ED 071 067   CS 000 350

AUTHOR   Courtney, Brother Leonard, Ed.
TITLE   The Use of Theoretical Models in Research. Highlights
                of the 1965 Pre-Convention Institutes (Detroit,
                Michigan, May, 1965).
INSTITUTION   International Reading Association, Newark, Del.
PUB DATE   May 65
NOTE   148p.
AVAILABLE FROM International Reading Association, 6 Tyre Avenue,
                Newark, Del. 19711 ($1.25 non-member, $1.00
                member)

EDRS PRICE   MF-$0.65 HC-$6.58
DESCRIPTORS   *Learning Theories; *Models; Motivation; *Reading;
                Reading Research; *Scientific Methodology; *Theories;
                Vocabulary
IDENTIFIERS   General Open Systems Theory; Integrated Functional
                Learning Theory; Substrata Factor Theory

ABSTRACT
                Three papers are presented and each is followed by
two reactions. The first paper presents methods of dealing with
questions about the conduct of scientific theorizing. The
theory-models approach is explained as a mode for conducting part of
the theory construction tasks required in the complete act of
scientific inquiry. In the second paper a summary of research on
reading acquisition is presented to demonstrate the importance of
integrated-functional learning theory in dealing with human behavior.
The third paper presents fundamental postulates common to the General
Open Systems Theory and the Substrata-Factor Theory. Hierarchical
working systems are noted for content areas. The sequential proration
technique is seen as possibly providing a basis for determining the
extent of a particular subsystem's impact on the suprasystem.
Diagrams and references are included. (This document previously
announced as ED 028 905.) (RT)

ED 071067

HIGHLIGHTS

of the

1965 Pre-Convention Institutes

Detroit, Michigan

May, 1965

Brother Leonard Courtney, F.S.C.
General Chairman and Editor

INSTITUTE V   USE OF THEORETICAL MODELS
IN RESEARCH

IRA

International Reading Association
Newark, Delaware

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International Reading Association
Newark, Delaware 19711

FOREWORD

The Tenth Annual Convention of the International Reading
Association was held in Detroit, May 5-8, 1965. For the
first time, the regular convention program was preceded
by a series of specialized Institutes, each devoted to a
specific area or problem current to the field of reading.
These Institutes attracted almost five hundred persons,
most of whom were intimately concerned with daily pro-
fessional involvement with current issues - specialists
and experts interested in studying leisurely, but in-
tensely, the emerging aspects of their work and exchang-
ing views, procedures, and solutions with other special-
ists.

The following six Institutes were offered in 1965, each
ranging from two to four sessions:

   I.   The Culturally Deprived Reader
            Chairman: Charlotte K. Brooks,
        District of Columbia Public Schools

  II.   The Role of the Reading Consultant
            Chairman: Dorothy M. Dietrich, Union
        Free School District, Uniondale, New
        York

 III.   Some Administrative Problems of
        Reading Clinics
            Chairman: Albert J. Harris, City
        University of New York

  IV.   Neurological and Physiological
        Contributions to Reading
            Chairman: N. Dale Bryant, State
        University of New York at Albany

   V.   The Use of Theoretical Models in
        Research
            Chairman: Albert J. Kingston
        The University of Georgia

  VI.   Linguistics and Reading
            Chairman: Priscilla Tyler, University
        of Illinois

At the luncheon, held for all participants of the six Institutes, Nila Banton Smith, Past-President of IRA, presented an address which succinctly traced the separate threads of research involving each of these divergent issues. Dr. Smith's address provides an admirable introduction to the collected papers from the Institutes which have been published by the Association in a series of five separate pamphlets entitled <u>Highlights of the 1965 Pre-Convention Institutes</u>. These selected papers include many stimulating materials from the various meetings.

David Gottleib examines the challenge of socially alienated youth, the trends and patterns in modern society which are conducive to difficulties in scholastic adjustment. Ida Kravitz draws from her own personal experience to offer measures by which reading specialists may meet the special needs of the "socially alienated" youth.

H. Alan Robinson considers the various roles of the reading consultant in the modern school, K-12: the consultant as <u>resource person</u>, <u>advisor</u>, <u>in-service leader</u>, <u>investigator</u>, <u>diagnostician</u>, <u>instructor</u>, and <u>evaluator</u>. Dorothy Dietrich has expertly supplemented this position paper with her editing of the discussion from the participants' specific and practical views on the subject.

Three papers focus on the daily administrative problems of the reading clinician. Two papers consider the reading clinic as training center. George Spache examines the University Reading Clinic in its various roles of teacher-training, staff-training, service and research with the difficulties and handicaps which tend to dilute complete effectiveness. Caroline Stubblefield studies the wealth of opportunities available to the Public School Reading Clinic as a training center. Based on several fascinating case studies, Bruce Balow offers five principles of behavior toward effective liaison with specialized diagnostic and treatment resources.

The several papers from the specialized Institute on "Use of Theoretical Models in Research" examine the basic conceptions, learning principles and theories which affect experimental techniques, not only in reading but in psychology and education generally. Finally, a joint Institute on "Linguistics and Reading," co-sponsored by the International Reading Association and

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the National Council of Teachers of English, considered
in depth the interrelationship of these two fields.
Some of the papers from this Institute have already
appeared in other journals, but the selection presented
"highlights" the current investigatory bent involved in
language, its components, and the mutual responsibility
of linguists and reading specialists for integration and
application of these ideas.

These few papers cannot adequately represent the total
impact of the First Annual IRA Pre-Convention Institutes,
nor convey the work and organization which went into
them, and the stimulation, challenge, and practical satis-
faction which derived from them. It is hoped, however,
that this sampling will provide some of the flavor.

                    Brother Leonard Courtney, F.S.C.
                    General Chairman

MILESTONES IN THE DEVELOPMENT
OF SPECIALIZED INTERESTS IN READING

by

Nila Banton Smith

During IRA's Pre-Convention Institutes, partici-
pants studied correlates of reading in six specialized
fields. Each of these specific areas has its own fasci-
nating story of growth in regard to its interest in
reading. Let us step from one milestone to another as
we follow the development of these interests. The mile-
stones are widely-spaced in time periods and mark diver-
gent pathways.

Reading Clinicians

My first acquaintance with the term "remedial read-
ing" was through an article by W. L. Uhl, published in
The Elementary School Journal, December 1916. Early
investigators used such terms as "reading inferiority,"
"reading deficiency," and "reading disability." It was
not until the Nineteen-Twenties, when the schools took
over the problems of disabled readers, that the term
"remedial reading" came into general use.

The first milestone in the development of reading
clinics was laid by Grace Fernald at the University of
California, Los Angeles. Dr. Fernald, who previously
had been working with deficient readers, was given a
room in the University Training School in which to diag-
nose and treat the reading retarded. From this developed
the "Clinic School," the beginning of reading clinics.

The second milestone was reached in the early
Thirties as indicated by William S. Gray in 1935:

> Because the needs of many poor readers cannot
> be determined readily through classroom diag-
> nosis, institutions and school systems in in-
> creasing numbers are establishing educational
> clinics. These clinics are rendering very
> valuable service as shown by the work of Baker
> and Leland in Detroit, Betts in Shaker Heights,
> Ohio, and Witty at Northwestern University.[1]

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[1] William S. Gray, Journal of Educational Research,
Vol. 28 (Feb. 1935), p. 410.

During the next seven years, a new high was reached in the establishment of reading clinics in public school systems. This growth is reflected in a heading which appeared in the Education Index. The topic of "Reading Clinics" had become so popular, and articles concerning them so numerous, that in 1942 Reading Clinics was given a separate heading in this Index under the general heading of Reading.

During the Forties, there was extended interest demonstrated by reading clinicians who worked cooperatively with the other disciplines, particularly in diagnosis.

By 1965 a new milestone had been laid by the many organizations to provide reading services variously called reading clinics, reading centers, reading laboratories, reading institutes, reading improvement services, etc. While such organizations have increased numerically, their functions have been extensively diluted, in many cases, so that their work is far removed from the original concept of a clinic. Hopefully, participants in the clinical Institute have set up some standards to differentiate clearly between organizations worthy of being considered as clinics and many others now operating on tenuous and unsubstantiated bases.

The Role of the Reading Consultant

The Role of the Reading Consultant, although a relatively new topic, is rapidly laying additional milestones.

The first supervisors in the public schools were those in charge of special fields: music, drawing, physical education, manual training, domestic science, and handwriting. Their employment grew rapidly between 1880 and 1915.

During the years 1915 - 1925, there was considerable discussion concerning the supervision of basic subjects in the elementary curriculum. While much of this attention was directed toward the need for principals to supervise instruction, some supervisors were appointed for general supervision of elementary school subjects. Perhaps, this was the first milestone.

The second milestone, concerned with supervision in reading, was the impetus given to such a provision by the Thirty-Sixth Yearbook, Part I of the National Society for

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the Study of Education. An entire chapter in this year-
book was devoted to "The Reorganization and Improvement
of Instruction in Reading through Adequate Supervision."
It outlined the supervisory program in reading and ex-
pressed the need for supervisory services in reading at
all school levels.

The third milestone was the first research concerned
with the role of the reading consultant: Kathryn Dever's
Positions in the Field of Reading, 1956 and H. Alan
Robinson's An Occupational Survey of Reading Specialists
in Junior and Senior High School, 1957. These researches
marked a new epoch. For the first time, different kinds
of specialized positions and the duties were revealed in
the field of reading.

The fourth milestone was a chapter in the Sixtieth
Yearbook of the National Society for the Study of Edu-
cation in which Gray recommended programs of special
courses as preparation for the position of "Supervising
Reading Specialists."

And the fifth milestone was reached when seven
states agreed to require certification for reading
specialists. The supreme milestone will have been
reached when all states have such a requirement.

Neurological and Physiological Aspects of Reading

The area of Neurological and Physiological Aspects
of Reading deserves special esteem. Reading interests
in this discipline antedated all others. The medical
men were the first in the specialized disciplines to be-
come interested in reading. The initial milestone was
marked in 1896 by the publication of an article by W. P.
Morgan in the British Medical Journal, "Congenital Word
Blindness." In all of the many reports during the next
15 years, the medics assumed that congenital word blind-
ness, or congenital alexia, was the cause of reading
retardation. Other laboratory studies, physiological in
nature, also were conducted. These involved eye-move-
ments, visual perception and inner-speech.

A second milestone was reached at about 1915 when
the psychologists challenged the word-blindness theory.
They suggested a broader range of causes of reading
disability and involved other psychological and physio-
logical factors.

Increasing contributions were made from 1920 to 1950 in regard to the hygiene of reading, visual defects, reversals, dominance, and relationships between intelligence and reading. It was during this period of advanced study and speculation that Orton expounded his theory of cerebral dominance and Fernald experimented with the kinesthetic method.

This present decade brought greatly increased and extended studies of brain damage, mental retardation, the sensory deprived, aphasics, perceptual ability and sex differences. Experiments based on new neurological-physiological theories have been expounded: Smith and Carrigan's synaptic-transmission theory, Delacato's neuro-psychological approach, Burk's attempt to provide medication for the brain-damaged, and Staiger's administration of a psychic energizer to disabled readers. All these studies indicate that those interested in neurological and physiological factors continue to search for solutions to reading problems.

Linguistics and Reading

Linguistics and Reading is a recent topic that is attracting much attention. The science of linguistics, of course, is a very old one. It is only recently, however, that attempts have been made to apply this science to the teaching of reading.

My first research of linguistics, as applied to reading, encompassed a book titled Linguistics in Education, by M. V. O'Shea, published in 1927. Chapter VII, "Acquiring of Word-Ideas in Reading," places much emphasis upon "language unities in teaching reading" and "learning the function of literal symbols."

The first real milestone, however, was an article by Leonard Bloomfield in Elementary English Review 1942, which discussed the direct application of linguistics to reading.

The next milestone was the recognition of possibilities by the leaders of IRA and NCTE, two large professional organizations, who appointed a joint committee on reading and linguistics. This committee has been very actively engaged with related problems in the two fields.

The first five years of the Sixties marked another milestone with the appearance of professional publications. Two books were published: Fries' Linguistics

and Reading and LaFevre's Linguistics and the Teaching of Reading. In 1961, the first children's book, based on linguistic principles, was published: Let's Read by Barnhart and Bloomfield. Other sets of material for first-grade pupils have appeared recently and an entire series of linguistic readers is soon to be published by Fries with collaborating authors.

This wide publication of linguistics materials, as applied to the teaching of reading, certainly marks an epoch of development in this discipline.

The Culturally-Deprived Reader

The Culturally-Deprived Reader is a topic that does not have a long history. A few philosophers in Europe talked about "educating beggars to live like kings," but we haven't heard much about this in our country until recently.

The establishment of the readiness concept between 1925 and 1930 for the culturally-deprived was the first milestone for American schools in the reading field. Surveys and statistical studies at this time yielded decisive evidence that all children were not ready to begin reading in the first grade; pupils from culturally-deprived homes were found to be particularly lacking in this qualification. Hence, reading instruction was often delayed for a year or perhaps two years while teachers attempted to develop their pupils physically, mentally, socially, experientially and linguistically. This was an excellent start in the right direction.

Recently, a second milestone was laid by the public schools in cities like New York, Los Angeles, Detroit and others which initiated experiments and special effort to meet the needs of culturally-deprived young children before reading and after beginning to read.

A momentous milestone was laid when President Johnson declared war on poverty in 1964 and embodied the goal of educating our poverty-stricken people. With financial aid from the government, enriching pre-school experiences can be provided. In many places, more books and materials may be purchased; better trained teachers will be available; additional research will be stimulated. The whole educational world is excited about possibilities in this area. With this wealth of interest, effort, and creative thinking, reading instruction as

well as other aspects of education should show marked improvement. It is a great day for the culturally deprived!

The Use of Theoretical Models in Reading Research

Finally, I shall discuss The Use of Theoretical Models in Reading Research. This topic leads to a delineation of milestones in the progress of research techniques in reading.

The earliest research in reading consisted of laboratory studies without specific designs or controls, and without need for statistical computation.

A significant milestone was laid with the emergence of the scientific movement in education. Between 1910 and 1920 the first standarized tests were developed; the first statistical procedures for treating test data were devised. Early studies which used these tools, however, were crude in delimitation of topic, design and statistical treatment. The latter usually consisted of only the simple techniques of finding central tendencies, and perhaps computing correlations.

Between 1925 and 1950, research showed marked improvement. The topics were more basic and more sharply restricted; experimental techniques were improved, and interpretation became more disciminating. There was still much to be desired, however, in advancing the quality of reading research.

Throughout this period, loud and frequent criticisms of research in reading were voiced. As an example, Scott's critical review of reading research, conducted between 1940 and 1950, characterized this research as "voluminous," "fragmentary and unrelated", "varied as to underlying concepts," "practical rather than theoretical," oriented toward content methods and mechanics," "varied in quality," and "in importance," and "inconclusive and limited." He added that the "most tantalizing and stimulating characteristic of reading research findings is their inconclusiveness."

As for the future, Scott reported, "with proper tending, pruning, and thinning the contributions of research in reading can be greatly enhanced." In spite of his criticisms, Scott stated finally that research in reading, "has contributed much to the welfare of readers

and to the skill of those who teach them."[2]

It seems that since the time of Scott's criticism
we have been "tending, pruning and thinning," and,
currently, laying another milestone.

In 1962 Harris stated at the end of his "Summary
of Investigations Related to Reading:"

> Research related to reading in the previous
> year shows several promising trends. A number
> of investigations revealed great care in ex-
> perimental design to control significant
> variables. Thorough and scholarly analyses
> of related research accompanied others. A
> willingness to examine intensively the
> significant learning processes in reading was
> likewise evident . . .[3]

In 1964 Holmes and Singer made these statements in
regard to reading research:

> A review of research during the past three
> years makes it clear that the profession is
> searching not only for ways of ordering the
> meanings behind objective data collected and
> relationships calculated in the past, but
> also for more fundamental data and deeper
> meanings underlying first interpretations.

> Recognition of the need to search for "under-
> meanings" is evident in concerted efforts (a)
> to construct new models that will more faith-
> fully than previous models represent the
> processes at work in the subsystems or casual
> chains of events that come to focus in the
> reading act and (b) to probe deeper with
> studies that aim to explain reading phenomena
> in smaller and smaller units.

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[2]Winfield C. Scott, "A Forest View of Present Re-
search in Reading," Educational and Psychological
Measurement, Vol. XIV (Spring 1954) pp. 208, 14.

[3]Theodore L. Harris, "Summary of Investigations
Relating to Reading," The Journal of Educational
Research, Vol. 55 (Feb. 1962), p. 210.

And finally the same authors stated:

> . . . The present analysis reveals that, during
> the period from September 1960 through September
> 1963, at least three new and exciting trends are
> clearly discernable: (a) a concerted effort at
> theory building (b) a greater concern for designs
> that are experimentally and statistically sophisti-
> cated, and (c) a host of new instruments and tech-
> niques.
>
> A field of study is generally headed for a spurt
> of creative productivity when theory construction
> and experimental research become closely inter-
> dependent and mutually directed.[4]

In the light of these evaluations and others by well-
qualified professional people, it would appear that this
period is one of marked progress in improving the quality
of reading research, and that we have reached a new mile-
stone in this important area of specialization.

I have attempted to cover some of the major mile-
stones in each of the six specialized areas studied dur-
ing the Pre-Convention Institute. I should like to con-
clude by expressing gratitude to those who are working in
these special fields. You are to be congratulated for
your interest in reading and your valuable contributions.
Cooperative effort is a trend of much promise. May you
continue to lay many more milestones, creatively and
constructively and within ever shorter time-intervals.

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[4]Jack Holmes and Harry Singer, "Theoretical Models
and Trends Toward More Basic Research in Reading,"
Review of Educational Research, Vol. 34 (April 1964),
pp. 127-55.

THE USE OF THEORETICAL MODELS IN

RESEARCH IN READING

Edited by

Albert J. Kingston

The University of Georgia

General Open-Systems Theory and the Substrata Theory of
Reading

Martin Kling
San Francisco State College

Discussion of Dr. Kling's paper

Dr. Alton Raygor
University of Minnesota

Dr. Donald E. P. Smith
University of Michigan

Selected References to Models in Research.

INTRODUCTION

The complexity of the reading process has been recognized by researchers and classroom teachers alike. During the past two decades the reading process has been examined from a myriad of viewpoints which range from instructional methods to elaborate systems of factor analysis. In the course of such explorations reading ability has been correlated with most of the human characteristics we are able to list as well as many of the environmental forces in which the human organism functions. Such studies have served both to intrigue and to frustrate. They intrigue because they prove the complexity of reading behavior, but they also frustrate because often many more questions are raised than are answered.

Yet reading is not the only discipline which faces such a dilemma. At present psychologists are facing similar problems in their explorations of human learning, intellectual functioning, personality and mental illness. Sociologists and social psychologists encounter analogous difficulties in their studies of human relationships. Medical scientists, bio-chemists and physicists also face this type of difficulty. A major problem all these scientists face is that of formulating adequate theories to explain the complex phenomena they observe. Such theories are necessary for they serve as the bases for further study and research. Theories, of course, must be constructed in the light of what is already known, and regardless of the discipline the first step in theory building must be to delineate what is scientifically "known." It often is difficult to distinguish what we really "know" from what we "infer" or "believe." Generally we must admit that we tend to confuse knowledge with value-judgments and beliefs. Again we have a problem with our nomenclature and wonder whether our choice of terms is adequate for describing the complex phenomena we seek to explicate. In reading, for example, does the term "reading rate" or "speed" adequately describe the process of visual discrimination and symbolizations of ideas required in the reading? Does the term "comprehension" adequately describe the process by which a reader derives meaning from a printed passage? Probably these terms are no more adequate than the use of the word "intelligence" to describe the range of intellectual functioning the human performs, or the word "concept" to describe the meanings a child derives from a vivid personal experience inside or outside of the

classroom, or the word "personality" to describe a person's affective components.

Similarly one must question whether our methods and tools of measurement and description are adequate to enable us to understand so complex a phenomenon as reading. Do our present tests and measures provide sufficiently valid and reliable samples of reading behavior so that we can put faith in a technique of teaching which yields statistically significant differences in pre= and past= test scores? Should we be amazed to discover that currently used tests can be factor-analysed so that they reveal other more fundamental components underlying the abilities measured by these instruments? Should we be surprised to discover that reading is related positively or negatively to other aspects of human behavior? Obviously not, if we truly understand that in any human action the total organism is involved. Yet much of the present research in reading seems to be focused on verifying these relationships.

In an effort to break through such problems, scientists have attempted to build theories which describe the complex behavior they observe. Often they attempt to explicate the phenomena under scrutiny by the construction of "models." Such models may help the researcher to understand more completely the underlying relationships between the various components of the phenomena. Furthermore, they may enable the researcher to control certain factors while studying other factors in order to discover the way in which the various parts function. For many the model represents a simplified version that can be more readily understood and studied. Models may be merely diagrams, mathematical for formulae or actually three dimensional representations. The form is not so important as the faithfulness with which it reproduces the phenomenon it models. Obviously erroneous or overly simplified models can be misleading. However, carefully developed models can be a great boon to the researcher in designing and conducting experiments.

The papers in this symposium represent a pioneer attempt to explore the concept of model with a view toward examining some of the possibilities of using theoretical models in reading research. All of the papers were prepared for and presented at the pre-conference institute held in conjunction with the 1965 Conference of the International Reading Association. The program was arranged as follows:

4.

Dr. Elizabeth Maccia, a philosopher of science introduced her paper "The Model in Theorizing and Research." Dr. Jack Holmes and Dr. Frederick Davis responded to this paper with particular emphasis on the extension of the possibilities for research in reading. Dr. Arthur Staats, a psychologist, described an experiment based upon an operant-conditioning model. Dr. Harry Singer and Dr. Edward Fry responded to this paper. The third major paper was delivered by Dr. Martin Kling, who attempted to relate the substrata factor theory model to open systems theory. Dr. Alton Raygor and Dr. Donald E. P. Smith responded to the paper. The symposium was organized and chaired by the writer and all of the papers are presented in this publication in the order in which they were read at the meeting. Unfortunately, it was not possible to include in this report the valuable discussions which ensued between participants and those attending the session. The lively discussion following each paper gave evidence of the interest and stimulation generated.

A brief list of references also has been included for the benefit of those who wish to pursue the study of "models" in some detail.

Albert J. Kingston
The University of Georgia

THE MODEL IN THEORIZING

AND RESEARCH

Elizabeth Steiner Maccia
Ohio State·University

Purpose

Educational theorizing is no longer rejected as
mere speculating. In fact, it has been singled out as
a critical need and a trend in research activity. With
respect to reading, see the review of research that
appeared last year.[1] Therein, Carroll called once more
for a comprehensive theory of language behavior[2,3]. Two
years earlier, he had called for such a theory to meet
a critical need.[4] Also in the review, Holmes and Singer
discerned "a concerted effort at theory building" as one
of the new and exciting trends in reading research.[5]

Even though educational theorizing is considered
necessary and there is an effort to theorize about it,
little consideration has been given to questions con-
cerning how one goes about theorizing. Instead, re-
search methodology is restricted to scientific[6] veri-
fication procedures. Today, for an endeavor to be given
the honorific title, 'research', it must include data
collection.

In this paper, I intend to present some of the re-
sults of our attempts to deal with the neglected ques-
tions about theory construction. The results will be
those centering on the model.[7]

Researching and Theorizing Are Related: Earlier I
thought it possible, like Humpty Dumpty, to make words
do what it would be better for them to do rather than do
what tradition would have them do. The phrase 'scien-
tific researching', would do a better job if it were
stretched to include theorizing as well as verifying.

> . . . theory construction is a phase of research.
> Men who do it do research. Logicians, mathe-
> maticians, theoretical scientists, and laboratory
> scientists are all researchers.[8]

From the stretching of 'scientific researching,' the
stretching of 'scientific research methodology' to in-
clude the methods of theory construction followed.

At the time, the thought of this possibility seemed
conservative. I had not attempted to stretch 'research-
ing' to include the nonscientific modes of inquiry. For
example, I had not claimed that philosophizing was re-
searching. Now, this possibility appears radical. We
are more tradition-bound than I imagined. Consequently,
I shall not attempt to talk of scientific research as if
it included theory construction. Instead of the com-
plete act of scientific research, I shall talk of the
complete act of scientific inquiry. Instead of scien-
tific research methodology, I shall talk of the conduct
of scientific inquiry.

Inquiry, whether it be scientific or not, is di-
rected toward knowledge production. What the inquirer
strives to attain are cognitive claims which can be
shown to be adequate[5]. The complete act of inquiry,
therefore, has two main dimensions: the development of
cognitive claims and the justification of cognitive
claims. The conduct of inquiry, therefore, involves
one in modes of constructing cognitive claims and modes
of checking cognitive claims.

If an inquiry is scientific, it includes develop-
ment of a hypothesis or hypotheses about reality. A
hypothesis is a not-yet-checked claim about relations
between aspects of reality, and these relations are
asserted to extend beyond a given time and given place.
A hypothesis takes the form of a generalized propo-
sition, a statemental assertion of a relation between
classes (variables). A hypothesis or hypotheses must be
in the context of other hypotheses. A single unrelated
hypothesis or a heap of unrelated hypotheses offers no
cognitive claim. Knowledge is adequate theory, and
theory is a set of related hypotheses. It is patent,
consequently, that the development of cognitive claims
in science is theory construction.

If an inquiry is scientific, it also includes justi-
fication by means of observations of instances falling
under the hypothesis or hypotheses. Indicators of the
variables must be specified, so that the variables can
be observed in each instance. For example, an indicator
of reading readiness is a portion of the Metropolitan
Readiness Tests. Furthermore, the arrangement to

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produce the readings of indicators (a design for data) must be set forth. <u>Solomon Four Group Design</u> is, of course, an illustration of an arrangement which is experimental in nature. Different designs give different plausibilities with respect to hypotheses. This plausibility enters into the interpretation of the data. Ascertainment of the generality possible from the instances checked is of primary importance here. Clearly, justification of cognitive claims in science is theory verification.

Schema 1 presents the complete act of scientific inquiry, and, therefore, the relation between researching (data collection and interpretation) and theorizing. The schema separates the tasks of verification (researching) from tasks of theory construction (theorizing). In doing one, however, must take the other one into account. Theorizing must be adjusted to verification procedures. Conceptual systems which cannot be brought into correspondence with indicators and designs are useless. Concepts without percepts are empty. On the other hand, verification procedures must be adjusted to theorizing. Verification procedures which cannot be brought into correspondence with variables and their relations are useless. Percepts without concepts are blind. Even though interdependence is a fact, should theoretical and methodological inquiries be restricted if they go beyond one another? Should not the fact that adjustment lacks a dynamic quality be taken into account before one automatically answers in the affirmative?

1. Development of Cognitive Claims: Theory Construction Tasks

   1.1. Setting Forth Terms (Variables)
   1.2. Relating Terms (Variables) to Form Propositions (Hypotheses)
   1.3. Relating Propositions (Hypotheses) to Form Theory

2. Justification of Cognitive Claims: Theory Verification Tasks

   2.1. Collection of Data

      2.1.1. Specification of Indicators
      2.1.2. Specification of Design

   2.2. Interpretation of Data

      SCHEMA 1: THE COMPLETE ACT OF SCIENTIFIC INQUIRY

8.

The Model in Scientific Inquiry

A model is an object or a characterization used either to represent or to be represented. When an object or characterization is used to represent, it is a model of; when used to be represented, a model for. A model of is called a representational model; and a model for, a non-representational model. In scientific inquiry, the characterizations of interest are generalized propositions which set forth relations between aspects of reality. The characterizations, thus, are empirical in nature. All propositions, whether they be empirical or not, have form. That is to say, the proposition is structured in a certain way (the terms are interrelated in a certain way) and the group of propositions is structured in a certain way (the propositions are interrelated in a certain way). The characterizations, thus, are also formal in nature. The content can be taken from an empirical characterization, and the remainder would be a formal characterization[10]. Schema 2 summarizes and illustrates the kinds of models discernable in a scientific context. The illustrations are given in terms of language behavior of which reading is a part.

1. Representational

    1.1. Object   :a programmed computer used to represent an aspect of language behavior, i.e. simulation of actual language behavior through a programmed computer

    1.2. Characterization

    1.2.1.   Empirical :propositions about language behavior used to represent the actual language behavior, i.e. theory of language behavior

    1.2.2. Formal   :the formal component of the propositions (the way in which the terms and propositions are interrelated) used to represent the actual interrelations of aspects of language behavior and related events, i.e. the

```
                              formal component of theory
                              of language behavior

2.  Non-representational

    2.1.  Obje-t              :a programmed computer used
                              to be represented in
                              language behavior

    2.2.  Characterization

          2.2.1.  Empirical :propositions characterizing
                             messages when they are taken
                             to be outputs of a Markov
                             process used to be represent-
                             ed in a theory of language
                             behavior

          2.2.2.  Formal    :Markov process used to be
                             represented in a theory of
                             language behavior
```

SCHEMA 2: KINDS OF MODELS AND ILLUSTRATIONS

Not all kinds of models discernable in a scientific context are of significance for scientific theorizing. Some kinds may be of no significance for scientific inquiry, and some kinds may be of significance only for scientific verification. Schema 3 indicates the significance of the various kinds of models for scientific inquiry.

Non-representational objects are of no significance for scientific inquiry, but representational objects are. It is through objects formed to represent instances that theory which could not be verified becomes verifiable. Unavailable instances are overcome by simulation. Also of significance for verification procedures are representational characterizations. Models of data, e.g. Gaussian distribution, are essential in collection and interpretation of data[11]. Representational characterizations are of no significance for theorizing. In theorizing, characterizations must be developed. Characterizations from which to devise characterizations are what is needed. Models for (non-representational models) are required.
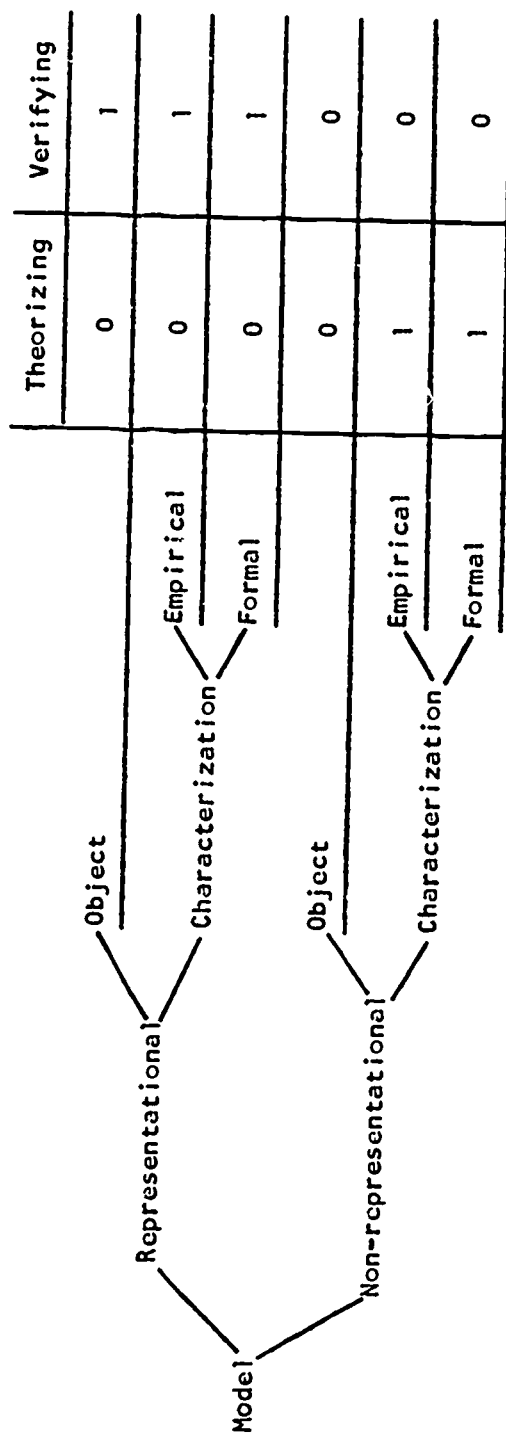
'1' denotes significance

'0' denotes no significance

SCHEMA 3: KINDS OF MODELS AND THEIR SIGNIFICANCE FOR SCIENTIFIC INQUIRY

The Theory-Models Approach

The conclusion that only non-representational models of the characterization kind are significant for scientific inquiry led to the formulation of the theory-models approach. The theory-models approach is a mode for conducting part of the theory construction tasks required in the complete act of scientific inquiry.

The theory-models approach is not inductive. One does not begin with observable data and work toward a group of precise and systematic characterizations; a theory. It is not possible to develop theory inductively. In a scientific inquiry, theorizing must precede researching. Nature cannot be approached in an empty-headed fashion. Data must be collected and one must know which data are relevant. Because one does not make the hypotheses of the investigation explicit until after data collection, or because one makes only one or two hypotheses of the theoretical context explicit, it is thought that the data dictate the theory. This thought is expressed in scientific papers. Medawar has asserted that this expression has made the scientific paper fraudlent:

> The scientific paper in its orthodox form does embody a totally mistaken conception, even a travesty, of the nature of scientific thought.[12]

Other consequences of this thought having significance to the conduct of scientific inquiry are inadequacy in data collection and interpretation, due to the failure of rendering the implicit explicit, and inhibition of the growth of adequate theory.

When one does not have or cannot find in the literature characterizations or theory which might describe or explain the events of concern, then one must devise a theory from other theories. Obviously, the theoretician can utilize only theory known to him. Theorizing, therefore, is limited in terms of one's background. But one can set out to intellectually roam the disciplines, if one does not have, in his background, theory that could be used to devise the desired theory. The approach is essentially interdisciplinary, but it is not simply a matter of taking theory from one discipline into another. The theory-models approach is not reductive. If one starts, for example, with physiological theory, and if one is attempting to construct a theory of language

behavior from this physiological theory, then the approach
is not to make the physiological theory the theory and so
reduce language phenomena to physiological phenomena. Do
Smith and Carrigan take a reductive approach in their
neurochemical theorizing about behavior?[13] I think not.
What I take them to be doing is relating physiological
variables to language behavior variables, rather than re-
ducing language behavior variables to physiological vari-
ables. Consider a relationship such as the amount of
acetycholine and the rate of reading.

The interdisciplinary nature of the theory-models
approach, moreover, does not make it a deductive approach
to theorizing. In the intellectual roaming of the disci-
plines, the search is not for a discipline of which one's
own discipline would be an instance. To state the matter
differently, one does not search for a theory in another
discipline from which the theory in one's own discipline
can be deduced. Does Fries take a deductive approach in
his theorizing about reading in the light of linguist-
ics?[14] I think not. To illustrate, what he has to say
about practice is not deducible from linguistics.

The theory-models approach, rather than being either
reductive or deductive, is retroductive. One does not
simply take theory for theory. Theory is used as a model
for theory. In forming the theory model, elements from
the theory are selected and arranged. The elements may
be modified in any way required for a point of view which
will lead to the devising of adequate theory. From the
theory model, one devises the theory. It is important
to note that there is no a priori way of determining
whether a theory model will produce an adequate theory,
just as there is no a priori way of determining whether
a theory is adequate. The theory model must be tried
out. Just as theorizing should be done in a context of
data, so theory model forming should be in the context
of theorizing. This process of devising is called retro-
ductive, since the theory that is devised (conclusion)
contains more than the theory model from which it was
devised (premises). The implication, therefore, can
only lead back from conclusion to premises. Schema 4,
below, summarizes the theory models approach to education-
al theorizing.

Other Theory _model formation_→ Theory Model _retroduction_→
Educational Theory

   Schema 4:   The Theory Models Approach to Educational
                Theorizing

Schema 5 presents a comparison of approaches to scientific theorizing.
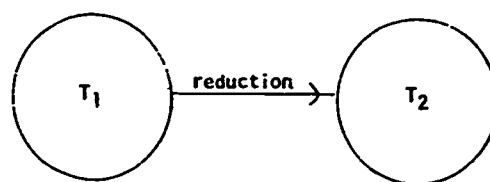
Reductive Approach
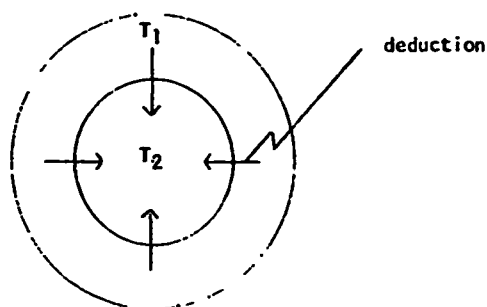
Deductive Approach
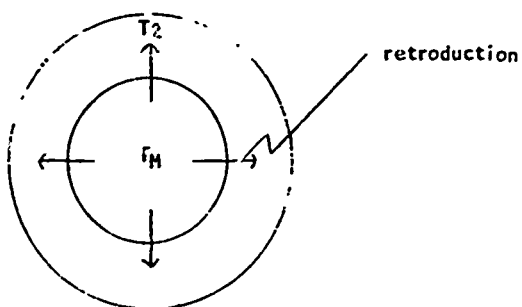
Retroductive (Theory Models) Approach

['T_1' denotes theory from which T_2, the wanted theory, is to be obtained.
'T_M' denotes the theory model. T_1 and T_2, of course, are equivalent
only in the reductive approach.]

SChEMA 5: COMPARISON OF APPROACHES TO SCIENTIFIC THEORIZING

Conclusion

The results of our attempts to deal by means of models with questions about the conduct of scientific theorizing are before you. Before I turn these results over for your conclusion, let me make a final point. On the basis of Holmes and Singer's review[15], for most reading theorists, the expression 'theory-model' would contain a redundancy, since a theory is taken to be a model insofar as a theory represents (is a model of) some aspect of reality. This identificiation of theory and model which is rooted in the representational sense of 'model' leads to a disregard of the approach to theory construction in which one theory is a model for another theory, but is not the same as the theory for which it is a model. Unless models are considered as a source of theory, they cannot function in theory construction.

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NOTES

1. Review of Educational Research: Language Arts and Fine Arts, Vol. 34, No. 2, April 1964.

2. I take reading to be one kind of language behavior. Other major kinds would be writing, listening, and speaking.

3. John B. Carroll "Linguistics and the Psychology of Language," Review of Educational Research: Language Arts and Fine Arts, op. cit., pp. 123-124.

4. John B. Carroll. "The Critical Need in the Study of Language," College Composition and Communication, Vol. 13, October 1962, pp. 23-26.

5. Jack A. Holmes and Harry Singer. "Theoretical Models and Trends Toward More Basic Research in Reading," Review of Educational Research: Language Arts and Fine Arts, op. cit., p. 150.

6. Throughout this paper, 'scientific' is not taken in its more precise, restricted sense, i.e., as character- ized through an analysis of physics.

7. In part, these results were supported by the Cooper- ative Research Program of the Office of Education, U. S. Department of Health, Education, and Welfare under Projects 1632 and E-022. Project 1632: The Construction of Educational Theory Models is com- pleted, while Project E-022: Development of Edu- cational Theory Derived from Three Educational Theory Models is in progress.

8. Elizabeth Steiner Maccia. "The Complete Act of Research," The Graduate School Record, The Ohio State University, Vol. 14, No. 3, Spring 1961, p. 10.

9. The use of 'adequate' rather than 'true' indicates my acknowledgment of the probable nature of truth.

10. As is apparent from their naming, the formal sciences, logic and mathematics, consist only of formal charac- terizations.

11. Patrick Suppes. "Models of Data," Logic, Methodology and Philosophy of Science, ed. Nagel, Suppes, and Tarski, Stanford University Press, Stanford, California, 1962, pp. 252-264.

12. P. B. Medawar. "Is the Scientific Paper Fradulent?" _Saturday Review_, August 1, 1964, pp. 42-43.

13. Donald E. P. Smith and Patricia M. Carrigan. _The Nature of Reading Disability_, Harcourt, Brace and Co., New York, 1959.

14. Charles C. Fries. _Linguistics and Reading_, Holt, Rinehart and Winston, New York, 1963.

15. Holmes and Singer, _op. cit_.

THE THEORY-MODEL APPROACH

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I have been asked to comment on Dr. Maccia's (1965) paper on the use of the theory-models approach, and, if possible, to relate her method to the way in which I actually formulated the substrata-factor theory. Let me make my position clear at the outset. I am intrigued with her idea of making explicit that which has always functioned as an intrinsic bridge in the process of scientific theory building--that is, the process of contriving, from theories in other fields, a rough or preliminary model which can then be used as a touchstone to give direction to the imagination in its creative endeavor to construct a new theory which will explain certain observed relationships and inconsistencies in one's own field.

Although I am intrigued with the idea of formalizing theory model building, I can detect a number of pitfalls in superficially roaming through other disciplines in search of a theory which may act as a model from which to construct a new theory. My concern is with the possibility that this technique will be applied mechanically unless we carefully guard against the tendency to generate theories which give only surface explanations of observed data within a particular discipline. Such explanations run all the way from superstition to scientific theory and can often have a profound influence upon behavior.

An amusing instance which occurred many years ago at a college banquet will help to illustrate my point. After dessert, my German friend, Hans, with some show of the old country's chivalry, struck a match, lighted his own cigarette, offered the flame to me, and finally to one of the young ladies who had sat poised with her cigarette through the entire episode. At that point she verily "exploded" with indignation. "How dare you!" she sputtered. "You know the third light from a match is bad luck." Hans appeared embarrassed and claimed that this must be some kind of American superstition because in Germany everybody "knew" the third light from a match was good luck, and that this was the reason he had saved it for her! Further, he believed that it made good sense because by that time all the sulphur fumes had been

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dissipated. Also, he added, this was a frugal practice
in a poor country to make a match go as far as possible.
Conversely, I noted I had heard that during World War I
it had been discovered that if one used a match for three
soldiers, it was almost always fatal because it gave the
enemy snipers time to draw a deadly bead on the third
man. Further, I understood that the American match
companies prolonged this notion so they could sell more
matches.

So, with tongue in cheek, I propose that it is bad
luck to be superstitious, no matter which side you take.
Seriously, however, the story alerts us to the fact that
in scientific theory building, as in the formulation of
public opinion, we must always be on guard lest we fall
into the following types of error: (a) superficial and un-
controlled observation , (b) personal, industrial, nation-
al or racial advantage gained from a particular explana-
tion, (c) conclusions colored by traditional prejudice,
wishful thinking, preconceptions, or outmoded circum-
stances, (d) anthropomorphism, (f) mistaking cause for
effect, or vice versa, attributing an effect to a single
cause when actually many are interacting to produce it,
or disregarding the dynamics of energy exchange so that
the possibility of mutual and reciprocal cause and effect
is never considered, and, finally (g) the uncritical use
of analogy.

Theory building is indeed a creative process. Analo-
gy, of course, is the very heart of creativity, and there-
fore should be the central activity of the theory-models
approach. In creative thinking, at least in the sciences,
the use of analogy, however, should always be a guarded
process, for the scientist knows that a slick analogy
tends to relieve him of explaining phenomena in his own
field on their own terms. In order not to be misunder-
stood, however, I would also stress that normally, in
science, analogy is properly used as a generator of ideas,
theoretical notions, and hypotheses, but should never be
used as proof.

The point here is that while Dr. Maccia is surely
aware of such traps, the uncritical user of her theory-
models must be warned for, at worst, this approach could
easily degenerate into a sophisticated rebirth of the
armchair method in psychology. My worry, of course, is
that in our new concern for theory building, we do not
overlook the necessity of paying careful attention to
the data we wish to theorize about. In other words, it

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is my considered judgment that a person should be thor-
oughly steeped in the literature of his own fielc before
he explores other fields to find a theory-model which
will help him explain phenomena not satisfactorily ex-
plained by existing theories in his own field. Like-
wise, the usefulness of different types of models is
dependent upon the degree to which one's particular dis-
cipline has advanced. It is sometimes necessary to
favor one kind of activity over another; and, therefore,
as a matter of degree and not principle, I would take
issue with Dr. Maccia when she says, in another publi-
cation, "The way of researchers inherent in the Baconian
perspective is antithetical to the theory-models approach."
She then takes the Baconian method to task because (a) it
gives no consideration to what constitutes a body of laws,
(b) it depends on inductive logic to build and generalize
laws from observed facts and simpler relations, (c) it
does not formally recognize the place of the working
hypothesis in scientific research, and (d) it appears
that the Baconian notion of theory was merely a summa-
rization of lower-order generalizations from which higher-
order generalizations could be made.

I agree with Dr. Maccia that the Baconian method has
its shortcomings. But after all, Bacon was writing in
the early 1600's at a time when, as he said in his
Fifteenth Aphorism, they had "no sound notions either in
logic or physics of substance, quality, action, passion...
much less weight, levity, density, tenuity, moisture,
dryness, generation, corruption, attraction, repulsion,
element, matter, form, and the like. They are all fan-
tastical and ill defined." Furthermore, it seems to me
that it is important to understand that in 1620 there
simply was no large pool of sophisticated theories avail-
able to be drawn upon for theory-models. What Bacon had
in mind, I believe, was to turn the scientist away from
the myths and superstitions of prevailing scholastic
dogma so that he might, with a clear eye, take a con-
trolled look at nature as it really was or is. Further-
more, he saw in the experimental method a way to force a
"yes" or "no" answer to crucial questions, and he was
determined to call it to the attention of the world. His
idea was to proceed from experiment to experiment, or
from experiment to axioms, which would then point the
way to new experiments. It seems to me that the idea of
working hypotheses was in fact implicit in the notion of
successive experiments. His major concern, however, was
to convince the scientist that he should not encumber his
observations by constructing first the grand design of

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the universe, which had been the usual approach of the philosophers. In fact, the way I read Bacon, it seems to me that he was determined to give stature to that greatest of lessons which Galileo had bequeathed to his fellow scientists, when he said in essense, "Let's take a look."

My point then is this: The scientist must take a good look _before_ he builds theory as well as after. It must be said, in fairness to Professor Maccia, that Galileo did not look blindly through his telescope. Indeed, he had the benefit of the pronouncement of Copernicus who said, "In the midst of all, the sun reposes, unmoving." The point is that the Ptolemaic theory, in a sense, was as good as the Copernican theory; and, as far as the church was concerned it was a better explanation of the planetary system, the movements of the planets, and the orderliness of the Julian calendar-- until the telescope made it possible for Galileo to take a look. Equally important, however, is the fact that the basic reason Copernicus devised his new theory was that the old Ptolemaic theory simply did not fit the facts as _he_ knew them. That is, the errors in the time tables which predicted the positions of the planets by reference to the fixed stars were so blatantly apparent by Copernicus's time that _he felt obliged_, as an astronomer, to re-examine the concept that the earth was the immovable center of the universe.

Copernicus's restatement of the Ptolemaic astronomy took some 30 years of hard work, and his conclusions were reached largely through the use of mathematics and logic rather than by direct observations. By setting the heavenly bodies in relation to the sun at their center, and by considering the earth as one of the planets, Copernicus found that he could account for all their movements better than he could by using the straight Ptolemaic theory. But what did Copernicus use as his theory-model? Well, the fact of the matter is, he used two or more models. Besides the Ptolemaic model itself, Hicetas, whom we are told lived in the fifth century B.C., had taught that the earth rotated on its own axis every 24 hours. Furthermore, Aristarchus, 200 years later, taught the same idea and added that the sun was the center of an immeasurably great universe (Schwartz and Bishop, 1958). 'It is apparent that Copernicus was familiar with these ideas and could have used them as his theory-models. Of course, someone will ask where Hicetas and Aristarchus got their ideas. Here we stop,

for this is like asking which came first, the chicken or
the egg. So I reassert that even the theorist must be
well immersed in the data of his field before he takes
on the task of theorizing about phenomena in that field.
This familiarity, of course, may be gained from a com-
plete review of the literature, for the theorist could
not himself perform all the experiments with which he
should be familiar.

I would now like to react to the second phase of the
question put to me. In short, what were my theory-models
in generating the Substrata-Factor Theory on Reading?
Most pertinent, I believe, was the fact that I had gradu-
ated in physiology, had taught chemistry and physics for
three years, and had then worked for two years as a physi-
cal chemist on the Manhattan project. On the Manhattan
project, using an enlightened Baconian experimental method,
I was able to publish some ten papers on the purity of
uranium and uranium compounds, four of which I understand
became classified patents. After World War II, I went
into the field of educational psychology, and, after re-
viewing some 500 experimental studies in the field of
reading in 1947, I selected 40 out of a garnered list of
80 variables, each of which had a scientific claim of
sorts to being (a) "the" cause or (b) an element in a
list of causes of success or failure in reading. I had
read an article by May Lazar (1942) in which she objected
to a single-cause hypothesis, but also lamented that from
the numerous lists presented by various researchers, there
was no method for successfully isolating the most signifi-
cant causal variable from the combination of many. In
short, I overcame this limitation by combining Descartes'
and Bacon's methods. Actually, my theory-model is con-
tained in the following quote which I draw from my disser-
tation:

> Prediction is a sound objective in the psychology
> of reading, because only with the ability to pre-
> dict comes the ability to control--a primary ob-
> jective in all science. However, reading and
> disabilities in reading are complicated affairs,
> and it soon becomes evident that the mathemati-
> cally limited case of the perfect correlation
>
> $$\phi \ (x,y) = 0$$
>
> will not help much in the solution of the problem;
> or when the Cartesian principle is coupled with
> the Baconian method of experimentation, all

variables must be taken into account. There-
fore...the mathematically limited case must
be expanded to have a large number of re-
lations between a large number of variables.
Fortunately, in the field of statistics a
symbolic expression has been set up which
gives the experimenter a scientific method
applicable to <u>systems</u> of many degrees of
freedom (in the sense of n-spaced dimensions).
This is the method of multiple correlation
and prediction by the multiple regression
equation, (Holmes, 1948).

Thus, by turning to the Wherry-Doolittle multiple
correlation test selection method, I was able to extract
a primary set of four variables from that list of 40
which could be thought of as the preferential variables
that "best" explained the variance of power in reading
in my sample of college students. I was not satisfied
with my results, for I felt certain that somehow some
of the other 36 variables were also important; yet, the
calculations of the Wherry-Doolittle method were finished.

Although I checked and rechecked my calculations,
and, therefore, was quite sure that the variables that
had been selected were in fact major contributors to
whatever it was that made one college student differ
from another in his ability to read with power, I was
unhappy because the analysis left no room for the other
variables my judgment told me were also important. No
existing theory or statistical analysis allowed me to
structure the relationships which I felt somehow were
there. However, in pondering the problem I recalled
that as science advances it tends to explain phenomena
in smaller and smaller units, so I began to wonder if it
were not this kind of thinking that was needed here.
What I needed to know was what variables were underlying
these preferential variables at the secondary level and
perhaps even at the tertiary level. I was aware of the
complexity of the brain and further believed that the
hierarchy present in its physiological structure must
subsume an equally complex mental system composed of sub-
systems of capabilities which must combine in orderly
ways to account for such fantastically complex abilities
as speed and power of reading. Furthermore, as the
physical chemist is wont to analyze molecules to find
atoms, and then to break down atoms into electrons and
nuclei, and nuclei into the neutrons, protons, mesotrons,
etc., I felt that <u>here</u> indeed was a rough sketch of how

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to go about further analyzing my data to better account for facts as I thought I knew them. But, for the life of me, I could not quite see how to do this. In all fairness I must say that these things were in the back of my mind, but to be completely candid, I must also say that two other extremely important events took place which caused the nascent components of the substrata-factor theory to fall into place.

While teaching at Oklahoma A. and M. College, I had been working hard on my dissertation so that I might meet a particular deadline established by the University of California, the institution where I worked towards my Ph.D. Just as I had finished my analysis down to the first level, I had been called to Western Reserve University to be interviewed for a position. After arriving there I was grilled by the Psychology Department and various deans for three consecutive days and entertained royally at night. A great deal of their discussion centered on my dissertation, its findings, and their re-lationships to practical problems in reading. Naturally, I got very little sleep in those two nights. Hence, when I caught the plane to go back to Oklahoma A. and M., I was highly stimulated, but completely relaxed, for I had just accepted a position as Associate Professor of Psy-chology and Director of the Adult Reading Clinic. Appar-ently as soon as I boarded the plane I fell asleep only to be awakened when the stewardness announced, "Fasten your seat belts," as we began to drop down over St. Louis. In a sort of subconscious daze I looked down at the glitter-ing lights of St. Louis and its surrounding cities. As I observed the complicated yet orderly meshing of the flow of traffic between the outlying towns and saw how it converged and flowed into and out of St. Louis, I had what Wallas called, in describing the creative act, the step known as illumination, everything "clicked" and fell into place. I thought that here, in essence, was the sort of dynamic model I was looking for to superimpose upon the chemically based model I had in the back of my head. This new combined theory-model immediately sparked the necessary insights for me to develop what I believe was a more adequate theory than any I had seen to explain the phenomena and resolve the inconsistencies which were apparent to me in the field of reading.

During this period, in the twilight of my conscious-ness I discerned first that my theory needed to be dynamic, and secondly, that the multiple regression technique need-ed to be extended so that a substrata analysis, not unlike

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that used in chemical analyses, could be made. Further-
more,while in the air, it became very clear to me just
exactly how the Wherry-Doolittle multiple correlation
technique could be extended to make the necessary sub-
strata analysis. As I was working out the finer details
of this analysis the next thing I knew I again heard the
words, "Please fasten your seat belts," for we were
about to land in Oklahoma. The fact of the matter is
that I had again fallen asleep even before we landed at
St. Louis. I therefore never knew what part of my think-
ing took place while I was looking down on St. Louis and
what part was done within the subconscious processes of
my mind while I was in a sort of twilight zone between
being asleep-and-awake or actually sleeping. At any rate,
it was all very clear to me when I got off the plane in
Oklahoma.

This brings me to my last, and perhaps most important,
point. That is, obviously, I could have no quarrel with
the general notion of using theory-models as a spring-
board for theory building. I do have some reservations
about the possibility of their being generated and used
in a mechanical way. I submit that anyone turning to
the theory-models approach for help in generating theory
in a particular field should first thoroughly research
the field itself. By this I mean that one must have a
complete preparation so that he not only sees the problems
but his soul, so to speak, cries out for better reso-
lutions of the observed facts than are given by the exist-
ing theories in the field. Then, and only then, in the
incubation stage of creativity should he turn in earnest
to a particular theory-model which has been prepared for
him by someone else.

However, in order to know which theory-model one
should turn to, one must previously have previewed a
number of likely ones; and so we again are back to the
chicken and egg problem. To this end, then, I feel
that Dr. Maccia and her co-workers at the Center for
Construction of Theory in Education are doing yeoman
service   In the past few weeks I have read a dozen or
more theory-models which they have constructed, and I
find them interesting and provocative. While I recommend
them to you as excellent reading, I would say that before
you choose one you should review many, because I am con-
vinced that when a better theory of reading is forth-
coming, it will consist of the creative integration of
two or more of Dr. Maccia's theory-models along with
some brand new insight contributed by the theory builder
himself.

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THEORY CONSTRUCTION IN SCIENTIFIC METHOD--
A Comment On Maccia's "The Model and Theorizing In Research"

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There is a long and productive histury of theorizing
in the field of reading. For example, in the field of
comprehe..sion, with which I am most familiar, Professor
E. L. Thorndike in 1917 published several interesting
articles seiting forth his theory that comprehension in
reading is a reasoning process analogous to that used in
solving arithmetic problems. Since that time, a good
many investigators have formulated theories about the
nature of comprehension in reading and conducted experi-
mental studies to investigate these.

The fact that theory construction has played a large
part in the scientific study of comprehension as well as
in other aspects of the reading process is not surprising.
Theory construction is an integral and important part of
all scientific investigation. In fact, it is reasonable
to say that the process of scientific investigation be-
gins with the formulation of a problem to be solved or a
question to be answered, usually one that arises directly
or indirectly from practical experience. After formu-
lation, the problem or question is cast into the form of
a hypothesis that can be subjected to experimental tests.

Data are then gathered to permit acceptance or re-
jection of the hypothesis at some predetermined level of
probability. It should be clear that this procedure does
not establish the truth or falsity of the hypothesis; it
merely determines whether the investigator accepts the
hypothesis as true or false, knowing that in making such
decisions he will in the long run be wrong in a pre-
selected percentage of them. It .s in the course of de-
signing and conducting experiments that the ingenuity and
insight of the investigator is of paramount importance.
With each year, scientific workers improve their instru-
ments and the experimental designs available for research.

On the basis of experimental data obtained in the
course of testing hypotheses, the latter are rejected or
accepted and woven together to form meaningful patterns.
Ordinarily, the rejection of a hypothesis leads to the
acceptance of an alternative to it.

Once a revised theory has been constructed, specific hypotheses are formulated and subjected to experimental testing. Thus, the process of constructing a theory, testing it, revising it in terms of new data, and constructing new hypotheses continues until experimental confirmation of expectations derived from the theory are consistently obtained.

From this description of the process of scientific investigation, we see that theory guides the formulation of experimental studies and is likewise the goal toward which they are pointed. It is the process of checking theory against experimental data that is the safeguard against the circularity and sterility characteristic of theories formulated by the classical philosophers, especially in the field of natural science. It is also clear that theory construction and data collection are interdependent. Neither one can be expected to take place alone with consistently productive results. It seems reasonable, therefore, to conclude that consistently productive theory construction is an inductive process, at least at one stage of scientific investigation.

Sometimes it is impossible to formulate theory that seems adequate to fit data that have already been gathered. It is my impression that theoretical physicists at present are unsatisfied with their theories about the nature of matter. These do not adequately fit the data about the various subatomic particles whose existence and properties have been established. To rectify this situation I don't think the physicists cast about in various other subject-matter fields (or disciplines) for inspiration. Instead, they appear to be busily engaged in improving their instruments for investigating the structure of the atom and in devising new experiments, in which they hope their improved instruments will yield data that fall into meaningful patterns and lead to the formulation of theories that can be tested and modified in successive stages.

This illustration leads me to suggest that Dr. Maccia might be willing to comment on her recommendation that one can "roam the disciplines" in search of theory useful for devising new theory. I'm sure that she can help us to see more clearly what she had in mind. At present, the idea of separating the content of theories from their form seems to me to leave a result that is analogous to Lewis Carroll's grin without a cat.

28.

INTEGRATED-FUNCTIONAL LEARNING THEORY
AND READING

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In various areas of the social and behavioral
sciences, including the field of education, it is gener-
ally conceded that human behavior is largely learned.
Anthropologists, sociologists, psychologists, educators,
and most individuals systematically interested in com-
plex human behavior, agree that, as one goes up the
phylogenetic scale, the experience of the organism assumes
more importance in contrast to the behaviors that are
laid down by the biological structure of the organism.
At the very least, everyone would agree that important
aspects of behavior are learned.

In view of this one would have to expect the experi-
mental science of learning in the field of psychology
would be a basic science to the social and behavioral
sciences. This has not been the case in the past, and
the task of bringing this about can only now be begun
with confidence. The newness of this opportunity is
reflected in the fact that many people in the field of
the psychology of learning itself, not to mention other
areas of study, are still unaware of the power of this
development. At any rate, the discrepancy between the
relevance of and the actual application of the psychology
of learning to understanding human behavior calls for
some explanation, as well as suggestions for accelerating
what, even on face value, should be a very productive
approach. The writer's major concern has been with the
development of a learning conception of human behavior,
central to which has been a comprehensive theory of
language. The present paper will thus make several
suggestions derived from this learning conception for
the understanding of and further study of reading.

It is illuminating to indicate to some extent why
the principles and methods of the psychology of learning
have not played a more significant role in the study of
actual problems of human learning, as well as in the
treatment of these problems. Two major reasons may be
cited here. Cne is simply natural to the development of
a laboratory science. In order to establish the basic
principles of learning, that is, the way that the environ-
ment (experience) effects the individual's behavior, it
is the strategy of a laboratory science to artificially

simplify the events with which it deals. Thus, the laboratory investigator does not in the beginning take a sample of the complex environments seen in everyday life. He takes a very simple sample of the environment, a simple stimulus that he can readily observe and manipulate. Nor does the laboratory investigator in the beginning take a sample of complex human behavior. Rather, he deals with a simple sample that can be objectively observed. Furthermore, he cannot, when looking for the basic principles, deal with an organism that has such a complex history that it would be impossible to tell if the experimental manipulation of the simple stimulus had any systematic effect on even a simple response. So, laboratory research was at first also restricted to work with simple organisms. Since these samples in their simplicity differ a great deal from the complex events that occur in everyday life, basic study would appear to have little value in understanding the practical problems of human behavior.

However, in looking at the progress of the experimental science of learning we can now select from among the various findings and chart a course of progress. That is, it may be suggested that the first step was to discover the basic principles using simple samples of the environment: a light, a bell, or the like; simple samples of behavior: solution, a bar press, and the like; and simple samples of living organisms: rats, dogs, pigeons, and the like. Later, after discovery of the basic principles, the principles and methods could be applied to humans and more representative samples of environmental events as well as more representative samples of the behavior involved. As will be described later, this has begun to occur with great success, and with ever accelerating activity, and needs to be extended even further.

In following this interpretation, it is suggested that one of the main lines of development of the field of learning theory must be devoted to the experimental and theoretical analysis of complex human behavior, as well as to the creation of findings with which to deal with actual human problems. This has not been self-consciously seen as a major line of progress of the science by the most influential members of the science, which is another reason the principles and methods of the science of learning have not had a greater impact upon the social and behavioral sciences.

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Theory in the new science of learning has been re-
stricted primarily to gaining the precision and general
character of the physical sciences in the statement of
its principles -- and thus largely restricted to the
findings of the basic laboratory. The prestige of this
type of theory has been enhanced to the degree to which
it resembled these sciences in the use of mathematics and
formal logical methods. It would not be remiss to suggest
that research that concerned actual human problems was
accorded much less stature.

In following this path, the psychology of learning,
as well as psychology in general, became very separatistic.
A major part of the field was broken into warring factions
that proceeded to develop separate research procedures,
separate philosophies of science, and separate terminolo-
gies (theories). For a long time, the matters of greatest
importance in the field involved the contests between the
major approaches. This continues today. As an example,
in the field of language learning there have been very
distinct and very separate approaches. Individuals con-
cerned with the learning of word meaning (see Mowrer,
1954; Osgood, 1953; and Staats, 1961) have been largely
unconcerned with the principle of reinforcement (reward)
as it pertains to the learning of speech (see Salzinger,
1959; Skinner, 1957; and Staats, 1963); the converse is
true to a great extent. On the other hand, the large
number of investigators interested in the learning of
word associations and other verbal learning experiments
(see Underwood and Schulz, 1960) have been largely ignored
by the other two, and vice versa.

Thus, although the restriction of the psychology of
learning to simple behaviors, simple situations and
simple organisms was a part of the growth of the science,
the separatism that has been described in the field, at
least as the field pertains to human behavior, can now be
seen as an unnecessary obstacle. And this obstacle has
had serious disadvantages. For one thing, the sepa-
ratistic approaches to learning have individually been
inadequate to deal with complex human behavior. In the
field of language learning, for example, the isolated
approaches have been open to criticism (Chomsky, Miller,
1965; Weinreich, 1958) because each by itself is unable
to handle the scope of this aspect of human behavior.

The various approaches and controversies in the
field of learning have presented a picture of confusion
to the scholars of other fields who were interested in

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human behavior. Thus, we find that educational psychologists especially, and clinical psychologists and social psychologists, as well as sociologists and other behavioral scientists attempted to organized the field of learning to focus on the problems in their area of study. They have accepted one or the other approach to learning and found that approach inadequate, or they have presented a potpourri of the various learning theories and their findings. Such a survey is difficult to understand, even in its own context, and has little to contribute to an understanding of human behavior.

It is suggested, however, that learning in its role as a theory of human behavior has to be approached differently. The field has much to offer in this role, but not through the study of single areas of the field -- or indeed by summarizing the various experimental findings and theories in the field.

It is necessary to abstract the major empirical principles of learning from the confusion of the experimental and theoretical controversies to establish a theory of human behavior. These must be the heavyweight, important, basic, principles of learning. In many areas the major research has gone past the major principles to deal with details that cannot readily be applied to human behavior. Inclusion of all the minor findings and controversies would yield a body of principles too cumbersome to apply to more complex realms of events. In selecting the major principles it is necessary to cut across theoretical lines, and then to state the set of principles within one set of theoretical terms.

In addition to the major principles, it is necessary to outline the ways that the principles can combine to produce complex interactions of environmental events (stimuli) and behaviors (responses). Thus, although single responses may be studied in the laboratory and the principles derived corroborated with humans, we are rarely interested in single responses when we are concerned with human problems. Although the basic principles of learning may be the same from animals to man, human learning is fantastically complex. For example, we are concerned with learning many, many, S-R processes in learning to read. Furthermore, rather than single responses, human behavior may involve complex sequences of responses. And one stimulus can come in the child's experience to elicit many different responses which depend upon other conditions. Conversely, many different

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stimuli may effect the occurrence of a single response. In addition, different types of responses may be intertwined - in fact, most important human behaviors are of this type. As an example, environmental stimuli may first elicit verbal responses in the individual, and these responses may in turn elicit emotional response, and the emotional responses will in turn determine what the individual actually does. Although the principles may be simple, learning occurs at each level, with each type of response, and the over-all acquisition of the behavior may be exceedingly complex.

Thus, a very important aspect of a learning theory of human behavior must involve a selection and integration of a comprehensive set of heavyweight learning principles from among the confusing mass of experimental findings and theoretical controversies that are presently available. These principles must then be elaborated to show how various combinations of stimulus and response can occur, including motor, emotional, and verbal responses.

It is necessary to take the principles and methods of this integrated learning theory and to begin to study various human behaviors and actually deal with those behaviors. Although at the beginning it was necessary to sample simple behaviors and situations, ultimately it is necessary to conduct research with human beings involved in learning complex behaviors, or behaviors that are more unique to man. The full status of the field of learning as a science will come when its principles and methods have been shown to be relevant for the consideration of various aspects of complex human behavior. A good deal of progress has already been made in this development.

The author has called this approach an integrated-functional learning theory of complex behavior (Staats, in press) to characterize the two main themes: (1) integrating learning principles and (2) extending the principles and results to functional human behaviors significant to the individual's adjustment. The author has presented the position more fully (Staats, 1964; Staats, in press; Staats and Staats, 1963). The major purpose of the present paper is to characterize the approach, especially in the functional aspect of the theory. That is, it will show how learning principles and methods can be applied to a consideration of an important, 'functional', human behavior and add to our understanding of this behavior as well as provide suggestions for the solution of some of the problems in the area of behavior. Thus, certain

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aspects of reading acquisition will be considered along
with the value of the learning approach for research in
this area of study. The scope of the present paper pre-
vents a full presentation of the learning principles and
the stimulus-response mechanisms involved in the theory
(see Staats and Staats, 1963). This paper can, however,
suggest that the integrated-functional learning theory
can serve as a model with which to approach problems of
human behavior and in so doing describe a program of re-
search which demonstrates this.

Motivation

A central aspect of human behavior concerns human
motivation, which in a large sense involves the things
that are rewarding (and punishing) for the individual,
or group, with whom we are concerned. It may be said
that some environmental events (stimuli) are rewarding
even though the individual has not had previous experi-
ence with them. These stimuli are called primary rewards,
examples of which are food, water, sexual stimulation, and
warmth. A stimulus that is rewarding shows itself by the
effect it has on behavior that it follows. A behavior
(response) that is follu ad by a rewarding stimulus will
be more likely to recur in the future -- or if the likeli-
hood of recurrence is already high, presentation of the
reward will maintain the strength of the behavior. The
technical term for a rewarding event is reinforcer, or
reinforcing stimulus.

Not all stimuli have this ability to strengthen the
behavior they follow, however. Some stimuli punishments
actually have the opposite effect; other stimuli have no
effect in either direction. A very important principle
concerns the way that a stimulus that does not have a
reinforcing effect can acquire this property. This is
very important because many of the most important moti-
vational (reinforcing) stimuli for man are learned - the
stimuli originally would not have had that effect.

The principle may be stated simply: A nonreinforcing
stimulus will acquire reinforcement value if it is system-
atically paired with stimulus that is a reinforcer. Thus,
a stimulus that is systematically paired with the presen-
tation of food, water, warmth, relief from pain and irri-
tation, and so on, should come to be a strong learned (or
conditioned) reinforcer. Because of the helplessness of
the human infant it immediately becomes apparent that
many social stimuli will become strong learned reinforcers.

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The sight, sound, touch, and other stimuli of people
must come to be social reinforcers, because it is almost
inevitable in raising a child that these stimuli will be
paired with a variety of other positive reinforcers. It
should be emphasized, however, that although it is almost
universal that some social stimuli come at least in the
child's early life to be positive reinforcers, the child's
total experience provides ample opportunity for great
divergences to develop in which stimuli will become rein-
forcing and to what extent. Thus, there will be great
differences in the individual's system of reinforcers even
in this narrow area. In addition, people, and groups of
people, differ greatly in the other stimuli that will be-
come reinforcing for them.

The system of reinforcers has great generality for
understanding many different aspects of human action and
interaction. The present concern, however, is with the
acquisition of reading. It can be generally asserted that
in this area, also, motivational variables are of primary
importance. Although in the area of reading the reading
program itself is important, perhaps of even greater
significance is the way that children differ in their
systems of reinforcement.

An example from the basic laboratory may be used to
demonstrate the important effect that the individual's
reinforcer system has upon what he will learn, as well as
to indicate how principles may be abstracted from the
laboratory.

Thus, according to the principle of conditioned re-
inforcement stated above, when a reinforcing stimulus is
paired with a stimulus that is not reinforcing, the
latter will also become a reinforcing stimulus. Let us
say that we arrange a circumstance so that when a buzzer
rings if a rat goes to the food bin in his cage, he will
find a pellet of food. Conditions are so arranged that
he only finds a piece of food there immediately after the
buzzer has rung, and this is done many times. It would
be expected that the buzzer, which formerly would not
have this effect, would under those circumstances of
training become an effective reward. It may seem strange,
but there is much evidence to support the expectation, and
Zimmerman (1957) has clearly demonstrated the specific
effect. That is, after the buzzer had been paired with
food a number of times, it alone could be used as a
reward to train the animal to other behaviors. If we
put a lever in the animal's cage and whenever he pressed

the lever down, the buzzer would be sounded for a short
period (with no food given), we would find that the
animal would learn the behavior of pressing the lever,
although the buzzer would be the only reward.

Furthermore, this situation can be used to illustrate
the importance of the individual's system of reinforcers
in his future learning. Let us say that we have two rats
of the same biology. One of them, rat A, we subject to
the training in which the buzzer is presented many times,
each time paired with food. The other, rat B, however,
would press the lever a few times incidental to his other
explorations, but would spend most of his time 'fooling
around.' In this situation he would not learn the be-
havior, and would be a desultory worker. The difference
between the animals, however, would rest solely upon the
fact that for one organism stimulus had become a re-
inforcer, a motivational stimulus, while for the other it
had not.

Children vary in learning 'ability' in just that way,
and for the same reasons. Some children are raised in
such a manner that some stimuli will become reinforcers
for them, while for other children who lack the same ex-
perience the same stimuli will not be reinforcers. It has
been widely recognized (see, for example, Rosen, 1956;
Carter, 1964; Maccoby and Gibbs, 1954) that differences in
the reward value of various events are effected by social
class and familial training circumstances. Middle-class
children, for example, find the approval of the teacher
more reinforcing than do lower-class children. And, ordi-
narily, middle-class children will have had many more ex-
periences in which the parents have rewarded any new
skill the child has developed. Many, many times, when
the child has learned to walk, to go to the toilet, to
dress himself, to learn new words, to tell stories, to
count, and so on, he will have been given many social re-
inforcers and perhaps material rewards of various kinds.
Under such circumstances it would be expected by a learn-
ing analysis that for such children the products (stimuli)
of acquired skills would themselves become very reinforc-
ing. In common sense terms, for children with such fortu-
nate backgrounds, learning (or its products) would itself
become reinforcing.

It is not a difficult extension to see how this will
effect learning in the classroom. The approval of the
teacher and the products of one's own developing skill are
the most important sources of reinforcement for 'student'

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behaviors. In a manner analogous to our two animals, let us say that two children are placed in the same classroom and the two children do not differ except in their respective reinforcer systems. For one child, child A, the teacher's approval and the child's own achievements are reinforcing, for the other, child B, these stimuli are not reinforcing. Let us also say that they receive the same treatment in the class. Whenever they pay attention to materials the teacher presents and respond in the manner directed, they receive the teacher's approval, and they produce things (letters, words, pictures, and so on) which result from their new skills. Under such a circumstance, child A's attentional and working behaviors will be maintained in good strength and as a result he will continue to develop new skills. Child B's behavior, on the other hand, will not be maintained. His attentional and working behaviors will wane, and other behaviors that are reinforced by effective reinforcers, will increase in strength. Child A will be seen as interested, motivated, hard working, and bright. Ultimately, he will also measure that way on class and achievement tests. Child B will be seen as disinterested and dull, and he will ultimately measure that way after a few years of being present in school while developing skills only very slowly or not at all. This latter child is also likely to develop other behaviors that further complicate his problems (see Staats and Butterfield, in press).

In both cases, we tend to look at the two types of behavior in terms of the personal characteristics of the child. The testing movement implies this, as do other concepts of child development. From a learning approach, however, we can derive a much more humanistic interpretation. The child's behavior in such cases is a function of what is reinforcing for him. And what is reinforcing for him is a function of his formal and informal conditioning experiences. Problems of educational training may rest upon changing the individual's reinforcing system -- or in altering the reinforcing characteristics of the classroom situation. For this task we can suggest procedures from a learning theory that will do more than diagnose school difficulties. A learning approach suggests actions to be taken to ameliorate such problems.

More specifically, in the area of reading, the topic of motivation (reinforcement) is extremely important, if not crucial. No matter how you slice it, even in perfectly phonetic languages, the acquisition of a reading behavior repertoire is an extremely difficult learning task.

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When one has worked in the laboratory with animal and
human learning, as well as with individual children in-
volved in learning something as complex as reading, the
fantastic complexity of the task can be seen.

Even if there were only 26 letter stimuli, each of
which had to come to control a different response, it
would be a very, very, difficult learning task -- quite
beyond the capacity of any subhuman organism. In English,
of course, the task is much more complex. Different
letter stimuli in different combinations must come to
control the same vocal response. And, conversely, the
same letter stimulus under different circumstances must
come to control different vocal responses.

It is for this reason that efforts to simplify the
learning task itself are important. But, as simple as
the task can be made, it will remain most complex and
require long-term training. This by no means denigrates
efforts to create and evaluate methods of reading train-
ing. In fact, the experimental methods to be discussed in
the present paper lend themselves to this task.

However, we must consider motivational or reinforce-
ment factors also as central to this type of learning. Be-
cause of the difficulty of the learning task and the
length of time it takes to acquire the reading repertoire,
we know that it will require a system of rewards that is
strong. The behaviors of attending in class and respond-
ing as directed (the behaviors involved in being a good
pupil) must be maintained for a long and arduous period.
Without reinforcement for the child these basic behaviors
will not be maintained in good strength, and then edu-
cational learning will cease.

Reading Research

It was on the basis of this type of analysis that
the author began the systematic study of reinforcement
variables in the context of early child learning -- es-
pecially the acquisition of reading. The first step was
to create a laboratory situation to verify the applica-
bility of the general analysis and to begin the develop-
ment of methods to work with this type of behavior and
with the population of subjects involved. The first
study to be reported will summarize this development.

The aim of the beginning aspect of the learning
analysis of reading was to construct a laboratory pro-
cedure within which reinforcement principles could be

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studied objectively with young children over long periods
of time, where the verbal stimuli were presented in a
controlled manner. The reading stimulus materials de-
vised for the first experimental work were selected to
fulfill certain criteria. While the task chosen was to
be a reading task, to produce good laboratory control
the materials were selected to be as simple and as homo-
geneous as possible. Since words and sentences are of
different lengths and difficulty, single vowels and
consonant-vowel pairs were selected. In devising this
program attention was also directed to a preliminary
analysis of the learning to be achieved, that is, the
type of stimulus discriminations which must be made and
the responses which must be controlled. This analysis
by no means solves the problems, but it does begin to
confront them. Many investigators concerned with reading
have pointed out that in the English language the same
letter stimuli often must come to control different
speech sounds when the letters are in different contexts.
The letter a is responded variously to, as in father, fate,
fast, and so on.One stimulus must thus come to elicit sever-
al responses, depending upon the context in which it oc-
curs. This represents a complex type of learning. Al-
though there are some general consistencies or rules ac-
cording to which the stimuli of context can come to con-
trol the correct one of the several responses, there are
many exceptions, and even the consistencies of context
form a very complex learning task.

There have been various suggestions for overcoming
such problems in the training of reading. For example,
(1) English spelling may be altered and new symbols intro-
duced; but this may make the transfer to normal English
spelling quite difficult; or (2) in order to retain the
actual English spelling, the system may deal with only a
limited number of words, not including the many exceptions;
however, this limits the generality of the learning.

The stimuli used in the present study were such that
they might later be used in the study of some of these
problems. The research method retains the letters used
in English. However, a different identifying mark appears
in conjunction with the letter for each different sound
the letter must come to elicit. For example, a controls
the "a" response in father, and ā controls the "a" in
fate. As a result, each letter with its symbol (when
necessary) controls only one response, a method con-
sistent with a preliminary behavior analysis of the learn-
ing involved. Once the child acquires such a letter

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repertoire he should be able to read any word including these letters. As the learning progresses and the context stimuli come to assume control over the correct response, the supplementary identifying stimuli could be "faded" gradually from the reading materials.

In addition, to obtain good experimental control, an apparatus was constructed in which the phonetic letter stimuli could be displayed systematically. The stimulus presentation apparatus consisted of a panel with four plastic covered windows and one of the windows centered above the other three. Pressure on any of the plastic covers activated microswitches which led to various experimental contingencies.

The verbal stimuli were presented to the child in a discrimination procedure. The top stimulus "matches" one of the three stimuli in the bottom row of windows. The child's task was to select the stimulus that matches the one in the top window. In the procedure the stimuli are presented, and the experimenter, who is not visible to the child, "names" the top stimulus. The child must repeat the name and then press the plastic cover over the top window. Then he must select the matching stimulus from among the bottom windows, press the plastic cover, and again "name" the phonetic stimulus. When this response occurs, and the match is correct, the child is automatically and immediately reinforced. If the child correctly "names" the stimulus before the experimenter does so, that is, "anticipates" the correct name, reinforcement immediately follows -- it is then not necessary to go through the matching task.

The development of the apparatus was found to be crucial in insuring that only the correct behavior is learned. For example, the apparatus insures that the attentional responses of the child are under experimental control; he must be looking at the visual verbal stimulus while emitting the response. The apparatus also insures that errors in performance are not rewarded. For example, to eliminate "guessing" the electronic control was designed so that an error required repetition of the task from the beginning. Reinforcement is thus contingent only upon a correct response.

A problem with the study of child learning over long periods of time has also been with construction of a reinforcer system that will maintain voluntary participation (see Long, Hammack, May and Campbell, 1958). Of course,

children cannot, as are animals, be deprived of food for long periods of time and kept at reduced body weight so that we may conduct research. And we cannot normally use the withdrawal of aversive stimulation as a source of reinforcement. One of the things we see on the basis of naturalistic observation, however, is that tokens, like money, become excellent reinforcers for people - even without states of deprivation of primary reinforcers. Taking this tip from everyday life, a reinforcer system following the sample principle was developed. This consisted of tokens backed up by various items which the children had previously selected - the ratio of tokens to back-up reinforcers dictated by the capacity of the tube in which the tokens are deposited.

Thus, e ch time a correct response is emitted, a token (a ma ble) is ejected from the tube into the dish in the righc corner of the table in front of the child. The tokens are backed up by reinforcers of different value, the difference in value determining the number of tokens that must be accumulated before the tokens may be exchanged for the reinforcer. One class of reinforcers, the small edibles and trinkets, may be exchanged for the token on a 1:1 ratio. Small toys are exchanged for 10 tokens, larger toys (or toys of higher quality) for 35 tokens, still larger toys for 80 tokens; and the largest toys for 150 tokens. None of the toys are expensive; each token averages about one cent in value.

In the procedure, the child selects a number of toys from a large class of each value, before he commences the training program. A toy from each class is then hung in the experimental room, each above a plastic tube. The size of the plastic tube indicates the number of tokens required to obtain the reinforcer. The child may thus "work" for any of the back-up reinforcers; he may obtain an edible or a trinket by depositing the token in the funnel-shaped opening in the right upper corner; he may consecutively deposit 10 tokens in the smallest plastic tube and obtain the reinforcer above it, and do the same with the other plastic tubes; or he may work for several different back-up reinforcers at the same time.

The child can thus use his tokens to obtain four different classes of reinforcers (or trinkets or edibles) that are available to him. As soon as he obtains a toy, another that he has previously selected from the same class is placed on display so that he always has a choice among four "for which to work."

After the child had been trained to use the apparatus and to make the phonetic character discriminations, which ordinarily took two of the 20 minute training sessions, the reading procedure proper was begun. The child could press a door-bell type of button in front of him. That would bring on the next phonetic character which would appear in the top window. The experimenter (who was invisible to the child) would say the name of the character, and the child would repeat the name. This would turn on lights of the bottom windows and activate the switches connected to the plastic covers of the windows. In one of the bottom windows would be the same character as appeared in the top window, and the other two windows would contain foil characters that differed either in the diacritical mark or in the consonant or vowel letters. The child would have to select the matching stimulus in the bottom window and press its plastic cover and say the character's name again. If the selection was incorrect, a buzzer would ring and the lights in the window would go out; the child would have to begin by pressing the door-bell type button again.

When the child's response was correct in all aspects, a marble reinforcer would be delivered. The mechanism would then be turned off until the child had deposited the marble in one of the possible alternatives and had put away any back-up reinforcer that he might have received. Each correct response was recorded automatically with standard cumulative recording equipment. That is, the record consisted of a pen that moved from left to right at a constant speed. Thus, time constituted the base line of the diagrams representing the child's rate of reading performance. Each time the child made a response, the pen would take a graduated step upwards. The more rapidly the child responded, the more steeply would the line slope upwards. The steepness of the slope of the line thus indicates how rapidly the child is reading. Markers were also used to indicate when the child was reinforced with a marble and when he received a back-up reinforcer, as well as what the back-up reinforcer was. These cumulative records constituted the main results of the first studies that are to be summarized.

The next step in the experimental analysis of reading acquisition was to test the combined apparatus and procedure. While each phase of developing the laboratory facility involved pilot work, it was important to determine whether the entire system would maintain the child's behavior for a long enough period of time to study

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significant variables in the learning process, to see if the stimulus materials and apparatus produced control of attentional responses, to establish the feasibility of cumulative recording, to note the sensitivity of the records, and so on. The learning curves of two children run for 40 daily twenty-minute training sessions under conditions of continuous reinforcement will be presented (Staats, et al, 1964b). The first child's record showed great consistency following the preliminary training sessions. For this child the tokens appeared to immediately constitute strong and invariant reinforcers. That is, this child customarily deposited his tokens in the tubes for the larger toys, which meant that several times his behavior was maintained for as many as three daily sessions with no back-up reinforcers - only tokens. The second child's working behavior in the reading training was more variable, including pauses of various intervals with consequent changes in the child's rate of reading as indicated by the varying steepness of slope of the record.

The preceding study indicates by the length and quality of the children's participation that the reinforcer system was effective. That is, although it is usually difficult to get pre-school children to attend to a task and work arduously for long periods of time, when this behavior was reinforced the behavior was well maintained. It should be remembered that voluntary participation in the training was in competition with free play since that is what the children would otherwise have been doing. Thus, the reinforcement system appeared to be very effective.

In addition, the apparatus for the presentation of the verbal stimuli appeared to function well. On the phonetic characters the child had not yet learned he received two learning trials per reinforcement. That is, he looked at the stimulus in the top window and said its name and then found the same stimulus in one of the bottom windows and said its name again, and this was followed by reinforcement. The apparatus and procedure also worked effectively in not allowing incorrect responses to be reinforced.

In addition, the recording apparatus worked effectively. The child's moment to moment responding could be recorded. The steeper slope of the curve showed when the child was reading the phonetic stimuli rapidly. Thus, the results for these children indicated that the various procedural developments were functional in producing a

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laboratory situation within which to study the complex human learning of a reading repertoire. Long-term studies now appeared to be possible as each of these two children emitted about 1,500 reading responses in the 40 days of training.

Although this study demonstrated the effectiveness of the use of the reinforcement system in maintaining the children's arduous learning behavior, it did not do so in an experimental fashion. That is, the reinforcement was not manipulated during the study to see the effect that its presence and absence would have on the behavior of the children. This would be necessary to more firmly show the importance of this variable in the original learning of small children.

Thus, the next step in the systematic analysis of reading was to use the laboratory facility to begin to assess variables important to the acquisition of reading. As part of this, also, there was the need to test the extent to which the facility was well enough controlled to be sensitive to the manipulation of important independent variables.

An important variable needing more systematic study concerns the schedule of reinforcement. We know from more basic studies that certain schedules of reinforcement will produce better working behaviors tha· others. On a practical level of dealing with children's learning, can we improve the rate of response by reinforcement-·scheduling variables when complex learning is involved?

A second goal of improving the reinforcer system is also related to this. That is, it would be advisable to minimize the delivery of reinforcers to prevent satiation. Anything which postpones satiation can be considered to increase the effect of the reinforcer system, and intermittent reinforcement would reduce reinforcer expenditure.

The next study (Staats, et al, 1964a) using additional children, was oriented towards answering these questions. Two different schedules of reinforcement were applied to each subject and rates of response under each schedule were compared. Discrimination learning was the procedure: the child was reinforced in one manner under one room-light condition, and in another manner under another room-light condition. These light-reinforcement conditions were alternated during each training session in a manner which has been referred to as a multiple schedule (Ferster and Skinner, 1957; Orlando and Bijou, 1960).

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The first child was run under continuous reinforcement for one light condition and under extinction - no reinforcement - for the other light condition. We would expect a discrimination to develop so that the reading behavior would occur under the appropriate light condition, but much less so under the other light condition. That is what occurred. Each reinforcement condition is depicted as a separate component after which the recording pen resets to the baseline. By the sixth session the discrimination begins to form and thereafter becomes even more pronounced. We clearly see how stimulus conditions (in this case the light), which are correlated with response-contingent reinforcement, can assume control over the working behaviors of the child. That is, when the light which was correlated with reinforcement, came on the child immediately began responding more rapidly. When the light condition changed, reading behavior deteriorated.

The second subject was run in a similar manner under continuous reinforcement and variable-ratio reinforcement. In the final training sessions the variable-ratio schedule had reached an intermittency of one reinforcer for an average of five responses. Higher rates of response were produced under the intermittent schedule, using, of course, fewer reinforcers. The third child's results include responding under continuous reinforcement and variable interval reinforcement where the first response the child made after an average of two minutes had passed was reinforced. As would be expected, the child's reading response rate was lower under the variable-interval condition than under continuous reinforcement.

These studies clearly show the importance of reinforcement in the context of this important type of learning. When the child is reinforced his participation is enthusiastic, interested, hard working. When reinforcement for the behavior is not forthcoming, the child's reading learning becomes desultory, disinterested, and other behaviors occur which are antithetical to learning. That is, the child when under the no-reinforcement condition would 'fool around' in various ways (for example, spin on the stool, sing, and so on).In addition, finer reinforcement principles were demonstrated. That is, it was possible to increase the vigor of the children's reading behavior with the use of partial or intermittent reinforcement schedules. Contrary to common sense notions, some intermittent schedules produce more rapid responding than does continuous reinforcement. This was evident with the children engaged in a reading task. The finding

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has strong implications for practical procedures of training, since intermittent reinforcement can allow one to reduce the number of reinforcers given, and thus reduce satiation while increasing performance. These variables need further study in the context of applications to actual educational learning.

The basic principles of reinforcement-learning may be considered to have been supported in these laboratory studies. The results and the preceding analysis, however, open up further lines of study in the systematic analysis of this type of learning. The next study to be summarized (Staats, et al, 1962) will indicate not only that reinforcement is important in maintaining the attenional and working behaviors of the child, but also that reinforcing these behaviors results in the actual learning of a reading repertoire. This study is a step on the way to transposing the findings in the laboratory study of reading to actual procedures for training children to read.

For this study a small group of words was arranged in a program in which words were presented singly as well as in sentences and in short paragraphs. The child was prompted to say a word as he looked at it, and was reinforced with small edibles, trinkets, or tokens backed up by small toys. Eight 40-minute training sessions were presented to the children and the number of new words the children learned to read was tested after each training session.

Three four-year-old children were introduced to the training without extrinsic reinforcement. They were given social reinforcers (i.e., approval) but not the other reinforcers. This was continued until each child requested discontinuance of the activity, which was only 15 minutes for two of the children and 15 minutes into the second session for the other child. At this point reinforcement was begun and in each case the child's reading behavior was strengthened and maintained for the remainder of the training. These children acquired 16; 17; or 18 word reading vocabularies in the eight training sessions.

Three other children were given the opposite treatment. That is, they were started under the reinforcement condition and after two training sessions were switched to no-reinforcement. They learned words readily under reinforcement, but when it was "cut off," their learning behaviors extinguished. After three or four sessions of

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no-reinforcement each child requested discontinuance and the condition was changed to reinforcement. In two cases the reading behavior was re-conditioned, and learning "picked up" again.

The results of this study support and extend the findings of the previously described studies. That is, when the attentional and working behaviors of the children in the reading task were reinforced these behaviors were strongly maintained. Without such reinforcement, however, the behaviors weakened and other competing behaviors that were not relevant to the task became relatively stronger. Furthermore, when the attentional and working behaviors of the children were strong, they learned new reading responses rapidly; the converse was true when the be- havior was not reinforced. The observations of the children's behavior in the learning situation as well as the recorded results indicated that the minute-to-minute attentional and working behaviors of the child are basic to learning to read. When the child attends to the ma- terial and works at a high rate, he rapidly learns to read. The major variation in learning seems to be a function of these basic behaviors. Thus, it would appear that under more appropriate conditions of reinforcement, even very young children are capable of sustained work activities and can learn complex verbal skills.

The next step in applying principles from the learn- ing model to a significant human behavior would be to conduct long-term studies in which children were actually trained to a reading repertoire. Actually, the author had begun working on the development of such procedures with his young daughter while the other studies were being conducted. The procedures established in this study have more recently been generalized to four other pre- school children, and these and other results are now being prepared for publication. It is possible to mention only some of the general results in the present paper.

The procedure and reinforcing system used were adaptations of the laboratory apparatus and procedure described in the first study presented in this paper. However, rather than being presented with the phonetic characters, the children were first trained to read the upper and lower case alphabets, and then they were train- ed to read single words which were later combined into words and sentences. In addition, the children were given training in being able to pronounce letters pho- netically.

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The children involved in this research ranged in age from two to five -year olds. A few results may be summarized for one of the children. He was a five-years and one-month-old boy at the time the study began. His Stanford-Binet IQ was 90, and he came from a working-class family with an average income. He was considered by his parents to be difficult to control and to train, and to learn more slowly than his siblings. The parents were somewhat worried about his behavior problems.

In the study it took 37 training sessions which averaged less than 15 minutes apiece, for a total of eight hours and 49 minutes, to introduce the child to the procedures and to train him to the upper-and lower-case alphabets through "t." In five hours and 49 minutes of additional training, in 22 training sessions, the child was taught 21 new words. In this period he also learned to read these words in a number of different sentences and short stories (paragraphs).

In the seven months of training in which this boy voluntarily participated before the author terminated the study, he learned a number of additional significant aspects of a reading repertoire. (It is noteworthy to point out that his parents used cessation of the training as a threat with which to control the child's behavior.) One of these, which is also a more formal study in itself, will be summarized. The study indicates that in addition to research on the motivational aspects of reading acquisition, the experimental methods and learning principles may also be used to investigate methods of training reading.

In learning to read it is necessary that single letters and other parts of words (syllables) come to control phonetic (part word) responses. In order to sound out a new word in reading new material, the child must be able to respond to the letter and syllable units with a correct sequence of vocal unit responses, the sequence then completing the word response. This type of repertoire can be trained in different ways. For example, Bloomfield (1961) has suggested that unit reading repertoires come about in a way that can be seen as an example of a type of concept formation, only more complex. Using the present procedures as examples, it would be expected that if the child were presented with the letter stimuli $\underline{d}$, $\underline{g}$, $\underline{l}$, $\underline{k}$, $\underline{n}$, and $\underline{w}$ each in combination with each of the vowels $\underline{a}$, $\underline{e}$, $\underline{i}$, $\underline{o}$, and $\underline{u}$ - the various combinations being presented - and were trained to read such syllables, the

single stimuli involved in each combination would come to
control the appropriate response unit involved in each
total response. That is, the d would come to control the
'duh' vocal response, the a the 'aye' response, and so on.
The present experiment only concerned the acquisition of
the consonant vocal sounds (consonant concepts) under the
control of the consonant letters. The learning of the
consonant responses (phonemes) under the control of the
consonant symbols (graphemes) was tested by teaching the
child to respond to two new vowels, y and a. The new
vowels were then combined with the consonants and pre-
sented to the child. These constituted novel syllables.
If the consonant 'concepts' had been learned, these new
syllables would be read correctly.

In contrast, another way that a phonetic reading
repertoire could be developed would be to directly train
the child to respond to the unit letter stimuli with unit
vocal responses, rather than to use the above described
concept formation presentation. That is, the child would
be directly trained to give a specific vocal response to
each letter. Presumably, then, when two such stimuli
were presented in a new combination, the result would be
the sounding out of a novel sequence of responses. In
the present study the test was made by combining two of
the syllables the child had already learned to read
separately, da and gy, to see if the two stimuli would
control the novel reading response, DAGY.

At the time the phonetic training began in the
present study, the child had already learned to read the
vowels: a as 'aye,' e as 'ee,' i as 'eye,' u as 'oo'
(actually, this required additional training since the
child had previously learned to pronounce the letter as
'you'), and o as 'oh.'' In the phonetic concept training
the a was first combined with the consonants to yield da,
ga, la, ka, na, and wa. These syllables were presented
in random order. The child was prompted to make the
appropriate vocal response while looking at the character
and was reinforced when he had done so. These characters
were presented until the child had read each of the 6 four
consecutive times without error. The same process was
then repeated with the other vowels in combination with
the same consonants. When this was finished for all of
the vowels, the total procedure was repeated twice more
to the same criterion level. The child's performance on
this task is shown in Table 1.

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Table 1

Learning the Consonant Concepts

	Consonants with the Vowel	Number of Trials	Number of Consonant Errors
First Presentation	a	54	7
	i	108	16
	e	90	12
	u	138	15
	o	42	4
Totals		432	54
Second Presentation	a	114	9
	i	66	4
	e	36	1
	u	36	0
	0	42	0
Totals		294	14
Third Presentation	a	36	0
	i	36	0
	e	42	1
	u	30	0
	o	36	0
Totals		180	1

The Table shows for each of the three presentations of the five vowels the number of trials necessary to reach the criterion as well as the number of errors made on the consonant involved. Thus, it takes 54 trials to learn the 'consonant-a' syllables on their first presentation, with 7 consonant errors occurring. The number of consonant errors increases with the next series, the 'consonant-i' series. This would be expected from what is known about retroactive inhibition. That is, presentation of the 'consonant-a' series has a negative transfer effect upon the subsequent learning. By the time the 'consonant-e' series is reached the errors begin to diminish. However, more trials are necessary to reach criterion for the 'consonant-u' series. It is possible that this increase in errors is influenced by the vowel u. That is, the child had just been trained to make a new response to this vowel (the 'oo' sound rather than the name of the letter) and this probably contributed to the complexity of the learning involved here.

In any event, by the time the 'consonant-o' series is reached, the errors have decreased markedly. But this may reflect the case of learning the vowel involved. In the second presentation of the 'consonant-a' series, the effects of retroactive inhibition may be clearly seen. More errors are made on the consonants in the second presentation than in the first presentation. At this point it is clear that the concept learning is incomplete. Nevertheless, the number of errors continues to decrease with the presentation of the other consonant-vowel series. By the time the third presentation of the various consonant-vowel sets occurs, the child is making almost no errors on the consonants. At this point it would seem that the consonant-letter stimuli had come to control the correct vocal responses, that is, that the consonant 'concepts' had been formed.

This was tested for generality by training the child to read two new vowels, a as 'ah,' and y as 'ee.' If the concept formation had actually taken place the consonants when in combination with new vowel stimuli should still control the correct consonant responses. This possibility was tested in the following manner. The child was trained to read a new vowel, a. This was done by presenting the letter singly and prompting the child to say the correct sound, following this by reinforcement. The sound of the a was 'ah.' The card was presented in this manner until the child read it correctly 3 times. Then the new vowel was paired with each of the consonants to yield da, ga,

la, ka, na, and wa. These characters were randomly pre-
sented 5 times each for a total of 30 trials (to the
same criterion of 4 consecutive errorless completions of
the 6 sets of characters). This procedure was completed
for the new vowel y also. In both cases the results
showed almost perfect transfer of the concept consonants.
There was only one error with the a series and one with
the y series. The results are shown in Table 2.

Table 2

Transfer of the Consonant Concepts to New Vowels

Consonants with the Vowel	Number of Trials	Number of Consonant Errors
y	30	1
a	30	1
Totals	60	2

In addition to these aspects of the study, explora-
tion was made of the possibility that the direct type of
phonetic training that has been described can effectively
produce general training that results in the child's
ability to sound out words. This was done in the follow-
ing manner. The child had a syllabic reading repertoire
as a consequence of the training he had already undergone.
In the present phase of the study two syllables were pre-
sented together to see if the child would then read them
in sequence, in essence sounding out a novel bi-syllabic
word.

First, all the a syllables were p.esented for review
to the criterion of two consecutive errorless performances
on all the syllables (da, ga, la, ka, na, and wa). This
was then done for the syllables containing y. At this
point the test for the novel behavior of reading the two
together was made. This was done by presenting da on a
card followed in four spaces by gy. The experimenter
placed a finger under da and asked the child to read it.
Then the experimenter pointed at the gy and asked the
child to read it. The same thing was repeated using
another card on which the two syllables were separated by
only 3 spaces. On the next card the syllables were

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separated by only 2 spaces; on the next by one space; and finally a card was presented on which dagy was typed. This card was re-presented two additional times. The same procedures were then followed with the syllable da and dy.

The results showed clearly that a new, original response may be emitted upon the basis of past learning. That is, although the reading responses had been learned separately, when the syllables da and dy were gradually combined into a two-syllable 'word', no errors were made. The child read the two syllables correctly at each step. In fact, when the dagy card was presented for the first time, as well as in its re-presentations, the child responded with the novel two-syllable response before the experimenter could point to the two syllables in series. The same results were obtained for the da and dy syllables.

Several other items are of interest in the results of this experiment. The training and test of the hypotheses in this study consumed 32 training sessions. The sessions were held 5 days a week and thus extended over a period of more than 6 weeks. The training sessions averaged 15.8 minutes. During this period of training the child's attentional and working behaviors were maintained in good strength by the reinforcer system. He made 1,420 reading responses for which he received the equivalent of about $13.45 in toys.

The results indicated that a process analogous to a learning conception of a type of concept formation may take place in the acquisition of reading. A part response of a total response that was reinforced in the presence of part of a total stimulus (da) would come under the control of that part of the total stimulus (d) even when the part stimulus was combined with a new stimulus (as in dy). Thus, the control of a unit vocal response ('duh') by a unit reading stimulus (the d) occurred and would transfer to new circumstances. The study also involves an analysis of the way in which a reading repertoire may be acquired, and suggests that this complex type of discrimination learning in children may be systematically studied in the laboratory.

In addition, the manner in which original behavior can occur was also indicated by the results of the study. That is, responses separately trained to separate stimuli will occur together in a novel combination when the separate stimuli occur together. This principle has been

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used by the author (Staats and Staats, 1963) to describe aspects of novel sentence generation, as well as social, scientific, and mathematical reasoning. The present results give support to the contention that behavior may be learned, yet under appropriate stimulus circumstances can occur in _novel_ forms. Since it was found that separately learned reading units may be later combined by the child into words, the results also suggest this as a method of training a child to read. That is, it was possible to directly train the units and not have them emerge through the process of concept formation in the manner proposed by Bloomfield. Further study will be necessary to evaluate in systematic laboratory study the relative efficacy of the two methods used in the present study. The present results indicated that the whole word method of training, as in the 'concept formation' presentation, can result in the formation of reading (phonetic) units. However, it was also shown that reading units may be taught first, and then combined into words.

In general, the results with the other children similarly substantiated the principles and methods of the learning theory approach in the context of this important functional behavior. It may be concluded that the principles and methods may be applied to the study of this type of behavior in pre-school children. Although the various indications cannot be given here, it was evident that this type of study would provide us with what has not heretofore been available, namely an analysis of _what_ reading is and _how_ it is learned. While these studies by no means complete the research that is necessary, the outlines of the analysis of this type of behavior can now be extracted, as can implications for further research and practical applications.

I would like to mention two other studies that have been completed in this systematic study of the learning model in the context of reading. The methods of the preceding study were adapted for use with somewhat older children; in one study it was adapted to a 14-year-old culturally-deprived juvenile delinquent, and in the other to 2 educable retardates and 4 trainable retardates.

The boy who was a juvenile delinquent (the study was terminated when the boy was sent to a reform school) was given 40 hours of reading training which involved 70 training sessions extending over a period of 4-1/2 months. He received specific training on 761 words that he did not know. Later tests indicated that he had learned and

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retained 431 of these words. To further evaluate the re-
sults of the training, this child was given reading
achievement tests prior to the study, approximately in
the middle of the study, and at the end of the study. At
the beginning of the study, the subject was performing at
the grade 2 level. After 45 reading training sessions,
his performance on the California Reading Test showed a
gain to the 3.8 grade level. By the end of the training,
after 25 additional training sessions, he had advanced to
the 4.3 grade level. When the child's rate of progress
is plotted with his regular school training as a comparison,
his rate of learning in the experimental procedures shows
a considerable acceleration.

Another indication of the general effect of the
reading training came from the child's performance in
school, both in school achievement and deportment. The
period of reading training coincided with a school term.
The boy received passing grades in all subjects at the
end of the semester: a C in physical education, a D in
general shop, a D in English, and a D in math. It should
be emphasized that these grades represent the first courses
that this child has ever passed, and thus his finest aca-
demic performance. Furthermore, S began to behave better
in school. The boy had always been a behavior problem
in school, and this continued into the period during which
he received reading training. During the first month of
the training, he committed 10 misbehaviors that resulted
in the receipt of demerits. These behaviors were dis-
turbance in class (which occurred twice), disobedience
in class (5 times), loitering (twice), and tardiness. In
the second month he was given demerits for scuffling on
the school grounds and for creating a disturbance. In
the third month he was given demerits for cutting a math
class and for profanity in class. However, no misbehaviors
occurred in the fourth month, or in the half month after
this until the conclusion of the school term.

The results of this study strongly supported the
analysis of reading acquisition in terms of the learning
theory, as well as the findings that had already been ob-
tained with the younger children. Through the use of an
adequate reinforcement system, this child who had always
been a behavior problem in school came to learn rapidly.
His attentional and working behaviors were well maintained
by the reinforcement and various measures of his achieve-
ment indicated good progress. The effects seemed also to
be general. The boy reported that he liked to read better
and that he liked his classes more. His grades were the

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best that he had ever gotten. In addition, his mis-
behaviors decreased. This study is now in press for
journal publication (Staats and Butterfield). However,
the author intends to adapt the procedures for broader
study in the context of cultural deprivation and edu-
cational retardation.

The basic laboratory procedures also have been tested
and further developed for use with mentally retarded
children: 2 educable retardates and 4 trainable retardates,
including 2 mongoloid children. The children used in the
study ranged in age from 7 years and 3 months to 10 years
and 8 months. The children's mental ages ranged from 3
years and 2 months to 6 years and 5 months; their IQs
from 36 to 67. Each child's participation in the study
was well maintained by the reinforcer system. However,
the more retarded children tended to use their marble
tokens to obtain immediate reinforcement. That is, the
marbles were deposited largely for the trinkets and edi-
bles, rather than for the toys which took longer to earn.

Another large difference that appeared among the
children was in the quality of the children's attentional
and working behaviors. In the study, additional ways of
recording the time the children spent in different aspects
of the task were tested. That is, the amount of time the
children spent in the phonetic character discriminations
was computed, as was the time spent in handling the rein-
forcers, as well as the time after putting the reinforcer
away until the button was pressed to bring on the next
card. The latter two periods were actually a measure of
the time the child spent 'fooling around.' One of the
major reasons for poor performance was the poor quality of
some of the children's work behaviors. The results sug-
gested that further study be made of the possibility of
improving these behaviors through training.

In addition, there were differences in the length of
time it took to train the children to use the apparatus.
For normal 4-year-olds, only two training sessions are re-
quired. In the present study the educable retardates took
2 or 3 times as long. However, thereafter they performed
the reading task even more rapidly than have normal 4-year-
old children. In general, the more retarded the child,
the greater was the length of the training required to
learn to use the apparatus and to make the phonetic symbol
discriminations. The most retarded child, a mongoloid re-
tardate with a mental age of 3 years and 2 months, re-
quired special materials and a long period of training.

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However, this child had no spontaneous speech repertoire
at the beginning of training; and it was necessary to
train the child to make an appropriate verbal response
to 10 pictures before the training in the reading task
could begin.

. One of the most important findings was that all of
these children could make the discriminations involved
in the task. It should be remembered that the stimuli
involved were letters with diacritical marks and that
the discriminations were much more difficult than those
involved with ordinary letters. The results thus suggest-
ed that the difficulty in training retarded children to
read will not involve their inability to make the visual
discriminations, although this possibility has previously
been suggested (House and Zeaman, 1960).

The study provided a number of other suggestions.
The most general is that the laboratory apparatus and
procedure provided a situation in which the complex learn-
ing of retarded children could be objectively studied
over a long period of time. The next step will be to at-
tempt to train these types of children to actual repertoires
to find out the specific types of difficulty involved. It
is likely that some of these children will turn out not to
have special learning problems - the problem will lie in
learning circumstances they have encountered, especially
in the inadequacies of the sources of reinforcement for
well maintained attentional and working behaviors. (The
educable subjects in the present study certainly appeared
very normal in their general performance. One thing is
quite evident throughout this project of study: when there
are not adequate sources of reinforcement, attention and
working beh viors are not maintained - and learning ceases.

The present series of studies thus indicates that
reinforcement (motivational) variables are important to
educational learning. It is also apparent that these
variables have not been adequately studied and, moreover,
that many problems of educational failure involve these
variables. The progress made on the project in the appli-
cation of an integrated-functional learning theory already
yields strong suggestions for further research as well as
actual applications.

Conclusions

These, however, are extensive topics and await a
more complete presentation. The summary here does not

constitute a full analysis of reading. Actually, only a part of the acquisition process has been described in brief. And only a part of the total learning model has been used. A more complete analysis of the complex behavior included under the term 'reading' must draw more fully from the learning model. (The author is presently completing this type of analysis.)

This summary of research on reading acquisition is presented as a demonstration of the importance of integrated-functional learning theory for dealing with complex human behavior, of various types. It is capable of producing not only theoretical understanding but also research suggestions as well as methods for actual application. It should be emphasized that the analyses stemming from the approach and from the experimental methods described herein are capable of dealing with problems of behavior - not merely diagnosing the problem of behavior, or of attributing its cause to personal defect. Theories of human behavior and its problems that are based upon test data, for example, ordinarily do not yield methods of specific treatment of the behavior problem. While testing is important for its diagnostic value, tests and test theory have not been as valuable in providing means for treatment of the problem. It is for this reason, in part, that it is suggested that learning analyses of behavior, and learning methods of treatment, have so much potential.

It is also suggested that a set of learning principles applied to problems of human behavior in the way described has all the attributes of a classical theory. That is, the basic principles have been systematically established in laboratory controlled experiments. These are the most general laws. The manner in which the basic principles combine to form more complex stimulus-response constellations has also been suggested. Both of these constitute the higher-order principles (or laws or axioms) of the theory. Each time a new analysis is made of a human behavior, it constitutes a lower-order hypothesis derived from the theory. Confirmation of the hypothesis through empirical study has the effect of verifying the specific hypothesis as well as the theoretical body from which the hypothesis derives. The studies on reading that have just been cited constitute both the confirmation of a specific hypothesis as well as more general support of the integrated-functional learning theory from which the hypotheses were drawn.

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This suggests that the extension of learning princi-
ples to an aspect of significant human behavior, in
addition to its practical value, serves to develop the
learning theory of human behavior. It may be suggested
that the theory already has more systematic experimental
support than other approaches. Further progress in the
development of such a learning theory will rest upon
projects like the present one. This will have to involve
various areas of behavior - the greater the number of
various behaviors sampled, the more general the theory.
It is suggested, however, that the theoretical body now
has hypotheses and methods for the study of and treatment
of various aspects of human behavior.

It may also be suggested that the progress of the
research on reading that has been summarized herein con-
tains a general strategy with which to investigate various
aspects of human learning. To begin such research, the
investigator who is familiar with the basic principles
must first analyze the behavior in which he is interested
in terms of the principles. This must include an explicit
statement of the observable behavior to be studied. This
task is usually easier to accomplish when one deals with
the behavior when it is originally being acquired; that
is, in its simplest form. Thus, it would be difficult to
make an explicit statement, for example, of the behaviors
involved in being a mathematician. It is much easier to
specify the behaviors involved in counting as well as how
these behaviors are learned. (See Staats and Staats,
1963.). When the simple behaviors are well understood,
more complex forms can be studied. Even in their simple
forms, however, significant human behaviors usually in-
volve sequences of responses. And competing behaviors that
present the acquisition of the ones in which one is inter-
ested may also be involved. However, the analysis of the
behavior is basic to the research that follows and cannot
be done ambiguously or in a simple-minded manner. Ordi-
narily a full analysis of a significant behavior will re-
quire the type of integration of learning principles
previously described. Most human behaviors involve more
than one behavior principle, or more than one type of
response.

In addition to systematic analysis of the behavior
involved, it will be necessary to include observations of
the variables involved in the acquisition of the behavior.
Thus, one may have to explore the effective reinforcers
involved, or absent, as well as other stimulus conditions
affecting learning.

The next step in the extension of an integrated-learning approach often appropriately involves a "demonstrational" study. This means testing some of the main principles of the analysis in the context of the behavior of interest. For example, is reinforcement actually important in the acquisition and maintenance of the behavior involved? In any event, I have found that in this type of demonstrational study one begins to learn more about the behavior and the subject population which is involved - and one may get ideas pertinent to more systematic study of the behavior.

The next step is to make a more systematic attempt to explore the principles involved in the acquisition, maintenance, or change in the behavior under study. Additional variables may be tested at this time - reinforcement schedules, discriminative stimulus control, etc. At this stage of the long-term study of a behavior problem, one may attempt to achieve better experimental control through, perhaps, the development of improved procedures or apparatus. If the behavior under study is complex, as most significant human behaviors are, it can be expected that short-term group studies will not suffice. Procedures in which the behavior can be studied over a long period of time will have to be worked out. We must distinguish the modification of relatively simple behaviors or classes of behavior from the modification of more complex behaviors. It is stimulating to us, and a momentous step, to extinguish temper tantrums, or shape walking versus crawling, or shape going to bed at night without a fuss. But we have to realize what the nature of this progress in learning extensions is, as well as the task that lies ahead. These are impressive demonstrations of the relevance and applicability of learning principles to the treatment of behavior problems. However, we can't expect to bring an autistic child to high level educational achievement, or even good communication and good language behavior in reasoning through a short-term procedure. There are many behaviors - the original acquisition of speech, the acquisition of reading, the development of complex social behaviors, work behaviors, so-called mental retardation, etc. - which are acquired (or are not acquired) only over a period of many years. We must expect that it will take years to change or institute those behaviors even under good training procedures.

Nevertheless, we must begin the study of such complex human behaviors - as well as the more simple ones. But a belief that the operant shaping of a simple behavior in a

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short time indicates that all behaviors will fall into place this way, or that the major problems have been solved, is unrealistic. Although it would be expected on the basis of our findings that the principles hold from rat to man, the repertoire to be acquired by man is fantastically complex. The task of establishing programs of training with which to deal with problems of complex human behavior largely lies ahead.

The learning approach appears to be tremendously productive - but there is much to do. This brings us to the final step in the extension of learning to the solution of practical problems of behavior. Based upon my research in the acquisition of reading, I would conclude that when one works over a period of years with the same problem of training behavior, first in demonstrational studies, then in other systematic studies, he learns a great deal about what can be done about some of the problems involved in modifying the behavior in a benign way. With this experience he is better prepared to begin research on actual practical problems. For example, prior to actually training a child to read, I had very well worked-out schemes for the procedure to be used, which were based upon my past research.

For solving actual problems, thus, the simple knowledge of basic learning principles will not provide adequate background. Many learning theorists, occupied solely with basic problems, will confess quite frankly that they would not have the foggiest notion of how to help solve human problems involving learning, e.g., how to train a child to read. On the other hand, I think the preceding steps I've outlined will provide knowledge for approaching various practical problems of behavior, in quest of general solutions.

The suggestion is, then, that it is important for investigators to become interested in the systematic and detailed study of a type of significant human behavior and continue with the study of the behavior over a long period of time, extending their progress in the extension of learning principles as far as possible towards the solution of practical problems. This suggestion, however, would obtain far less than universal support, either from many of the prominent people in the psychology of learning, or many people involved in the various applied areas dealing with human problems. Nevertheless, it is time for a change in both of these opinions.

It may be suggested that the objections by experimentalists in the field of learning to the application of learning principles and methods stem from a misconception of what science is and does. These individuals many times see the status of a science only as emerging from laboratory precision and control, and mathematical theory. This is certainly true in part. However, the paraphenalia that smack of science - for example, elaborate apparatus and the use of mathematics - may unfortunately be seen to be the heart of science. The applied areas, lacking these accoutrements of science, at least in the realm of complex human behavior, may be seen as an entirely separate type of endeavor. Such 'super-pure scientists' are thus apt to erroneously denigrate applied versus basic research.

It is true that in psychology the methods and principles of the practitioner have almost always been derived in ways other than through laboratory research. Thus, there actually has been a true separatism between basic and applied work - with little overlap. But, it is suggested that this is an artificial separation, a result of the previous lack of development of relevant principles and methods in the basic science. When the relevance of learning procedures and methods has been demonstrated in an area of human behavior, it will be possible for the practitioner to use them, and as he does so, the applied and basic fields will be drawn closer together.

It should also be added and stressed that the high status of a science is reached when its methods and principles receive verification in the events of the real world. Although we revere laboratory apparatus and elaborate theoretical endeavors, we do so largely because they have produced methods and principles that make better predictions about the real world and enable us to manipulate the real world - better than the methods and principles produced by other types of study. A type of verification of a science, when its principles are relevant to events of the real world, involves the extent to which the principles of the science improve upon non-scientific conceptions. Thus, one of the avenues of support of a theory of learning is the extent to which its principles and methods can deal in an improved fashion with actual problems of human behavior. It is suggested that extension of learning principles into the area of human behavior will prove to be one of the most important avenues for producing verification and generality of the principles.

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Another resistance to the extension of laboratory derived learning principles into the realm of human problems comes from the ranks of practitioners concerned with those problems. This resistance has also had its rational basis. That is, learning approaches were for a long time restricted to dealing with simple organisms, simple situations, and simple behaviors. During this period it was quite correct for the practitioner to conclude that 'brass-instrument' experimentalism had nothing to offer him in his task of dealing with complex human behavior. As a consequence, most practitioner's knowledge of learning approaches has remained limited to a few basic principles and experimental procedures. This state of affairs has persisted because the traditional course in learning theory contributes little to an understanding of human behavior. However, this is changing. There are now materials in the area of learning, as the present paper illustrates, that are relevant to practical problems of behavior. It may also be suggested that an integrated-functional learning conception of human behavior is now available (see Staats, 1964; Staats, in press; Staats and Staats, 1963) that is actually and potentially more useful to the practitioner than are the various non-experimentally derived theories of human behavior that are now more generally accepted.

Thus, at this point the practitioner who ignores a learning approach to his realm of behavior is analogous to the hunt-and-peck typist who refuses to retrain himself to the touch system. It is easier to continue hunting and pecking, but the 'waste' of the period of re-training would later be repayed many times by the increment in skill finally attained. The practitioner who converts to a learning approach will find the same rewards. He will have an advantage in his practice, and he will have an opportunity to contribute to general knowledge.

It is also suggested that the extension of learning principles and methods to the study and treatment of human behavior problems, and thus to the verification of an integrated-functional learning conception of human behavior, is occurring at an ever accelerating rate. Great advancements lie directly ahead. In this task, because the general method of the approach is based upon the manipulation of observable independent and dependent variables, the method should have advantages characteristic of other applied sciences - one of which is their "self-corrective" nature. That is, when working with observable events, it is evident when something has been

accomplished and when it has not, where principles hold
and where they do not, where development is still
necessary, and so forth. Since learning approaches to
behavior modification are based upon a set of experi-
mentally established principles, a development consistent
with that occurring in other applied sciences can be
confidently predicted.

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A THEORY OF HUMAN LEARNING FOR TEACHING READING:
A DISCUSSION OF PROFESSOR ARTHUR STAATS'S
"INTEGRATED FUNCTIONAL LEARNING THEORY FOR READING"

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The integrated functional learning theory for read-
ing, proposed by Professor Staats as , model for explain-
ing the acquisition of accurate responses to printed
stimuli, carefully controls (a) frequency of input stimu-
li, (b) reinforcement of correct verbal responses by
means of tokens for purchasing food or toys, and (c) at-
tention to relevant stimuli in the learning situation.
With an instructional device based upon his theory, Staats
has demonstrated (a) that children, even preschoolers,
remedial readers, and delinquents, can be trained to re-
spond accurately to printed words, at least in the
initial stages of learning to read, and (b) that experi-
mental manipulation of certain parameters of the in-
structional model, particularly the reinforcement sched-
ule, results in changes in response behavior that could
have been predicted from research on the effects of inter-
mittent reinforcement (Humphreys, 1939). The technical
control and quantification attained through the uti-
lization of this instructional model is praiseworthy from
an experimental viewpoint because it is through such con-
trol and quantification that precise relationships can be
determined. However, there are some explanatory and heur-
istic limitations to Staats's proposed learning theory
and some humanistic inadequacies to his model for teach-
ing reading that will be discussed in this paper. Through-
out this paper suggestions will be made for a theory of
human learning for teaching reading.

Instead of the claimed integration of learning theory
principles, Staats's theory fits solely into the stimulus-
response group of learning theories (Hilgard, 1956), as
formulated prior to the development of the mediational
hypothesis (Osgood, 1953), which provides a bridge be-
tween stimulus-response and cognitive theories of learn-
ing. Staats's written theory seems to be derived entire-
ly from Skinner's reinforcement of emitted response theory
of learning, but as orally presented, Staats's theory re-
sembles Thorndike's S-R theory of learning.

Some years ago, Thorndike explained that since learning to read depends upon acquisition of correct responses to words, his S-R theory could be used as a model for reading instruction. Because of the rationale of S-R theory, Thorndike reasoned that the most frequently occurring words in reading should be taught first because these words would result in a high degree of natural reinforcement. This curriculum strategy led Thorndike to construct his Teacher's Word Book (Thorndike, 1921, 1931; Thorndike and Lorge, 1944), which became the word frequency source book for all present day basal readers.

Although reinforcement may be necessary for learning, at least in the judgment of some learning theorists (Hilgard, 1956), the nature of reinforcement for human learning can be different from that which seems to be necessary for infrahumans. Reinforcement of primary drives plays a prominent role in learning experiments on infrahumans partly because such reinforcement serves (a) as a necessary communication system between the experimenter and the infrahuman subject and (b) as a goal emphasizer in the learning situation. Caution, however, has to be exercised lest this external reinforcement itself becomes the goal. If such a substitution occurs, then the absence of the reinforcing stimulus would result in inattention or the loss of goal-oriented behavior. Such behavior, observed as "fooling around," apparently did occur when Professor Staats experimentally omitted reinforcing stimuli in the midst of an instructional sequence.

Use of such external reinforcement for communication with human subjects is unnecessary, for even three-year old children can converse directly with the experimenter or the teacher. In other words, verbal feedback can be used to give human subjects knowledge of correctness of response. Furthermore, instead of primary motivation, higher order motives such as curiosity can be relied upon for motivating the learner, particularly if the learner's primary needs have been satisfied (Maslow, 1943). The use of curiosity as a motivational force was well stated by Harlow (1953) when he explained that children as well as monkeys are curious creatures who can enjoy achievement for its own sake; witness the monkey who continues to solve problems even though his cheek pouches are full of food so that he can "reward" himself for both correct and incorrect responses. Even under such conditions, monkeys can increase their ability to learn how to learn (Harlow, 1949). Certainly higher order primates, like children, can also learn without extrinsic reinforcement.

Therefore, instead of relying upon a behavior repertoire
of external reinforcements alone for communication and
gratification of primary drives, the experimenter or th-
teacher, following certain principles of field theories
of learning (Hilgard, 1948) can arouse children's curiosity
about the printed stimuli, verbally orient children to
reading goals, and show children means of reaching the
goal of deriving meaning from the printed page.

Arousal of children's curiosity about printed stimu-
li is relatively easy in the initial stages of reading
instruction because when children first come to school
they expect to, and are eager to, learn to decode these
stimuli so that they too can participate more fully in
the printed aspects of their culture (Stendler and Young,
1950). Moreover, the experimenter or the teacher could
strive to have children learn to anticipate and confirm
their own responses through a stimulus-response chaining
determined by the accumulated sense of the passage. Also,
children can be taught to actively engage in reading by
formulating, and then reading to answer, their own ques-
tions (D. W. Gilbert, 1956) and thus read to attain the
goal of satisfying their own curiosity. In fact, most
children _want_ to learn to read, are pleased when they can
decode printed stimuli, and increasingly seek out this
activity for its own sake (Olson and Hughes, 1944), par-
ticularly as they become cumulatively more successful in
obtaining meaning from the printed page. Hence, an
individual's curiosity can be utilized to arouse, sustain,
and direct the individual's energy, provided the indi-
vidual has had adequate instructional guidance so that he
can be reasonably successful in solving reading problems,
as in recognizing non-sight words or getting the intended
meaning from a story.

Staats's instructional model does provide very well
for such guidance through careful control of the sequence
and frequency of printed stimuli to which the individual
is to respond. Implicit in his curriculum is the narrow
definition of reading that correct oral responses to
printed words _is_ reading, but even if Staats's model were
used to teach children to read according to the broadest
definition of reading, the question that would still arise
is whether his theory would explain the acquisition of
reading behavior and would stimulate research that would
enhance our understanding of how individuals _do_ learn to
read. This question would arise because no attempt has
been made in his theory to explain _how_ the learner can
acquire, organize, store, reorganize and mobilize word

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recognition, word meaning, and reasoning-in-reading
abilities for responding to the printed page (Singer,
1960, 1962). Essentially, Staats's S-R model does not
take into consideration the cognitive capabilities of
the learner for acquiring, processing, organizing, and
utilizing a response repertoire for reading.

One of the facts that confronts the theorist in ex-
plaining how children learn to read is the enormous varie-
ty of phoneme-grapheme relationships in the English lan-
guage. For example, "eye, aisle, I, try, aye, and high"
have different graphemes for the same phoneme, "i." The
learner must acquire not only a repertoire of responses
to such printed stimuli, but if he is not to suffer a
cognitive overload in learning to read, he must somehow
(a) reduce the variety of stimuli and (b) develop flexi-
bility in shifting his mental organization from one word
recognition approach to another (Gates, 1953; Russell
and Groff, 1955). Because an individual does have mentally
manipulable cognitive and linguistic capabilities, it is
possible for him to achieve the necessary data reduction
in learning to read by building up a repertoire of word
recognition and word meaning concepts that can be appro-
priately mobilized for attaining speed and power in read-
ing (Singer, 1960, 1962). To the extent that the indi-
vidual can and does learn to group and mentally categorize
such stimuli as those that have (a) the same sound, but
different visual characteristics, as in "eye, I, aisle,"
and (b) the same visual characteristics but different
sounds, as in "cough" and "though," he can reduce the
complexity of his storage and response system to printed
English. If an individual also demands meaning as he
reads, he can employ a powerful tool of accumulated word
meanings or context clues for judging whether he has
made an inappropriate response and therefore should
switch to a more appropriate one. To facilitate the
development of this conceptual storage and response
system that could be flexibly mobilized for reading, the
curriculum could be organized according to common auditory,
visual, and perhaps kinesthetic word or word-part group-
ings. Then, instead of a word frequency curriculum which
complicates the learning task because of the high degree
of perceptual similarity in words that occur frequently
in the printed language, a curriculum designed for what-
ever structure is inherent in printed English would not
only simplify the perceptual discrimination task, but
would also stress cumulative transfer (Bruner, 1963) and
enable individuals to learn how to learn to read.

Although individuals can and apparently do learn to read in a word frequency determined curriculum, which places a premium upon memorization, they could learn to read perhaps better and at a more rapid rate if instruction were organized and geared to such higher mental processes as abstraction and generalization (Gans, 1940). Even when reading instruction may require only memorization, some individuals may devise their own learning strategy so that they can mobilize higher mental processes, perhaps because such mental processes, which result in the formation of word recognition and word meaning concepts, are probably necessary in order to reduce the memory load that would result if individuals had to develop a separate response for each stimulus word. This learning strategy may have been employed by some of the children who, as early as the second grade, could recognize words to which they had not been instructionally exposed (Gates, 1962). Perhaps these children, on their own, had mentally sorted out, abstracted, and formed word recognition concepts from appropriate memory images of instructionally-determined sight words. Then, in response to the demands of the task-stimuli, these children could have gradually learned to mobilize these stored word recognition concepts in the necessary sequence and with sufficient versatility so that they were subsequently able to accurately recognize printed words that were not in their sight word repertoire. The curriculum, however, can be arranged to develop such word concepts, as was done for spelling with successful transfer results (Gates, 1935); because of the similarities between spelling and word recognition (Spache, 1940; Russell, 1946), the probability is high that a similar organization in reading instruction would also result in greater transfer in word recognition. Certainly, provision would also have to be made to teach children appropriate conceptual spans (Zaslow, 1957) or limits to their generalizations (Singer, 1960).

Of course, S-R theory can explain how individuals can learn to discriminate, abstract, and generalize; but S-R theory cannot predict the formation of conceptual systems. However, if the cognitive capabilities of the human learner were added so that the theory would be an explicitly formulated Stimulus-Organism-Response model, then hypotheses could be derived and tested to determine the conditions under which the cognitive capabilities of the learner can be developed into an adequate system for handling the mass of detailed information that is necessary for responding accurately and meaningfully to printed words. Hypotheses on the functions of mediational systems are

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already being tested. For example, Ausubel (1960) has
reported that individuals who had acquired specific
mediators through preliminary experimental manipulation
could organize and retain more information from their
reading than a matched group of individuals who had not
received pretraining on these specific mediators.

Summary

The "integrated learning theory for reading" pro-
posed by Professor Staats is not integrated with S-O-R
nor with field theories of learning. Because Staats's
theory does not explicityly take into account such human
attributes as conceptual and linguistic ability, it has
limited explanatory and heuristic value. An instruction-
al model, based upon a theory which encompassed such at-
tributes, could utilize a more humanistic approach to
teaching reading. In this approach, printed stimuli
would be organized to facilitate the development of con-
ceptual systems for responding to printed words. This
conceptualization process would consequently reduce
"cognitive strain" (Bruner, Goodnow, and Austin, 1957)
that would otherwise ensue from trying to form a separate
response for each non-identical printed word stimulus.
Moreover, in accordance with field theory concepts of
learning, an individual could be taught to demand meaning
from reading so that he could learn to confirm the ade-
quacy of his responses as he reads. If the individual
were also taught to formulate his own questions as he
reads, he could read for the hedonistic goal of satisfy-
ing his own curiosity. Perhaps individuals who have
learned to arouse their curiosity by formulating their
own questions and reading for the mental pleasure of
finding answers to these questions are the ones who proba-
bly choose to read during their leisure time partly be-
cause of the consequent self-reinforcement obtained while
reading.

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A DISCUSSION OF STAATS' "INTEGRATED-FUNCTIONAL LEARNING THEORY IN READING"

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In Dr. Staats' paper we see a direct application of B. F. Skinner's operant conditioning principles. These principles are based largely on work curves generated by reinforcing or rewarding hungry rats and pigeons for doing specific tasks. There is certainly nothing wrong with generalizing and testing principles of animal behavior on human behavior. Skinner, Ferster, and others have contributed some valuable insights which we see applied here in the reading situation. However, Skinner, and, as we see in this paper, Staats, are laboring under the serious difficulty of men who have found but a piece of the truth and proceed as though they have found either the whole truth or a major portion of it.

Staats indeed makes several precautionary statements about the need for more work and further development of learning principles, but one gets the general feeling from the very way in which he uses such terms as "the learning principles" that really a good deal of the whole field of learning has now been set down.

Staats places himself clearly on the side of the angels. He tells us that he is using "the methods of science" and then he proceeds to teach reading to such currently popular subjects as four year olds, the juvenile delinquent, and a few retarded children. How can you go wrong with not only science on your side but also populations like that?

This reviewer does not wish to throw only cold water on this interesting invaluable paper but rather to put it in perspective. The acquisition curves published in Ferster and Skinner's book were developed with pigeons but have been applied to humans before. It is valuable that researchers like Staats can take and apply these to the reading situation. However, the problem of these operant conditioning people is their extreme reliance on tangible rewards. We note that Professor Staats says (page 37):

"For one thing is quite evident throughout this project of study, when there are not adequate sources of reinforcement, attention and working behaviors are not maintained--and learning then ceases."

If the operant reinforcement people would get their heads a few inches above the rat cage or the children cage they might notice that in America some 4 million children enter first grade each year and the overwhelming majority of them learn to read without the teacher giving them tokens for toys.

Staats makes a number of references to an "integrated-functional learning theory of complex behavior" which apparently will be discussed in greater detail in his forthcoming book. In attempting an integrated theory he departs from Skinner. who at least verbally states a disa-vowal of "theory." Staats is also willing to discuss such things as emotion as a mediating activity between the en-vironmental stimuli and the behavior. A pure Skinnerian would prefer to discuss only the stimuli and the behavior. Hence there is hope that Staat's forthcoming theory will be broader and more encompassing of the total reading act than we see in the experiment he has described. His ex-periments are very close to a conditioned reflex-type model but his theory may be somewhat broader, as this reviewer thinks it must be to encompass the complex phe-nomena we call "reading."

In conclusion I would like to say that I am delighted that there are scientific experiments being conducted in reading along these lines and I am also pleased, though not quite delighted, that there is theorizing going on about it. However, this paper and the experiments de-scribed in it seem to me to be very closely tied to that school of rigid behaviorism known as operant conditioning. The manner in which "learning principles" are discussed seems to me to be a bit narrow.

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GENERAL OPEN SYSTEMS THEORY AND THE
SUBSTRATA-FACTOR THEORY OF READING [1]

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Purpose

This study was designed to extend the generality of
the Substrata-Factor Theory via two methods of investi-
gation:
1. Theoretically, to establish the validity of
   the hypothesis that an isomorphic relation-
   ship exists between the Substrata-Factor
   Theory and General Open Systems Theory;

2. Experimentally, to discover through a series
   of substrata analyses the patterns of inter-
   action by which a set of subject matter areas
   (reading, vocabulary, information, literature,
   grammar, numerical reasoning, arithmetic funda-
   mentals, geography, history, and civics) mutu-
   ally and reciprocally support each other.
   These patterns are used to illustrate the
   nature of the subsystems subsumed within a
   suprasystem as postulated in the theoretical
   models under consideration.

Method of Analysis

In Part I, a logical analysis of the postulates de-
rived from the General Open Systems Theory and the Sub-
strata-Factor Theory is made. Attention is particularly
centered on the eighth postulate as an appropriate focus
to illustrate in Part II the statistical application of
the postulate.

In Part II, two substrata analyses are presented to
discover the statistically significant contribution which
each of the content areas makes to the other specified
subsystems in an idealized" mental cosmos which the
model conceives as a syprasystem of interrelated working
system hierarchies.

Part I

The integrating construct of this paper is General
Open Systems Theory. General Open Systems theorists make

the following presumptions:

1. that inanimate and animate matter can be repre-
    sented by systems,

2. that a greater unification among the various
    sciences is both desirable and attainable, and

3. that there exist general systems laws "which
    apply to any system of a certain type, irre-
    spective of the particular properties of the
    systems or the elements involved" (Bertalanffy,
    1950b, p. 138).

General Open Systems Theory has been described by
Ashby (1958, p. 1) as symptomatic of a movement directing
its attention to systems that are complex. Ashby notes
that for the past two hundred years science has been
interested primarily in whatever is simple, i.e., in
identifying the units out of which complex structures are
made. Thus Sherrington isolated the stretch reflex;
Pavlov, the salivary conditioned reflex; Dodge, the
corneal-reflection method for photographing eye movements.
The rule was to fractionate and study one variable at a
time.

Bertalanffy (1956, p. 2) indicates that one of the
main problems of General Systems Theory is to deal with
organized complexity. Logic would seem to demand not a
special systems theory but a larger construct utilizing
universal principles valid for "systems" in general in
order to understand the characteristics of such organized
complexity.

Bertalanffy defines a system as "sets of variables
standing in interaction" (1956, p. 3).

Floyd Allport gives a comprehensive definition of
a system:

> . . . any recognizably delimited aggregate of
> dynamic elements that are in some way inter-
> connected and interdependent and that continue
> to operate together according to certain laws
> and in such a way as to produce a characteris-
> tic total effect. A system, in other words,
> is something that is concerned with some kind
> of activity and preserves a kind of integration

and unity; and a particular system can be recog-
nized as distinct from other systems to which,
however, it may be dynamically related. Systems
may be complex, they may be made up of interde-
pendent sub-systems, each of which, though less
autonomous than the entire aggregate is, never-
theless, fairly distinguishable in operation
(1955, p. 469).

Astronomers have little difficulty defining a solar
system, even though it is obvious that a particular solar
system is part of a larger system such as a galaxy, which
in turn is part of the Milky Way, which is embedded in
the universe. The definition of a system is arbitrary and
is highly dependent on a priori definitions of a task or
problem:

The concept of system, then, implies a goal or
purpose, and it implies interaction and communi-
cation between components or parts . . . .

A man-machine system is an organization whose
components are men and machines, working to-
gether to achieve a common goal and tied to-
gether by a communication network (Gagne, 1962,
pp. 15-16).

Systems may vary along two dimensions: (1) by their
level of abstraction (pictorial, descriptive, or abstract
mathematical); and (2) by the type of metaphor they em-
ploy (machine, organism, field, etc.) (Hearn, 1958, p.
40). The most appropriate metaphor for representing
human individuals and human aggregates is the Organismic
Open Systems Model.

From an analysis of dynamic and serviceable theories
in a number of sciences including biology, chemistry,
and physics, Bertalanffy (1945, 1950a & b, 1956) identi-
fied or abstracted seven attributes of an Organismic Open
Systems Model; Werner (1948), an eighth:

1. Open Systems exchange energy and information with
    their environment through input and output channels.

2. Open Systems tend to be characterized by steady
    states as those of organic metabolism - a constant
    ratio being maintained by the components of the
    system. An inanimate example is that of a candle.

> When first lighted it's flame is small, but grows
> rapidly to its normal size and maintains this size
> as long as the environment of the flame remains
> constant.

3. Open Systems manifest regulating tendencies of the
   organism to reestablish a steady state after being
   disturbed. A sudden draft will cause a flame to
   flicker, but the flame quickly regains its normal
   characteristics once the ventilation of the room
   has been restored.

4. Open Systems exhibit equifinality - a final state may
   be reached from different conditions and/or different
   ways. Hearn illustrates the concept of equifinality
   by the case of two babies born at the same time, one
   of whom is premature, the other full term:

   > While at birth they will have been different
   > in appearance and stage of development, with-
   > in a very few weeks after birth they will
   > probably have achieved a similar stage of
   > development. What this seems to mean is
   > that for every species there is a typical
   > or characteristic state; indeed, for every
   > individual within the species there is a
   > characteristic state which he, by nature,
   > must strive to assume. It is perhaps
   > more accurate to say he has characteristic
   > states for each successive stage of develop-
   > ment (1958, p. 45).

   Consistent with the postulate of equifinality is
   that different initial conditions may lead to an
   equivalent characteristic state.

5. Open Systems display a dynamic interplay of sub-
   systems operating as a fruitful process which is in
   part responsible for the maintenance of a steady
   state. A change of some quantity is a function of
   the quantities of all elements. "The system, there-
   fore, behaves as a whole, the changes in every
   element depending on all others" (Bertalanffy, 1950b,
   p. 146).

6. Open Systems evince feedback processes, wherein the
   output is compared against desired performance and
   past behavior, which contribute to the maintenance
   of the steady state.

7. Open Systems display progressive segregation - a process wherein systems divide into a hierarchical order of subordinate systems. It has been assumed that the process of segregation is related to negative entropy wherein the organism progresses to higher levels of order and differentiation. Disorganization (positive entropy) and organization (negative entropy) operate in a living organism during the entire course of life.

> In the early stages of life, organization outruns de-organization, so that the organism becomes more and more differentiated or, in other words, grows. With adulthood, life continues, but growth slows to a stop. With old age de-organization outruns organization, and with death organization terminates and de-organization, resulting from the free play of entropy, has full reign (Bray and White, 1954, p. 75).

8. Open Systems also display progressive integration. Higher order systems are continually being formed from the organization of smaller systems into functional hierarchies united to cope with problems of greater complexity than can be handled by any of the subordinate systems alone. This is a function of negative entropy.

Concurrent and independent of Bertalanffy[2] (1945: 1949 (trans. to English, 1952), 1950a & b, 1951, 1955, 1956, 1962a & b) and other open system theorists who have published in The Society for the Advancement of General Systems Theory since 1956, and the Journal of Behavioral Science also founded in 1956, Holmes (1948, 1953, 1954, 1960, 1961a & b, 1963a & b, 1964a) and Holmes and Singer (1961, 1964, 1965) developed the Substrata-Factor Theory of Reading.

The major hypothesis of the analysis to be described in this paper is that the Substrata-Factor Theory of Reading and Open Systems Theory are isomorphic to each other, i.e., are structurally similar.

Brodbeck points out that isomorphism requires two conditions:

1. There must be a one-to-one correspondence between the elements of the model and the

elements of the thing for which it is
a model. For every chimney stack, there
is a miniature chimney. Every window
has its replica and vice versa.

2. Certain relations are preserved. For
instance, if a door is to the left of
a window in the original, their replicas
are similarly situated; the model is
constructed to scale. The model may or
may not "work" on the same principle as
the original. If it does, the iso-
morphism is complete. If for instance,
a model of a steam engine is also steam
propelled, then the isomorphism is com-
plete (Brodbeck, 1959, p. 374).

The breadth of the Substrata-Factor Theory is indicated
by Holmes in the following summary which defines reading
in terms of his theory:

In essence, the Substrata-Factor
Theory holds that normally reading is
an audio-visual verbal processing skill
of symbolic reasoning, sustained by the
interfacilitation of an intricate hier-
archy of substrata factors that have
been mobilized as a psychological work-
ing system and pressed into service in
accordance with the purpose of the
reader (1960, p. 115).

Significance of Analysis

The significance of the following analysis rests in
its attempt to show that the essential _form_ of the postu-
lates of the Substrata-Factor Theory are identical with
the generalized _form_ of the fundamental postulates that
have been discovered to hold for modern theories in other
sciences. If this can be done, it will show that the
postulates of the Substrata-Factor Theory which were
formulated to explain the _content_ of a specific discipline,
reading, without regard to form, nevertheless, fit the
formal criteria of the General Open Systems Models as ab-
strated from other sciences. What would this prove?
Most importantly, it would show that the formal aspects
of the Substrata-Factor Theory were not only consistent
with similar Open Systems theories in other sciences, but

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also that it was internally consistent. The presentation
that follows is an attempt to show how the Substrata-
Factor Theory parallels General Open Systems Theory.

In this paper, each of the General Open Systems
Theory postulates is stated. After each general postu-
late a discussion relates the Substrata-Factor Theory in
that area to the General Open Systems Theory.

General Open Systems Theory Postulate I: <u>Exchange
of energy, information, or matter with the environment
through input and output channels</u>. Interaction between
the individual and the environment implies that the total
variance of any response can be accounted for only in
part by individual differences. It depends also on the
stimulus characteristics of the environment and the inter-
action between the individual and his milieu.

The total range of "outside" and "inside" variables
has an impact on the output of the individual's achieve-
ment. S. B. Sells (1963, pp. 9-13) has outlined some two
hundred manageable variables that can be empirically
measured. Sells' effort is a first step toward the de-
velopment of taxonomic dimensions to account for the total
stimulus situation.

The five major headings around which these two
hundred variables are grouped include natural aspects
of the environment; man-made aspects of the environment;
description of task-problem, situation and setting; ex-
ternal reference characteristics of the individual; and
individuals performing in relation to others.

The Substrata-Factor Theory predicts that a child's
achievement hierarchy, which would include many variables
in each of the above five major headings, will undergo
a gradient shift or orderly change as he progresses
through school. As the individual increases his proficiency
in newly learned subskills, the content and structuralorgan-
ization of the substrata factors in the hierarchy which
underlie his developing ability to achieve will also change.

General Open Systems Theory Postulate II: <u>Maintenance
of steady states</u>. The concept of a steady state was proba-
bly first stated by Mareau de Maupertuis (1698-1759) in
his <u>Essai de Cosmologie</u> (1750) in which he described the
principle of least action. In biological terms Claude
Bernard (1865) expressed Maupertuis' principle as the
maintenance of the internal environment. Fechner (1873),

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in a practically unknown monograph, describes his idea of the steady state as follows:

> All development progresses in the direction of an always more complete utilization of energy for stationary systems - maximum stability, therefore, always means maximum utilization of energy (quoted in Menninger, Mayman, & Pruyser, 1963, p. 82).

Cannon conceived of homeostasis, wherein a physio-chemical constancy is maintained, such as the automatic regulation of body temperature, the pH level of the blood, and the maintenance of osmotic pressure.

In the field of reading, the Substrata-Factor Theory postulates a working system of subabilities which are directed toward the solution of a problem.

> . . . . The problem organizes the abilities, as the abilities determine what may be organized. That is, the particular kind of problem requires a certain organization of abilities, as the individual possession of certain abilities limits what he may organize (Holmes, 1953, Ch. 32, pp. 1-2).

Neurologically, a working system is conceived of by Holmes (1960, p. 117) as a nerve-net pattern in the brain that functionally links together the various subsystems that have been mobilized in a workable communications supersystem. A first approximation of how this working system might be determined is at present statistically derived by a Wherry-Doolittle-Holmes Substrata Analysis.

On the basis of Holmes' extension of the steady-state principle to reading, the Substrata-Factor Theory predicts that working systems would vary with the problem, the purpose, and the stage of psychoeducational neurological development of the individual.

General Open Systems Theory Postulate III: <u>Self-regulating tendency--reestablish a steady state after being disturbed</u>.

> . . . . The very counteractivity which corrects the undesirable deviation often proceeds in an oscillating fashion. Restoration of the original state of equilibrium

is not a very smooth process, but con-
sists of a series of pulls and pushes,
like the swings of a pendulum, which
gradually approximates the center-of-
gravity position. The corrective ac-
tivity may overdo or underdo the job
it is called to do; there may be an
overshooting or undershooting of the
mark while the corrective process is
going on (Menninger, Mayman, & Pruyser,
1963, pp. 87-88).

In terms of reading, the deviation of a working sys-
tem from its steady state may be manifest in the return
sweep, number, and pattern of fixations, regressions, and
the duration of fixation. For instance, regressions have
been studied most intensively by Bayle (1942), who noted
that causes of regressions may be found in the type of
material and the difficulties the reader experiences in
deriving meaning. Six interpretation difficulties which
affect the eye-movement patterns were identified by Bayle
as word order; word grouping; misleading juxtaposition
of certain words; lack of punctuation to make the meaning
clear; shifts in the meaning of words; and the necessity
for concentrating on key words or key elements in sentence
units.

The Substrata-Factor Theory holds that when the work-
ing system is inappropriate for the reader's purpose
(specific word attack in an otherwise easy passage), the
steady state will be disturbed, and the working system
will make internal adjustments in an effort to solve the
problem. Upon clarification, the original working sys-
tem will be restored.

Several interesting questions are raised by Menninger,
Mayman, and Pruyser (1963) about the concept of self-
regulation and return to the steady state.

Is there a complete return to the status
quo ante?
Is the process of disequilibriation to
equilibriation a circular one?
Are the mechanics of control the same at
every level?
Does it equally apply to parts and wholes,
to systems, subsystems, and supersystems?
Is there growth of self-regulating action
and decline of it?

Most of the answers to these questions would involve carefully executed microscopic and macroscopic studies, but the Substrata-Factor Theory would predict, as far as reading is concerned, a qual ied negative answer to the first four.

General Open Systems Theory Postulate IV: Equifinality. Bertalanffy has pointed out that equifinality in Open System Models is another of the characteristics which distinguish them from closed systems:

> In closed systems the final state is unequivocally determined by the initial conditions: for example, the motion of a planetary system where the position of the planets at a time t are unequivocally determined by their position at a time t_o. Or in a chemical equilibrium, the final concentrations of the reactants naturally depend on the initial concentrations. If either the initial conditions or the process is altered, the final state will also be changed. This is not so in open systems. Here the same final state may be reached from different initial conditions and in different ways. This is what is called equifinality, and it has significant meaning for the phenomena of biological regulation . . . . The sea urchin can develop from a complete ovum, from each half of a divided ovum, or from a fusion product of two whole ova. The sample applies to embryos of many other species, including man, where identical twins are the product of the splitting of one ovum (1955, p. 77).

The Substrata-Factor Theory states that different individuals (or the same individual at different times) may perform the same task to an equal degree of success by drawing upon different sets of abilities. This hypothesis was substantiated for power of reading based on a comparative substrata analysis of the working systems of boys and girls at the high school level (Holmes & Singer, 1961).

General Open Systems Theory Postulate V: Dynamic interplay of the subsystems. The dynamic interplay of subsystems is well described by Menninger, Mayman, and Pruyser (1963):

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> A hierarchy of levels can be recognized,
> each with its own mode and means of
> homeostatic regulation, interrelated by
> an over-all homeostatic tendency (p. 65).

Five specific interactions of the various subsystems are indicated by Luby (1962): a receptor system for external stimuli; a receptor system for internal stimuli including those from muscles, joints, and viscera; a system for filtering the diverse sensory input and integrating and interpreting it; an effector system involving autonomic and volitional motor acts; a chemical energy production system necessary for the adequate evocation of reactions in each of the separate systems mentioned.

The Substrata-Factor Theory postulates that the various substrata factors are tied together in a working system; and as their interfacilitation in the working system increases, the efficiency of the child's reading also improves. Such diverse substrata factors initially become associated in a particular working system by the psycho-catalytic action of mobilizers--hypothetical constructs which are deep-seated value systems (Holmes, 1959).

General Open Systems Theory Postulate VI: Feedback process. The feedback concept has been highlighted by cybernetics in terms of servomechanisms, i.e., some device that controls some variable in a special way by comparing its actual value with a desired reference value.

Recently, Fender (1964), a professor of biology and electrical engineering, has described the human body as a collection of servomechanisms. Feedback critical systems regulate such functions as body temperature, constitution of body fluids, the flow of blood to the organs and extremities, and the rate of breathing to the level of physical activity.

Fender did an intensive microscopic analysis of the control mechanism of the eye and found that the microscopic structure of the retina is similar to that of the brain. In fact, he notes, the retina is part of the brain that became detached in the course of evolution (1964, p. 32).

The implication of Fender's systems analyses of the eye enhances the idea that the retina contains not only light-sensitive rods and cones but also bipolar cells,

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amacrine cells, and ganglia which may equip it to process
some information in its own right. The eyes are not
merely a reflector of higher mental process or a mechanical
camera. (See also Granit, 1955.)

The Substrata-factor Theory postulates a continuous
monitoring of the meaningful material in order for mobi-
lizers to effect the successive compensations necessary
within the working systems as they fluctuate around their
hypothetical steady states.

. General Open Systems Theory Postulate VII: <u>Progress-
ive segregation and hierarchical order of subsystems</u>. This
postulate is very similar to the organismic-holistic orien-
tation of Werner and Kaplan who assume". . . that organisms
are naturally directed towards a series of transformations--
reflecting a tendency to move from a state of relative ·
globality and undifferentiatedness towards states of in-·
creasing differentiation and hierarchic integration" (1963,
p. 7).

Further, Werner and Kaplan maintain that, with the
attainment of higher levels, lower-level functions are not
lost but under normal circumstances subordinated to more
advanced levels of functioning. Under special conditions,
such as dream states, pathological states, intoxication,
drugged states, various experimental conditions or con-
frontation with especially difficult and novel tasks a
partial return to more primitive modes of functioning be-
fore progressing towards higher-level operations may be
evidenced. This tendency has been described by Werner
(1948) as the genetic principle of spirality.

The Substrata-Factor Theory postulates the gradient
shift in perceptual-conceptual differentiation within
and between kinesthetic-auditory and visual modes of
learning. There is continual interaction between the
whole and its parts. As the parts become more differenti-
ated and meaningful, so does the whole; and as the whole
becomes more meaningful, so do its parts (Holmes, 1953,
Ch. 32, p. 7).

What constitutes part and whole is a perennial scien-
tific problem continually being analyzed by the nature
of scientific reduction. In any scientific observation
what is taken as the whole and what, as the parts? The
history of science indicates that the answers to this
question are inextricably bound up with the personal
preference of the experimentalist, his concepts of cau-
sality, the culture he belongs to, the Zeitgeist of the

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times he lives in, and the nature of the material or
experiment.

General Open Systems Theory Postulate VIII: Pro-
gressive integration. Postulate VIII develops from
Postulate VII; with the continued organization of smaller
subsystems into functional hierarchies, a more integrative
supersystem also emerges.

Each of the constituent subprocesses must be thought
of as integral parts of the whole that work together and
contribute proportionately to its total in each and every
situation in which the supersystem works.

By additive processes, series-combinations
of suitable systems, interlaced with parallel-
combinations as desired, may be constructed
into larger and larger systems. Thus, hier-
archies of subsystems may be developed: sub-
system of subsystem of subsystem, etc. (Ellis
& Ludwig, 1962, p. 11).

Miller, Galanter, and Pribram come to grips with
the supersystem subsystem relationships as follows:

The implication is relatively clear, however,
that the molar units must be composed of
molecular units, which we take to mean that
a proper description of behavior must be
made on all levels simultaneously. That is
to say, we are trying to describe a process
that is organized on several different levels,
and the pattern of units at one level can be
indicated only by giving the units at the
next higher, or more molar, level of descrip-
tion.

For example, the molar pattern of behav-
ior X consists of two parts, A and B in that
order. Thus, X = AB. But A, in turn, con-
sists of two parts, a and b; and B consists
of three, c, d, and e. Thus X = AB = abcde,
and we can describe the same segment of be-
havior at any one of the three levels. The
point, however, is that we do not want to
pick one level and argue that it is somehow
better than the others; the complete descrip-
tion must include all levels. Otherwise,
the comparative properties of the behavior

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will be lost--if we state only abcde,
for example, the (ab) (cde) may be-
come confused with (abc) (de), which
may be a very different thing.

This kind of organization of be-
havior is most obvious, no doubt, in
human verbal behavior. The individual
phenomena are organized into morphemes;
morphemes are strung together to form
phrases; phrases in the proper sequence
form a sentence, and a string of sentences
makes up an utterance. The complete des-
cription of the utterance involves all
these levels. The kind of ambiguity that
results when all levels are not known is
suggested by the sentence, "They are fly-
ing planes." The sequence of phonemes
may remain unchanged, but the two analyses
(They) (are flying) (planes) and (They)
(are) (flying planes) are very different
utterances (1960, pp. 13-14).

Holmes utilizes the concept of substrata factors
which is a dynamic set of subsystems continually being
organized and reorganized in the brain depending on the
task confronting the organism. Neurologically, substrata
factors are

. . . neurolcgical subsystems of brain
cell-assemblies, containing various
kinds of information such as memories
for shapes, sounds, and meanings of
words and word parts, as well as
memories for vicarious and experiential
material, conceptualizations, and meaning-
ful relationships stored as substantive
verbal units in phrases, idioms, sentences,
etc. Such neurological subsystems of
brain cell-assemblies gain an inter-
facilitation, in Hebb's sense (Hebb, D.O.
The Organization of Behavior. New York:
John Wiley & Sons, 1949, p. 335), by
firing in phase. By this means, appro-
priate, but diverse subsets of information,
learned under different circumstances at
different times and, therefore, stored
in different parts of the brain are
brought simultaneously into awareness

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when triggered by appropriate symbols
on the printed page. These substrata
factors are tied together in a working-
system, and as their interfacilitation
in the working-system increases, the
efficiency of the child's reading also
increases (1960, p. 116).

Related to the hierarchy of subsystems upon which General
Open Systems Theory and Substrata-Factor Theory depend
is the assumption of multicausality or reciprocal cau-
sation.

McEwen (1963, p. 337) refers to reciprocal causation
as the reversibility of cause-effect relations. Physical
events are relatively free from reciprocal influence; but
biological and sociocultural situations often mutually
determine each other.

MacIver notes that "one can reverse with some degree
of truth almost any statement of social causation." He
illustrates this as follows:

    Does the kind of education account for the
    standard of intelligence in a community?
    True, but does not the standard of intelli-
    gence account for the standard of education?
    (1942, p. 68).

Neurath (1938) called this postulate 'reciprocity-
mutual causation' and abandoned it because it makes socio-
cultural data too "clumsy and perplexing."

In contrast to such a conception of multiple causation,
there are the monocausal models of Watson's conditioned
reflex or Freud's sexual compulsion and Marx' economic
determinism. As Feigl has sagaciously noted:

    . . . in most of the significant applications
    we must remember that it is an entire set of
    conditions that represents "the cause of an
    event" and that what we may abstract as "cause"
    or "effect" in a complex situation is usually
    only some factor, aspect, magnitude, etc., that
    we select from a more complex (and possibly in-
    exhaustible) welter of factual details (1953,
    p. 410).

Hook (1937) calls for a "functional theory of causation together with all the apparatus of statistical inquiry" and for "developing a theory of measurement to determine the relative weight of various causal factors considered." Only a multicausal theory could "offer an explanation of the correlations found."

The substrata factor analysis which is the statistical model supporting the Substrata-Factor Theory accepts the reciprocal causation postulate. Statistically, a substrata analysis consists of Holmes' extension of the Wherry-Doolittle Multiple Selection Technique. The W-D-H substrata analysis

(a) yields successive sets of subvariables,

(b) gives each set a definite place in a complex hierarchy of subabilities, and

(c) discovers statistically significant contributions which each of the subabilities in the hierarchy makes to the criteria immediately above it in the over-all hierarchy of skills and also to the major criterion itself.

Figure 1 shows the generalized schema of a substrata analysis. The studies to date, however, take into consideration only the X on Y regression. Hence, while the Substrata-Factor Theory postulates reciprocal causation and makes provisions for such analyses in the design of the 7094 digital computer program for a substrata analysis, the actual analyses, to date, have been in only one direction. Since cause and effect cannot be directly inferred from either simple or multiple correlation, the postulate of reciprocal cause and effect cannot be either substantiated or refuted on the basis of a statistical substrata analysis.

On the other hand, all knowledge possessed by a normal individual and all mental processes within the same individual must be actively associated or at least may become associated by an existing mental mechanism in the brain. The actual degree to which they are associated on the average may be expressed by the coefficient of correlations. While correlations cannot in any way substantiate reciprocal cause and effect relationships, the correlational analysis can and does give an estimate
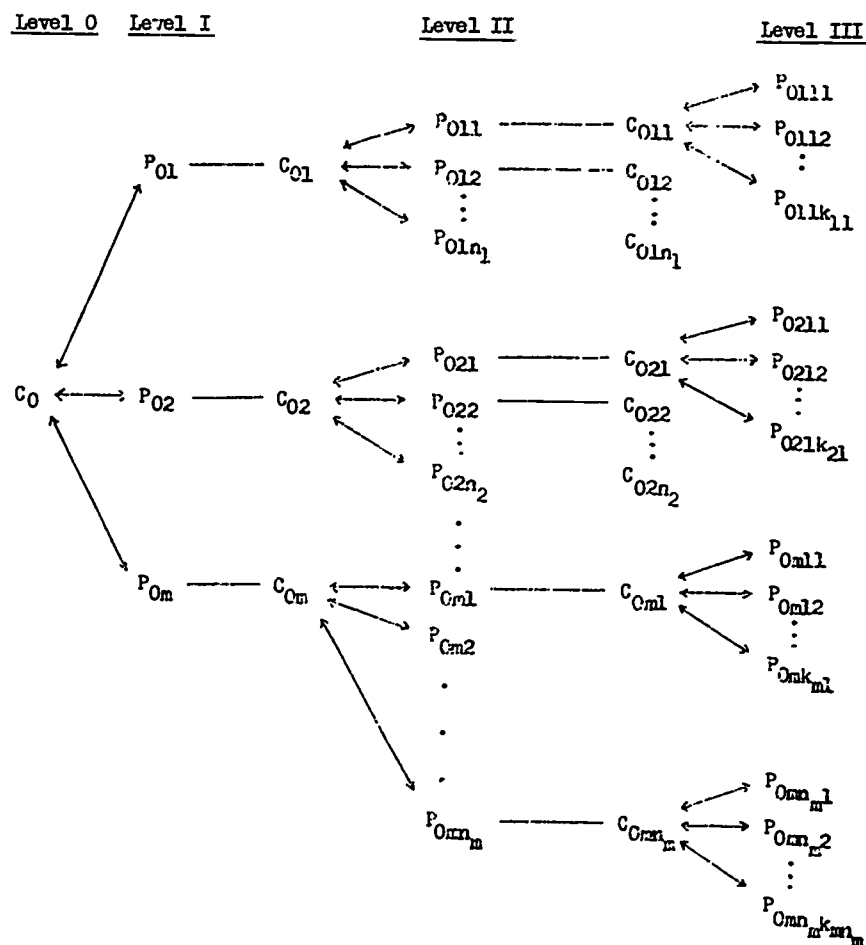
Fig. 1. Schematic Diagram with generalized notation of a substrata analysis through three levels.

Major criterion C_0 is undergirded by substrata factors P_{01}, P_{02}, ... P_{0m}. Each of these rest on a wider base at Level II. Likewise, at Level III the base is even broader. P_{0m} —— C_{0m} terminology is used to indicate an identity, except that what was considered a predictor is in turn considered a subcriterion.

From: Holmes, J. A., & Singer, H. The substrata-factor theory: substrata factor differences underlying reading ability in known-groups at the high school level. U. S. Office of Education Contracts 538, SAE-8176 and 538A, SAE-8660, 1961, 59.

of the reciprocal interactions that may be going on among
the variables.

In addition to hierarchical organization of sub-
systems' reciprocal causation is a need to reformulate the
dependent-independent variable nexus. The dependent vari-
able is (a) the response or criterion; and/or (b) the
symbol whose values are determined by the other variables
linked with it in an algebraic equation. The independent
variable is (a) any variable which is not the criterion
variable; and/or (b) the variable which is not dependent
upon changes in any other variable.

However, in educational psychology there is no such
thing as an absolutely independent variable. The "inde-
pendent" variables usually identified with environmental
conditions or personal characteristics are reciprocally
dependent and often statistically related.

The fundamental relation of all variables may be
expressed in the form $Y = f(X)$, which reads "Y is a
function of X", and means that Y changes in a way to be
discovered and/or stated whenever X changes (English &
English, 1958, p. 578).

The question of when a variable should be regarded
as an independent or "causal" variable and when as the
dependent or "resultant" variable is, in the final analysis,
left to the judgment of the experimenter. (Ezekiel & Fox,
1959).

The choice of the metaphors used by General Open
Systems Theory and the Substrata-Factor Theory for this
investigation has been guided by the following character-
istics of human beings which Hearn (1958) outlined so well:

1. Humans exchange material with their environment,
   in the form of both energy and information.

2. This energy may arise either from within the
   system or from the environment of the system.

3. Human behavior is purposive.

4. When considered both as individuals and as
   species, humans have a characteristic state
   toward which they move.

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5. Humans may achieve their same characteristic state from different initial conditions and from varying inputs of energy and information.

6. In the human individual as well as in human aggregations such as groups and communities, there is a dynamic interplay among their essential functional processes enabling them to maintain a steady state.

7. There is a tendency in human systems toward progressive mechanization; that is, in the course of human development, certain human processes tend to operate more and more as fixed arrangements.

8. Human systems show a resistance to any disruption of their steady state.

9. They are capable, within limits, of adjusting to internal and external changes.

10. They can regenerate damaged parts.

11. They can reproduce their own kind.

Part II

The empirical aspects of this study are related to a systems analysis as defined by Peach (1960) and Ryans (1964):

> By systems study or systems analysis will be meant observation directed at the determination of relevant elements of a system and their operations and interactions as they contribute to the relative efficiency with which the system outcome is produced. It will be necessary to identify and analyze properties and subsystems in order to determine chains of influence which contribute to activities and elements, and it will be necessary to put these pieces together and to synthesize the information to describe the larger systems in which our interests may be focused (Ryans, 1964, p. 23).

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Specifically, Part II is concerned with determining the answers to this problem: When each of the content areas are in turn used as criterion tasks, how do the remaining content area subsystems relate to the particular subject matter under consideration? To what degree does each of the content areas co-vary with the rest of the independent variables?

It is hypothesized that working system hierarchies for each of the content areas will manifest quantitative and qualitative differences in the organization sequences as well as magnitudes of the various subsystems.

The Substrata Analysis Method

The statistical method used to infer working-systems is a substrata analysis, an extended form of the Wherry-Doolittle Multiple Test Selection Technique. Wherry (1931, 1940a & b, 1947) and Stead and Shartle (1940) modified the Doolittle least squares technique (1878) so that the variables selected would be only those which were most independent of those already chosen and would, therefore, tend to make a maximum contribution to the multiple prediction of a criterion. The selection process stops when more chance error than predictive variance would have been contributed by the selection of another predictor.

Holmes' (1948) extension, the substrata analysis, repeats the Wherry-Doolittle procedures using each predictor as a subcriterion. The preferential predictor selected at each level becomes in turn a subcriterion at a subsequent level to be analyzed by predictors selected from the remainder of the correlation matrix. Reiteration at present extends to three levels.

Consistent with the second major purpose of the study which forms the basis of this paper, nine substrata analyses took each content area as a criterion in order to determine what proportion of intraindividual variance is accounted for by the remaining content area subsystems. Two of the nine areas analyzed, Power of Reading and Vocabulary in Isolation, are presented here.

Table 1

Intercorrelations, Means, and Standard Deviations of
Content Areas for Subsystem Interaction Analysis
$(N = 120)$[a]

No. Variables[b]	1	2	3	4	5	6	7	8	9	Index of reliab[c]
1 Power of Rdg.	——	.823	.693	.718	.576	.695	.663	.486	.548	.93
2 Vocab. in Isol.			.734	.795	.713	.664	.679	.387	.499	.95
3 General Info.[d]				.720	.587	.721	.697	.357	.501	.87
4 English Lit.					.565	.691	.649	.312	.465	.90
5 Grammar						.511	.528	.280	.371	.90
6 Geography							.769	.296	.441	.93
7 History-Civics								.311	.450	.84
8 Arith. Rsng.									.586	.91
9 Arith. Fund'ls									——	.95
Mean	101.01	99.72	13.28	95.49	95.37	89.34	85.65	91.97	90.99	
Std. Dev.	11.59	11.89	4.07	13.15	16.50	19.74	15.32	12.35	19.32	

[a]Correlations must be .24 to be significant at the 1% level of confidence.

[b]Based on Stanford Achievement Tests administered in Adolescent Growth Study as part of longitudinal analyses at Institute of Human Development, University of California, Berkeley. See: Jones, 1938, 1939a & b, 1958. Tests renamed for theoretical consistency.

[c]The index of reliability gives the maximum correlation possible between the obtained scores and their theoretically true scores. See: Garrett, 1958, p. 349.

[d]A subtest from the Terman Group Test of Mental Ability.

Working System Hierarchy of Power of Reading

An examination of the correlation matrix in Table 1 reveals that Vocabulary in Isolation has the highest zero-order correlation with the criterion Power of Reading ($r = .823$). Therefore, Vocabulary in Isolation will be selected as the first predictor test by the Wherry-Doolittle Test Selection Method. Since r^2 in this instance equals .6773, Vocabulary in Isolation cannot account for more than 67.73 per cent of the criterion's variance. However, 67.73 per cent needs to be corrected in terms of the other predictors which the method selects as well as the bias which arises from chance factors characteristic of sampling and selection techniques.

Specifically, when the contributions of all the selected predictors to criterion variance are computed, Vocabulary in Isolation will account for less of that variance than the value of r^2. This is due to the calculation of the beta weights for this particular predictor in addition to the other variables which make independent contributions to the variance of the criterion. These variables will take from the Vocabulary in Isolation subsystem some of the variance which this "most valid" predictor appears to have contributed to the Power of Reading criterion by being selected as the first test. In terms of the Substrata-Factor Theory the ". . . immediate problem is to discover which of the other variables in the matrix will be selected along with (Vocabulary in Isolation) as those variables at Level I which can be thought as having a direct and joint influence" (Holmes and Singer, 1961, p. 81) in the variation of ninth grade students' scores in Power of Reading. After Level I predictors have been selected, the next step is to use these predictors as subcriteria and determine what preferential predictors underlie these at Level II.

A pictorial display of the interaction among the various subject-matter subsystems in the working system of Power of Reading is presented in Figure 2. The major criterion, Power of Reading, is placed on the left under Level 0. Arrayed from left to right are the subject-matter subsystems selected by the substrata analysis. The path of the regression relationships between subsystems is indicated by unidirectional arrows. Mutual interaction representing interaction equally assigned in both directions is shown by double-ended arrows. The numbers adjacent to the unidirectional and bidirectional arrows
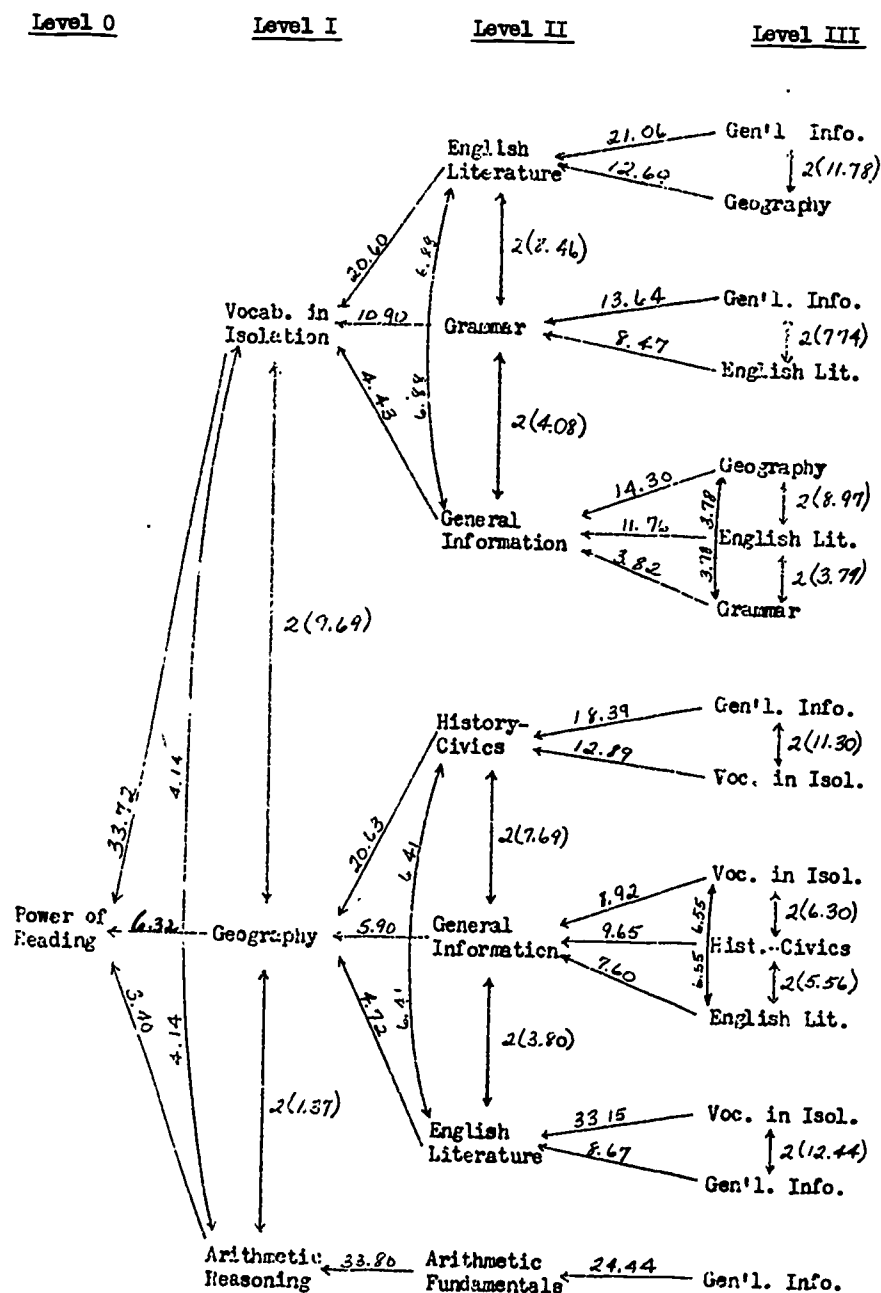
Fig. 2. Schema showing interaction among subject matter subsystems in the working system of Power of Reading; figures represent adjusted proportional variance as per cent.

indicate the relative strength of the interaction accounted for by each subject matter subsystem.

The content area subsystem, the substrata sequence, and the per-cent contribution to variance in Power of Reading at the ninth-grade level can be read from Fig. 2 as follows:

Beginning with Power of Reading, the major criterion, one can see that three subsystems precipitated from the substrata analysis to account for 73.84% of the variance in Power of Reading. The total contribution (direct plus shared variance) to Power of Reading made by each of the content areas is 47.55% by Vocabulary in Isolation, 17.38% by Geography, and 8.91% by Arithmetic Reasoning. By referring to Figure 2 one can see that

Vocabulary in Isolation can be further analyzed into

       Direct variance to Power of Reading 33.72
       Shared variance with Geography................ 9.69
       Shared variance with Arith. Reasoning......... 4.14

                     Direct plus Shared Variance   47.55

Geography can be analyzed into

       Direct variance to Power of Reading........... 6.32
       Shared variance with Vocab. in Isolation...... 9.69
       Shared variance with Arith. Reasoning......... 1.37

                     Direct plus Shared Variance   17.38

Arithmetic Reasoning can be broken down into

       Direct variance to Power of Reading........... 3.40
       Shared variance with Vocab. in Isolation...... 4.14
       Shared variance with Geography................ 1.37

                     Direct plus Shared Variance   8.91

              Total contribution to Power of Reading   73.84%

At the Level II analysis, with Vocabulary in Isolation as the subcriterion, English Literature, Grammar, and General Information account for 74.77% of Vocabulary in Isolation's variance. Now, with English Literature as the subcriterion, two subsystems, General Information and Geography, account for 57.13% of English Literature's variance. The other branches of the schema shown in Figure 2 can be read in a similar manner.

Summary of Substrata Analysis of Power of Reading

Power of Reading is a complex suprasystem dependent upon interrelationships of various subject-matter subsystems. Vocabulary in Isolation accounts for nearly half of the variance which creates individual differences in Power of Reading at the ninth-grade level. Geography and Arithmetic Reasoning, functioning either directly or indirectly, account for another 25% of the variance in Power of Reading. Not accounted for and probably intrinsic to Power of Reading or not measured in this study, is approximately 24% of the variance in Power of Reading. The remaining subject-matter subsystems are systems within systems, and the substrata analysis reveals the extent to which these subsystems interact with each other as well as the major criterion, Power of Reading.

Working System Hierarchy of Vocabulary in Isolation

The substrata analysis of Vocabulary in Isolation will provide information about the hierarchical organization of this suprasystem. Although Vocabulary in Isolation and Power of Reading correlate .8226 with each other, the major concern is with the substructural relationships underlying each of these complex subject-matter areas. While it is expected that there will be much overlap between Vocabulary in Isolation and Power of Reading, it is also anticipated that the substrata analysis will reveal constellations of subsystems which will show quantitative and qualitative differences in interaction among the various subsystems.

Level I: Substrata Analysis of Vocabulary in Isolation. The correlation matrix, Table 1, was submitted to the W-D-H Test Selection Method in order to determine the primary subsystems which underlie the ability to do well in a Vocabulary in Isolation test appropriate to the junior high school level.

Table 2, section A, presents the direct and shared variance among the subsystems selected to predict the criterion, Vocabulary in Isolation. When the beta weights are combined with the zero-order correlations, corrected for chance fluctuations according to the shrinkage formula and multiplied by 100, it is found that three subject-matter areas account for 80.77% of the variance of Vocabulary in Isolation and break down in the following manner:

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(1) Power of Reading contributes 34.35%,

(2) English literature accounts for 26.45%, and

(3) Grammar explains 19.97% of the variance.

It is interesting to note that the variance which English Literature and Grammar share indirectly with Power of Reading is about equal to the direct association of these subsystems with Vocabulary in Isolation. It is reasonable to infer that proficiency in these subject-matter systems in itself is not sufficient basis for the attainment of high achievement in Vocabulary in Isolation; relationships among the subject-matter systems will enhance performance on Vocabulary in Isolation.

Level II: Substrata Analysis of Vocabulary in Isolation. Consistent with the statistical model of the substrata analysis, it is relevant to ask what subsystems of subject-matter variables underlie each of the predictors just reported for Power of Reading, English Literature, and Grammar?

To answer this question, a substrata analysis was made deleting Vocabulary in Isolation from the zero-order correlation matrix in Table 1 and allowing each of the predictors for Vocabulary in Isolation to become a subcriterion for a Level II-substrata analysis on all the remaining variables.

Table 2, Section B, presents the regression relationship of the various subject-matter subsystems selected to predict the subcriterion, Power of Reading. This portion of the table is read the same way as the previous analysis of Vocabulary in Isolation at Level I. Three content areas, English Literature, Arithmetic Reasoning, and Geography, account for Power of Reading. The three predictors directly indicate that a bit more than half of the variance is accounted for by Power of Reading. The remainder of the variance is distributed among the content areas.

The second subsystem predicting Vocabulary in Isolation is English Literature, which is now used as a subcriterion. General Information and Power of Reading account for 60.41% of the direct and shared variance of English Literature. Each of these subsystems accounts for about an equal amount of the variance, or 30.53% and 29.88%, respectively.

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Table 2

Substrata Analysis of Vocabulary in Isolation--Subsystem in the Order
Selected and the Accounted-for Portion of Variance Directly
Associated With, and Shared Among, the Subsystems at Levels I, II, III
(N = 120)

Criterion	Subsystem selected	Correl. w/crit.	Beta	Adj. Prop. Variance (as per cent) Direct to:				Shared from:

Section A

Level 0	Level I	·		Voc.I	Power	Lit.	Gram.	Total
	Pwr. of Rdg.	.8226	.42	17.54	0.00	10.03	6.78	34.35
Voc. in Isol.	English Lit.	.7952	.33	11.13	10.03	0.00	5.29	26.45
	Grammar	.7129	.28	7.90	6.78	5.29	0.00	19.97
	Variance accounted for:			36.57	16.81	15.32	12.07	80.77

Section B

From Vocabulary in Isolation at Level 0 to:

Level I	Level II			Power	Lit.	A.Rsg	Geog.	Total
	English Lit.	.7177	.40	15.90	0.00	3.20	9.31	28.41
Pwr. of Rdg.	Arith. Rsng.	.4855	.26	6.65	3.20	0.00	2.58	12.43
	Geography	.6947	.34	11.43	9.31	2.58	0.00	23.32
	Variance accounted for:			33.98	12.51	5.78	11.89	64.16

Level I	Level II			Lit.	G.Inf	Power		Total
	Gen'l Info.	.7201	.43	18.17	0.00	12.36		30.53
English Lit.	Pwr. of Rdg.	.7177	.42	17.52	12.36	0.00		29.88
	Variance accounted for:			35.69	12.36	12.36		60.41

Level I	Level II			Gram.	G.Inf	Power		Total
	Gen'l Info.	.5869	.36	12.67	0.00	7.95		20.62
Grammar	Pwr. of Rdg.	.5765	.33	10.40	7.95	0.00		18.35
	Variance accounted for:			23.07	7.95	7.95		38.97

Section C

From Vocab. in Isol. through Power of Reading at Level I to:

Level II	Level III			Lit.	G.Inf.	Geog.		Total
	Gen'l Info.	.7201	.46	21.06	0.00	11.78		32.84
English Lit.	Geography	.6912	.36	12.69	11.78	0.00		24.47
	Variance accounted for:			33.75	11.78	11.78		57.31

Level II	Level III			A.Rsg	A.Fun			Total
Arith. Rsng.	Arith. Fund.	.5861	.59	33.80	0.00			33.80
	Variance accounted for:			33.80				33.80

(Table continued on next page)

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Table 2 (Continued)

Criterion	Subsystem selected	Correl. w/crit.	Beta	Adj. Prop. Variance (as per cent) Direct to:			Shared from:	

Level II	Level III			Geog.	Hs-Cv	G.Inf.	Lit.	Total
Geography	Hist.-Civics	.7693	.46	20.63	0.00	7.69	6.41	34.73
	Gen'l Info.	.7205	.24	5.90	7.69	0.00	3.80	17.39
	English Lit.	.6912	.22	4.72	6.41	3.80	0.00	14.93
	Variance accounted for:			31.25	14.10	11.49	10.21	67.05

From Vocab. in Isol. through English Literature at Level I to:

Level II	Level III			G.Inf.	Geog.	Power	Cram.	Total
Gen'l Info.	Geography	.7205	.42	17.15	0.00	8.00	4.45	29.60
	Pwr. of Rdg.	.6925	.28	7.74	8.00	0.00	3.37	19.11
	Grammar	.5869	.21	4.41	4.45	3.37	0.00	12.23
	Variance accounted for:			29.30	12.45	11.37	7.82	60.94

Level II	Level III			Power	Geog.	A.Rsg	G.Inf	Gram.	Total
Pwr. of Rdg.	Geography	.6947	.35	12.24	0.00	2.49	6.05	3.29	24.07
	Arith. Rsng.	.4855	.24	5.77	2.49	0.00	2.06	1.24	11.56
	Gen'l Info.	.6925	.24	5.76	6.05	2.06	0.00	2.59	16.46
	Grammar	.5765	.19	3.38	3.29	1.24	2.59	0.00	10.50
	Variance accounted for:			27.15	11.83	5.79	10.70	7.12	62.59

From Vocab. in Isol. through Grammar at Level I to:

Level II	Level III			G.Inf.	Geog.	Lit.	Hs-Cv	Total
Gen'l Info.	Geography	.7205	.28	7.54	0.00	6.98	5.12	19.64
	English Lit.	.7201	.37	13.52	6.98	0.00	5.78	26.28
	Hist.-Civics	.6974	.24	5.87	5.12	5.78	0.00	16.77
	Variance accounted for:			26.93	12.10	12.76	10.90	62.69

Level II	Level III			Power	Lit.	A.Rsg	Geog.	Total
Pwr. of Rdg.	English Lit.	.7177	.40	15.90	0.00	3.20	9.31	28.41
	Arith. Rsng.	.4855	.26	6.65	3.20	0.00	2.58	12.43
	Geography	.6947	.34	11.43	9.31	2.58	0.00	23.32
	Variance accounted for:			33.98	12.51	5.78	11.89	64.16

The third-subject matter system which predicts Vocabulary in Isolation is Grammar. A substrata analysis of Grammar reveals that General Information and Power of Reading account for 38.97% of the direct and shared variance. Three fifths of the variance is accounted for by the two subsystems in direct association with Grammar. The remaining variance is shared between General Information and Vocabulary in Isolation. Most of the variance, 61.03%, remains to be accounted for.

Level III: Substrata Analysis of Vocabulary in Isolation. The substrata analysis is continued from Vocabulary in Isolation through Power of Reading at Level I to English Literature at Level II, which is now set as a subcriterion.

At Level III, two subsystems, General Information and Geography, precipitate to predict the variance in English Literature.

Table 2, Section C, shows that the two systems account for 57.31% of the total variance in English Literature. The direct and shared variance as well as the total variance is identical to that found for English Literature in a Level III substrata analysis when Power of Reading is the major criterion. This illustrates that each subsystem has an integrity of its own and yet bears a relationship within a larger suprasystem of knowledge.

Arithmetic Reasoning is the next subcriterion to be analyzed. As in the substrata analysis of Power of Reading, Arithmetic Fundamentals is the only system precipitated, accounting for 33.80% of the variance.

The third subcriterion is Geography. Although this subsystem is analyzed at Level III, the variables precipitated and the amount of variance accounted for are identical to those found for Geography at Level II, when Power of Reading was the major criterion.

All the predictors precipitated from the three subsystems, English Literature, Arithmetic Reasoning, and Geography, in the working system hierarchy of Vocabulary in Isolation account for an identical amount of the direct and shared variance. This parallels what was found when these subsystems were subcriteria in the substrata analysis of the working system of Power of Reading.

Figure 3 shows the interaction among the subject-matter subsystems and the suprasystem, Vocabulary in Isolation. However, because the substrata sequence in which the three subsystems are represented in the working system hierarchy of Power of Reading and Vocabulary in Isolation are different; the predictors precipitated in each of the three subsystems also make different contributions ro their respective major criteria.

Table 3 presents the relevant parallel branches of the working-system hierarchies of Power of Reading and Vocabulary in Isolation in order to show the substrata sequences which provide a basis for prorating the variance accounted for in the major criterion from either Levels I, II, or III.

By using the sequential proration technique developed by Holmes (Holmes & Singer, 1961, 1965) the following is accomplished:

1. Each substrata factor's contribution to the variance in the working-system hierarchy of a given major criterion is determined regardless of the level at which it was precipitated.

2. Residuals are taken into account.

3. Particular predictors that were precipitated more than once at a given level can be accumulated, thus presenting a more concise picture of the working-system.

4. Comparisons can be made between other substrata factors precipitated in the various working system hierarchies of this study as well as other studies.

It is apparent that the second major purpose of this investigation has been substantiated, namely, that there are quantitative and qualitative differences among the subject-matter supra- and subsystems.

The reciprocal interaction that one system has on another may be inferred from an analysis of X on Y and Y on X regression equation. That reciprocity need not be symmetrical, as has been suggested by Holmes (1964a) and given theoretical neurological support by John (1962, p. 86). An indication of this non-symmetrical interaction
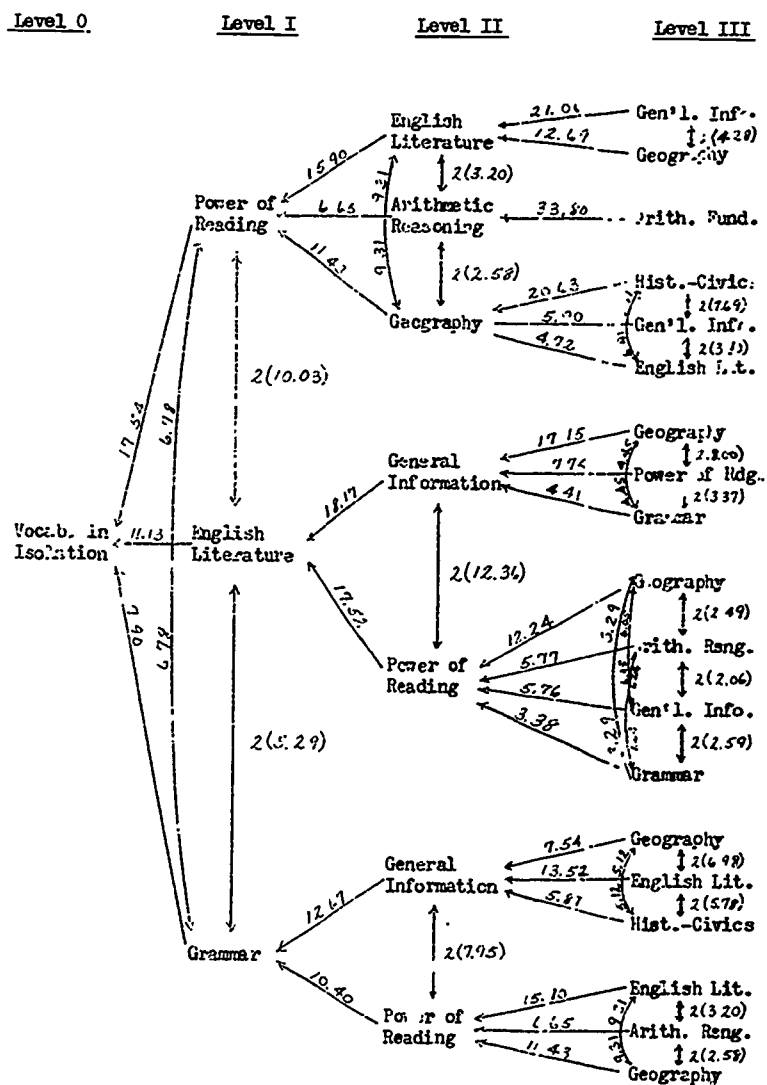
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Fig. 3. Schema showing interaction among subject matter subsystems in the working system of Vocabulary in Isolation; figures represent adjusted proportional variance as per cent.

Table 3

Comparative Substrata Sequences and Prorated Distribution of
Percentage of Criterion Variance in the Working Systems of
Power of Reading and Vocabulary in Isolation

	Sequences of substrata factors and their per cent contributions at each level of analysis						Prorated Dist. of percentage of criterion variance[a]
Level O	Level I	%	Level II	%	Level III	%	
Power (See Fig. 2)	1. Voc.I	47.55	a. Lit.	35.94	1)G.Tnf. 2)Geog.	32.84 24.47 57.31	5.61 4.18 9.79
	2. Geog.	17.38	a. Hs-Cv b. G.Inf c. Lit.	34.73 17.39 14.93 67.05			6.04 3.02 2.59 11.65
	3. A.Rsg	8.91	a. A.Fun	33.80			3.01
Level O	Level I	%	Level II	%	Level III	%	
Voc.I (See Fig. 3)	1. Power	34.35	a. Lit.	28.41	1) G.Inf 2) Geog.	32.84 24.47 57.31	3.21 2.38 5.59
			b. A.Rsg.	12.44	1) A.Fun	33.80	1.46
			c. Geog.	23.32	1) Hs-Cv 2) G.Inf 3) Lit.	34.73 17.39 14.93 67.05	2.84 1.41 1.21 5.46

[a]The prorated distribution of percentage of criterion variance is calculated by multiplying together the contributions to variance at each successive level by analysis. For example, General Information contributes 32.84% to the variance of English Literature, which, in turn, contributes 35.94% to the variance in Vocabulary in Isolation, and Vocabulary in Isolation contributes 47.55% to the variance in Power of Reading. Thus, .3284 x .3594 x .4755 x 100 equals 5.61%, the contribution made by General Information through this substrata sequence, over and above that per cent of variance contributed through other substrata sequences.

is shown by using Power of Reading as the major criterion, or dependent variable, and Vocabulary in Isolation as the predictor, or independent variable, for an X on Y regression. The converse, or Y on X regression equation, is applied by using Vocabulary in Isolation as the major criterion, or dependent variable, and Power of Reading as the independent variable. This approach to non-symmetrical interaction is summarized in Table 4.

Table 4

Non-Symmetrical Reciprocal Interaction Between
Power of Reading and Vocabulary in Isolation

Dependent variable	Independent variable	Correl. Dv vs. Iv	Adj. Prop. Variance		
			Direct	Shared	Total
Power of Reading	Vocab. in Isolation	.8226	33.72	13.83	47.55
Vocab. in Isolation	Power of Reading	.8226	17.54	16.81	34.35

John (1962, pp. 86-87) attempts to explain reciprocal interaction in terms of a physiological model for simple conditioned responses as follows:

While reciprocity of the interaction is suggested, this reciprocity need not be symmetrical, particularly when the associated discharges did not occur simultaneously in two particular foci. Assume that if a definite dominant focus is established in an area due to associated discharge of a group of neurons, afferent activity propagated into the region has an increased probability of achieving markedly nonrandom discharge from the focal area. The more recent the previous associated discharge which activated the focus, the higher the probability of subsequent nonrandom discharge which might be expected. Thus, activity propagating through a network from some region A, where associated discharge of an aggregate occurred earlier in time, might occasion markedly nonrandom discharge of some region B organized into a dominant focus by a more recent strong input from another origin. Conversely, the activity propagating through the network from the discharge of this strong focus B, established later in time than A will subsequently enter the region A. While some cells in region A may well be responsive to this input originating at B, discharge

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in region A is likely to be more random than at
B because more time has elapsed since the focus
was established, excitability of neurons in the
region is more likely to have deviated from the
common state, and thus the strength of the group
discharge tendency is lowered.

In terms of the far greater impact of Vocabulary in
Isolation, 33.72% direct variance on Power of Reading in
contrast to Power of Reading's impact on Vocabulary in
Isolation to the extent of 17.14% direct variance, it
appears that the strength of the neural aggregate dis-
charge is not only a function of recency, but also of
the following neurological and psychological reasoning
adopted and extended from John (1962, p. 86).

1. Vocabulary is the sine qua non of reading com-
prehension. If there is no vocabulary, there
can be no comprehension.

2. Although Vocabulary in Isolation is taught
earlier than Power of Reading, its repeated
association will increase the strength of
neural aggregate discharge.

3. By repeated association Vocabulary in Iso-
lation reaches a more "significant level of
activiation" (John, 1962, p. 86) than Power
of Reading.

4. The very high correlation between Vocabulary
in Isolation and Power of Reading may also
indicate

   a. a particular temporal pattern that has
   characterized the mode of discharge of
   the system and

   b. that various neural aggregates which have
   been associated during the establishment
   of a system constitute a set of recipro-
   cally interlocked dominant foci.

The foci and the relationships between them
constitute a representation of the configu-
ration of central excitations which have been
so associated. Such a system of interrelated
dominant foci will subsequently be referred
to as a representational system (John, 1962,
p. 86).

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John's representational system is equivalent to
Holmes' working system (1948). And John's neurologizing
is consistent with Holmes' (1957) model of the workings
of the brain during the reading process.

A representational system of the dominant foci in
the working-system hierarchy of Vocabulary in Isolation
is displayed in the schema shown in Figure 3. The
schema is read in the same manner as Figure 2, which
represents the working system of Power of Reading.

Summary of Substrata Analysis of Vocabulary in Isolation

A substrata analysis of Vocabulary in Isolation re-
veals a complex suprasystem undergirded by subsystems with-
in subsystems of dominant foci at Levels I, II, and III.
A comparison of the substrata sequences in the working
systems of Power of Reading and Vocabulary in Isolation
indicates that although the subsystems English Literature,
Arithmetic Reasoning, and Geography have identical direct
and shared variances within their respective subsystems,
a sequential proration based upon the multiplier princi-
ple indicated that the three subsystems make different
contributions to the variance of their major criterion.

The logic of the proration approach is given in
terms of two basic postulates which assume that substrata
factors are composed of systems within subsystems and,
secondly, correlation reflects a mean, reciprocal inter-
action among two such subsystems.

Symmetrical and non-symmetrical interaction is
further postulated with an analysis of X on Y and Y on X
for Power of Reading and Vocabulary in Isolation. Non-
symmetrical contributions to variance are found and ex-
plained by extending John's (1962) neurophysiological
model and the author's psychological reasoning about the
interaction of Power of Reading and Vocabulary in Iso-
lation.

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SUMMARY AND CONCLUSIONS

Basic Postulates of General Open Systems Theory and
the Substrata-Factor Theory of Reading: Because the inte-
grating construct of this study was General Open Systems
Theory and the Substrata-Factor Theory, fundamental postu-
lates common to the two theories were presented. Eight
postulates were identified.

Postulate I: Exchange of energy, information,
                 or matter with the environment
                 through input and output channels

Postulate II: Maintenance of steady states

Postulate III: Self-regulating tendencies-re-
                 establishment of steady states
                 after being disturbed

Postulate IV: Equifinality

Postulate V: Dynamic interplay of the subsystems

Postulate VI: Feedback processes

Postulate VII: Progressive segregation and hier-
                 archical order of subsystems

Postulate VIII: Progressive integration

Assumptions

Several fundamental assumptions had to be made in
order to proceed with the substrata analyses:

1. Content areas examined in this study are com-
    plex suprasystems consisting of many diverse,
    yet functionally related and supportive, sub-
    systems.

2. Substrata factors are dynamic sets of subsystems
    continually being organized and reorganized in
    the brain, depending on the task confronting the
    organism.

3. Hierarchies of subsystems upon which the sub-
    strata analysis is made depend on the concept
    of multi-causality or reciprocal causation.

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4. While correlations cannot in any way substantiate reciprocal cause and effect relationships, the correlational analysis can and does give an estimate of the reciprocal interaction that may be going on among the variables.

5. Reciprocal interaction may be represented by an analysis of the X on Y and Y on X regression equation - for in educational psychology there is no such thing as an absolutely independent variable. Independent variables are reciprocally dependent and often statistically related.

6. The biological sciences, i.e., physiology, biochemistry, and neurology, can provide a framework for further understanding of the psychoeducational results of this study.

Conclusions

Generally, the theoretical and empirical aims of this study were achieved, i.e.,

1. There is an isomorphic relationship between all General Open Systems Theory postulates and Substrata-Factor Theory postulates. Therefore, in terms of the abstracted General Open Systems Theory postulates, the Substrata-Factor Theory exhibits internal consistency and external agreement with similar theories in other disciplines such as biology, chemistry, and physics.

2. Subject-matter areas can be conceived of as suprasystems girded by diverse, yet functionally related, subsystems.

More specifically,

1. Working-system hierarchies were found for each content area manifesting quantitative and qualitative differences in organization of substrata sequences, amount of variance accounted for, and redundancy of particular variables.

2. Reciprocal interaction can be inferred from an X on Y and Y on X regression analysis.

3. The proration sequential technique may provide a basis for determining the extent of a

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particular subsystem's impact on the suprasystem.

Limitations

This study is a first approximation, and its gener-
alities are limited to the basic assumptions, postulates,
sampling, methods, and tests used. Further, theory build-
ing, testing, and logical analysis as well as knowledge
of the nature of the brain is necessary to more fully
understand the present findings as well as subsequent
findings.

NOTES

[1]This paper is based in part upon a Ph.D. disser-
tation done by the writer at the University of California
(Kling, 1964). The writer wishes to acknowledge the
financial assistance of the Carnegie Corporation of New
York.

[2]On a theoretical level Bertalanffy made pioneering
inroads in the field of biology. See Bertalanffy, 1928,
1932.

[3]Personal communication, Holmes (1964b).

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A CRITIQUE OF GENERAL OPEN SYSTEMS THEORY
AND THE SUB STRATA-FACTOR THEORY OF READING

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Like most others I am tremendously impressed by the amount of statistical labor that has been done by means of modern computer technology in manipulating the information in these substrata analyses. But I must admit that I would prefer to see it in a context in which fewer assumptions about the nature of the metaphysical world were involved. First, I would like to discuss my perception of general open systems theory. Judging from the various sets of postulates and assumptions, it seems to me that it is a sort of verbal game involving some statistical manipulations. The game goes something like this - let's make 24 assumptions that we state (and possibly a few more that we do not state), and given an existing set of data, see what we can say about the universe.

Notice that this is an ad hoc kind of argument or explanation. It is a statistical elaboration of existing data, and in spite of Kling's discussion which has indicated that the study has theoretical and empirical aims, it seems to me it is not, strictly speaking, an empirical study. It is true that the author has described a somewhat isomorphic relationship between general open system theory postulates and substrata factor theory postulates. This, of course, is only a theoretical aim and no empirical evidence is either demanded or produced. The second conclusion, however, that subject-matter systems can be conceived of as supra systems, undergirded by diverse, yet functionnally related subsystems, is indicated as an empirical finding. I think it is very important to notice the sense in which this is an empirical finding. We ordinarily think of empirical investigations as those in which we attempt to make predictions about events, produce an experimental situation in which data is gathered while experimental variables are manipulated, and then examine a subsequent state of affairs to determine whether or not our experimental manipulations changed anything. In this sense the research reported by Kling is not experimental research. It is experimental only in the sense that it was an effort to find out whether or not subject-matter areas could be conceived in the manner described in the Wherry-Doolittle-Holmes substrata analyses technique.

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It seems to me that the only hypotheses that were verified were that the computer was functioning and that it is possible to get correlations between these particular variables. However, that does not seem to me to be a particularly surprising finding. It reminds me of an example that Bertrand Russell once used in which he described the difference between explanation of already existing data and the prediction of future data. He indicated that it would be possible, given a sufficiently complex system, to explain on a purely mathematical basis the numbers on the last 10 license plates to go by. However, as he indicated, this would not necessarily assist you in predicting the numbers on the next license plate to come.

I think it is true that open system theory has been shown here to be applicable to the kind of data that one gets when one gives a set of tasks to a sample of students. However, I find it difficult to see the specific relevance of the open systems theory to the substrata factor theory. Everything that was said about open systems theory could very well have been said as a defense for attacking this data, as many other researchers would have done, using factor analysis techniques.

I think my problem is that I am nervous about a model such as open systems theory which is applicable to any kind of data to which you apply it. The question of whether it is a useful theory in this particular realm of inquiry depends entirely upon the experimental, rather than statistical, designs that it spawns and the utility of the results of those experiments.

Secondly, I want to discuss the notion of substrata factor theory analyses as they are carried out in the Wherry-Doolittle-Holmes statistical design.

First of all it is important to realize that this is not a factor analysis in any of the usual senses of the word. It is precisely the kind of analysis that is routinely done, for example, in our University every year in each of seventeen colleges to predict the "power of performance" of students in college for the purpose of determining which tests might best be used in entrance testing. As a matter of fact, the technique was originally proposed by Wherry and Doolittle as a method of selecting tests for the purpose of selecting people for vocations. It was proposed not as an explanatory system but as a predictive system designed for maximum effective

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decision making. It is difficult for me to see decision
making, in the sense that Wherry and Doolittle intended,
in the kind of analyses that result from the extension
that Holmes has produced. The primary difference between
the Wherry-Doolittle system of multiple regression analy-
ses and Holmes' is that Holmes carries it out to succeed-
ing steps by taking those predictors which make signifi-
cant additions to predictive power and using them as
criteria to be predicted by the rest of the variables.

It is important to remember several things about
this particular prediction model. First, it makes all
the usual correlational assumptions about all of the
variables. Any relationships in this whole analysis
which are not drawn from normally distributed variables
on samples randomly drawn from a normal population violate
the assumptions inherent in the method.

Second, its important to realize that the level of
relationships exemplified by the Beta weights in such a
predictive model are a function of the number of subjects
and the number of tests. This, of course, is easy to see.
If you had two subjects and two tests, no matter what the
results were, you would have perfect prediction and would
account for all of the variance.

Third, it is necessary to consider what changes in
the predicted variable and changes in the population
would mean in this analysis. Figures 1 and 2 show two
Wherry-Doolittle analyses carried out on populations of
college students. You will notice that some different
predictors are used in each. The numbers between the
variables indicate the zero order correlations between
the indicated variables. They have not been converted to
variance accounted for, as they are in some of the dia-
grams furnished by Dr. Kling. We were able to run only
one multiple regression analysis through the computer for
each of these samples and then constructed the first iter-
ation of a Wherry-Doolittle-Holmes method by simply in-
dicating the three highest-ranked correlations in each
case. It is possible that of the three predictors of
the first order variables, one would drop out of each if
we were able to carry it to completion. These limited
analyses, done only for the purposes of this critique, are
not carried out through the second or third step because
of the expense involved. However, there is enough data
here to suggest that one gets out of an analysis essen-
tially what he puts into it. We have known this for some
time about factor analysis, but the point has not been

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made, so far as I know, with sub-strata analysis.

I could not resist renaming the variables much in the manner of the California theorists. As you probably know, "Power of Reading" usually turns out to be a subtest; on some existing test of reading comprehension. In one case it was a Gates subtest, and as I understand it, in another case, it was a subtest of the Van Wagenen. The criterion on the two multiple regression analyses in Figures 1 and 2 is grade point average, renamed "Power of Performance." One of the interesting things that grows out of the comparison of these two analyses is the fact that in one case personality variables came out as one of the predictors. This, of course, was because personality variables were put in it in the first place. That, "defense systems," variable is the L, or lie score on the Minnesota Multiphasic Personality Inventory. The fact that this variable turns up at the first level inevitably determines that all of those personality measures which are highly correlated with it will turn up later in the aralysis. If it had been possible for us to carry this out to the third step, I am sure we would have found almost all of the variables from the MMPI showing up as predictors in later "subsystems." One of the reasons I bring this up is Kling's concluding statement that "sub-abilities make significant contributions to the variables immediately preceeding them and to the major criterion itself." A look at any one of the Holmes and Singer papers, either of the analyses reported in the Kling paper, or either of the analyses in Figure 1 and 2 would seem to me to indicate that this is not true. In fact, if it were true, these would not be second-order predictors but would have contributed significantly to the explanation of the original variance and would be included in the first iteration. This is a particularly important point since it seems to me to indicate one of the major criticisms of this kind of analysis. The reason that Wherry and Doolittle proposed dropping out those variables which did not significantly add to prediction of the criterion was that they did not make a significant contribution to it.

I think it is extremely important to recognize the need for replication of substrata analysis if it is to be taken seriously. I may have missed an article somewhere by Holmes, Singer, or Kling, but I have seen no reference to any analysis in which the same criteria were predicted using the same instruments on different populations. I cannot over-emphasize the importance of such replication.

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Possibly I can make my point by example. Supposing I were to take the data provided in the original table of intercorrelations on Power of Reading and to throw all of the tally sheets up a stairway - thus ordering the variables in what would porbably be a chance order. Supposing then that I were to take the ones on each step as a separate group and throw them up several other stairway - ordering them again according to the step they fell on. I could do this, if I had enough stairways, for two, or three, or possibly four iterations and I would end up with a great deal of data, representing an after-the-fact organization of the data at hand. I would have no way of knowing whether or not I would get the same distributions of variables if I took a sample of people from another population and used the same variables and the same stairways. Until we get a cross-validation using a similar population with the same criterion and the same predictors, we will be in a very similar position with regard to the Wherry-Doolittle-Holmes substrata factor theory.

So much for the statistics. I would like to make a few comments about the paper in general and its relationship to the the scientific method. Probably the most widely accepted notion of the nature of science is that its purpose is to predict and control events. It seems to me that there are two reasons for doing the sort of thing that is reported in Kling's paper. One is to do science - to attempt to predict and control events. The other is to do something because its an enjoyable pastime- a sort of mental gymnastic. If it is an effort at doing science, it probably has something to say to us in terms of outcomes. However, I fail to see anything in this particular way of approaching data that does very much for us in terms of suggesting appropriate experimental designs. Theoretical models are of use to us only if they produce research which in turn is useful to us. The models themselves never produce data. Only experimental results based on the theory from the models actually produce new knowledge. In this case, I wonder what we are to gain by this information about shared variance. Simply because a variable shares some variance with another variable does not necessarily mean that a change in one will produce a change in another. In the example given first in the Kling paper, if we are to assume that this is somehow a description of the nature of reality, rather than simply some fun and games with numbers, I guess we would have to assume that since the variable Arithmetic Reasoning came out as one of the first factors and

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English Literature didn't come out until the second iter-
ation, this means that if we were to improve arithmetic
reasoning we would then improve power of reading, and
that we would do more for power of reading than if we
were to teach English literature. I resist very much
talking about the data in this way because, it seems to
me,to represent a very long leap across the chasm that
separates science from metaphysics. However, I do not
see any other interpretation of the data that would enable
us to take any scientific advantage of it.

I think it is extremely important to keep in mind
two fundamental questions when we talk about theoretical
models. The first one is What action does the model
suggest? - in other words, what exactly does it tell us
to do? The second question is What evidence is there
that these actions work? Until we get the answer to both
of these questions, it seems to me we are in no position
to evaluate the utility of any theoretical model.

I would like to summarize my remarks about the sub-
strata factor theory of reading by quoting briefly from
an article written by B. F. Skinner, based on a lecture
given at the University of Pittsburgh in January, 1958.
In this speech he was concerned about what he called the
"Flight from the Laboratory."[1]

> "Some psychologists have fled to an ivory
> image of their own sculpturing, mounted on
> a mathematical pedestal. These Pygmalions
> have constructed a Galatea who always be-
> haves as she is supposed to behave, whose
> processes are orderly and relatively simple,
> and to whose behavior the most elegant of
> mathematical procedures may be applied. She
> is a creature whose slightest blemish can
> be erased by the simple expedient of changing
> an assumption. Just as political scientists
> used to simplify their problems by talking
> about an abstract Political Man, and the
> economists theirs by talking about Economic
> Man, so psychologists have built the ideal
> experimental organism - the Mathematical
> Model....
>
> No matter how many of the formulations de-
> rived from the study of a model eventually
> prove useful in describing reality (remember
> wave-mechanics!), the questions to which

answers are most urgently needed concern
the correspondence between the two realms.
How can we be sure that a model is a
model of <u>behavior</u>? What <u>is</u> behavior, and
how is it to be analyzed and measured?
What are the relevant features of the en-
vironment, and how are they to be measured
and controlled? The answers to these
questions cannot be found by constructing
models....

What is needed is not a mathematical model,
constructed with little regard for the
fundamental dimensions of behavior, but a
mathematical treatment of experimental
data. Mathematics will come into its own
in the analysis of behavior when appropriate
methods yield data which are so orderly
that there is no longer any need to escape
to a dream world."

[1]Skinner, B. F., <u>Cumulative Record</u>, New York:
Appleton-Century-Crofts, Inc. p. 250-252, 1959.

Wherry Doolittle Multiple Regression Analysis

Figure 1   N = 406
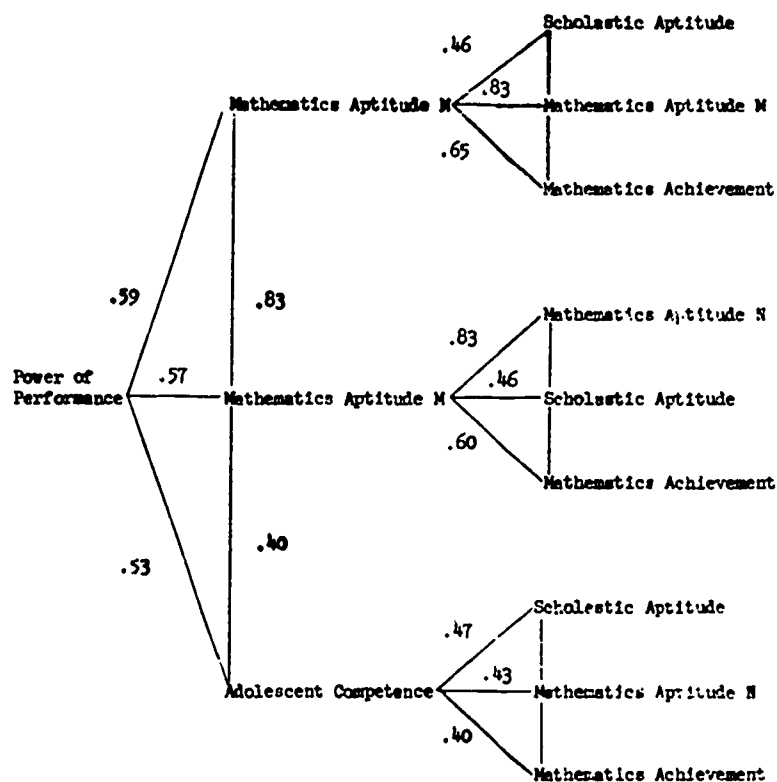
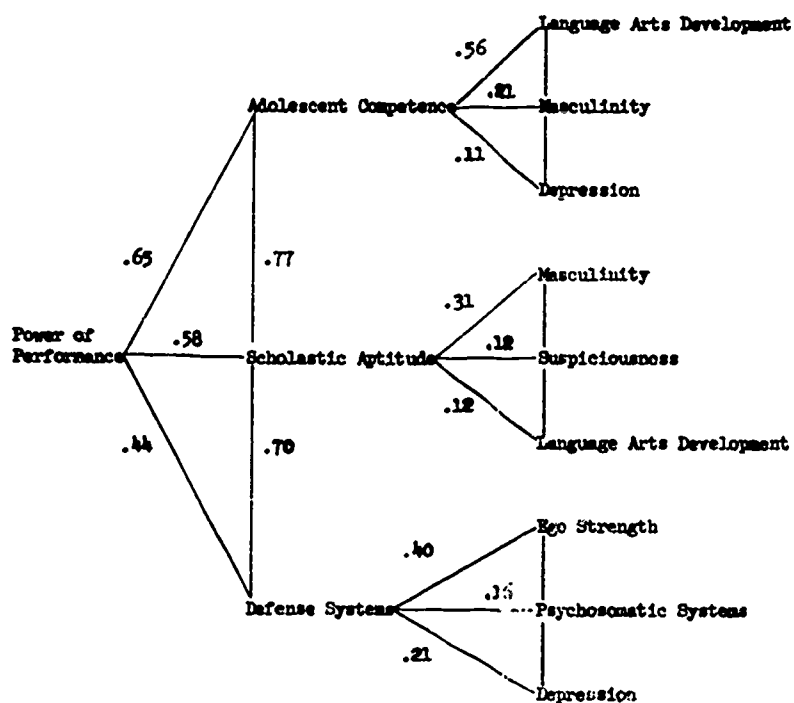Criterion:

  Power of Performance

Predictors:

  Adolescent Competence
  Mathematics Aptitude N
  Mathematics Aptitude M
  Mathematics Achievement

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Wherry Doolittle Multiple Regression Analysis

Figure 2   N = 260

Criterion: Predictors:

Power of Performance   Hysterical Conversion   Rebelliousness
                              Adolescent Competence   Language Arts Development
                              Psychosomatic Systems   Honesty
                              Scholastic Aptitude   Ego Strength
                              Depression   Masculinity
                              Defense Systems   Suspiciousness
                              Togetherness   Psychasthenia
                              Separateness   Energy Level

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A CRITIQUE OF
"GENERAL OPEN SYSTEMS THEORY
AND THE
SUBSTRATA-FACTOR THEORY OF READING"

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Open systems theory is a theory about open systems.
Systems, by definition, have parts called sub-systems
and these sub-systems, in turn, commonly have sub-systems.
Sub-strata factor theory describes the cognitive struc-
ture of the reader as a system with sub-systems, etc.
Thus, Kling says, systems theory and sub-strata theory
are similar. They're both theories and they're both con-
cerned with systems. We certainly can't argue with that
reasoning.

The Holmes and Singer's sub-strata factor theory is
worthy of careful study. The concept of a hierarchical
structure of skills is a seminal one. We have used such
a conception in analyzing language skills in our labo-
ratory at Michigan. For example, we found that sub-skills
in manuscript writing include discrimination of form, dis-
crimination of points in space, and a motor component.
Writing, then, may be described as the imposition of
letter forms on space. The visual components together
account for twelve times as much variance as the motor
component. Thus, our instructional programs in manuscript
and cursive writing are primarily visual-discrimination
exercises which produce orthography many times more ef-
ficiently than do standard handwriting practices.

The hierarchical concept of sub-strata theory is use-
ful. Furthermore, the statistical procedures developed
to reveal the structure appear to me to be sound. But,
as Raygor points out, one must be clever about the skills
selected for the analysis. No factor analysis will derive
protein, carbohydrates, and fats from whole tissue.

Thus, my only quarrel with the present explication
of the theory is the selection of tests. For example,
Kling reports a relationship between a score on a civics
test and "Power of Reading". Am I then to conclude that
knowledge of civics is a sub-strata factor? If so, I
should teach civics in order to increase "Power of Reading."
This conclusion strains my credulity.

On the other hand, Holmes' earlier analyses using auditory components (pitch, tempo, etc.) looked promising. Other components in the visual sphere also look good: length and direction of line; continuity of line; points in space; closure; and others. It looks to me as though the sub-strata theory itself is sound for ordering skills. Now it needs some skills to order.

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