Appendix A.

12 The nature of the mediating processes have an important part in Feigl's comments (Feigl, 1955, p. 232).
### Table: Relationship between Ecological Validities and Physical Laws

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<th>Ecological validities</th>
<th>Partial correlations</th>
<th>Law of physical optics</th>
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<td>B x P</td>
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<tr>
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<td>.77</td>
<td>P</td>
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</tr>
<tr>
<td>D x P</td>
<td>.08</td>
<td>B</td>
<td>-1.00</td>
</tr>
</tbody>
</table>

Fig. 1. Relationship between ecological validities and physical laws (Brunswik, 1955, p. 209).
can be considered as reductionistic (Krech, 1955). Brunswik's point of view in this question (Tolman and Brunswik, 1935) is rather eclectic. First, because distal achievement---a key problem in Brunswik's perceptual development---can be mediated in many different ways and, second, because Brunswik himself is not opposed to the fact of mediational processes. He stresses mainly an order of preference in the action of behavioral patterns. If we know accurately the nature of the organism's achievement and the varieties of the proximal patterns that make the achievement possible, we can look for reductionistic explanations that will not be a challenge to a functional analysis of behavior but rather its normal compliment.

The analysis of behavior by means of the regional reference

The center of Brunswik's system is evidenced by the classification of those variables that are the bases of the functionalist analysis of behavior (Brunswik, 1955; Allport, 1955). Such a classification of variables rests on the concept of the regional reference, clearly exposed by Brunswik, which constitutes a fundamental step in his work (Brunswik, 1939). Figure 2 presents:

13 As one example of distal–proximal concepts: the upper arm is in the proximal position, the lower arm is in the distal position relative to the shoulder which is in the central position. See a detailed explanation in Appendix A.
ENVIRONMENT (Causal texture)

Remote past of organism

Manipulable physical bodies (DISTAL STIMULI)

(PROXIMAL STIMULI)

Intraorganismic events and dispositions

CENTRAL

Proximal reactions (MOLECULAR BEHAVIOR)

Distal effects of reactions (MOLAR BEHAVIORAL ACHIEVEMENTS)

Far-reaching successes, products of life activities

ENVIRONMENT (Causal texture)

Fig. 2. The regional reference (Brunswik, 1939, p. 42)
(a) the regional reference defined as the degree of remoteness from the organism depicted by a given variable;

(b) the antecedent circumstances of behavior that are shown in terms of distal and proximal variables;

(c) those distal variables that are events in the environment while proximal variables are events at the limits of the organism;

(d) those events which, happening within the organism, are ordered as central variables.

Examples of distal variables are the measured physical objects with which the organism is not in near contact; examples of proximal variables could be the retinal images produced by distal stimulus.\(^{14}\)

The observable effects of the antecedent circumstances of behavior are again classified into distal and proximal variables. The change in position of a manipulated object steps up the distal effect while the distinctive movements of the organism illustrate the proximal effects.

Hence in terms of variables:

(a) the distal and the proximal stimuli are the systematic independent variables;

\(^{14}\)The regional reference "in action" is shown in Figure 3.
ECOLOGICAL ENVIRONMENT

* DISTAL (Flying ball)

* PROXIMAL (Image approaching ball) RECEPTOR'S SURFACE

* CENTRAL (Perceiving approaching ball)

** Subject raising hands (MOLECULAR)

** Subject catching the ball (MOLAR)

ECOLOGICAL ENVIRONMENT

Fig. 3. The regional reference "in action"
(b) the proximal effector responses and distal environmental effects are the systematic dependent variables, and

(c) central events are considered as intervening variables.

Brunswik has not pointed out a special relationship among central events and dependent and independent variables. These functions are explained in Figure 4 under the name of "process details." The example of perceptual judgement as a central event can be qualitatively conceptualized as expressing the use of cues by the organism.

The functionalist analysis especially stresses the meaning of the relationships among dependent and independent variables on the basis of:

(a) the degree of association between Distal and proximal stimuli-variables defining the ecological validity of cues;

(b) the degree of association between proximal movements and distal effects, pointing out the amount of uncertainty related to the acquisition of goals by means of specific classes of operations.

**Regional reference and historical development**

Once the meaning and distribution of all those variables are known, it is possible, following Brunswik's conceptualization (Brunswik, 1930, 1952, 1959, 1963; Heider, 1939), to describe those regions whose inner relations come under the study of scientific psychology during a period of time, and to classify trends and goals in these relationships. Brunswik looks at the historical development of psychology basically with respect to Psychophysics,
Fig. 4. The lens model (Brunswick, 1952)
Gestalt psychology and his own functionalism (Brunswick, 1952; see also Figure 5).

Psychophysics

The psychology of sensations developed at the very beginning of experimental psychology. Its essential relation with the micromediational physiologism (Hammond, 1966) was a decided advantage in the development of scientific research. The basic foundation of this investigation was proximal stimulation, peripheral physiological excitation and neural transmission. Hence the "declared core of the classical approach in psychology is structurally to analyze... the basic elements of consciousness" (Brunswik, 1952, p. 52); a place has to be found for consciousness. In Brunswik's words, again, psychophysics is

Concerned with a functional relation which, although short-arc and thus elementaristic by comparison with later types of research, establishes the principle of studying a gross stimulus-response relationship, while problems of sensory and nervous technology are moved to a secondary position. One of the terms of the relationship, here the response, is conceived of as conscious content, i.e., sensation; verbal or other expressive behavior is interpreted as a tool of introspection. The programmatic outlook of psychophysics is thus physicalistic with respect to the stimulus, while it remains mentalistic concerning to response; in short, it proposes to be S-objective, R-subjective (Brunswik, 1952, pp. 52-53).^{15}

^{15}See Figure 5.
Fig. 5. Major stages of introspective and objective psychology (Brunswik, 1952).
For Brunswik, psychology is narrowly confined because this type of approach concentrates on relations with the proximal stimulus impact, and doesn't reach the biologically most relevant layer (Brunswik, 1952, p. 57). This layer or region is that of manipulable and social objects. Brunswik's view is that psychology in this situation only shares an insignificant form of functionalism.

Gestalt

In Brunswik's opinion, Gestalt psychology expands the limited proximal-peripheral focus defended by Psychophysics. However, the step forward taken by this group was not enough to constitute a compromise between Gestalt and the objects in the environment. It seems that there is an inconsistency inside the Gestalt position in relationship to the distal determination of perception. As previously noted, Gestalt's "original program was to make meaning dynamically real and to give a solution to the problem of the correlation of the organism to the object world. . . in the psychology of perception the environmental distal determination is disregarded," (Heider, 1939, p. 167).

Functionalism

While Gestalt psychology refuses to treat objects, Functionalism appears as a supporter of the contrary position. Coming from the evolutionary theory position functionalism has always concerned itself with the environment and the organism, which, translated into Brunswikian terms, means treating
of distal events, objects and persons. Psychology had to expand its framework to include distal and central regions as well as objects. To achieve this, Brunswik urged some important steps (Brunswik, 1952):

(a) distal variables—including objects and persons—must be employed in psychology;

(b) central states—motivation, attitudes, personal characteristics—goal achievement—should be observed;

(d) wide-arched dependencies must be considered the basic source of problems for psychology and the dependencies of distal causes and distal effects.

The use of variables and perceptual constancies

Brunswik's system has its conceptual foundations in the analysis of the perceptual constancy (Brunswik, 1944, 1956; Allport, 1955; Hilgard, 1955). The perceptual constancy shows:

First, how the organism discriminates and copes with distal events;

Second, the probable rather than unequivocal connection between distal and proximal events; and

Third, the equivalence of a broad and variate assembly of proximal stimuli in mediating a constant perceptual achievement. Thus, achievement, probabilistic laws and vicarious functioning that are the prominent traits of Brunswik's system are inferred directly from the study of the perceptual constancies.
The handling of the constancy experiment requires the choice of empirical variables in much of Brunswik's investigation. Thus, (a) on the independent side, physical measurements of size, weight, brightness, etc., are used to measure the distal variables; (b) the traditional family of sensory cues represents the proximal variables and (c) the dependent variables are in general the conventional responses of the psychophysical experiment that occur in matching and in verbal reports. As has been repeatedly pointed out, Brunswik did not assume a one-to-one correlation between verbal expressions and experience. The dependent variables, like the independent ones, are in the last analysis changeable into operations of physical measurement, so the study of perceptual achievement can be carried out without any reference at all to conscious experience.

**Functional relationships and correlational measurements**

The probabilistic condition of psychological laws is expressed in the statement of functional relationships (Postman and Tolman, 1959). Relationships between distal and proximal variables are expressed almost exclusively in terms of the correlation coefficient. The correlation coefficient is also used as an index of perception achievement, e.g., the correspondence between the measured physical properties of an object and perceptual estimates. Higher orders of correlational analysis, e.g., multiple and partial correlations, can be used to measure more complex sorts of functional relational relationships.
It must be noted that correlations are used to reflect the relationships among independent and dependent variables and do not measure the association between the responses of individuals. In the functionalist's use of the correlation coefficient, objects and individuals have changed places: it is the tests that are varied and the individuals that are held constant. Functional relations can be determined on the basis of data obtained from one subject in a sample of situations.

One-variable and multiple-variable designs versus systematic design

Brunswik's first interest was in the experimental design that provide the data for psychological measurements. He disregarded the classical one-variable design, and found the more recent multivariate design insufficient. In such systematic designs, both the values of the independent variables and the manner of covariation among variables are arbitrarily and artificially restricted (Brunswik, 1955, 1956). Systematic design had to be replaced by representative design, that is, a design that was more representative of the organism's natural and cultural habitat and whose characteristics could be sampled. Measurement must not be allowed to interfere with the patterns of variables that move in uncontrolled environmental situations. Thus (1) the representative sampling of situations becomes a necessary condition for the determination of valid functional relationship; (2) it is important to keep in mind that the requirements of representative sampling
are more relevant to situations than to variables; (3) once a sample of situations had been established, the relationship between specific variables (distal and proximal) could be determined from the instances included in the sample and expressed as correlation coefficient. And finally (4) whereas representative design precedes experimental manipulation and control, it allows the isolation of variables by statistical means.

Partial correlation can be used to hold a given variable or set of variables constant and thus to determine the relationship between an isolated cue and perceptual response. Similarly, the effects of particular combinations of variables can be estimated by means of multiple correlation (Postman and Tolman, 1959).

Some last remarks on Brunswik's system

Brunswik was disposed to consider his system of analysis as one that would fulfill the criteria of a model in the broad sense of the word. Thus, his lens model mentions in detail the fundamental variables to be used in the analysis of achievement and shows the empirical functions that make it possible, namely (1) to measure the degree of achievement and (2) to reconstruct the sequence of processes which make it possible. Using the concept of model in this sense, we find that formal characteristics of reasoning--the so-called "ratiomorphic" model (Brunswik, 1954)--supplies Brunswik with a set of criteria for the evaluation of cognitive achievement. In the application of these criteria there is no less concern with deviations from the model than
with conformance to it (Postman and Tolman, 1959). In summary, in the "rational reconstruction of behavior" (Brunswik, 1954) no assumption is made that behavior is, in fact, rational; on the contrary he stresses the intuitive nature of the perceptual process and the difficulty in managing it.

Range of Brunswik's study

As has been pointed out in this description of Brunswik's system, its major application is in the field of perceptual constancies (Brunswik, 1937, 1940, 1944, 1956). The main goal of the investigation was the study of the conditions representative of daily life. The difference in the treatment of perceptual constancies in Brunswik's research is revealed in the following steps:

(1) The extent and flexibility of perceptual achievement were proved in extensions of the constancy paradigm to new dimensions of discrimination.

(2) The sensitivity of the constancy process to the changing conditions of the organism was exhibited in studies of the effect of attitude.

(3) The modification of perceptual constancy by experience was investigated in studies of developmental trends and of the effects of training.

(4) Studies of social perception (judgments of facial expressions and personality charac were carried out by Brunswik for the exposition

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16 See, for example, Figure 6 for descriptive titles of consecutive episodes in the behavior stream of a six-year-old girl (Barker, Wright, and Schoggen, 1961).
Watching bigger girls form a pyramid (gymnastic)
Taking off her shoes
Going closer to the big girls
Putting on her shoes
Admiring bracelet on Alice
Poking Alice
Looking at Winifred's ladybug
Following Alice
Watching boys
Looking into porch of schoolroom
Closing door of schoolroom
Watching girls play hopscotch
Giving Harry his shoe
Getting bracelet from Alice
Interfering in Delia's and Winifred's fight
Admiring bracelet on Alice

Fig. 6. Barker's ecological observation (1968)
of his experimental design theory.\textsuperscript{17}

(5) Acknowledgement of the essential uncertainty of the connections among environmental events led to the realization of the systematic value of partial reinforcement. Thus probabilistic functionalism goes further in psychology than the field of perception as for example in probability learning.

Finally, it is important to stress the influence of Brunswik's methodological and theoretical tools on modern educational-psychological research. They have been directed toward two main specific goals, namely, the search for consistent theories in teaching (Snow, 1968) and the quest for representativeness in educational experiments (Bracht and Glass, 1968; Snow, 1973). Description and analysis of both is obligatory to an exposition of Brunswik's conceptual body as provided in this paper.

\textsuperscript{17}See Figure 7. See also the term "physiognomy" on Appendix A.
Fig. 7. Factorial variation of schematized face and schematized face experiment, with indices of apparent intelligence. (Brunswik and Reiter, 1937)
CHAPTER IV
THE ENVIRONMENT

Stimulus arrangement and environmental ecology

It has been usual among experimental psychologists to define stimulus presentations in terms of the physical operations used to measure them. Any classification of such stimuli is made with two basic considerations: (1) the requirements of experimental design and (2) the theory or organismic behavior to be examined. But what is disregarded in this consideration is the problem of what relation the stimulus arrangement has to the distal objects in the ecology in which the organism has developed and to which it has to be accommodated. As we will see in a series of Brunswik's quotations later in this thesis, it has become rather clear that organisms must act in relation to objects and object properties in their environment and not in relation to isolated proximal data. If organisms did react to immediate stimulus events—in ecology's lexicon, proximal—they would be bound to a semi-erratic environment. The immediate question now is: what is the relationship between the nondirect observable characteristics of distal objects and the proximal data brought out by these objects? The conceptualization of this relationship has to be made at the very beginning to prevent construction by
most of the classical modern psychologists of irregular presentation in their experiments which tend to emphasize concerns for operations in the central region rather than the more environmentally based distal-proximal or distal-distal relationships.

**Toward a conceptualization of the environment**

Brunswik's first step toward a conceptualization of the environment was to express in a clear way what he meant by discrimination between the surface of the environment and its depth. In other words, the possible relationship between the distal layers of the environment and their proximal complement leans on the fact that the relation between the distal variables and proximal data, or proximal cues, is uncertain. Let us look at this fundamental passage:

On the perception side, an example of a distal variable is the distance of objects. Causal chains determined by distance will, on their way into the organism, exert certain proximal effects, or criteria, upon the sensory surface of the organism. The most important feature of the general relationship between distal and proximal stimulus variables is its lack of univocality.¹

¹Mainly related to Logic, univocal is a term that refers to only one object or class of objects; it tends to be used also for singleness of denotation (i.e., singleness of reference to things).
Firstly, there is ambiguity\(^2\) in the direction from cause to effect. Inventories of possible cues for third-dimensional distance have been compiled from the beginnings of psychological inquiry. Current textbooks list something like ten depth criteria, such as binocular parallax, convergence of the eye axes, accommodation, linear and angular perspective, interception of far objects by near objects, atmospheric effects, number of in-between objects, vertical position. The list could be extended considerably further. The necessity for becoming so involved derives from the fact none of these proximal variables can be considered to be the distance cue in the sense of an effect which would be present without exception whenever the distal condition should obtain. Some of the cues will more often, others less often, be present, depending on circumstances, and occasionally all of them may be cut off (so the fact of a certain distance relationship must remain unrecognized by the organism in question).

Secondly, there also is ambiguity in the reverse direction, that is to say, from effect to cause. A certain proximal stimulus feature, such as binocular parallax, may ordinarily be due to differences in depth, but could

\(^2\)Ambiguous: term pertaining to a statement, or to a situation, that has two meanings, or is capable of two interpretations. The doubleness of meaning is implicitly attributed to the statement, situation, or object, however much it may later be proved to have been due to the observer.
occasionally as well be caused by an artificial set up of two flat pictures in a stereoscope. Or the characteristic trapezoidal shape of retinal images constituting the depth criterion of perspective may frequently be due to distortion of rectangular objects seen under an angle, i.e., extending into the third dimension; but it may also be due to an actual trapezoidal object in a frontal position with all its points at the same distance from the eye.

On the environmental portion of the effect side, the relationships between objects and cues are replaced, in a symmetrical fashion, by the relationships between means and ends, or between proximal actions or habits and distal results. Examples showing the ambiguity of these relationships in both causal directions could easily be given in analogous fashion to the ones discussed above for the perception side (Brunswik, 1943, pp. 256-257).

**Information and means for organismic achievement**

In order for the organism to perceive accurately, to achieve, the object, the organism must have information that is provided by stimulation at the proximal layer, also called sensory cue. These cues are the physical stimuli that strike on the surface of the organism; they are also local signs related to the world of objects. In other words, proximal stimuli are local representatives of distal variables. All these statements were clearly expressed by Brunswik and Tolman in 1935:
Each of us has come to envisage psychology as primarily concerned with the methods of responses of the organism to two characteristics features of the environment. The first of these features lies in the fact that the environment is a causal texture (Kausalgefuge) in which different events are regularly dependent upon each other. And because of the presence of such causal couplings (Kausal-koppelungen), actually existing in their environments, organisms come to accept one event as a local representative (Stellvertreter) for another event. It is by the use of such acceptances or assertions of local representatives that organisms come to steer their ways through that complex network of events, stimuli and happenings, which surrounds them. By means of such local representation (Stellvertretung) the organism comes to operate in the presence of the local representative in a manner more or less appropriate to the fact of a more distant object or situation, i.e., the entity represented (das Vertretene).

The second feature of the environment to which the organism also adjusts is the fact that such causal connections are probably always to some degree equivocal (mehrdeuting). Types of local representatives are, that is, not connected in simple one-one, univocal (eindeutig) fashion, with the types of entities represented. Any one type of local representative is found to be causally connected with different frequencies with more than one kind of entity represented and vice versa. And it is indeed, we would assert, this very equivocality (Mehrdeutigkeit) in the causal "representation" strands in the environment which lend to psychological activities of organisms many of their most outstanding characteristics.

It appears also that, whereas the one of us, Tolman was led to emphasize these two facts of local representation and of equivocality (Mehrdeutigkeit) by a study of the relations of means-objects (Mittelgegensstande) the ends (Zielgegenstande) in the learning activities of rats, the other, Brunswik was led to emphasize these same concepts as a result
of an examination of the relations of stimulus-cues or signs (Reize als Anzeichen) to Gegenstände as a result of a study of relations involved in the "Konstanz"—phenomenon in human perception (Brunswik and Tolman, 1935, pp. 43-45).

Brunswik and Tolman represent a fortunate combination in treating of the nature of behavior environment interaction despite the historical fact that Brunswik has dedicated himself mostly to perception and Tolman to learning.

Ecological validity of cues

It must be concluded from the preceding paragraph that cues—and mean-objects—have an equivocal or probabilistic relation to the object intended. It follows also that this relation must be described in terms that permit quantitative measures of the degree of relationship. Brunswik employed the correlation coefficient for this purpose, and the correlation between distal and proximal variables describes the ecological validity of the cue. Brunswik's experimental work on this problem is exposed in this text and in Figure 7:

Any fairly consistent rapport, be it intuitively perceptual or explicitly rational, with distal layers of the environment presupposes the existence of proximal sensory cues of some degree of ecological validity to serve as mediators of that relationship (Brunswik, 1956, p. 48).

as it does in this broader one:
Preliminary results obtained by Seidner, as yet unpublished, suggest the following logical validities, i.e., correlations of the real distances in the situations photographed-reconstructed from the pictures in terms of a crude five-point scale with a sufficient degree of reliability--with the actual location, color, etc., of their projections in the photographs:

About .6 for the cue of "vertical position," i.e., for the probability of greater real distance for objects appearing higher up on the picture.

About .4 (biserial) for "filling of space" (measured by the number of items, i.e., distinguishable steps, between the projection of two objects), more items between objects being associated with greater differences in real depth.

About .2 for "color" (i.e., on the achromatic pictures used, the local brightness of a spot), greater brightness increasing the chances of greater real distances--as would blue vs. red.

The relatively small and possibly biased samples of situations so far used by Seidner--75 instances from 12 pictures for each cue,--as well as the inherent inaccuracy in the determination of real distances from photographs alone and, finally certain difficulties in precisely defining the variables, especially the retinal gradients, involved, make the numerical values listed subject to considerable revision. In Figure 8 the obtained coefficient are given to two decimals; a question mark is added to indicate the tentative character of the results. . . . It will be remembered that in Figure 10 (Figure 8 in this text) a few question marks were inserted to indicate the tentativeness of Seidener's results concerning the ecological validity of some of the well known perceptual depth criteria. In the meantime, Seidner continued his ecological analysis of
Fig. 8. Schema of perceptual stabilization mechanisms as exemplified by size constancy, including their ecological foundation, with special emphasis on distance criteria (Data from Brunswik, Seidner and Schriever).
these criteria with a set of 30 original photographs of scenes from the daily routine of a specific person. Subsequently, on-the-spot depth measurements were taken for 20 points per picture, the points being selected with the use of random number tables. A total of 600 points (300 point pairs) was thus available for analysis; for a sample of this size, correlations of .03 and over are statistically significant.

Coefficients obtained for the three edepth cues discussed on page 49 and ff. are being presented here again with the kind permission of Mr. Seidner. They are in part lower and in part higher than those reported on the basis of the original asample of 75 point pairs from magazine pictures; for each cue a reasonable definition can be found under which significant validities are obtained. Problems of definition center about such questions as whether or not sky-points in the picture should be included (assuming a fixed, rather large distance for them), or whether extreme colors or a neutral gray be taken as the zero point in defining the color cue.

The validity of "vertical position" as an indicator of real distance was tentatively given as .61 in Figure 10. With the new sample it was found to be .41 with sky-points included, .21 with sky points excluded; both these values are significant.

The validity of "space-filling" was given as .42 in Figure 10 (Figure 8 in this text). Now it is about .10—still significant— with sky-points included; it is .15 or .22 without sky-points, depending on whether the total number of discernible homogeneities between the two sample points or their density per length unit on the picture considered. In this context it must be kept in mind that loss of detail in photographing of situations at greater distances tends to obscure the validity of this cue.

The validity of "color" (albedo—"brightness" — in the picture) as cue for distance was given as .23 in Figure 10. Now it is as high as .39 with sky points included; but it becomes insiginificantly negative
(-.60) with sky-points excluded. The values remain very similar (.36 and .05, respectively) when extreme albedos are taken as negative and a medium gray as positive (Brunswik, 1956, pp. 49-50, 123).

Causal texture of the environment

As described in the paper by Brunswik and Tolman (Brunswik and Tolman, 1935) there is a kind of vicarious mediation between distal and proximal layers of the environment called causal texture. The environment has texture because it is not sharply defined and it is not constituted by a series of one-to-one relations. The environment implies partial causes and partial effects, in its own ecological relationship, independent of the behaving organism. That is, not only are there less than perfect relations between distal objects and proximal cues, but there are also correlations of less than one between various cues for the same object (Hammond, 1966). Hence, (1) the term "ecological validity" refers to the correlation between proximal cue and distal object; (2) the "intra-ecological correlation" refers to the relation between various features—cues—of the environment, and (3) if the intra-ecological correlations between the cues for a given object are high, the environment is redundant, regarding the object in question (Hammond, 1966).

3Redundancy is said of the property of a message—in information theory—which reduces the error of prediction for a given event to less than chance by virtue of the fact that the message contains information about what will come next.
One important feature of these kinds of studies on the texture of the environment is that they do not involve a subject. For Brunswik the goal of psychology is the mutual comprehension between environment and organism.

Brunswik explicitly points out that:

One of the comparatively neglected tasks of a molar environmental psychology is to find out the extent to which environmental hierarchies of probabilities of object-cue as well as of means-end relationships do find a counterpart in similar hierarchies of evaluation by the organism. This would mean that the environmental probabilities be first ascertained for all of the cues or means involved, with, say, the "normal life" conditions of the organism taken as the defining reference class. This part of the research would be strictly environmental and preparatory in character and would not involve any reference to organismic reaction. Very little has thus far been done in the direction of such an environmental analysis.

The most conspicuous exception is a certain knowledge we have about the so-called "physiognomic" relationships between certain mental states or abilities in our fellow-men, and their external physical characteristics. Such studies have, however, been undertaken primarily because of an interest centering in questions of the expressiveness of human beings viewed as subjects rather than because of an interest in some other subject's social environment and the problems confronting such a subject in his approach to objects of social perception (Brunswik, 1943, p. 259).

Thus, it is Brunswik's feeling that vicarious mediation—inter-substitutability of cues—in the environment is a reality of Nature.
Theoretical versus empirical considerations

There is a paper authored jointly by Brunswik and Kamiya (1953), on the ecological validity of the Gestalt factor of "proximity," that is intended to show how theoretical issues can be sometimes opposed to empirical ones. Of course the discussion implies a critical point of view toward the nativistic Gestalt theory. Some excerpts of this work follow:

Gestalt psychologists have stressed the influence of certain stimulus–factors upon figural unity in perceptual organization. Prominent among these factors are "proximity," "equality" (or "similarity"); "symmetry," "good continuation," and "closure" in the sense of the closeness of a line pattern in the stimulus-configuration.

According to orthodox Gestalt theory, the effectiveness of these factors rests on dynamic processes inherent in the brain field, rather than on accumulated past experience; while occasioned by respective characteristic of the stimulus configuration which acts as a set of "topographical" factors at the boundary of the system, the dynamic themselves are in the nature of "physical Gestalten," that is, of spontaneous physiological "self-distribution" built into the organism prior to, and as a condition for rather than a result of--learning. For this reason it is also said that the factors mentioned operated in an "autochtonous" manner, that is, are indigenous to the organism so far as their organizational effect is concerned (Brunswik and Kamiya, 1953, p. 20).

Where, then, is the novelty of the Brunswik–Kamiya approach?

A more broadly functionalistic view of perception would suggest an alternative interpretation of the factors of perceptual organization which at the same time would be well in keeping with modern learning theory. According to this view these factors would be seen as
guides to the life-relevant physical properties of the remote environmental objects, and thus as playing a part in adjustment; in more technical language, they would be conceived of as proximal "cues" to the so-called distal body reality.

The possibility of such an interpretation hinges upon the "ecological validity" of these factors, that is, their objective trustworthiness as potential indicators of mechanical or other relatively essential or enduring characteristics of our manipulable surroundings. This problem is analogous to that of the "physiognomic" or external cues offered to the organism for potential utilization in social perception. . . . Another analogy is with the so-called depth-cues in the perception of third-dimensional space, such as vertical position or subdivision of the field. For some of these cues, ecological validities somewhat higher than those typical of social perception, but still of definitely limited value, have been established by Seidner (Brunswik and Kamiya, 1953, p. 21).

Brunswik's and Kamiya's emphasis on the necessity for sufficient empirical analysis of the connection between stimuli and their natural sources is stressed in this next paragraph:

Any study of ecological validity can be no more than propedeutic to psychology: concern is limited to a survey of statistical relations among variables as typical of the natural or cultural habitat of an individual or group while the question of the actual utilization of cues or of other aspects of organismic response is left untouched. In short, such studies deal with potential cues, not with cues actually employed. Yet ecological surveys are indispensable not only for an understanding and appraisal of responses but, as is especially true in our particular case, for general problems in psychological theorizing as well.
There can be no doubt that the ecological validity of the Gestalt factors, when seen as potential perceptual cues, could likewise be of no more than very limited value. In part, perhaps for this reason, but certainly at least in part by virtue of their predilection for dynamic rather than learning-type explanations, Gestalt psychologists were prone to brush aside suggestions of "generalized experience" as the possible source of the laws of perceptual organizations (Brunswik and Kamiya, 1953, p. 21).

To state it briefly: (1) proximity is a potential cue to mechanical coherence, so gestalitists are wrong in their thesis that the environmental correlation between proximity and object characteristic is zero; (2) the organism must utilize the cue to whatever extent it may be ecologically valid or useful if the organism is to make a successful inference. In this regard Brunswik and Kamiya make some important remarks in the final "Discussion" of their work:

As in all studies aiming at representativeness, the present analysis may in a strict sense be applied only to the specific natural-cultural universe from which our sample is drawn. Although we have made no effort to define this universe in a formal way, it can probably be taken as a first approximation to the universe to which most of us are perceptually exposed.

The successful demonstration, within any framework stipulated, of the ecological validity of a Gestalt-factor does not automatically imply the legitimacy of its interpretation as a learned cue. It merely shows that an objective basis for probability learning is offered the individual within the framework chosen. Since, however, all ecological validities represent a challenge to the organism for utilization, and since probably many cues are actually being utilized roughly in proportion to the degree of their validity,
our findings lend plausibility support to the reinterpretation of proximity as a cue acquired by generalized probability learning. If this should become possible for other gestalt factors also, they all could be seen as externally imposed upon, rather than as innately intrinsic to, the process in the brain; they would then appear as functionally useful rather than as whimsically "autochthonous." It goes without saying that such an interpretation would lose much of its cogency if it would turn out that proximity has similar organizing effects in individuals, groups, or species in whose habitat or cultura it has no (or opposite) ecological validity (Brunswick and Kamiya, 1953, pp. 30-31).

It appears in all of these long quotations that Brunswik has a quite important conception of his own on the nature of the environment as it used by the subject, as well as an outstanding belief in the value of the organism's ecology and in the acceptance of a theoretical and empirical analysis of the environment.
CHAPTER V

THE NATURE OF THE ORGANISM AND THE LENS MODEL

The Organism and its survival strategies

Having exposed some of the bases of Brunswik's conceptual system and given an account of the environment, the next step is to infer from those bases the essential qualities of adaptation and survival\(^1\) and their meaning in terms of a theory of the organisms.

In his paper "Organismic achievement and environmental probability" Brunswik points out several of these qualities for adaptability (Brunswik, 1943, p. 257).

The contributions of the organism. Survival and its sub-units, which may be defined as the establishment of stable interrelationships with the environment, are possible only if the organism is able to establish

\(^1\)Survival is used at least in three senses in the social sciences. The first usage is the general-continuing to live after some event. The second usage carries over into the social sciences the idea of the survival of species by the processes of random mutation and natural selection. Much social science theory is built around this concept, but the concept itself is biological. The third usage refers to "continuance of a custom" observance, etc., after the circumstances in which it originated or which gave it significance have passed (Tylor, 1913; Hodgen, 1936; Malinowski, 1944; Murdock, 1949).
compensatory balance in the face of comparative chaos within the physical environment. Ambiguity of cues and means relative to the vitally relevant objects and results must find its counterpart in an ambiguity and flexibility of the proximal-peripheral mediating processes in the organism. This pattern contrasts somewhat with the relatively specific focusing of vital processes upon the central-organismic and the distal-environmental variables. Thus each class of behavioral achievement may be represented, when telescoped into a composite picture covering extended periods of time, by a bundle of light rays passing through a convex lens from one focus to another, with a scattering of the causal chains in the mediating layers.

When admitting that exact universal law control the environment, it is important to note that this quality of lawfulness is often hidden behind a semirerratic medium of probabilistic cue-objects relations. In other words higher organisms must have flexibility enough in their proximal-peripheral mediational processes to content successfully with the ambiguity between cause and effect. Dispersion being one of nature's main features, the organism must insure its survival by achieving durable relations with the hidden regularities of a lawful world. It reaches such permanent relations by means of a perceptual apparatus that interprets environmental cues as asserted by their probable association with the distal variable and that considers environmental means according to their probable association with success (Hammond, 1966). In Brunswik's words:

Within the natural sciences, an example of the purely enumerative approach is given by those branches of geography that deal with topographical mapping. The fact that no application of the general physical laws
is possible without the constants, parameters and boundary conditions furnished by geographic types of information is frequently neglected in theoretical discussion. Except at the level of control ordinarily accessible only to the physicist observer, these constants are not available (at least not fully so) to the responding organism. Hence the chains from select distal to proximal to central variables in perception are chains of (probable) partial, rather than of total, causation. The universal lawfulness of the world is of limited comfort to the perceiver or behavior not in a position to apply these laws, and he therefore must rely largely on whatever snitches of particular or semigeneralied information he may be able to assemble. This is what we meant earlier in this paper by the assertion that, ordinarily, organisms must behave as if in a semierratic ecology (Brunswik, 1955, p. 237).

Dealing with a probabilistic rather than completely determined set of cue-object relations, the psychologist can reasonably expect to look on the organism as being probabilistic at the proximal-peripheral layer. He can also expect that the surviving organism has the capacity to establish variables in the distal region. And it is fundamental for psychology to reach such stable relationships with the distal layer "in the face of comparative chaos" at the proximal-peripheral boundary. In short, the organism reacts not to proximal data but to objects, and focuses on them. As Brunswik clearly illustrates:

The necessary imperfection, inflicted upon achievements— as relations between classes—by the ambiguity in the causal texture of the environment, which remains apparent as long as a single variable, that is partial causes and partial effects, are considered under otherwise not specifically controlled conditions. Because of this environmental ambiguity, no matter how smoothly the organismic instruments and mechanisms may function,
relationships cannot be foolproof, at least as far as those connecting with the vitally more relevant remote distal regions of the environment are concerned. This intrinsic lack of perfection, that is of univocality, will on the whole be greater the more wide-spanning the relationships involved are. The only way in which perfection could be secured would be by control over all the remaining conditions which could possibly become relevant in the given case. This however is something the reacting organism cannot do for lack of time if not for other more serious reasons--and thus something which the psychologist who wishes to catch and rationally to reconstruct organismic adjustments at large, with all of its faults and fallacies, should also not do. All a finite, subdivine individual can do when acting is--to use a term of Reichenbach\(^2\) to make a posit, or a wager (Reichenbach, 1938; 1943).

A good way to understand how Brunswik handles the ambiguity of the causal texture of the environment is to look at his construction of the lens model.

\(^2\)Hans Reichenbach (Hamburg, 1891--Los Angeles, California, 1953). Though closely related to the "Vienna Circle" as well as to logical and scientific empiricism and the Unity of Science movement, his position on this premises are less radical. He calls his system "probabilistic empiricism," and stresses the importance of an "open" methodology that goes beyond empirism and operationism. However, the probabilistic-empiricist language cannot be separated from the external physical world. Thus, any linguistic statement must be expressed in the context of the empirical epistemology. But since any empirical statement is not absolutely certain, it can only be established in terms of "posits" or, in other words, in probabilistic terms.
The lens model and more on ecological validity

The fundamental characteristics of probabilistic functionalism as a main strategy for coping with the ecological relations within the environment-organism situation are better understood in terms of the lens model (Brunswik, 1939, 1952, 1955). This model is a refinement of the diagram of the regional reference presented in Figure 2. The lens model stresses distal achievement and vicarious functioning of proximal stimuli and responses. The clearest way to understand its elements and context is to apply it to the analysis of the perceptual thing-constancies.

The formal features of the model are those of a double convex lens. A bundle of light rays emanating from an initial focus is made to converge at a terminal focus. The initial focus represents a distal stimulus, i.e., a measured physical property of an object in the environment. The rays proceeding from this initial focus, labeled "process details," represents the energy changes produced by the source. The energy changes result in a sample of proximal effects acting on the sensory surface or exterior part of the organism. The proximal effects act as cues and are represented in the central column. The existence of proximal stimuli on the sensory surface of the organism advances some processes within the organism--process details--which mediate the final perceptual response. This perceptual response is the equivalent of the achievement of the organism in relation to
distal stimulus and is represented as a terminal focus. In short, this analysis points out three well defined functional relationships, those between distal variable and proximal effects; those between proximal effects and perceptual response, and those between distal variable and perceptual response. A close inspection of these relations will be useful in revealing the basic uncertainty of causal connections in the environment and the probabilistic nature of psychological laws.

1. Distal variables and proximal effects.

In relation to the problem of ecological validity, some issues are important for a clear interpretation of the lens model (Postman and Tolman, 1966; Reichenbach, 1938). First of all, the existence of a given distal property does not imply a specific and predictable pattern of distal effects. Thus, in the example of the distal variable of distance from the eye in which we can list a series of proximal "distance cues" (retinal disparity, convergence, accommodation, etc.), any of these variables can be intended as the cue distance. In other words, at times some of these variables may be present whereas others may not. Second, it is not possible to deduce with certainty the nature of the distal variable from a specific pattern of proximal stimulation. Using the same example, retinal disparity is normally the result of differences in depth but can also be produced in a laboratory under artificial conditions. As a result, there is uncertainty in predicting proximal effects. Finally, some proximal cues vary systematically more than others as a function of distal
stimulus changes. Hence, the degree of covariation between a proximal cue and a distal property defines the ecological validity of the proximal cue with respect to that property. Variations in ecological validity may again be illustrated in terms of proximal cues to distance (for example retinal disparity tends to be in close correspondence with distance and thus has high ecological validity as a cue to distance). As a summary, since the ecological validities are less than perfect, the relationship between the distal variable and its proximal mediators can be described as one of probable partial causes and probable partial effects.

2. Proximal effects and perceptual response.

In the process of adjusting to distal events, the organism uses any kind of proximal cues that are available to it. In the face of cues of limited validity, the organism must adopt a probabilistic strategy or a strategy of posits. Taking action in this way the organism can use altogether different proximal cues or combinations of cues. Because flexibility in the utilization of cues is essential to adjustment, the pattern of cues produced by a given distal object is variable. Finally and for a substantial accomplishment in adjustment different cues must be weighted by the organism in agreement with their validity. Therefore, the psychologist must determine the ecological validity of different proximal cues and their weight as assigned by the organism.
3. Distal variable and perceptual response.

The relationship between two focal variables, viz. distal variable and perceptual response is a measure of the organism's perceptual achievement (Brunswik, 1952). When the organism is successful the distal variable may be considered to have been "functionally attained." If we want to determine the degree of attainment we can correlate distal (physical) value with perceptual response. This correlation is a measure of the functional validity of the perceptual response. As the perceptual thing-constancies demonstrates functional validity is normally high, though by no means perfect (Postman and Tolman, 1959). This kind of imperfection is a consequence of the environmental uncertainties with which the organism must contend and in which the association between distal and proximal events is probable rather than certain. Absolute evidence of perceptual achievement is in principle impossible for an organism that depends on proximal cues. However the greater source of error in perceptual achievement rests in undependable object-cue relationships rather than in the interference of available cues (see Figure 9).

3. Relevancy of the lens model for behavioral achievement.

An example that may lead to a better understanding of the application of the lens model in behavioral achievement is described here (Brunswik, 1952; Tolman, 1932; Postman and Tolman, 1959):
Fig. 9. The lens model as applied to perceptual constancy (Brunswick, 1952)
The analysis represented by the lens model applies to behavioral as well as to perceptual achievement. [See Figure 4] Let the initial focus stand for a condition of the organism, e.g., state of food deprivation. This condition activates a family of habits. The hierarchy of habits associated with the condition of hunger is formally analogous to the pattern of proximal stimuli in the case of perception. Confronted with a particular environmental situation, the organism may perform or "utilize" one or the other, or a combination of these habits in order to achieve the end state of hunger reduction. This end state is represented by the terminal focus in the lens model. A series of such behavioral units may precede the attainment of the end state. As the arrow labeled "feedback" indicates, the consequences of past acts may influence the nature of the subsequent units of behavior.

Uncertainty of causal linkages obtains in molar behavior just as it does in perception. No single habit or group of habits is uniformly associated with the initial condition of hunger. The correlation of means and ends equally falls short of perfection. There is probable rather than invariant relationship between any specific bodily action and the achievement of the end state, thus the organism will shift to an alternative one and continue to so until the end state is achieved. Just as proximal cues are weighted and utilized according to their "assumed" probabilities, so alternative actions are performed according to "expected" probabilities of success.

The emphasis on the use of alternative means in the achievement of an end is closely related to Tolman's definition of purpose as persistence and docility of behavior with respect to some end. A description of behavior as purposive in Tolman's sense is thoroughly consistent with Brunswik's pervasive interest in the adaptive properties of behavior.
The applications of the lens model to behavioral achievement is as yet fragmentary and lacks the specificity of analysis of perceptual achievement. In illustrating the potential applicability of the model, we have chosen as the focal variable an initial condition of deprivation and the end state of need reduction. The relationship between these variables was treated independently of the specific physical situation, and the analysis bypassed the interaction between perceptual and behavioral achievement. This later interaction would have to receive extensive attention in the further development of probabilistic functionalism (p. 514).
Historical and metatheoretical considerations

Two major considerations are necessary to an exact understanding of psychology's historical context:

1. From the very beginning, psychologists have been aware that a problem exists concerning the scientific status of their discipline. Although a distinct consideration of the complexity of cause-effect relations runs parallel to an awareness of the need for scientific methodology as illustrated by the progressive improvement in scientific research from early Greek times to the Nineteenth Century, commitment to a given method has often obscured the need to cope with complexity by other means (Crombie, 1959). Only toward the end of the first half of the twentieth century did the first decisive break with this tradition occur. This rupture has been considered important enough to be called a scientific revolution (Kuhn, 1962).

2. Historically, psychology's basic method has been to follow the classical design which dictates that experiment in such a way that all variables but one are controlled. The effects of that variable can thus be assessed independently of confusing influences. Scientists have felt so compelled to
use this special kind of experimental model that it has been called a classical paradigm.¹

However, though the idea of paradigm is basic to experimental methodology, it seems clear through an historical analysis that it represents an historical choice rather than an inevitable technique. In other words, perhaps it is not so obvious that it is not the only way to carry out psychological experiments as e.g., ethologists have many times carried out experiments using a "watch and wonder" approach.

¹Two additional considerations on "design" and "paradigm" are important here:
(a) "The two types of design are juxtaposed here in conformity with a distinction established by Brunswik (Brunswik, 1947). In the sense in which he uses the terms "representative design" he refers to the transfer of the principles of sampling statistics from the subjects of a psychological investigation to the objects or situations which constitute the stimuli in the investigation. The arbitrary orderliness with which these external (independent) variables are customarily handled is summarized by Brunswik under the opposite heading of "systematic design," and Fisher's factorial design is presented as a relatively recent and relatively complex example. Fisher has also used the term "systematic" in a similar, albeit somewhat causal, manner" (Hammond, 1954, p. 150).
(b) A paradigm is a term applied to a model (meaning para--beside and digm--to show) designed to stimulate research questions, develop a methodology for gathering and classifying data, and secure standards necessary for evaluating accumulated evidence. Various paradigms exist in psychology, such as behaviorism, psychoanalysis, and topological psychology (Jones and Gerard, 1967).
The role of the paradigm in science

Paradigms are used in science to describe the fact that "some accepted examples of scientific practice—examples which include law, theory, application, and instrumentation—provide models from which evolve particular coherent traditions of scientific research" (Kuhn, 1962, p. 10). A paradigm is thus methodological as well as theoretical: "Paradigm procedures and applications are necessary to science as paradigm laws and theories, and they have the same effect" (Kuhn, 1962, p. 60). The paradigm serves a useful function in the progress of science by providing a means for guiding research within a coherent framework. By means of the paradigm, a certain randomness is removed from scientific effort and direction is given in choosing problems for scientific attention and determining the method of this investigation. But if paradigms guide, they also impose restrictions:

"Inevitably they restrict the phenomenical field accessible for scientific study at any given time. . . A paradigm can even insulate the community from those socially important problems that are not reducible to the puzzle form, because they cannot be stated in terms of the conceptual and instrumental tools the paradigm supplies" (Kuhn, 1962, p. 37). This description of scientific paradigms shows quite well the functioning of psychology's principal methodological paradigm, the systematic design. The method was adopted by a young field of psychology "hungry for scientific respectability" (Loch, 1959), and accepted as an answer to the problems of that field because
it was judged sufficient to meet the standards of science.

The changing of paradigms in science

A major problem with scientific paradigms is that, because they satisfy a scientific exigency, once implanted they are difficult to change. But as previously noted, as important as paradigms can be, they can also be changed by means of scientific revolutions. Such revolutions start when "some awareness of an anomaly or a discrepancy between the paradigm and the requirements of the real world is experienced. . . Discovery commences with the awareness of anomaly, that is, with the recognition that nature has somehow violated the paradigm-induced expectations that govern normal science" (Kuhn, 1962, p. 52). We have seen in Brunswik's critical work on Sensory psychology and Gestalt that the systematic design paradigm does not fit the need of modern psychology. Another example of this anomaly is also given by Brunswik in his comments on Psychoanalysis (Brunswik, 1938). In Brunswik's words, Freud provides an example of this sort of anomaly. Although Freud did not make any direct methodological contribution he recognized that a carefully controlled stimulus could provoke various responses and that the same response could result from various stimuli. Thus, this emphasis on vicarious functioning can be considered the major contribution of psychoanalysis to psychology. In short, diagnosis is endowed with all the characteristics of probabilistic inference.
A second characteristic of scientific paradigms is that revolutionary change is always followed by a new implementation "... the decision to reject one paradigm is always simultaneously the decision to accept another, and the judgment leading to that decision involves the comparison of both paradigms with nature and with each other... To reject one paradigm without simultaneously substituting another is to reject science itself" (Kuhn, 1962, pp. 77-79).

Brunswik's contribution to the changing of paradigms

Brunswik's desire was to bring the anomaly into focus again and to suggest that psychology must recognize it and propose some solution. Brunswik points out that "only scattered recognition had been given to the fact that object-cue and means-end relationships are not in accord with the mathematical certainty built into the so-called laws of nature, but are rather of the character of probability relationships (Brunswik, 1943, p. 260). For Brunswik the recognition of the probabilistic character of the causal relationships in the environment demanded a "fundamental all inclusive shift in our methodological ideology regarding psychology" (Brunswik, 1943, p. 261). If the organism has to deal with the uncertainty of nature we can learn more about its behavior by representing it experimentally, with the same sort of probabilistic environment that is inherent in nature. If an isolated variable does not exist outside the laboratory we cannot force the organism to deal with it inside the laboratory.
As Brunswik asserts "it can be shown that classical design does not succeed in its purpose of contribution to psychology" (Brunswik, 1943, p. 263) as he did not accept the inevitability of experimental isolation. Brunswik was anxious to deal with nature as it presents itself to the behavioral organism but the study of pure causes, artificially separated from disturbing influences, can only be relevant for the physical sciences, not for the main object of psychological enterprise.

From the previous considerations we can come to some fundamental conclusions regarding the relevance that the theoretical orientation of probabilistic functionalism as a paradigm has for psychological methodology. First of all, the analysis of organismic achievement cannot be carried out within the boundaries of experiments that are rooted in the exact control and isolation of variables. Second, organismic achievement must be studied in situations that are representative of the subject's natural habitat. And third, systematic design has to be replaced by representative design in the same way that general laws implied in classical experiments must be replaced by statistical generalizations, i.e., the probabilistic approach.
Experimental designs may be evaluated with respect to the following criteria (Boring, 1929; Cattelli, 1966; Plutchik, 1968; Sidowski, 1966):

(a) choice of variables; (b) manner of variation of the variables chosen and (c) manner of covariation of the variables chosen.

(a) Choice of variables.

The basic decision here is in choosing the number of variables for investigation in a given design. In classical experimental psychology, the almost perfect pattern was the one-variable model. One variable was considered at a time while all other variables either were held constant or were assumed to be irrelevant. With the introduction of ANOVA there has

It may be useful to point out again that classical experimental design is defined as experimental testing of hypothesis in regard to the dependence and interdependence of variables. With this kind of design it is possible to calculate the effects of one or more independent variables on one or more dependent variables. In general, experimental design refers to measures adopted to ensure that the planning and procedure of an experiment use all available appropriate information and as far as possible take into account all the implicated factors.

All this description rests heavily on the Postman and Tolman account (Postman and Tolman, 1959, p. 514 ff).

ANOVA (analysis of variance) is a method for determining whether the differences—expressed as a variance—found in a dependent variable, when it is exposed to the influence of one or more experimental variables, exceeds what may be expected by chance. The F test is a measure of the probability of the difference beyond chance. Each variable in turn can be treated as the dependent variable. See also Appendix A for a definition of the same term.
been a tendency toward multivariate design. The number of variables included in any one systematic design has, however, remained small both for practical considerations and because of the difficulties in interpreting higher-order interactions.

The choice of variables also embodies decisions with respect to regional reference (Brunswik, 1939). As we have shown previously there is in the History of Psychology a constant prejudice toward central and proximal events while concern with distal variables is of more recent origin. The study of distal variables calls for multivariate designs, since distal achievement usually depends on a multiplicity of factors rather than on a single one.

(b) Manner of variation of the variables chosen.

In a classical systematic experiment, the evaluation of the variable of variables is limited to a restricted range. Within this range, the values are usually spaced in even, discrete steps, e.g., a set of weights or sizes differing from each other by equal amounts. Values of other variables that can be considered as potential determinants of the response under investigation are either held constant at some finite value or reduced to zero (Postman and Tolman, 1959).

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Multivariate design is complemented by a multivariate analysis that uses in turn any of the methods or techniques (such as multiple-factor analysis and analysis of covariance) that are employed to identify, or show the effect of, many variables when acting together.
(c) Manner of covariation

Experimental control determines not only the manner of variation of each individual variable but also the nature of covariation, among variables. Within the limits of systematic design there are three methods of controlling covariation, namely, the artificial tying of variables, the artificial interlocking of variables and the artificial untying of variables.

Three examples clearly illustrate each type of controlling covariation: for the first type we can use the measurement of length discrimination on the Galton bar, for the second type the constancy experiments, and for the third one Brunswik's example on social perception. The first is representative of an experiment under highly controlled conditions—maximal tying of variables—in which psychophysics and measurement tend to become indistinguishable. The second is an example of how covariation can be present but restricted in range, in which case it is considered an artificial interlocking of variables. In Brunswik's example (Brunswik, 1956), individuals whose personality traits were to be judged were required to wear the same clothes and assume identical

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6 The Galton bar is an instrument invented by Sir Francis Galton (1822-1911) for measuring thresholds (limens) of visual distances by having the subject try to match a standard line to a movable line; used in psychophysics for determining average error or barely noticeable differences.

7 See also the terms "constancy" and "perceptual constancy" in Appendix A.
postures at each interview. This was done to avoid differences in judgments, since control was achieved only at the expense of eliminating whatever correlation naturally obtained between the interaction of clothing habits and muscular tonus on the one hand and personality traits on the other.

Advantages of Brunswik's representative design

The basic goal of representative design is on the one hand to reflect the probabilistic nature of environmental circumstances and on the other to show the complete measure of the organism's capacity to manage the environmental uncertainties. These goals are achieved by the representative sampling of ecological situations.

An ecology is a cluster of situations that the organism is likely to find in daily living (Postman, 1955). An ecology is described independently of the organism's responses and is therefore an objective account of the stimuli and behavior supports that may be presented to the organism by the environment. These characteristics, called ecological variables, are considered most representative of the organism's survival. The manipulation of such characteristics is distinctive of systematic design, while representative design refuses to interfere with environmental situations. But sampling of situations refers neither to the sampling of variables, but fundamentally to

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8 See the term "ecology" in Appendix A.
the fact that there is a whole ecology interacting with a whole organism. 9

Brunswik was the first psychologist to take the probabilistic point of view. This attitude had two important advantages. First of all the fact that the probabilistic view arose directly and logically from his theoretical and empirical positions (Brunswik, 1952). Nowhere had Brunswik made a prior judgment as to whether technical problems could or could not be overcome. Actually he admits that his approach presents even more serious technical difficulties than the conventional approach. Looking for statistical laws does not, therefore constitute a withdrawal from technical problems; rather it proceeds directly out of propositions different from those accepted by classical behaviorists concerning the interaction of the organism and its environment. Secondly, as Brunswik suggested (Brunswik, 1943), uniformities or invariances would not be found by psychologists. On the contrary, he affirmed that survival may be defined as the establishment of permanent interrelationships with the environment. In Brunswik's terminology,

9 A study about the influences of Goldstein's organismic psychology on Brunswik's probabilism has not yet been done although similar views can be found in both Brunswik and Goldstein. Kurt Goldstein (1878–1965) is a psychologist well known for his theory of personality of an organismic and holistic nature, with an overlay of Gestalt influences; he claimed that the only motive in life is to actualize oneself.
(1) invariances are to be found between scientific constructs in the distal region of the environment and the central region of the organism, and (2) the probability lies in the mediational processes of the physical world—-from the surface of the environment to its remote causal layers—and in the mediational processes of the organism—-from the surface of the organism to its central layers.

Luckily Brunswik did not withdraw from the methodological implications of his theoretical position, however burdensome it may have appeared. Because Brunswik's view of the history of psychology and its conceptual framework guided his methodological strength, all these aspects of his work constituted a functional whole. Beginning with an historical and conceptual analysis Brunswik was forced to look closely into psychological methodology and there he found that classical methods were not consistent with the history of psychology in the twentieth century. Thus he developed some methodological principles, deriving them from his general outlook. In doing this he accomplished two valuable tasks: first, he provided psychology with a detailed and systematic methodological body, and second, he supplied a fresh methodology not derived from the traditional canons of logic or from the natural sciences (Brunswik, 1947, 1956). In other words, Brunswik perceived that although Nature was in some sense regular and could be described in terms of nomothetic laws of physics this aspect of regularity was not immediately available to the behaving organism. Thus, the functionalistic
approach in psychology must take into account this basic limitation of the
adjustive apparatus, and must link behavior and environment statistically
rather than by placing the predominant stress on physic's laws.

Last remarks on Brunswik's statistical analysis

In realizing the probabilistic nature of the environment and behavioral
laws, psychology necessarily becomes a statistical discipline. In the
particular context of Brunswik's functionalism this attitude took on a refine-
ment that is clearly contrasted with the methods of systematic design and
differential psychology. The statistical analysis in systematic experiments
aims to hold constant the differences among individuals, independent of the
controlled changes in the environment. In differential psychology, the major
task is to hold the environmental conditions constant and focus on the analysis
of individual differences. Thus the quest for representativeness runs
parallel with the development of mental testing. But the last concern is
with representative samples of individuals rather than of situations.

Differential psychology enriches its own analysis of variability with the

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10 The mental testing movement began with the development of the
first intelligence test by Binet and Simon in 1905. The test sprang from the
purely practical goal of discovering an objective method of assessing the
intellectual level of French school children. The Binet-Simon scale was
developed around a theoretical framework involving three main conceptions
of the nature of intelligence: (1) a goal or direction to the mental processes
involved, (2) the ability to show adaptable solutions, (3) the capacity to show
selectivity of judgments and self criticism of choices. In attempting to
measure these processes, Binet and Simon constructed their test from items
of common information, word definitions, reasoning items, ingenuity tests,
and the like.
analysis of covariation. Like differential psychology, probabilistic functionalism also used the correlation coefficient but there is an important difference between both issues, namely, that in moving from differential psychology to the functionalist analysis of achievement, individuals and situations change positions. Thus the correlations are now between the objective characteristics of situations as well as between the objective characteristics and responses of the organism.

The correlation coefficient is used to measure the degree of dependence among environmental events and as a result provides the psychologist with intra-ecological correlations. The degree of association between distal variables and proximal cues is of special interest in dealing with perceptual achievement. The correlation between distal and proximal values of a stimulus is a measure of the ecological validity of the proximal cues. The accurate description of ecological conditions depends on the stability of the physical measures of the environmental characteristics. The correlation between successive measurements of an environmental stimulus establishes the ecological reliability of that stimulus. As a result of all these operations, ecologically reliable features endow the organism with stable data for its near orientation.

Some final words on perceptual achievement and statistical techniques are necessary. The fundamental measure of perceptual achievement is the correlation between the distal value and the attained value of a stimulus.
This correlation measures the functional validity of the perceptual response. Once the functional validity of the individual's response has been fixed, the psychologist can look for the reliability of that response. If he wants to measure intra-observation reliability he directs the same individual to respond repeatedly to a given sample of situations, and then determines the correlations among that series of responses. If he wants to move from one individual to a set of subjects, he can obtain responses to the same sample from this increased population. The correlation among their responses measures intraindividual observational reliability. This problem, which actually falls outside the aim of functionalistic analysis, refers more to generalizations among individuals rather than situations. Nevertheless, it is necessary to remember that the search for complete differences between subjects is consistent with the premises of representative design.
CHAPTER VII

SOME BRUNSWIKIAN APPROACHES USED IN

EDUCATIONAL RESEARCH

The regional reference and educational research

Sections I and II presented a broad picture of how a classification of variables in terms of their remoteness from the central processes of a behaving organism works in Brunswik's system. Looking also at the representative picture given there we see that, the variables acting upon the organism's behavior lie in regions increasingly and symmetrically peripheral to the central response. A choice of variables representing all regions was understood as forming a causal chain, the links of which are probabilistically, rather than deterministically, related. The educational research inspired by Brunswik's system has been carried out, however, with some important modifications (Snow, 1968; Foa, 1961, 1962). First of all a statistical model was sought not for one organism but for many—a teacher and one or more students interacting in a classroom. Second a single sample was chosen as a forerunner of the more complex research to follow; Brunswik's regional reference was restricted to the case of one teacher and one student. Figures 10 and 11 show the regions bearing upon both teacher and student and supply
REGIONS
Far-reaching achievements
products of life activities

-molar behavioral achievements
 (distal effects of reactions)

-molar behavior
 (proximal reactions)

-intraorganismic events and dispositions
 (central responses)

-proximal stimuli

-manipulable physical bodies and events
 (distal stimuli)

-remote past of organisms
 (antecedent prior to stimulation)

Fig. 10. The regional reference of psychological systems: a classification of variables in terms of their distance from the organism (Snow, 1967)
some examples of variables existing in each region. Third, remote antecedents and achievement variables were defined operationally by test, questionnaire and rating scale responses. These are the so-called macro-criteria measurements of teacher effectiveness (Gage, 1963, 1964). The inside regions represent micro-criteria of teaching and learning usually quantified by means of classroom observation (Medley and Mitzel, 1963).

The lens model and educational research

Section I I described the main features of the regional reference and probabilistic relations among events appearing in Brunswik's fundamental instrument, the lens model. Figures 12 to 15 depict several kinds of lens models adapted from Brunswik by later researchers who were looking for a distinction between the various aspects of the perceptual and behavioral processes. Thus Figure 12 illustrates the essential qualities of human vicarious functioning. Cues relating some stimulus variables--i.e., the size of a distant object--are available from the ecology as an array of projections on the subject's sensorial apparatus which is depicted as a convex lens. These projections are focused to produce a central response (in the example quoted the responses is a size judgment). The correlation between the initial and terminal size variables, estimated for a single subject over a number of naturalistically varying situations, reveals the functional validity of size judgment calculated for a subject. Estimated correlations between the distal variable and each cue separately supplies
Fig. 12. The lens model (Brunswik, 1952) and a double lens model (Leeper, 1966).
statements of ecological validity for each cue; those estimated between individual cues and the judgmental response supply cue utilization coefficient. Multiple correlational, and other species of multivariate, analysis can also be used, (1) to represent criterion variables in terms of weighted combinations of cue variables; (2) to interrelate established or predicted criterion variables and (3) to investigate dimensions and patterns among cue variables. Any of these coefficients may vary systematically from person to person, or for the same person under different conditions, but will always be less than unity due to the probabilistic character of natural behavior (Snow, 1968). Brunswik's representative sampling of actual learning situations in other settings allows research on teaching to deal with the difficulties of natural behavior inside the classroom. Thus some authors (Leeper, 1966) have further developed Brunswik's model into a double-lens form pointing to both receptor and motor aspects of a subject's behavior. Others (Hammond, Hursch and Todd, 1964) have drawn another sort of double-lens model for investigating the nature of clinical inference.¹ The important feature here is that two subjects are involved but the stream of information is only in one direction, namely, from the observed, through various tests scores and other cues, to observer. Another invention has been a single-lens model

¹See Figures 12 and 13.
Fig. 13. A lens model of clinical inference (Hammond, Hursch, and Todd, 1964) and a lens model of interjudge comparison (Naylor and Schenck, 1966).
for comparing two judgments of a response (Naylor and Schenk, 1966). Naylor and Schenk's picture shows the kind of distinct correlational indices that are available from data prepared in the lens model frame.

On teacher-student interaction

The models described in the previous pages are relevant to an analysis done by the classroom observer. However a model for teacher-student interaction presents some difficulties in its adaptation. First of all, the interpersonal cue variable must be given great significance in the study of teaching action in classroom behavior (see Figure 13). These cues mediate communication between the teacher and the student. But problems are evident here, as the teacher's "proximal" traits—dispositions, intended meanings, etc.—may be imperfectly represented at the student focal point, and student internal activity and attention may not be fully transmitted to the teacher. Second, it is also important for theoretical purposes that the model lead to ideographic rather than nomothetic research. In operational terms, this means that the variables included in teacher-student interaction have to be studied longitudinally with single teachers in their various teaching situations, as they vary over a number of teaching situations ordered in a time series, i.e., minutes, days, weeks or years, or teaching cycles, lessons, courses,

\footnote{See Figure 14.}
Fig. 14. Circuit-lens of Teacher-student classroom showing central, proximal, and distal levels of longitudinal analysis (Snow, 1967).
etc. The main purposes are: (1) to study variation in cues across units, (2) to discover natural organization within these variables and (3) to relate these fundamental behavioral characteristics to the subjects involved. Following Snow's expositions (Snow, 1968) it is possible to quantify various behavioral characteristics of a single teacher—i.e., the use of gestures, vocal tone changes, emotion-laden words, etc.—as they occur in videotape recordings of teaching cycles, and to relate these to similar recordings of student behavior in the same setting. It is also possible to assess groups, factors, or other systematic patterns of teacher-student variables. These sorts of variables may also be related to uniformly collected physiological data, self ratings of attitudes or observer ratings of various teacher qualities such as anxiety, warmth, preparation, motivation, etc. Such groups of data are represented as proximal traits. As Snow explains "historically, research on teaching has sought to move from more general variables found in the outer, distal regions toward or across the inner central regions of specific classroom behavior. Attempts to construct such relationships have met with limited success, perhaps because of a kind of "principle of correlation distance" (Snow, 1968, p. 482). The farther apart two variables are from each other in terms of regional reference, the greater the number of probabilistic connections that must be bridged between them and, hence, the lower the correlation. It has been contended that the teacher's personal characteristics and student test performance have been particularly difficult
to assess because cue variables and proximal traits have been left out of the probabilistic chain. However some coherence beyond that time has been found in the characteristics of teachers and students that can be taken as indices of individual differences. This is of course in combination with data from corresponding analysis on other teachers or students that can be related to other personal characteristics or experimental variables (See Figure 15).

In short: (a) microanalysis of teaching acts may be connected with more macroanalysis supporting conceptions of teachers and students as persons engaged in psychological development outside the classroom; (b) differences between subjects in this sort of analysis may be used to evaluate the effects of previous experimental variables imposed, for example, in a teacher training program. Thus while the proposed methodology is basically correlational, it allows the effects of training treatments on single dependent variables to be traced out into the multivariate context of real classroom behavior.

Representative design and educational research

Internal validity, external validity, population validity and ecological validity in educational research.

In looking for the possible limitations in the validity of educational experiments some authors (Campbell and Stanley, 1963; Bracht and Glass, 1968) have made accurate distinctions between internal validity and external validity. Hence, the stronger research that has been done on the latter two
Fig. 15. Data matrices relevant proposed analyses (Seibert and Snow, 1965)
kinds of problems, namely population validity and ecological validity, have been concerned with external validity. In studies dealing with population validity it is possible to explore issues involving generalization from specific examples, the use of experimentally treated populations of students and the possibility that personal characteristics might be mutually influenced by experimental variables that can restrict generalizations about treatment effects. In problems dealing with ecological validity it is possible to study descriptions of independent variables, multiple treatment interference, experimenter effects, pretest and post-test results, measurement of dependent variables, history and treatment interaction, etc.

External validity and representativeness in educational research.

There are two main problems in dealing with external validity. One is that the experiment does not cover the essentials of behavior obtained in research, and the other is that the experiment does not always constitute the most accurate instrument for describing this behavior as it really is. Only this relationship termed "representative validity" by Egon Brunswik applies as it did in psychology to modern educational research, correcting the deficiencies of external validity.
Representative validity, representative design and research on learning in school and laboratory settings

In Brunswik's view psychological investigation in the laboratory removes perceptual variables from the context of nature. If, for example, we study two cue variables for size perception as correlated with the normal external world, they cannot be treated adequately in an experimental laboratory setting that considers them independently and relies on orthogonal factorial designs. This pattern is, in Brunswik's words artificial and directed to systematic design and molecular reductionistic goals. On the other hand, representative design is molar, functional, probabilistic and adjusted to real environmental locations. In accordance with these premises—which also work well in educational research presentations—Brunswik worked out some correlational methods to describe the behavior of subjects in perceptual constancy experiments and also sometimes used his subjects in attempts to probe various mental attitudes in making perceptual judgments. The subjects were—as previously noted—behaving naturally while experimenters practiced only a sort of noninvolvement control. All this ultimately means in Brunswik's opinion that (1) human beings are intelligent, active, flexible and adaptable; (2) human beings are able to operate on the basis of information from a probabilistic environment and (3) any methodology that treats of human subjects must cope with all these factors rather than trying to adapt selected factors to an artificial design.
The representative design in educational research.

The concept of representative design has never been developed in educational experiments. Many authors on educational research (Campbell, 1957; Bracht, 1970, et al.) have quoted Brunswik's conceptualizations, but almost none has gone further with them. One important reason may be that most educational experiments are carried on in schools and thus are believed to be ipso facto representative. But this is only one reason; another is that educational experiments must actually be representative. To make them so, some of those psychologists who look more to biology rather than to physics in constructing a scientific operative model have stressed the value of ecologically oriented research in psychology, as have other authors (Cattell, 1966; Sells, 1966; Perebom, 1971) in constructing educational designs. Usually educational experiments are carried out under the systematic design pattern, so that only a few independent variables are controlled and what the learner really absorbs in the meaning is disregarded. In Brunswik's terminology we would say that most educational experiments are not externally or ecologically valid.

The nature of generability: external validity in educational experiments

In treating of population validity, three degrees of conceptualization may be considered in deducting from empirical data: First, generalization from the observed sample of students to the available population from which it was derived; second, generalization from the available population to the
target population with which one is finally concerned; third, translation into intelligible terms of the meaning of the generalization in relation to the events being studied. Note that the first two degrees of generalization are statistical based on a random sampling of students from populations. The sample is then considered representative of the ultimate target population. However, random sampling is rarely attained in the first instance and never in the second. Usually, neither population is even adequately defined or described. Nevertheless, the researcher need not be especially troubled by these progressive statistical operations, especially in the first instance (Lindquist, 1953; Cornfield and Tukey, 1956; Bracht and Glass, 1968).

Generalization can proceed, for example, from this first sample to a hypothetical population assumed to have similar characteristics. The key to generalization in the first and second degrees is in the description of student characteristics.

Treatment effects and generalization

When outstanding significant characteristics of learners are sampled in a limited way, research generalization actually reveals itself to be doubtful. To cope with the problems that appear in the process, namely, the treatment effects, a new tool has been developed in the ATI or aptitude-treatment-
interaction. Some of its applications have been done in the field of aptitude for learning, while others have been in the broader field of instructional progress. A proper representative design in relationship to population validity would be one in which random sampling of the subjects was done with extreme care and posterior reliability. As is well known, almost all empirical education studies omit this and, thus, the only recourse is to go ahead employing detailed descriptions of the populations and samples as well as the testing of interactions. Using special care in this regard, description and analysis can be carried out indicating some of these relevant and dependent variables: sex, age, I.Q., previous research on the subjects, etc. In Snow's opinion (Cronbach and Snow, 1969), this sort of study is quasi-representative in relationship to population characteristics. Of course exercising with the personal characteristics of the subjects makes "statistical analysis untidy and may weaken it, since classical factorial design and analysis of variance may be compromised or lost in the process surplanted by regression methods, path analysis and other incompletely developed correlational

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3 The topics of cognitive style and aptitude-treatment interaction (ATI) have recently interested many educational psychologists and educational researchers. In 1957, Cronbach stated that "Ultimately we should design treatment, not to fit the average person, but to fit groups of students with particular aptitude patterns. Conversely, we should seek out the aptitudes which correspond (interact with) modifiable aspects of the treatment" (Cronbach, 1957, 671-684).
approaches" (Snow, 1973, p. 10). But the contradiction between methods is one that has to be accepted for the present in the evolution of educational research.

Ecological validity and quasi-representativeness

Ecological validity refers to the property inherent in habitats or situations selected for an experiment as being representative of the situations about which the investigator intends to generalize (Brunswik, 1956; Cronbach and alt., 1972). In ecological validity, as previously mentioned in the instances of population validity, treatments are sampled from "a target universe of treatments, whether the investigator recognizes this explicitly or not. And one can conceive of intermediate accessible universes of treatment as, for example, the teachers in a given school, or the subject matter with which a particular investigator is familiar" (Snow, 1973, p. 11). However treatments have rather different features, each from the other. For instance in a sample of treatments those of experimental interest vary as do others with many peculiarities as well. Some of these will often interact with those being studied forgetting that one of the present basic aims of experimental research has to be the control of the extraneous variables. Isolation and orthogonalization of key variables in factorial design and the assessment of their independent effects by analysis of variance has been the common strategy
in conducting educational research experiments. Hence some student characteristics constitute a series of continuous variables whose treatment is continuous, but, paradoxically, the systematic experiment holds only a few treatment conditions. In summary, no progress has been made in studying the dimensionality of instructional treatments and no taxonomy is available similar to the ones used to characterize student differences. We rarely have an idea of how the subjects see themselves, neither how they would be described in multivariate objective observations made during the experiment. We need a representative design of ecological validity sampled from the universe of treatments that is to be the target for future generalizations. But since this is rarely possible there is no recourse but to make a detailed description of the universe being studied, and try a sample of treatments and then test the interactions. Quasi-representative design directed to treatment characteristics demands methods that permit these characteristics to covary as they do in nature.

Referent generality and external value of experiments.

The term "referent generality" is used to point out the range of freedom in a possible experimental outcome measured in a given study. While stressing the fact that students and their experimental treatment must be characterized by many dimensions, some authors insist on the necessity of treating learning outcome as multivariate. While in Brunswik's opinion analyses can be
carried out in terms of the concept of the regional reference of psychological variables, educational experiments are used to deal only with the measure of immediate achievement in fields such as memory, reasoning, etc. Hence, the value of referent generality of an experiment should refer to the spread of the effect, the number of anticipated outcomes and their influence on pervasive characteristics of the subjects. The educational investigator in "referent generality" may select a sample of dependent measures to represent several regions of reference. We are now familiar with the possibility of applying Brunswik's regional classification of variables to teacher-student interaction. In Figure 16, we see the possible spread of effect of treatment to more distal outcomes with increasing referent generality.

Changing from the representative to quasi-representative settings.

It appears, in Snow's words (Snow, 1973, p. 14) that "true representative design, while perhaps attainable in some fields of research, is largely unattainable in educational experiments. The only thing we can do is to reach a sort of compromise between ecological imperatives and representativeness. In checking all the alternatives exposed until now, it seems reasonable to move from systematic to more representative designs (Campbell and Stanley, 1963). This move can be ordered in the following steps:

1. **From laboratory to school.** In the search for representativeness
standard experiments should move as unobtrusively\textsuperscript{4} as possible into actual school rooms in an attempt to be representative of the environment and the usual stream of everyday events.

2. \textit{Systematic replications}. Any investigator conducting his systematic experiment in two or more places is carrying out a systematic replication. He may vary only the subjects, looking for additional population representativeness. He may also vary teachers, methods, context and material to be learned, looking for larger ecological representativeness. However, while replication supplies a significant step toward generalization, it is not in itself sufficient.

3. \textit{Intraexperiment observation}. Some questions arise on what the subjects are actually doing during the experiment, how they perceive the experimental treatment and how it affects them. The results of several experiments strongly suggest that investigators should take detailed accounts of what occupies the subject's thoughts during the experiment. But the traditional emphasis in systematic design has been on events at the boundaries of the experiment, neglecting the events occurring within the pretest and the

\textsuperscript{4}Unobtrusive measures (also called non-reactive measures) refer to social sciences research data not obtained by interview or questionnaire. They intend to set up a new method against the overdependence upon a single, fallible and weak one. They stress also the necessity for a multiple operationism, a collection of methods combined to avoid sharing this weakness (Webb, Campbell, Schwartz, et al., 1965).
posttest situations. There is always the possibility of adding a control group while allowing the subject group to behave in its characteristic way.

4. **Additional experimental observation.** Additional observation is a further move toward representativeness. A large number of experiments are carried on without consideration for the context in which they exist. For example, material to be learned in the experiment is not continuous with the subject matter of the course, some experimental conditions are more disruptive than others for some subjects, etc. Some solutions would include:

- **(a)** to observe such situations and detect disturbing effects, including novelty;
- **(b)** to describe quantitatively the social context in which the experiment is carried out;
- **(c)** to explore the recent past and the instructional and social history of the students and the classroom situation. All these features add valuable information on ecological representativeness.

5. **Preparation of students.** The representativeness of an experiment is intensified if the learner's behavior is adapted to a task as similar as possible to tasks that are typical of the ordinary school learning situation. Brunswik's establishment of different attitudes in the perceptual process is an example of the use of preparation in experiments. One might, for instance, train some groups of learners to function systematically in different ways during educational experiments in which other groups remain free to make their usual approaches to learning. These kinds of experiments may also help to clarify the kinds of artificial behavior that appear in systematic
design, thus stressing the value of the representative ones.

6. Continuum of treatment. The duration of instructional treatment has to be determined using time samples of sufficient length. As is well known, there tend to be experiments in which the subjects are exposed to learning material for only a few minutes. The longer the treatment, the broader the experimental effects and in relation to extraneous influences. These effects, however, are to some extent more beneficial in the context of Brunswikian representative design inasmuch as they can render the experimental treatment more similar to the natural situation of school learning. Some of the benefits of a longer time element are (a) repetitive application of treatment and (b) increased number of occasions on which criterion measurements can be obtained.

Sampling experimental effects.

As illustrated in Figures 16 and 17, there is a wide range of possible measures for an investigator to consider in drawing up his dependent variables. First of all, his choice will be based partly on his experimental conditions and what primarily influences them, and partly on the economy of research. Secondly, it may also depend on some theoretical conception of the texture of the framework of causal relationships concerning the phenomenon with which we are dealing. If the researcher can build hypothesized chains or sequences of effects, and/or perhaps alternative chains, he can sample representatively
Experimental treatment imposed
Intra-experiment observation of
specific effects
covert and overt learning activities
other learner (and teacher behavior during experiment)
specific content toward similar content
achvmt. reasoning
factual memory
retention
transfer to similar content
to dissimilar content
central proximal distal regions of reference

Fig. 16. Schematic scale of referent generality for outcome measures in instructional experiments (Snow, 1973).
Fig. 17. Schematic scales of population and ecological representativeness in instructional experiments (Snow, 1973).
from the assembly of possible variables settled along the chain. The cluster of measurements will be useful in judging the referent generality of his experiment.

An example of ecological-educational representativeness.

One interesting example of ecological-educational representativeness is that carried on by Seaver (Seaver, 1971). In this study, both positive and negative expectancy are clearly shown in a natural setting without continued systematic circumstances subjected to a doubtful validity. This author worked with archival data on 79 pairs of siblings who had attended the same elementary school within three years of one another. The pairs were separated according to whether or not the siblings had had the same teacher or different teachers in the first grade. Then the older sibling of each pair was judged "good" or "bad" on the basis of first-grade IQ and achievement scores. Within this four-fold table, achievement scores of the younger siblings served as dependent measures. It was found on four achievement subtests that younger siblings of good students had higher achievement scores if assigned to their sibling's teacher than if assigned to a different teacher. However, younger siblings of poor students did better when given a different teacher from that of their older siblings. In short, Seaver's study is more representative ecologically than any of the usual educational experiments, but it is also limited in terms of population validity and referent generality. As a correlational
study, it is open to some alternative interpretations in reference to causation. Thus, the teachers may not have been instrumental. More observation of pupils and teachers would be necessary to define possible mechanisms, etc. In other words, ecological variation was permitted but not studied in detail. Nevertheless, a range of such studies presenting consistent results would achieve a level of descriptive generality that could be highly useful in developing a richer conceptual basis for future educational scientific experiences.

Recapitulation

In this description of Brunswik's influence on educational research it has been suggested that: (a) systematic experiments can be made more representative by adding improved design characteristics (see Figure 17) and (b) that, however they neither supply an operational taxonomy nor point out possible combinations of design characteristics. If we look carefully at Figure 17, and combine the three dimensions of quasi-representativeness, we discover: (1) a dimension for population representativeness running from studies with minimal sample description through studies that analyze aptitudes specifically selected for their relevance to treatment variables; (2) a dimension ranging from laboratory experiments to experiments or naturalistic studies in which ecological variation is both allowed and investigated and (3) a continuum
of outcome measures increasing in referent generality. These three measures are not, of course, orthogonal in describing the basic traits of past and future in educational research. In a logical and theoretical order, these three dimensions are rather different, and they point to distinct strategies. But they lead to an operative decision, which is to say that there is a place for artificial laboratory investigation as well as systematic experimentation in schools, and that there is also at the present time space for quasi-representative experiments and naturalistic-quantitative case studies. The selection of a particular design at a particular point must be made in accordance with the exigency of ecological necessity.


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APPENDIX A

A SIMPLISTIC DESCRIPTION OF PSYCHOLOGICAL AND EDUCATIONAL TERMS RELATED WITH BRUNSWIK'S CONCEPTUAL BODY
A SIMPLISTIC DESCRIPTION OF PSYCHOLOGICAL AND EDUCATIONAL TERMS RELATED WITH BRUNSWIK'S CONCEPTUAL BODY

Achievement

The degree or level of success attained in some specific area.

Achievement motivation

An inferred specialized characteristic of the human being that is learned early in life, causing him to strive for bigger and better accomplishments. Achievement is generally considered to be a significant social goal and, as such, an incentive that pressures people to strive for higher standards.

To measure achievement motivation, a group of Harvard psychologists carried on research using a modified thematic apperception technique. Subjects were asked to create stories about sets of pictures presented to them. From their creations, a need achievement score was obtained, measuring a probable indicator not only of the
subject's need for successful accomplishment but also the extent of his need either to avoid failure or to forget failure experiences (Atkinson, 1958; McClelland, Atkinson et al., 1953; McClelland and Winter, 1969).

**Adaptation**

Change in structure or behavior that has survival value; now, more generally, any beneficial change to meet environmental demand. In a more reduced but related sense, "sensory adaptation" is the maintenance of sensory effectiveness under changing conditions of stimulation. See also "adaptation level".

**Adaptation level**

Adaptation level (AL) is the hypothesized neutral point or region of organic functionalism at which coinciding stimuli are indifferent or ineffective, stimuli above AL having a given character, and stimuli below AL having an opposite or complementary quality. AL represents the pooled effect of three classes of factors: (a) stimuli immediately responded to, or in the focus of attention; (b) stimuli having background or contextual influence; and (c) residuals from past experience with similar stimuli. Quantitatively, AL is the logarithmic mean of these three classes of factors weighted according to relevant dimensions of effectiveness, e.g., size, nearness, intensity, quality, affective value, significance, etc. (Helson, 1947, 1959).
Adjustment

A state in which the needs of the individual on the one hand and the claims of the environment on the other are fully satisfied. This state of harmony is of course expressible only in theoretical terms, since in practice no more than a relative adjustment is reached in the sense of optimal satisfaction of individual needs and untroubled relation to the environment. Adjustment takes the form of variation in the organism through the acquisition of responses appropriate to the situation; the variation in the organism may be biological. See "adaptation" and "adaptation level".

Albedo

Quality of being (-edo) white (alb-); the whiteness of a surface. The percentage or fraction of incidental light or radiation reflected by a surface (as the moon, the ground, or snow). An albedo of 50 percent of the light falling on it. Coined by German mathematician and philosopher Johan H. Lambert (1728-1777), who said that albedo was the refractive quality of light that was diffusely reflected by a body (Berelyne, 1958).

Analysis of variance

Analysis of variance (ANOVA) is a statistical procedure that involves partitioning the total sum of squared deviations of scores into components, each part being associated with some experimental variable.
or with chance. In the samplest case, analysis of variance involves the ratio of two sources of variation: 1) the variation of scores around their sample means and 2) the variation of sample means around the population means. This ratio, called an F ratio, is given by

\[ F = \frac{MS_{\text{among groups}}}{MS_{\text{within groups}}} \]

If the preceding two variance estimates are really estimates of the same population variance, the F approaches 1.0. If the sample variance of means around the population mean is greater than the score variance around the sample means, the sample probably do not represent random samples from the same population. In this case, the F ratio is greater than 1.0. In general, analysis of variance is used to test statistical hypothesis concerning two more population means.

**Analysis of covariance**

A statistical technique combining advantages of linear regression analysis with analysis of variance methods. Analysis of covariance allows the dependent variable to be adjusted so that the effects of the uncontrolled error variance can be removed from the concomitant variable. Thus, it helps control nuisance variables. Analysis of covariance, however, requires not only the usual assumptions necessary for the analysis of variance approach but also demands progressively more involved assumptions concerning the regression effects. Additionally, it is more laborious to compute. See "analysis of variance".
Arc

Nervous arc or circuit is the path taken by a neural impulse travelling from a receptor through one or more connector neurons to an effector or executive organ.

Case history

A collection of all available evidence - social, psychological, physiological, biographical, environmental, vocational, etc. - that promises to help explain a single individual or a single social unit, such as a family. It is used particularly in psychopathology, guidance, and social work. Since it emphasizes the single case or instance, it differs in aim from an experiment and from statistical studies. But the case study often incorporates data from experiments or tests, and a series of case studies may be subjected to statistical study and generalization.

Cluster analysis

An analysis of trait intercorrelations, based on clustering those traits (or items) showing similar patterns of inter-item correlations. The method is more superficial than factor analysis, for which it sometimes substitutes. See "factor analysis".

Cluster sampling

A procedure for restricted random sampling that involves dividing the population into clusters and then taking a random sample from each cluster or from different clus-
generally, clusters might be obtained by putting every pupil's name on a card, shuffling the cards, and piling them in groups of equal numbers, each pile being a cluster. Clusters need not be equal; thus, a cluster differs from a stratum in that its essential quality is its concern with a homogeneous group of individuals. Generally, a cluster sampling is considered an integral part of area sampling. See "sampling techniques".

Consistency index

A means of determining the extend to which the members of a group give the same responses to the same stimulus or task at a state time:

\[ i = \sqrt{\frac{1}{N} \cos \pi - \frac{(BC)^{1/2}}{(AD)^{1/2} + (BC)^{1/2}}} \]

Where \( A \) = number of responses both times; \( D \) = number of responses omitted or denied both times; \( B \) and \( C \) = number of responses present one time and not the other respectively; \( i \) = consistency index.

Constancy

The constancy hypothesis is the postulate that there is a strict parallelism or correspondence between the local or proximal stimulus and the sensory response or sensation, so that the sensory response to the same stimulus occurs in unaltered form, no matter what the attendant circumstances. The theory is attributed by Gestalt theorists to their opponents; in its strict form, it is subscribed probably by none.
Perceptual constancy

A person's tendency to perceive experience as expected, as being relatively stable under diverse conditions of stimulation, such as in environmental variability. The tendency of perceptual responses to be relatively independent of environmental alterations, so that one perceives objects as constant (same size, shape, color, etc.) even though they stimulate sense receptors differently. Perception constancy does not operate if a reduction screen (which eliminates context cues) is used to view an object. Because of color constancy, for example, hues tend to be correctly perceived in spite of changes in illumination; because of size constancy, background or foreground objects tend to be perceived in terms of their objective sizes. One tends to correct for illumination differences (brightness constancy), for angle of view (shape constancy), or for distance (size constancy). Perceptual constancy, in social psychology, has been studied in relation to expectancy of outcome.

Covariation

Covariation or correlation coefficient is the degree to which two or more variables vary together. The parallelism between variables is usually imperfect; the measure of the degree of concomitance is the correlation coefficient. The correlation coefficient is a number that indicates the strength of the tendency of two or more variables to vary concomitantly. Perfect correspondence between the two is expressed by -1.00; complete lack of correspondence, i.e., independence of the two variables, is expressed by 0.00. Fractional va-
lues of the coefficient are not to be read as percentages. The product moment correlation or "r" is most frequently used, and this coefficient is meant unless the context shows that an alternative method of computation has been employed. See "correlation".

**Control**

Scientific or experimental control is regulation of conditions so that the effect of a given supposed cause is clearly and unambiguously displayed. Included in this general meaning of scientific control is the systematic variation of the experimental (or treatment) variable. When control is used concretely, however - i.e., for a particular control - it refers to any intentional modification of conditions other than in the experimental variable, such changes being made to insure that the effect being measured is really a function of the experimental variable.

From this concrete meaning of control are derived the concepts of "control group" and "control experiment", series, or test. A control group consists of a number of persons who are not exposed to the experiment variable but are exposed to as many as possible of the other conditions in the experiment, the purpose being to insure that the effects under examination are not the results of differences in the persons. The control group should be representative of the population for which a generalization is to be made. A control experiment or series or test is a repetition of a previous process with or without a change in conditions other
than those involved previously, to determine whether the same cause-effect relations hold. The control experiment or series often includes checks on the functioning of apparatus, the clarity of the instructions and any changes in collateral conditions such as time of day. The basic notion in control is negative; one seeks evidence that the experimental results are not due to irrelevant variables.

Correlation

Correlation coefficient is a statistical value that indicates the degree of relationship between two or more variables. Correlation coefficients vary between -1.00 and +1.00; 0.00 indicates the complete absence of any correlation, while the coefficients -1.00 and +1.00 indicate a wholly negative or positive correlation. Correlation is evidence of relationship but does not necessarily indicate a cause-and-effect relation.

The term correlation was introduced into mathematics in 1708. Auguste BRAVAIS (1811-1863), French mathematician, worked out theorems of correlation in 1846; Galton used correlation concepts from 1877 and particularly in 1885 in his regression studies; Karl Pearson developed mathematical concepts of correlation in 1896. See "covariation".

Criterion

A standard selected as the goal to be achieved in a task. A set of scores or some other measure of performance against which the success of a productive test is ve-
rifled or compared. For example, a supervisor's rating of a worker's performance on the job is a criterion for judging the validity of an aptitude test. The criterion variable is the variable used to test another variable or by which another is judged.

**Cue**

A cue is a signal for action. That specific portion of a perceptual field or pattern of stimuli to which an animal has learned to respond. It is usual to restrict the meaning of cue to that which produces an operant response, but it is also used to denote that which arouses expectancy.

A cue is also an identifying mark that permits discrimination or recognition of a stimulus pattern. The term cue is particularly appropriated in denoting a mark that is an obscure part of the stimulus or an accidental concomitant. If the cue stimulus is very faint and not specifically attended to, it is called a "minimal cue".

**Culture**

The pattern of those arrangements, material and behavioral, whereby a particular society achieves for its members greater satisfactions than they can achieve in a state of nature. It includes social institutions and knowledge, belief, art, morals, custom, and any other capabilities and habits acquired by man as a member of society.
The localization of perceived objects in phenomenal (perceived) space in regard to the distance between the objects and the individual (egocentric depth localization, or absolute depth localization), or in regard to the distance between the objects themselves (relative). Depth perception can occur in various modalities, though most precisely in the visual modality (the term often means only one's awareness of the distance between one and the visually perceived object); it also occurs in hearing (loudness, frequency spectrum) and in some animals through use of tactile-optic sensors. In man the sense of smell plays hardly any part in depth localization. Although different senses can be implicated, a unified impression of phenomenal distance is obtained (unified phenomenal or perceived space, also active space).

Design

Two sorts of design are specifically considered here: experimental design and representative design.

Experimental design is the testing of hypothesis in regard to the dependence and interdependence of variables. In a "design" of this kind, it is possible to plot the effects of one or more independent variables on one or more dependent variables. In general, experimental design refers to measures adopted to ensure that the planning and procedure of an experiment use all available appropriate information and as far as possible take into account all implicated factors. In this sense, ex-
perimental design includes selection of behavior to be observed, precise formulation of the hypothesis to be tested (choice of the appropriate statistical procedure before carrying out the experiment), and determination of the sample size and control variables in accordance with the precision of the statistical test chosen.

Representative design seeks to give effect to all relevant variables in such way as to represent their frequency of occurrence and range of variation. It combines experimental with statistical manipulation of variables. See "ecological validity".

**Differential psychology**

Differential psychology is concerned with the nature and origin of individual differences in psychological traits. Such differences are not limited to man, but occur throughout the range of the animal kingdom. Psychological studies of animals, from one-celled organisms to anthropoid apes, reveal wide individual differences in learning, emotionality, motivation, and other behavioral characteristics. So great is the range of these characteristics and differences within individual species, that the ranges of performance often overlap even when widely separated species are compared. When submitted to the same learning task, the brightest rat in a group may excel the dullest monkey.

Although in the popular mind persons are often thought of as belonging to distinct categories, (dull vs. bright, excitable vs. calm), actual mea-
Measurement of any psychological trait shows that individuals vary in degree along a continuous scale. In most traits, the distribution approximates the bell-shaped normal probability curve, with the greatest clustering of cases near the center of the range and a gradual decrease in numbers as the extremes are approached. First derived by mathematicians in their study of probability, the normal curve is obtained whenever the variable being measured results from a very large number of independent and equally weighted factors. Because of the extremely large number of hereditary and environmental factors that contribute to the development of most psychological traits, it is reasonable to expect that such traits should be distributed in accordance with the normal curve (Tyler, 1965).

Distal

The distal and proximal variables are those that in the total chain of events constitute an act or behavior; those located at the boundary between a body and its surroundings are called proximal, those more remote from that boundary are called distal.

A proximal stimulus acts directly on the receptor—e.g., the light wave at the surface of the eye ball or as it impinges at the retina. A distal stimulus is any event in the environment causally related to the proximal stimulus—e.g., the energy of light at the source or at a reflecting surface (the latter being less distal than the former). The distance of an object, as distance, is also a distal stimulus. A proximal response is the actual movement of muscles; a distal response is the
part of the executive aspect of an act that is measured by its effect in altering the environment-organization relation. The movement of writing constitute a proximal response, the words written are the distal response. Stepping movements are proximal, arrival at the far side of the street is distal.

The proximal is correlated with the distal (whether stimuli or response are in question) but does not stand in one-to-one relation with it. This fact is the basis for what Brunswik calls representative design. See "design", "distance" and "response".

**Distance**

Distance is first of all the linear distance between two psychological data represented in the same spatial schema. Distance is also the degree of difficulty one person experiences in psychological relationships with another. The difficulty may be due to a sense of difference in manners, ideology, personality, or status; or to an awareness of inapproachability or unfriendliness. Psychic distance in this sense is topologically described as a function of accessibility to one personality of the several regions of another personality, or of the amount of communication possible between their respective central regions.

**Eclecticism**

In theoretical system building, eclecticism is the selection and orderly combination of compatible features from diverse sources, sometimes from otherwise
incompatible theories and systems; the effort to find valid elements in all doctrines or theories and to combine them into a harmonious whole. The resulting system is open to constant revision even in its major outlines. A general temper of mind seems to determine the degree to which a systematizer searches for the maximum in rational order and over all consistency (with resulting temporary loss in exclusiveness and explanatory power), or for the maximum in understanding of particular issues (with some loss in the tightness of organization). For the later approach, eclecticism is an established term; for the former there is currently no good name, but "formalism" perhaps describes its chief attribute. Formalism leads to the advocacy of competing schools and theories; eclecticism, though often called a school, is essentially the denial of schools. Eclecticism is to be distinguished from unsystematic and uncritical combination, for which the term is "syncretism". The eclectic seeks as much consistency and order as is currently possible; but he is unwilling to sacrifice conceptualizations that put meaning into a wide range of facts for the sake of what he is apt to think of as a premature and unworkable overall systematization. The formalist thus finds the eclectic's position too loose and uncritical. For his part the eclectic finds formalism and the schools too dogmatic and rigid, too inclined to reject, if not facts, at least helpful conceptualizations of fact. Few psychologists, however, occupy a fixed position on the continuum that runs from eclecticism to formalism. See "theory".

**Ecology**

Study of all interrelated factors pertaining to
the environment or habitat. Originally only of biological significance the concept has become of increasing psychological importance in the study of animal psychology and ethology. The German equivalent of the word was coined by Ernst Henrich HAECKEL (1834-1919), the German biologist, in his work "Naturaliche Schopfungsgesichte" (1868).

Ecological psychology refers to the area of psychology concerned with the study of its relationships to the environment. Ecological psychology embraces the molar behavior of man in relationship to all possible factors that might affect him. Barker considers the basic problem of ecological psychology to be the manner in which psychology copes with "non-psychological inputs". The ecological environment is the natural, objective real-life setting within which each living organism behaves.

Whereas a person's life space determines his momentary behavior, the ecological environment provides the situational context necessary for him to behave meaningfully as a total human being. According to Barker and his behavior setting theory, "the environment is a set of homeostatically governed eco-behavioral entitie consisting of nonhuman components, human components, and control circuits that modify the components in predictable ways to maintain the environmental entities in their characteristic states" (Barker, 1968, p. 186).

Lewin as early as 1936 suggested that the real environmental situation and the individual's experience of his own environment might be studied under what he called "psychological ecology". But he made no further reference to this relationship in his field theory. See "environment" and "molar".
Educational psychology (specifically in reference to learning and teaching processes).

One of the important tasks of educational psychology is the investigation and theoretical elucidation of learning processes. Today the significance of the biological and constitutional bases of learning processes is generally accepted (Burt, 1949; Newman, Freeman and Holzinger, 1937). The elucidation of the individual state of development, of personal capacity at a particular moment of time, plays an important part in the investigation of human learning processes (McGeoch and Irion, 1952; Gagné, 1967). Stimuli for novel research work are offered in the postulates of Gagné (1967), who holds that human learning—insofar as it can be independent of variable conditions—occurs in various forms, whose interaction can be expressed by a hierarchical ratio of interdependence. An emphasis on the human aspects of learning processes is accompanied in more recent educational research by an emphasis on their social context (Backman and Secord, 1968). In addition to the analysis of learning processes, research into the conditions for and functions of teaching is a primary area of educational psychology. In this regard, researchers are concerned both with general instructional methodology (Bloom, 1956, 1964) and the analysis of styles of teaching and the roles of educators (Aebli, 1961; Hermann, 1966). Investigations of the effects of specific dimensions of teacher behavior (Tausch and Tausch, 1965), or of the interaction of teaching style and learning performance...
are examples of a current direction of research in this area. The effects of education on motivation (Heckhausen, 1966), the optimal arousal of interest by specific teacher strategies, the extensive field of curriculum studies (Achtenhagen and Meyer, 1971; Bruner, 1960, 1966) and instructional technology (Skinner, 1968) are also important areas of investigation.

**Empirical**

At least six distinct meanings can be assigned to the term empirical: (1) in relation to facts or experience; (2) in evaluating facts and disparaging or subordinating theory or speculation; (3) in proceeding without guidance from theory; trial and error investigation (this is never possible in an absolute sense); (4) as a generalization not based on, nor as yet related to, a superior generalization or theory; (5) in reference to experimental knowledge; (6) having a basis in factual investigation. The term is sometimes one of price (avoiding "empty" speculation or mere theorizing); sometimes one of disparagement (lacking necessary rationality or theory, unsystematically gathering facts). Usage (5) seems to introduce unnecessary duplication. Usage (6) in referring to experimentation and all other systematic collection of data, is the one most useful to modern psychology. The meaning of the term empirical contrasts with, but it is not necessarily opposed to, the terms a priori, rational, or deductive.

**Empirical law**

A law based on data (i.e., on facts or observa-
tions) and expressing in general form the invariant relationships between two or more sets of data (i.e., two or more variables). It contrasts with the concepts of rational law, deductive law, and a priori law, each of which designates a general statement of relations that does not, at least, immediately, rests on data or observations.

Empiricism and scientific empiricism

The philosophical view that experience is the only source of knowledge and that science must deal exclusively with objectively observable facts. Behaviorism is in this sense a form of empiricism. Some empiricists however accept the view that "observable fact" in any science is a matter of experience (the observed fact that an object has a certain density is provided by experience). But the experience that then constitutes the fact of science is, thus, only the experience of the observing scientist (not subjective experience) stated in physicalist terms. See "physicalism".

Empiricism can also be understood as a science or an art based as little as possible on deduction from general principles and guided almost entirely by inductive generalizations, usually by generalizations having narrow range and not rationally related to each other.

Scientific empiricism is somewhat diffuse philosophic movement that seeks to establish a science of sciences. It holds that the instrument of all sciences is the experience of the scientist himself used
as a means of examining the several coherent bodies of facts that constitute the various sciences. Statements about experience must be operationally defined. The movement calls for studies of the language of sciences and the principles governing the building of theory around empirical facts. As applied in psychology, the term implies that mentalistic concepts may be used if introduced by operational definitions anchored to changes along a physical or physicalist continuum.

Environment

The sum of external conditions and factors potentially capable of influencing an organism. Not the same as the sum of stimuli, since some of these are internal; and some parts of the environment (i.e., ultraviolet rays) influence the organism without being stimuli. "Milieu" is properly the organism and its immediate environment, but is often used to refer to the latter alone. See "stimulus", "ecology".

Environmental psychology

The study of behavior in relationship to its environmental influences (considering constraints on ranges of behavior as well as freedom to operate), involving such specifics as climatic extremes, crowding, etc., and their effects on setting patterns of behavior (e.g., the behavioral patterns of a salesman in Buenos Aires, Chicago or Los Angeles). Environmental psychology also studies why persons move toward or away from some aspect of a geographi-
cal or environmental location (the approach-avoidance conflict of persons attempting to decide whether or not to live in the sun-smog environment of Tokyo). Considered synonymous with ecological psychology (Whohwill, 1970).

**Event**

A part of reality that changes within space and time limits. The limits may be greater or small according to context: for geologist a centuries-long emergence of a mountain chain may be a single event. But a definite beginning and end, both in time and space, are necessary; and to be one event the processes, activities, or happenings must be somehow related. A phenomenon is relatively stable and generally less extensive grouping of data, so that several phenomena may be said to compose one event. However the two terms are often interchangeable. Event is also a fundamental concept in probability theory. Each possible outcome of an experiment is called an elementary or simple event, an element that is completely abstract. Compound events are constructed from simple events, the outcome of several elements of an experiment.

**Experiment**

An experiment is the planned manipulation of variables for observation purposes; at least one of the variables, i.e., the independent or experimental variable, is altered under predetermined condi-
tions during the experiment; any other variable whose alteration is observed as a function of this change is known as the dependent variable. If an alteration of the dependent variable appears possible, the other variables needed in the experiment are either held constant for the duration of observation (controlled variables, experimental parameters) or disregarded as irrelevant variables. Every controlled variable is therefore a possible independent variable for further experiments. The observation must allow a clear identification of the changes in the dependent variables within the limits of accuracy needed for a particular experiment; the observation therefore requires a measurement at least on a nominal level.

Experimental methods contrast with empirical methods (differential methods), in which a special set of variables is sought for observational (measurement) purposes. Since none of the variables can be manipulated in a predetermined manner during the observation, the distinction between dependent and independent variables ceases to apply; no direct conclusions can therefore be drawn from the results on the direction of the dependence. The definition of the experiment includes consideration of its purpose. An arrangement used experimentally to determine the direction and nature of relations between variables can also be used for measurement - i.e., for other experiments - as soon as these relations are known. Experimental methods are therefore frequently used as empirical methods (tests).

The types of experiments are ordered as follows:
(1) univariate experiments, in which one independent variable is altered and the effect measured on one or more dependent variables; (2) multivariate experiments, in which several independent variables are altered in combination, in such a way that the effects of each variable can be determined separately and their interaction examined. Techniques are described in the literature of experimental testing and evaluation (generally by analysis of variance). Further classification of experiments can be derived from the degree of gradation of the independent variables. In bivalent experiments, the independent variable assumes only two values (e.g., dependence of calculability on the occurrence or non-occurrence of an interfering noise). Although such experiments have only limited value, they are still frequent and sometimes inevitable. They may show whether an effect of the experimental variables can be proved such a demonstration will not be reliable if there is a non-linear or non-monotonous relationship between the independent and dependent variable: an average noise intensity may facilitate performance while performance remains unchanged at higher and lower intensities. Multivalent experiments provide the answer in this case. In the most favorable assumption, nonmonotonous relationships of dependent variables can beforehand be determined using three independent variables. If even more independent variables are used in the functional experiment, it is possible to show the functional relationship with the dependent variable. The corresponding enlargement can also be made in the multivariate experiment: if the functional dependence of a variable on seve-
ral independent variables is determined in this way, we call it a parametric experiment. See "analysis of variance", "multivariate analysis".

**Factor analysis**

One or several mathematical-statistical procedures involving the intercorrelation of a large number of sets or matrices of numbers. Factor analysis starts with the location of a model that agrees with the data and when such a model is found, estimating its parameters. Factor analysis is aimed at discovering, isolating, and analyzing the minimal number of common factors (determinators) that can account for the observed correlation (communality) among a set of variables (items of a test, etc.). Factor analysis shows in summary form the selective importance of each factor as it is sorted out of a more complex population, the factors being preferably fewer in number than the original variables.

There are definite advantages using factor analysis in experiments, such as allowing efficient use and evaluation of all subjects and resources as well as of experimental and interaction effects. Disadvantages lie in the demand for a number of probabilistic subjects requiring different treatments in the large number of experiments required and in the complex interpretations needed as interaction evolves.

**Functionalism**

A movement in psychology whose adherents are prima-
rily interested in finding the answers to the "how" and "why" of psychological phenomena. Originating about 1896, it was sparked by James Rowland Angell and John Dewey of the University of Chicago, after William James and others had gathered the fuel. Functionalism was a revolt against the structuralism of Titchner and Wundt, who studied mental processes as activities leading to practical results. It utilized common sense as part of its field. It was concerned with the active, adaptative, and functional processes of mental life (conscious experience), not solely the conscious "structures", such as thoughts, feelings, and sensations. Functionalism, therefore, led naturally into applied psychology, primarily educational psychology.

The term presents confusion, however, when considered internationally. The schools called "structural" in Europe correspond to those called "functional" in the United States. In Germany, for instance, "functional psychology" and "act psychology" are practically synonymous, with "mental acts" producing "content". German structural psychologists have attacked the very concepts that United States "structural psychologists" have defended.

G e s t a l t

A group of related psychological ideas, developed about 1910-1912 by the German psychologists Wertheimer, Kohler and Koffka, emphasizing holistic concepts, or the unity of an individual or group rather than analysis of its parts or elements. The properties of a
gestalt are properties of the whole as such, and are not derived from the summation of its parts. Conversely, the parts derive their properties from their membership in the whole. The notion of "parts" with attributes of their own, independent of the whole is held to be misleading. The standard illustration is that of a melody, which has qualities as a melody that are not merely the sum of the component tones, but that result from the playing of many instruments at different pitches so that the constituent tones are totally different, yet the melody remains the same. Conversely, a given tone, say B flat, has different psychological (and musical) characteristics in different melodic settings - i.e., its qualities as a part of a whole depend on that whole. This is not to deny that B flat, heard in isolation, is a whole or gestalt in its own right. But such a B flat is not psychologically the same B flat that is heard in a melody.

As applied to behavior, Gestalt theory denies that response to a situation can be stated in terms of a combination of separate responses to a combination of separate stimuli; it is a whole response to the whole situation, with specific components serving as salient figures rather than as distinct elements. Learning is said to proceed, not by accretion, but by reorganization.

Isolation of variables

In an experiment, intentional alteration of a condition (independent variation), in order to observe a dependent variable, while all other conditions are kept constant, or are not altered systematically. The
effect of individual conditions which are otherwise closely bound up with the phenomenon or process can then be observed by isolation. See "variable".

**Longitudinal studies**

Studies concerned with the changes occurring in individuals over extended periods of time, or studies in which samples of a population are selected and then studied intensively as age and experience increase.

**Matching**

An experimental method of control by which subjects under different conditions are rendered similar on the basis of some variable other than the independent variable.

**Matrix correlation**

A table showing the correlation coefficient of every variable with every other variable in a set. The matrix displays each variable at the head of a row and a column; hence, each coefficient occurs once in that portion of the table located above the diagonal running from upper-left to lower right, and once below that diagonal.

**Means object**

Any object, the response to which brings an organism closer to its goal. It may be merely a cue to the proper course of action - e.g., the activity of entering a co-
rrect alley in a maze brings into view some cue indicating that the goal is being approached. The means object can be thought of as a subordinate goal but, unlike the goal (or goal object), it does not bring the action to a conclusion. The means object instigates an expectancy.

Measurement

In contrast to the classical natural sciences, psychology does not have at its disposal a uniform system of measurement. At the present day, the various aspects of behavior that are of psychological interest appear to be so incommensurable that very few, if any, attempts are now made to apply a uniform method of measurement to the individual psychological disciplines. That is why, in the course of the history of psychology, different methods of measurement have evolved for different areas or fields of psychology. Thus, in psychophysics for example, scaling methods are chiefly used; in neuropsychology, methods of measurement deriving from physiology (chemistry and physics, etc.); and finally, in experimental psychology and psychodiagnosics, very diverse methods of measurement, which are described under the appropriate terms.

Measurement theory indicates the conditions (assumptions, peripheral conditions) under which an empirical relative value can be converted into significant numerical relative value with the help of specific models (measurement models). Psychologists have always devoted considerable interest to measurement theory because of the
problems that arise in recording psychological variables. See "variable".

**Mediator**

The system that intervenes between receiver and the transmitter. It combines the function of destination and source. An organism, in its function of receiving and transmitting information is a mediator.

The mediation theory asserts that certain stimuli (usually called signs in this theory) do not directly initiate instrumental behavior but activate an intervening process that is connected in a complex systematic way with many action systems. The mediation theory is described in S - R terms.

**Mentalism**

The doctrine that there is a distinct group of conscious or mental phenomena not reducible without reference to physical phenomena. Traditionally all mental phenomena were supposed to be conscious; but many authorities recognize as distinctly mental (i.e., distinguishable from purely physical processes) a class of phenomena that are not conscious.

**Method**

In the broad sense, a systematic way of dealing with facts and concepts. It includes four different kinds of operations: (1) rational principle, the form of reasoning utilized, e.g., hypothetico-deductive principle, inductive principle (both often called methods); (2) point of view, a way of looking at the
data, or the intention assumed in an investigation, e.g., the nomothetic point of view, the mechanistic point of view; (3) procedure, a specific type of operation or order of attack in a investigation, a bringing into relationship of the variables that bear on the problem at hand, e.g., the procedure of the limits (more often called the method of limits), the nondirective (or client-centered) procedure.

**Model**

A logical, mathematical, or mechanical miniature system that parallels some larger or more complex system. Models are used in simulation studies for predicting, and for comparing one system with another (such as comparing an electronic brain with the brain itself). It also can be described as a set of data in terms of a system of symbols, and the manipulation of symbols according to the rules of that system. The resulting transformations are translated back into the language of the data, and the relationships discovered through the manipulations are compared with the empirical facts.

Psychology has borrowed the "model" concept to help to define, delimit, and express various problems in a more convenient and structural manner. Operations for an abstract model (e.g., an attitude change) are programmed as if for a computer. When certain informational bits are relayed to the human psychological machine, for example, only certain specific and predictable attitudes changes can result. Some classes of mode:
dels are: the algoristic, descriptive, or deterministic type (involving certainty in outcome); stochastic or probabilistic (involving uncertainty in outcome); predictive or relative (for purposes of evaluating potential results); normative models or gaming models (for decision making and development of strategies in which tentative guide lines can be devised and studied, such as in executive games with management and labor unions with various matrices describing the game and subsequent pay off); linear programming models (often used in operations research procedures for determining ratios and relative efficiency of one solution over another); congruity models, etc. Stimulus-sampling is a special example of the use of stochastic model, using a combination of set theory and probability theory (Walker, 1968).

Molar - molecular

There are five possible definitions of molar that in fact refer to the same data. One: molar behavior is a large unit segment of a total behavior stream that possesses essential unity. Two: a unit of the behavior stream whose unity and distinctiveness derive from the end it serves or the effects it produces in the external world. It is not implied that all behavior leading to the same goal belong in the same unit; the molar unit is a unit of actually occurring behavior, not a class. Thus, the varied ways a person behaves in getting to his office—by motoring, walking, etc. are equivalent, but the molar unit consists in the particular way in which he actually did get there. Three: a behavior unit considered an emergent
phenomenon, having qualities not stable as a sum of parts. Four: any behavior that shows docility, i.e., that has been learned and may be further modified by learning. Five: behavior described in non-physical, psychological constructs.

Molar behavior is contrasted with molecular behavior, which refers to a small unit, generally defined in terms of specific movements elicited by specific stimuli, or in physiological terms. As the opposite of an emergent phenomenon, molecular means the behavior unit reached by deductive analysis. This is the method of investigation that holds that analyzed parts are real and that the whole can be completely explained in terms only of the analyzed parts. It is thus the opposite of emergentism and Gestalt, which hold that the whole is more than the sum of its parts. The reductionism of structural psychology attempted to reduce all psychological phenomena to the most elementary psychological processes. Contemporary reductionism generally seeks to phrase psychological problems in stimulus-response terms and to reduce these further to psychological or even psychochemical terms. See "Gestalt", "reductionism".

**Multivariate analysis**

The statistical analysis of data consisting of n-triples (pairs, triples, etc.) of observations, that is, the simultaneous analysis of data for two or more dependent variables. A multivariate distribution consists of data in which more than two measu-
rements are taken for each individual.

Multivariate sampling-distribution theory had its origin in an article published in 1928 by U. Wishart. See "experiment", "variable".

Natural sciences

Natural sciences are those dealing with natural objects, generally taken to include physics, chemistry, and biology and to exclude mathematics, philosophy, and the social sciences. The question whether psychology is a natural science is essentially terminological. Because of its uncertain boundaries, the term is of doubtful value.

Nomothetic - Ideographic

Relating to the search for and the establishing of general laws to explain behavior. An approach to personality study emphasizing the collection measurement of statistics to describe general principles concerning individual differences. Used by educators in studying, for example, large groups of "underachievers", by sociologists in their statistical emphasis upon studying people, and by psychologists (such as McClelland) in developing concepts designed to predict the average score.

The ideographic approach is related to the study of uniqueness in the individual. A psychological viewpoint in which the unique individual is the only proper and final unit of analysis. The clinical psychologists, psychiatrist, social worker, and others using
a case study method, employ the ideographic approach. In 1921 German philosopher Wilhem Windelband coined the terms ideographic and nomothetic in his book "An Introduction to Philosophy". He proposed that ideographic had to be used to gain an appreciation of the single event of a scientific or natural law. Ideographic psychology, for example, is the art of understand people in their uniqueness.

Initially, Allport (1937) considered this method the most productive and reasonable one to use for developing true concepts and laws concerning behavior. In 1962, however, he selected the term "morphogenetic" to replace ideographic, since it did not bear the stigma of being so extreme and restrictive in its focus on uniqueness (Allport, 1937, 1960).

Object constancy

An object is always recognized as the same even when the stimulus context or spatial interval changes. Often an object can still be identified even when it is only visible in part. This constancy of an object depends on the constancy with which definite qualities are perceived, e.g., shape, size or color. To explain this constancy one may refer to the gestalt principle by which perceived objects stand out from their surroundings as complete shapes. When such shape has once entered the memory, it is recognized when seen again, whatever its background.

Operationalism

The doctrine by which terms, propositions, concepts,
and theories derive all their meaning - in the last analysis - through the methods of observation or investigation used to arrive at them; in other words they have no other meaning than that yielded up by the procedures or operations by which the things or processes to which they refer are known. Thus a given mental age means merely that under certain standard conditions the child can perform such tasks as counting backward, fitting blocks into appropriate slots, or reproducing a design from memory. A threshold means only that the individual has made certain judgments when certain prescribed psychological procedures have been followed. It follows that a threshold obtained by one psychological procedure does not have the same meaning as one obtained by another procedure, unless the equivalence is proved by other procedures. In the same way, classical and instrumental conditioning, being defined by distinct operations, must be considered distinct concepts until linked (as some think they have been by common operations. On the other hand, many terms that are given apparently different verbal definitions turn out to have reference to the same operations, in which case is only one concept.

Operationalism is related to but distinguishable from physicalism and from positivism.

According to the doctrine of operationalism, the whole meaning of any term rests ultimately upon facts gained through direct observation but it may be several degrees removed from the observation. The meaning
of I.Q. is derived by dividing mental age by chronological age, neither of which is an observed fact but extends back to direct observations. Sometimes however, the linkage with empirical fact is missing and the definition lacks meaningful reference.

When we do have operational definition, it does not guarantee the actual existence of the object or event named, but only that it has meaning.

**Organism**

A living being capable of maintaining itself as a system and composed of parts capable of performing certain coordinated functions. Thus organism is defined as that which performs the functions of an organism. No agreement on what constitutes organismic function has been reached. It is customary, however, to define organism by pointing to physiological functions only. However this either concept is an arbitrary one, or it represents the imposition of a metaphysical bias in the mere act of defining. An organism should be defined in terms of all functions it is empirically observed to perform, including those which, in our present state of knowledge, are called psychological. The organism should, therefore, be conceived as psychophysiological, in other words as a system that performs both psychological and physiological functions.

**Organismic**

Organismic is used by positivistic and behavioristic writers to point up an opposition to menta-
listic notions, but also by some extreme anti-behaviorists (chiefly educationists) to emphasize a holistic attitude. Thus a certain kind of emotional fervor (on both sides) has resulted in strange terminological bedfellows. But the denomination of the term is quite clear: it just means pertaining to an organism.

Orthogonal

Relating to (-al) two mutually independent comparisons in which the products of their corresponding coefficients result in zero, since they intersect at straight (ortho-) angles (-gon-).

A solution in which the axes representing factors are at the right angles to each other. Such factors are uncorrelated or independent. Orthogonal is contrary to an oblique (axes) solution in which the factors are correlated.

Perceptual constancy

A person's tendency to perceive experience as expected, as being relatively stable under diverse conditions of stimulation, such as environmental variability. The tendency of perceptual responses to be relatively independent of environmental alterations, so that one perceives objects as constant (same size, shape, color, etc.) even though they stimulate sense receptors differently. Perception constancy does not operate if a reeducation screen (which
eliminates context cues) is used to view an object. Because of color constancy for example, hues tend to be correctly perceived in spite of changes in illumination; because of size constancy, background of foreground objects tend to be perceived in terms of their objective sizes. One tends to correct for illumination differences (brightness constancy), for angle of view (shape constancy), or for distance (size constancy). Perceptual constancy, in social psychology, has been studied in relation to expectancy of outcome. See "object constancy".

Partial reinforcement

An experimental condition in which subjects receive reinforcement not after every response but for only a portion of occurrences (at various time intervals or after a certain number of responses). It is the type of reinforcement most often found in nature. Different schedules of partial reinforcement may lead to different response rates; for example, rats on a fixed time schedule may make few responses, while those reinforced after a certain number of responses may respond often and rapidly (Lewis, 1950).

Physicalism

A term advanced by Carnap in 1931 and adopted by the Vienna Circle. It designates a thesis according to which all the sciences, and specially the human sciences, can and should be expressed in the language of the physical sciences, in order to unify the sciences by means of a universal language that is homogeneous and free from any metaphysical implication, and that includes only empirically manipulable
propositions, i.e. those which designate observable properties of things. After having explained the rules of formation and transformation so that any proposition in the various sciences can be expressed by means of them, it is possible (by transforming the qualitative into the quantitative) to reduce the total number of disciplines to a small number of deductive systems, and, ultimately to one such system. In Carnap's words "the application of physicalism to psychology is the logical basis for the method of behaviorism" (Morris, 1937; Jorgensen, 1951).

Physiognomy

The human face as a vehicle of expression when at rest (free from mimicry). The nature of expression is determined by the body's structure and the imprint left by the traces of habitual mimic innervation. Physiognomic research (physiognomic as the theory of facial expression) makes use of photographs, sketches (Brunswik), average likenesses, and learning experiments. Results so far have shown that the validity of judgments based on the impression given by the physiognomy is slight (coefficient between 0.00 and 0.50); nevertheless, certain systematic tendencies dependent on various factors appear in the judgments.

Posit

To assume or to take for granted what is necessary for the immediate action or argument. Posit was
formerly used for hypothesize by those who hesitated to use that verb (which has only recently been accepted as standard English). But the two have somewhat different meanings that may now be kept distinct.

**Praegnanz**

A law in Gestalt psychology relating to perceptual organization that tends toward achieving equilibrium and balance in the simplest manner possible. For example, a symbol has Praegnanz when its meaningfulness is comprehended as a part of the total fabric; it is never an isolated concept.

**Prediction**

Psychological prediction, strictly speaking, means forecasting the probability of future courses of action on the basis of present and past behavior. This behavior is influenced by environmental, innate and personality factors and can be consciously or unconsciously motivated. In a broader sense, individual prediction has its place in all fields of psychology and involves not only the personality at its best but the shape it will take in the future. A distinction is drawn between clinical, typological and statistical prediction according to the method adopted. Statistical individual prediction makes use of prediction tables that have been compiled on the basis of a fairly wide range of experience. These tables are simply aids in the hands of an experienced psychologist when he is objectifying prediction decisions. They must not be applied mechanically or automatica-
Clinical individual prediction does not consciously use any statistical prediction. However, as a preparation for deciding on some prediction, it carefully studies the life history and the family circumstances of the individual, makes a purposeful exploration and applies psychodiagnostic tests methods. Improper forms of clinical prediction are based upon the intuition, speculation, and subjectivism (prejudice) of the researcher; they cannot provide a sufficient foundation for psychological decision. Either the statistical or the clinical method may be used for the individual prediction (this may consist of a typological application of factorial groups taken from statistics), or may be made on the basis of clinical experience (Mehl, 1954).

Probabilism

The doctrine that is possible with some degree of probability to predict certain sequences of events on the basis of past experiences and by means of logical operations. Probabilism is the general statement of a principle of which determinism is a highly special case. The latter is the belief in perfect predictability when all relevant facts are known, the former a belief in the possibility of degrees of predictability depending on the degree of relevant information. Probabilistic hypotheses are the postulates that correctness of perceiving does not mean that action in accord with the perception will be adaptative, but onlyly that it will probably be so. In the long run, a correct (or veridical) percept can be relied on. In
general, e.g. what looks straight can be safely be as straight, and vice versa. Not so the illusory or incorrect. The straight stick in the water producing the bean stick illusion cannot safely be reacted to as it appears. Illusion is the exception to a statistical probability.

**Proposition**

A verbal or equivalent symbolic statement put forth as true, or as something to be tested for truth. Formal propositions are statements without reference to observable events; their truth consists in being related according to laws of logic to a system of rules. For example, the truth of a theorem in geometry is based simply on the correct manipulation of the symbols according to the principles of geometry (or of a particular geometry). Empirical propositions are arrays of symbols corresponding to observable events.

**Psychophysics**

The study of psychology in terms of the relation between a physical stimulus and its perception by the subject. Although initiated by a physiologist (Weber) in his noticeable-difference observations, psychophysics was absorbed by psychology, indirectly leading to the first psychological laboratory in 1879 and subsequently to experimental psychology. Fechner considered psychophysics to be the science of body-mind relationships. Today, however, it is primarily an experimental field of investigation concerned with specifying the relations
between stimulus-dimension and response variations of the subject. Its special methods are used in studying controlled sensory processes. Historically, psychophysics translates physical characteristics of stimuli into corresponding psychological characteristics (intelligence, attitude, etc.)

Purposive

Tolman's purposive behaviorism is a behavioristic Gestalt approach oriented toward the study of purpose in all behavior. Tolman's purposivism eschewed introspection and all subjective data, placing them outside the realm of science, since such phenomena could not be judged objectively. He stressed a molar approach to behavior, that is, he felt that purposive behavior must be seen as a whole and not as separate (molecular) responses. Only overt behavior is important, and it must be objectively observed and operationally defined. Between stimulus and response he hypothesized intervening variables (such as cognition and demand), not necessarily physiological but probably necessary to the production of goal-directed behavior.

Reductionism

A general point of view that holds that complex phenomena are to be understood and explained by analytically reducing them to ever simpler, and ultimately to strictly elementary, components. Analysis, even reductive analysis is a method of investigation employed by everyone. Reductionism is a point of view regarding the
results of analysis: it holds that analyzed parts are real and that the whole can be completely explained as consisting only of the analyzed parts. It is thus the opposite of emergentism and Gestalt, which hold that the whole is more than the sum of its parts. The reductionism of structural psychology attempted to reduce all psychological phenomena to the most elementary processes. Contemporary reductionism generally seeks to phrase psychological problems in stimulus-response terms and to reduce these further to physiological or even psychochemical terms.

**Redundancy**

A term from information theory that describes quantitatively the possible abbreviation of a sequence of symbols when using an optimal coding, and the same repertoire of symbols. The redundancy of a code allows transmission of information to take place without disturbance. Without redundancy, an error in transmission of code elements always leads to the coding of another symbol and consequently cannot be discovered. Redundancy can be used to discover, locate and even correct errors. The redundancy of human speech, which is relatively secure against disturbance, stands at 0.7 - 0.8. The disadvantage of redundancy in the discovery and correction of errors is that the length of the code words increases with the degree of redundancy and safety from disturbance.

**Region**

Broadly defined, a region is a general area or space.
As a topological concept, region is any distinguishable part of the life space. Psychological regions are defined by present or contemplated activities rather than by objective spatial areas in which activities occur. For example, a child using a porch as a stage is in the region of "play acting" rather than in the region of the "porch".

It is important to point out that regions are separated by boundaries. When a person changes activities, he moves from one region to another across a boundary. In Lewin's field theory, region is connected with the concept of life space, the totality of the individual existing in his perceived environment at any given time.

Response

Any kind of behavior, psychological event, or reaction produced by a stimulus. A response is determined either directly by its physiological activity (movement, glandular activity, etc.) or indirectly by its effect (e.g., tears after an insult), or not overtly at all (images or fantasies, which are reportable only by experiencing person himself). In the pharmacological sense, a measurable change in the organism resulting from intake of a drug.

S (plural Ss)

Subject in an experiment.

Sampling techniques

The sampling technique determines the extent to which
measurements made of the sample hold good for the population as a whole. Greater accuracy can always be achieved by increasing the size of the random sample. However, to obtain twice the degree of accuracy, it is necessary to quadruple the size of the sample; choice of the sampling technique is therefore determined to some extent by cost. A distinction can be made between sampling techniques based on the principle of random sampling (probability sampling) and those based on non-random (non-probability) sampling. Non-random samples are generally chosen by experts using their own judgment, while in the case of random samples there is a known probability for each element of the population included in the sample. Although it is conceivable that more accurate results may be obtained by non-random sampling, this is not generally confirmed by practical experience; the decisive factor, however, is that an indication of the accuracy of results can only be obtained in the case of random selection.

The random methods can be divided into simple, limited and multistage categories. In the sample method every element of the population has the same likelihood of being included in the sample. The choice can be made by drawing lots or by simulation with random numbers. Simple random samples are also sometimes understood to constitute systematic selection, in which case individuals are selected at given intervals from a list of total population elements. The most important techniques using limited random selection are those of the stratified sample and the cluster sample.

In the stratified sample the basic population is divided into strata which must be as homogeneous as possible; selection is then affected on a strictly ran-
dom basis within the individual strata. The size of the sample selected from each stratum must be proportionally representative of the size of the stratum in relation to the basic population; if it is representative we speak of a proportional sample. In a cluster sample we refer to groupings already present in the population (e.g., school classes, houses, towns, which must be as non-homogeneous as possible. Random clusters are then and used as the sample. By comparison with pure random samples, stratified samples result in an increase in accuracy that becomes more substantial as the strata become more homogeneous and are more clearly separated from each other. On the other hand, the cluster method is less accurate than the purely random procedure. The greater the lack of homogeneity in the composition of the clusters and the smaller the differences between individual clusters, the smaller the reduction in accuracy. The cluster method is characterized by low sampling costs. Multistage sampling generally takes the form of a sequence of cluster selections, e.g. villages may be selected first and individual houses then chosen at random within the villages. Stratified and cluster methods may also be combined. In non-random sampling, the quota method plays an important part, since it is successfully used by opinion research institutes. Each interviewer is required to question a number (quota) of individuals having selected characteristics denoted by a given code, e.g., a specific number of persons of a particular sex with specific income level and political attitudes, etc. The quotas are determined proportionately to the structure of the population as a whole, to the extent that this is known. The quota method therefore has some similarity to the stratified sampling technique,
with the important difference that within the quotas, selection is left to the skill of the interviewer. Examples of common errors are: that more intelligent persons tend to be consulted because they can be expected to answer the questions more quickly, and that telephone subscribers tend to be chosen because it is easier to contact them in advance and so avoid any loss of time, etc. Due to these distortions, quota sampling cannot be classified as a random method. A further type of non-random sampling is frequently used for preliminary studies where a sample may be taken simply because it is easily accessible, e.g., students at an institute of psychology may be used as subjects. This method is known as opportunity sampling. It is not really possible to generalize from the results achieved (Cochran, 1953).

**Science**

The study of natural phenomena by the methods of the physical and biological sciences. This usage, while common, arbitrarily excludes most investigations and systematizations of knowledge in the psychological and social disciplines. Such division is unwarranted in the light of both historical development and contemporary affairs, and it gives to science as expressed in the English language a narrow connotation than that of related expressions in other European languages.

**Scientific method**

The systematic statement of the general principles and
precepts (found in all the sciences and in all sound investigation and thinking, whether or not specifically considered scientific) that deal with the systematic, accurate observation of facts and their permissible interpretation.

Scientific psychology

Any psychological system that concerns itself with the search for facts or that utilizes scientific methods. Scientific psychology is often contrasted with speculative psychology; but all science (not only psychology) necessarily includes speculation. Scientific and philosophical psychology can properly be contrasted, but the latter is so little discussed that this is seldom the contrast implied. Since virtually all present-day psychology is scientific in orientation, the term has little value.

Stimulus

The cause of a response. Energy, or change in energy in the environment that is perceived through any receptor, internal or external, and that produces a response. Anything to which the organism responds; it may be as specific as the prick of a needle or as general as a seascape.

Structure

The term has proved adaptable to many uses — one speaks of the structure of the atom, the structure of a sentence, the structure of a bodily organ, mental struc-
tures, the structure of society. The use of structure in connection with buildings and the like gives the term an overtone of strength. Structure is contrasted with function or process (though these may themselves have structure), with the formless, and with the temporary or rapidly changing. Structure usually implies stability of the component parts, whereas the parts of Gestalt or of a system may alter so long as the interrelationships remain the same. Gestalt emphasizes wholness; system emphasizes rationality of arrangement of parts according to their role or function. But these distinctions are not rigid and the four terms are often interchangeable.

Symmetry

The property of having similar, equal, or parallel form or character on both sides of a dividing line (bilateral symmetry); or by extension, at regular intervals about a center (radial symmetry). Used literally for spatial distributions, or metaphorically for any kind of relationship, e.g. the equality relation (x=y) in mathematics is symmetrical.

Taxonomy

The classification of data according to their natural relationships or the principles governing such classification.

Theory

In philosophy, a construct, deduced logically by the
intelligence and isolated from action; a consistent group of concepts and statements derived from principles, built up methodologically and systematically and detached from their application. In science, laws expressed in a systematic form, which are based on observation and remain true until they are superseded by new data; they are therefore dependent on a specific state of knowledge. The purpose of a theory is not only to explain that which is known but to forecast the unknown. In the narrower sense, a theory is a system of axiomatic mathematical statements that serves as a model for a set of empirical laws (hypothetico-deductive theory). Examples: theory of reminiscence, theory of relativity.

### Universe

In statistics the total group under consideration in study or experiment from which samples are drawn. Some statistical writers distinguish between universe and population by referring to the population as "collections of real persons or objects" and the universe as hypothetical grouping or accumulation of data (tests, scores, etc.) (Diamond, 1959; O’Tool, 1964).

### Variability

The divergence or scatter from trait to trait within the individual obtained by having him take a number of tests, scoring these on a common scale, and computing the variability of the scores around the mean of the tests.
Validity

The quality of being strong or well grounded; the property of being legitimately derived from premises by logical inference. The degree to which a test actually measures what it was designed to measure. The validity correlation or coefficient ($r_v$) is the correlation between scores on a measurement instrument and the criterion scores that that instrument is supposed to measure.

Other than construct validity and predictive validity, which are defined separately in their proper alphabetical listings, there are other types of validity usually associated with validation tests. Content validity of a tests is determined by systematically analyzing samples of the test items to assure that adequate coverage and representation of the items (such as word for a spelling test or history items for a history test) are made. Content validity is used frequently in the evaluation of achievement tests. Empirical (true) validity demonstrates the relation between test scores and a criterion (which is an independent and direct measure of that characteristic or quality the test is designed to predict). Such validation must compare two sets of data (for example, tests scores and criterion measures) on the same person. Factorial validity expresses correlation between the test under consideration and the factor(s) common to a group of tests or other measures of behavior, as determined by the statistical technique of factor analysis (Hays, 1964; Cronbach, 1970).
Validity (ecological)

An established relationship (within a given habitat or set of environmental circumstances) between a proximal sensory impact and a distal variable in the more remote environment, such that the presence of the proximal stimulus implies a strong probability that the distal stimulus is operative and vice versa. For example, if there is a certain small image on the retina (a proximal stimulus), it is probable that there is an object in the environment (a distal stimulus) somewhat like the image.

Variance

A quantity that may increase or decrease, continuously or discontinuously, without other essential change, e.g., the area of skin stimulated, the intensity of the stimulus, the number of correct answers on a test, the time taken to react. Note that it is the area which is the variable, not the skin itself; the intensity, not the stimulus; the number not the correct answer; the time, not the reaction. In this sense, a variable is always an abstraction, a quantity.

Variable refers also to the actual quantities that constitute data; trait refers to that to which the data are assigned. Thus, trait suggests an entity, variable does not. In psychology three classes of variables are distinguished: R variables, responses or acts; S variables, properties of the physical or social environment; O variables, the organic or organismic or personal variables, the changeable properties of the person
or organism. The R variable is always the dependent variable. See "measurement".

Zero

Referring to a correlation coefficient computed from the original data; thus, the correlation having no variables held constant. The ordinary correlation \( r_{12} \) is a zero order one, in contrast with a partial correlation of the first order \( r_{12.3} \) which has one variable, 3, held constant; or with one of the second order \( r_{12.34} \) which has two variables, 3 and 4, held constant.
APPENDIX B

BRUNSWIK'S WORKS -- (IN GERMAN)
BRUNSWIK’S WORKS - GERMAN


(und H. KINDERMANN). Eidetik bei taubstummen juveniles (Eidotics in deaf-mute juveniles). Zschr. f. angew. Psychol. 1929, 34, 244-274.


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