A STUDY OF CONCEPT FORMATION, CONCEPT LEARNING,
AND VOCAL PEDAGOGY

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A STUDY OF CONCEPT FORMATION, CONCEPT LEARNING, AND VOCAL PEDAGOGY

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CHAPTER I

INTRODUCTION

One of the problems in the area of cognitive functions which is receiving considerable attention in professional educational and psychological journals is that of concept formation, concept learning, and their relationship to the teaching and learning process.

Educationists and psychologists are experimenting and theorizing concerning various processes of concept formation and concept learning. Experimental studies have been conducted in various subject matter fields such as mathematics, science, and English in an effort to determine what basic concepts of the particular discipline should be taught and what are the optimal methods for the teaching of these concepts.¹

Considerable work has been done in the development of theories regarding the processes of forming a concept and learning a concept,² and there is increasing interest with regard to the development and teaching of basic concepts.


in the various academic disciplines. Gagne states that "it would surely be agreed by all investigators of learning processes that 'conceptual learning,' as opposed to other, presumably simpler, forms of learning, constitutes by far the major portion of the learning associated with what is supposed to go on in schools."3

While there have been numerous attempts to relate the conceptual processes with various disciplines, as previously stated, there has been relatively little attempted in the area of music. There have been those such as Hartshorn,4 Fowler,5 and Woodruff,6 who have attempted to relate areas such as elementary music, instrumental music, and general musicianship to concept formation and concept learning.

Another area, underlying the theories of concept formation and concept learning and the determination of basic concepts in academic disciplines, is that of developing theoretical teaching approaches which would be most conducive for conceptual learning experiences. In essence,


this would consist of a theoretical structure underlying conceptual learning in a given discipline.

This study is an attempt to develop such a theoretical structure underlying a conceptual approach to teaching. This theoretical structure has been the direct outgrowth of research in the areas of concept formation and concept learning.

Statement of the Problem

The problem of this study is the development of a theoretical structure underlying a conceptual approach to teaching with special consideration given to vocal teaching.

Purposes of the Study

The purposes of this study have been to

1. Review the theory of concept formation as developed by Anatol Pikas and the theory of concept learning as developed by Earl B. Hunt.

2. Analyze the theories of concept formation and concept learning as to areas of compatibility and incompatibility.

3. Develop a theoretical structure underlying a conceptual approach to teaching based on the theories of concept formation and concept learning.

4. Formulate selected concepts which are inclusive of all the factors involved in singing, and contrast these vocal concepts with selected vocal techniques.
Definition of Terms

For the purpose of this study the following definitions of terms have been formulated:

1. **Concept formation.**—Concept formation refers to the process by which an individual selects and categorizes the combination of factors from the complex of relevant and irrelevant factors which are related to a particular behavioral response. In a more technical approach, Pikas defines concept formation as "the act of concept or category formation . . . the inventive act by which classes are constructed." He uses the basic definition of Kendler, which states that concept formation "is taken to imply the acquisition or utilization, or both, of common response to dissimilar stimuli."

2. **Concept learning.**—Hunt's definition of concept learning is used in this study and consists of a rewording of Kendler's definition. Concept learning is the "acquisition or utilization, or both, of a common identifying response to dissimilar stimuli." According to Hunt, concept learning

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7 The definition of Pikas, op. cit., regarding concept formation has been used since it is his concept formation theory which is used as one of the bases for discussion.

8 Pikas, op. cit., p. 119.


10 Ibid.

11 Ibid.
and use "refers only to the identification step." Hunt wishes to make a distinction between the process of discrimination and concept learning. He therefore gives the following definition of concept learning and places the following restrictions on the process.

As it is used in this monograph, concept learning is defined as a term which applies to any situation in which a subject learns to make an identifying response to members of a set of not completely identical stimuli, subject to the following restrictions:

1. The subject must, conceivably, be able to instruct a human to apply the classification rule. The subject is not allowed to use examples during the course of this instruction.
2. The rule to be learned must be one that can be applied to any appropriate stimulus regardless of the context in which the stimulus appears.
3. The rule must be deterministic; once a given stimulus is completely described it must be uniquely classifiable.

Design of the Study

The following procedures indicate the approach used in this study:

1. The theory of concept formation as developed by Anatol Pikas and the theory of concept learning as developed by Earl B. Hunt were reviewed and used as guidelines for the development of a theoretical structure underlying a conceptual approach to teaching.

2. The theory of concept formation and the theory of concept learning resulting in step 1 were synthesized and

13 Ibid., p. 7.
analyzed as to their areas of compatibility and incompatibility.

3. A theoretical structure underlying a conceptual approach to teaching was developed, which consists of a set of propositions regarding the following areas: (a) thought processes of the teacher, (b) actual presentation of concepts, and (c) teacher-student relationship. This set of propositions resulted from the theories of concept formation and concept learning and was based on implications from the research conducted in these areas.

4. From an investigation of current published literature and informal interviews with selected members of the voice faculty of North Texas State University, selected vocal techniques are discussed. These techniques were (a) technique of respiration, (b) technique of phonation, (c) technique of resonance, (d) technique of range, and (e) technique of dynamics. Further, a set of three major vocal concepts which are inclusive of the factors involved in the singing process is presented. Vocal teaching of concepts is contrasted with vocal teaching of techniques.

Significance of the Study

During the past fifty years there has been an effort to establish the area of vocal teaching and singing on a more scientific basis. Research has offered many insights into the various factors in singing such as the respiration
mechanism, problems of resonance, range of voices, voice classification, and phonation.

However, while vocal pedagogues, physiologists, and experimental scientists have continually investigated the various factors involved in the production of the singing voice, their efforts have been directed primarily to the physiology of singing. Sources dealing with the training of the singing voice overflow with admonitions regarding the functions of the breathing mechanism, the placement of the voice for correct resonance, the correct posture for singing, and many other such similar statements. While some writers in the field of vocal teaching have given some attention to the mental or cognitive processes involved in the act of singing, this attention has usually taken the form of vague generalizations. The following are characteristic statements regarding the cognitive processes as they are involved in singing:

1. We can sing as beautiful a tone as we can think.
2. The best and most successful teachers train the mind rather than the voice; the ear rather than the physical mechanism.
3. Voices are under orders from headquarters—the human brain.
4. Thought is the only power by which to control a vocal organ.
5. Singing is as much a matter of psychology as of tone.
6. The mind sings, not the voice.
7. Vocal controls are mental, not physical.
8. The brain, the heart, the whole body sings, projecting tones which the singer's mind first conceives.
9. Correct control of all the vocal muscles can be achieved through "mental pictures."\(^{14}\)

The foregoing statements are illustrative of the apparent lack of scholarly investigation into the cognitive functions underlying the act of vocal singing.

Many writers in the field of vocal pedagogy are emphasizing the teaching of concepts in singing. The problem which is evident is the lack of investigation regarding the relationships between concepts in vocal singing which are taught and the experimental evidence concerning the formation and learning of concepts. Fields\(^{15}\) divides his work into various approaches to the teaching of areas in singing, such as breathing, phonation, resonance, range, dynamics, diction, interpretation and pedagogy. Reid\(^{16}\) has placed considerable emphasis on the teaching of concepts. He states that

> All reference to vocal pedagogy as "voice" training is misleading. The purpose of vocal study is to improve the coordinate relationship between the laryngeal and the pharyngeal muscles responsible for the positioning of the vocal organs as they respond to mental concepts embracing pitch intensity and the vowel.\(^{17}\)

One of Reid's basic contentions is that "mental" concepts are necessary ingredients in singing. He states that the


\(^{15}\)Ibid.


\(^{17}\)Ibid., p. 74.
... voice is a product of function and, except to the degree to which all tone must conform to acoustic laws, has no mechanical function of its own. It is the end result of a coordinative process involving a complex of laryngeal and pharyngeal muscles whose pattern of response occurs as a direct reaction to a mental concept.\footnote{Reid, op. cit., p. 75.}

Another writer who emphasizes the importance of concepts (although he chooses to call them images) is Sergius Kagen.\footnote{Sergius Kagen, \textit{On Studying Singing} (New York, 1950).}

His basic contention is that the singer must possess a mental image of the sound. He states that this "mental image of a sound must, of course, include a most precise mental image of the vowel the singer intends to sing."\footnote{Ibid., p. 57.}

Christy\footnote{Van A. Christy, \textit{Expressive Singing}, Vol. 1, (Dubuque, Iowa, 1961).} makes frequent reference to various concepts in the singing process. Regarding the production of tone, he states that one should "never control the breath, but rather control the tone. Proper diaphragm action is a result of proper tonal concept."\footnote{Ibid., p. 25.}

The American Academy of Teachers of Singing states that "good vocal tone depends upon concept of beautiful sound and upon a sensitive and educated ear."\footnote{Ibid., p. 39.} These are but a few
of the writers who make reference to the significance of concepts in vocal singing.

Even though many vocal pedagogues emphasize the importance of teaching basic concepts in vocal singing, there has not been an effort to determine, from research in the area of learning theories, the most advantageous approach or approaches to the teaching of these concepts.

Some writers contend that a relationship exists between theories of learning and teaching. The problem is that even though much valuable information has been determined in the area of learning theories, this information has not been translated into the act of teaching by any significant numbers of teachers. Gage contends that "theories of learning will have greater usefulness to education when they are transferred into theories of teaching." There needs to be a concentrated effort to develop theories of teaching from the information already known concerning the processes of learning. Gage states further that

Theories of learning . . . cannot suffice in education. The goal of education—to engender learning in the most desirable and efficient ways possible—would seem to require an additional science and technology of teaching. To satisfy the practical demands of education, theories of learning must be "stood on their head" so as to yield theories of teaching."26

25 Ibid., p. 268.
26 Ibid., p. 269.
There appears to be little disagreement as to the need for theories of teaching but the development of such theories has not kept pace with the progress of research in the area of learning. Theories of learning have concentrated on that which was learned by the learner. There must, at this point, be some attention given to the role which the teacher plays in the learning process. Gage contends that

Practical applications have not been gleaned from theories of learning largely because theories of teaching have not been developed. The implications of learning theory need to be translated into implications for the behavior of teachers. Teaching will then act on these implications in such ways as to improve learning.²⁷

The specific areas of learning theories with which this study is concerned are concept formation and concept learning. In recent years many studies have been conducted regarding the processes involved in concept formation and concept learning. The results of these studies should be of considerable value to teachers of singing who attempt the teaching of concepts. There have been a great number of variables which have undergone experimental investigation. Many of these variables have obvious relationships to the teaching of concepts in singing. Some of these variables which have been studied extensively are anxiety, memory, reinforcement or reward, relevant and irrelevant attributes of concepts, verbal mediating responses, and information feedback.

²⁷Ibid., p. 271.
Phillip H. Phenix contends that with the current explosion of knowledge and facts it is impossible for the human brain to absorb even the "irreducible minimum" of this information. He feels that the only rational approach to this crisis in learning is the formulation and use of key concepts. He states, "ineffective teaching and learning . . . are due in no small degree either to the failure to understand the need for comprehensive organizing concepts and their functions in the economy of learning or to using the wrong key concepts. . . ."  

There has been a significant approach to the basic problem of this study. Woodruff has, in essence, presented a conceptual approach to the teaching of concepts in education. As it appears at this point, there are two significant areas of research with which this study is concerned: conceptual teaching of vocal singing and theories of concept formation and concept learning. The obvious relationship between the two areas should have been established.  

It should be of significant benefit to teachers of singing as well as vocal students to determine, from the

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29 Ibid., p. 437.

30 Asahel D. Woodruff, Basic Concepts of Teaching (San Francisco, 1961).
experimental research conducted in the areas of concept formation and concept learning, the implications which this research has for the teaching of concepts. These implications, which have been gleaned from Anatol Pikas's theory of concept formation and Earl B. Hunt's theory of concept learning, have been related specifically to a conceptual approach to vocal teaching.
CHAPTER II

REVIEW OF THE LITERATURE

In reviewing the literature for this study it will be necessary to cover two basic areas: concept formation and learning and vocal pedagogy. The following discourse will include relevant literature in these areas.

Concept Formation and Concept Learning

The areas of concept formation and concept learning have a history which is considerable in length. The specific areas of concept formation and concept learning have grown out of earlier investigations into the processes of abstract thinking.¹

If, therefore, interest in abstract thinking is used as the origin for this discussion into concept formation and concept learning, a review of the literature in the area may be traced theoretically back to Aristotle. Toulmin states that "from the time of Socrates, philosophers have been recurrently concerned with the analysis of concepts . . . one thinks, for instance, of Aristotle's De Anima. . . ."²


Aristotle contended that there did exist such a phenomenon as abstract thought. He defined abstraction as "disregarding the particulars in order to extract what is in common." While it is significant to this study that interest in abstraction may be traced back to Aristotle, the problems of dealing with abstraction on a conceptual level are more accurately traced back to Wilhelm Wundt and the era in which psychology began to evolve as a separate science.

Wundt, in his *Logik*, treated in a definitive way the general area of abstraction. He stated

> By abstraction we generally mean the procedure by which certain constituent parts are eliminated from a compound idea or from several such ideas and what remains is retained as the elements of a concept. Moreover, abstraction is the principal means of forming general concepts. . . . Abstraction is accomplished in two different ways, which we may distinguish as isolating abstraction and generalizing abstraction. The first of these is the original one, because the analytical method always leads immediately to it and necessarily precedes every generalizing abstraction. Moreover, the two do not form two stages of development which regularly succeed each other; the isolating abstraction has an independent value and in several of the most important uses of the abstraction process, it is completely restricted to the isolative form and the generalizing form makes a comparatively unimportant complement . . . Generalizing abstraction consists in neglecting the attributes (which vary from one case to another) of a number of objects or facts subjected to comparative analysis, in order to retain certain of them that are common to the whole group and raise them to the status of characteristics

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3 Pikas, op. cit., p. 9.
4 Ibid., p. 10.
constituting a general concept. This kind of abstraction has two subforms, according to whether the objects which are subjected to the analysis are real to the perceiving or to the thinking mind or whether they are individual propositions which refer to any of the objects' relations whatever. In the first case abstraction results in generic concepts and in the second case abstract rules or laws.\(^5\)

The definition of abstraction, as given here by Wundt, has been used by present day learning theorists writing in the area of thinking and specifically in the area of concept formation and learning.

William James, a philosopher-psychologist, approached the area of abstraction somewhat differently. He defined concept and the process of conception in the following manner:

> The function by which we thus identify a numerically distinct and permanent subject of discourse is called conception; and the thoughts which are its vehicles are called concepts. But the word "concept" is often used as if it stood for the object of discourse itself; and this looseness feeds such evasiveness in discussion that I shall avoid the use of the expression concept altogether, and speak of "conceiving state of mind," or something similar, instead. The word "conception" is unambiguous. It properly denotes neither the mental state nor what the mental state signifies, but the relation between the two, namely, the function of the mental state in signifying just that particular thing.\(^6\)

Aristotle, Wundt, James, and others established some theoretical background for the study of abstract thinking.

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About the turn of the twentieth century there were some who became interested in conducting experiments in the area of abstract thinking.

**Early Experimental Approaches**

Oswald Külpe is considered by some to have conducted the first experimental approach regarding the study of the process of abstraction. The following is his definition of abstraction:

> By "abstraction" is generally meant the process by which we succeed in emphasizing individual part-contents of the conscious and letting others retire into the background. We say that we abstract from the latter, disregard them, leave them out of account; they do not achieve valid status in the consciousness.7

This definition of abstraction is certainly compatible with abstraction as defined by Aristotle. Both definitions emphasize the attention in a given learning encounter with those factors which are "common" and disregard of that which is "particular."

There were others, such as Watt and Ach of what was called the Wurzburg School, who continued along the same lines of investigation as those in which Külpe had been interested.8

T. V. Moore was a disciple of Wundt and studied in his laboratory in Leipzig. After his experimental studies in

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Leipzig, Moore came to the United States to continue his work. A summary of the hypotheses resulting from Moore's experiments concerning abstraction is as follows:

1. The process of abstraction is initiated by the breaking up of the group presented for perception.

2. This initiates the process of perceiving the common element. This is accomplished by assimilating to known mental categories the sensations perceived.

3. The retention in memory of the figure perceived depends in great measure on the method of memory.

4. The recognition of a figure once seen involves an element of certainty or uncertainty. Consequently there is implied in recognition assent or doubt and therefore a judgment or a suspended judgment.

5. The final product of abstraction, that which is perceived as common to many groups is essentially a concept distinct from imagery and feeling. It represents the assimilation of that which is perceived by the senses to a more or less complex mental category, or perhaps to several such categories. These mental categories may be regarded as the results of past experience.

The preceding introductory material has given some indication of the work done in the area of abstraction. In order for this to be related to the primary concerns of this study, it must be understood that the sense in which abstraction was used by the foregoing discourse is theoretically identical to what, in more recent studies, is classified as concept formation and learning.

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Schweitzer appears to be one of the first to conduct experiments which concentrated on the area of concepts. However, the ultimate product of his work was primarily a classification of different types of ideas by measuring reaction times to word associations.

In 1912, Aveling published a work entitled *On the Consciousness of the Universal and the Individual*. Aveling seems to be one of the first to use the method of associating a class of figures with a meaningless word as the name of the class. He is considered by some to be one of the pioneers in the actual study of concept formation.11

One of the most significant works of an early nature was that of S. C. Fisher entitled *The Process of Generalizing Abstraction and Its Product, the General Concept*. This work was published in 1916 and contains the following definition of concept formation:

Abstraction is generalizing abstraction when the abstracted contents are features which are common to a group of experiences; in other words, when the previous conscious situation is one in which features which are similar to the ones at present attended to have likewise been stressed.12

During the next several decades, 1920-1950, there were many learning theorists who dealt with the problem of concept

11 Pikas, op. cit., p. 19.

formation and learning. Hull's approach consisted mainly in the use of nonsense syllables, twelve series of Chinese letters, which the experimenter would expose to the subjects. This exposure and pronunciation would serve as the name for the concept. One of the major outcomes of Hull's studies was his conclusion that "concepts could be formed unconsciously; the Ss had attained functional concepts, as the term was."\(^{13}\)

Hull's experimental procedure served as the foundation for a number of similar approaches during the following decade. In 1932, a work by K. L. Smoke, "An Objective Study of Concept Formation," criticized Hull's experiment approach in using Chinese letters. Smoke's contention was that Hull's approach, especially in the use of the Chinese letters as nonsense syllables, is not representative of concept formation. Smoke stated that "the relations which constituted the concepts ... gave a truer picture of the nature of the concepts than the identical elements or 'radicals' which were exactly alike in each example within a certain concept in Hull's work.\(^{14}\)

Smoke defines a concept as "a symbolic response (usually, but not necessarily, linguistic) which is made to the members of a class of stimulus patterns but not to other stimuli.\(^{15}\)

\(^{13}\)Pikas, op. cit., p. 31.

\(^{14}\)Ibid.

One of the most prolific writers and experimenters in the field of concept formation and learning is Heidbreder. Her investigations have been concerned primarily with ordering certain types of concepts and their relationship to ease of formation.

Pikas criticizes Heidbreder's investigations on the following bases:

1. Nowhere in the ten experiments which she and her collaborators published between 1946 and 1949 does "concrete objects" refer to anything other than drawings of "concrete objects" or words denoting "concrete objects."

2. "... the "abstract forms" and "numbers" consist in most cases of drawings of concrete objects which in themselves contain some "abstract form" or occur in definite numbers on the stimulus cards."

In order to expedite this lengthy discourse on historical approaches to concept formation and concept learning it should prove beneficial to include here the results of two independent surveys conducted by Vinacke and Leeper. These summary statements represent a synthesis of the standpoints adopted as a result of the experimental research into abstraction, concept formation and learning carried out in the thirties and forties.

Pikas relates the following abbreviated paragraphs from Vinacke's book as a relevant epitome of his exposition:

1. Concepts are not direct sensory data but something resulting from the elaboration, combination, etc., thereof...

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16Pikas, op. cit., p. 45.
17Ibid., p. 57.
2. ... concepts depend upon the previous experience of the organism.
3. Concepts are systems within the mental organization which tie together or link, or combine discrete sensory experiences ...
4. ... such ties or links are symbolic in nature; that is, the same concept may be involved by a variety of stimuli ...
5. On the side of the internal processes of the organism, concepts represent selective factors. An external stimulus arouses a symbolic response, on the other hand, or a symbolic response guides perceptual activity ...
6. ... the extensional aspect of concepts may be regarded as that part of the concept system corresponding to the objective properties of the stimulus object, in so far as they can be identified by the perceiver. The intensional aspect corresponds to that part of the system which derives from the individual's unique experiences with the stimulus object and the ramifying relationships which the concept system has with other systems. In a rough way, therefore, the extensional aspects of a concept system aroused in different people by the same stimulus would be similar, because objects have certain properties perceived similarly by most people, whereas the intensional aspects would be similar only to the degree that different people have had similar experiences with the same object and all other objects to which it is related ... It is especially dangerous to equate words with concepts, because one cannot be sure to what extent one kind of data rather than the other is involved.
7. ... concepts are never completely consistent but have their inconsistent components resulting from accidental groupings of objects, inaccurate perceptions etc.
8. ... Horizontally, objects may be classified into different categories, all of them equally inclusive ...

Leeper's survey is supportive of that by Vinacke but includes the contention that the cognitive processes, including concept formation, do not necessarily presuppose

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consciousness. He says "it is the process of developing a habit or a cognitive mechanism that permits a person to respond to an object or event in terms of some property of which he may or may not be immediately aware." 19

This discussion in a very general sense summarizes the conclusions of the studies conducted in concept formation and concept learning up to the past two decades. During the past twenty years the work in the areas of concept formation and concept learning fall into at least three major categories: (1) those comprised of experimental studies designed to determine the effect of some one or group of variables on either concept formation or concept learning, (2) those works which are theoretical in nature but which use the results of experimentation in the field as the foundations for their theoretical discussions, and (3) those works which emphasize the importance of conceptual teaching in various academic disciplines. The remainder of this chapter will consist of a brief descriptive survey of representative contributions in these three areas.

Recent Experimental Studies

In recent years many experimental studies have been conducted regarding concept formation and concept learning. These studies frequently involve the testing of the effect

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of certain variables on either concept formation or concept learning. Some of the variables which have undergone experimental testing procedures are anxiety and concept formation, memory and concept formation, reinforcement and concept learning, relevant and irrelevant cues in concept formation and concept learning, verbal mediating responses and concept formation and information feedback and concept formation. Representative studies from these various areas will be discussed briefly as to the subject or intent of the study and the major results or conclusions.

Threat, anxiety and concept formation.—Dean W. Forbes conducted an experimental study regarding the effects of threat and anxiety on concept formation. The study was designed to study concept formation under four basic conditions: (1) threatening instructions and visible report of performance, (2) threat, invisible, (3) non-threat, visible, and (4) non-threat, invisible.

The results of the study showed that "for complex materials (analogies) . . . significant decrements in concept formation scores appeared under conditions of threat. . . . Similar results did not appear for the simple materials (grouping problems)."  


21 ibid., 2067-A
It was found further that "concept formation performance was not related to anxiety scale scores but was related to anxiety-producing situational circumstances. The results did not show anxiety to be a facilitating or energizing state and are interpreted as not confirming the drive state theory of anxiety."  

Memory and concept learning.--Typical of the studies conducted regarding memory and concept learning was the study by R. L. Dominowski. The results of the study were that "two kinds of memory may be distinguished in concept learning, the retention of stimulus characteristics, hypotheses and other information while the process of attaining the experimental solution, and the retention of the concept once it has been learned." Another implication resulting from the study was that "spaced practice was superior to massed practice" in the learning of a concept. 

Relevant and irrelevant factors and concept learning.--There have been numerous studies conducted regarding the effects of relevant and irrelevant factors on concept learning.

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22 Ibid.


24 Ibid., p. 271.

25 Ibid., p. 272.
as well as concept formation. Archer's investigation into the function of relevant and irrelevant information was based on the following assumptions:

It seems reasonable to suppose that the obviousness of information is a manipulable variable and that such a characteristic of the information affects concept identification. Furthermore, at least one simple prediction can be made concerning the relationship between the two variables, i.e., if the relevant information were also obvious, the concept should be easier to discover than if the information were less obvious. On the other hand, if the irrelevant information were obvious, the concept should be more difficult to discover than if the information were less obvious. 26

The conclusion reached by Archer in the final statement is that when a subject's attention is drawn to irrelevant information, he will possibly attempt a solution involving information which should not be used.

The results of his experiment may be summed up by stating that "the optimum conditions to enable subjects to identify a concept will be when the obviousness of the relevant information is maximized and the obviousness of the irrelevant information is minimized." 27

Bourne and Haygood, in conducting experiments dealing with relevant and irrelevant factors, "found a facilitating


27 Ibid., p. 620.
effect of redundant relevant information on concept identification performance.\textsuperscript{28}

There have been many similar experiments dealing with the effect of relevant and irrelevant information on concept formation and learning. The conclusions reached by Archer, Bourne and Haygood, as previously cited, are compatible with the results of other studies investigated.

\textbf{Verbal mediating responses and concept formation.--}

There has also been some interest in determining the role of verbal mediating responses in concept formation. Albert E. Goss attempted to analyze the effect of verbal mediating responses on concept formation. He approached concept formation primarily through the stimulus-response analyses of conceptual behaviors which emphasize the role of mediating responses and stimuli. The areas which Goss dealt with were

1. The relationship between concept formation and conventional paired-associates tasks.
2. The structures and some explanatory consequences of one-stage and two-stage paradigms of conceptual behaviors.
3. The complementary relationship between the one-stage and two-stage paradigms and classes of variables and principles involving those variables which enter into explanations of the strengthening, generalization, and weakening of the component stimulus-response associations.\textsuperscript{29}


Information feedback and concept formation and learning.-- Another area which is receiving some attention is the effect of information feedback on concept formation and learning. Bourne "proposed that increasing the temporal separation between presentation of the stimulus and indication of the correct response to that stimulus should interfere with concept attainment because the stimulus and the correct response occur less contiguously."\(^{30}\)

The results of the experiment indicated that the number of errors made increased with the amount of time between performance. This is in support of the contention that a person will tend to forget the stimulus situation during an interval of delay. Bourne states that "introducing longer delays should produce more forgetting of the stimulus pattern and thus retard concept learning."\(^{31}\)

There are many experimental studies which could be cited as related literature at this point. However, these discussed are illustrative of the approaches taken and the areas investigated by various researchers in the field of concept formation and learning.


\(^{31}\) Ibid., p. 207.
Theoretical Studies

There have been significant contributions to the conceptual processes in the area of theoretical discourses. It should be stated at the outset, however, that most of the theoretical presentations are based on the results of experimental studies such as those previously reviewed.

One of the earlier major contributions to concept formation and concept learning, which may still be considered contemporary, is the book, *A Study of Thinking* by Bruner, Goodnow and Austin.32

The basic intent of this book is to present a theoretical discourse on the processes involved in concept attainment. It should be noted here that Bruner et. al. employ the terms concept attainment rather than concept learning. There is a fine distinction made between concept formation and concept attainment. However, by definition, the terms concept attainment may be used synonymously with concept learning. Bruner et. al. define concept attainment in this manner:

This component, which we have called "concept attainment" in contrast to "concept formation," is the search for and testing of attributes that can be used to distinguish exemplars from nonexemplars of various categories, the search for good and valid anticipatory cues.33


33 Ibid., p. 233.
A second major contribution to the field of concept formation and concept learning is that of Earl B. Hunt. Hunt's approach is specifically toward that of concept learning. It will be evident from this point forward that a distinction is made among contemporary writers regarding the processes involved in concept formation and those involved in concept learning. Hunt analyzes the problem of concept learning. He defines "... concept learning ... as a term which applies to any situation in which a subject learns to make an identifying response to members of a set of not completely identical stimuli ...".

Hunt relates to concept learning the areas of basic learning, stimulus organization, memory, strategies and attempts to present an information-processing model of concept learning.

One of the most comprehensive works in the area of concept formation and concept learning is that by Anatol Pikas. Pikas approaches the problem of abstraction first from an historical viewpoint. He then deals with the problems involved and related to concept formation. The theory

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of concept formation proposed in this work cited is formulated primarily by a synthesis of recent experimental studies.

There have been others who have written to a somewhat lesser degree than the aforementioned, but who have made worthwhile contributions to the area of concept formation and concept learning. Archer has written regarding the psychological nature of concepts. Possibly his major contribution lies in his descriptive terminology regarding the psychological characteristics of concepts. He identifies the following as characteristics of concepts: (1) Identifiability, (2) Learnability, (3) Labelability, (4) Transferability, and (5) Forgetability.

Archer contends further that his approach to concepts represents a "chronological sequence that would be involved when a subject progressed from an initial identification of a concept through its acquisition and through to its forgetting." 

Benton J. Underwood has experimented and written extensively in the areas of verbal learning and concept learning. He sums his basic approach by stating

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38 Ibid., p. 45.

In detecting new relationships among objects or events, the concept-formation task is essentially a problem-solving task in which there is a search for common associative responses among the many produced by the objects and events. These associations had to be established sometime, and how they are established is the province of verbal learning. That a new instance of a concept can be readily classified can only occur because it elicits an implicit associative response that defines the concept. In short, the study of concept learning is the study of the acquisition and utilization of common associates to different objects and events. The study of the development of associative responses is the study of verbal learning as is also the study of the implications of their elicitation after development.

Given this orientation, it is sometimes difficult to make a distinction between concept learning and verbal learning. Given this orientation, it is sometimes difficult to make a distinction between concept learning and verbal learning. 40

Arthur R. Jensen, in his writings, has given what he refers to as "the Taxonomy of Conceptual Learning." 41 His taxonomy basically involves

1. One basic distinction would seem to be that between concept formation and concept attainment.
2. There is concept learning on the basis of primary stimulus generalization.
3. A second kind of concept learning depends upon discrimination learning.
4. The third main type of concept learning involves transfer of learning on the basis of symbolic mediating responses.
5. Finally, we must distinguish between tasks that involve only concept identification, without any learning whatever being tapped by the task, and tasks that involve learning parameters. 42

40 Ibid., p. 62.
42 Ibid., pp. 143-145.
Another contribution to the area of concept formation and concept learning is that of Robert M. Gagne. He deals primarily with conceptual learning but approaches the area somewhat differently than those previously mentioned. Gagne contends that simple concepts combine to form more complex concepts which he identifies as principles. "A principle (or rule) is composed of two or more concepts having an ordered relationship to each other." Gagne theorizes regarding the learning of principles:

Principles are learned under conditions that have two major requirements:
1. The component concepts of which they are composed must be previously learned and readily recallable; and
2. A communication, usually verbal, must be made to the learner indicating the correct sequence of these components.

These authors and their works are representative of the literature regarding concept formation and concept learning approached from a theoretical vantage point.

A third body of literature which has some relationship to this study is the work done in the development of theoretical concepts underlying the teaching-learning process.

Havighurst has included in some of his writings brief discussions of concepts. He writes specifically in the

44 Ibid., pp. 85-88.
45 Ibid., p. 94.
areas of "forming simple concepts of social and physical reality" and "developing concepts necessary for every day living." Havighurst's definition of concept is compatible with other definitions which have already been cited. He states that "a concept is an idea which stands for a large number of particular sense perceptions, or which stands for a number of lesser degrees of abstractions."\(^4^9\)

The direction of Havighurst's approach to concepts is certainly significant. He states "the task is to acquire a store of concepts sufficient for thinking effectively about ordinary occupational, civic, and social matters."\(^5^0\) However, his approach lacks the specificity with which other writers treat the relationships of concepts and the teaching-learning process.

In his discourse on philosophy and education, Harry S. Broudy makes frequent reference to concepts and the conceptual systems. He contends that "sense, memory, imagination, and the combination of these in perception provide us with more or less complex images of particular individual things ... we shall call such a meaning a concept."\(^5^1\)

\(^{4^7}\) Ibid., p. 16.  \(^{4^8}\) Ibid., p. 46.
\(^{4^9}\) Ibid., p. 34.  \(^{5^0}\) Ibid., p. 34.

Broudy's approach to concepts is usually found within the framework of a philosophical discussion regarding realism and education. His statements referring to concepts are usually broad and general in nature and have little to do with the actual psychological processes involved in concept formation and concept learning.

Phillip H. Phenix approaches conceptual learning and the need for it by contending that the current "explosion of knowledge and the crisis in learning which has resulted from sheer impossibility of stuffing even the irreducible minimum of vital information into one protesting brain-case" can only be solved by a "...shift to conceptual learning." He states further that "the only satisfactory answer to the crisis in learning lies in the formulation and persistent use of key concepts."

Phenix sums the import of his approach by stating:

Ineffective teaching and learning ... are due in no small degree either to the failure to understand the need for comprehensive organizing concepts and their functions in the economy of learning or to using the wrong key concepts ...

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54 Ibid., p. 437.

55 Ibid.
There are numerous brief, theoretical discourses regarding concepts and education similar to those mentioned. One of the most ambitious contributions in this area is that by Asahel D. Woodruff.56

Woodruff, in a summary statement, presents a group of philosophical concepts which

... include that common body of ideas about people and their world, prominent among which are the recognition of the dignity of the individual, his right to self-determination and to as much development and learning as he is willing to attain, the experiential basis of learning, and the futility of verbal procedures as a substitute for the personal experiences of the individual ... 57

In essence, Woodruff's book might be considered to be a conceptual approach to the teaching of concepts in education. He treats such areas as the purposes of formal education, the processes involved in the learning experience, the preparation for the teaching of concepts and the student's receptivity for learning.

The literature previously discussed is illustrative of the interest being shown and the work being done in the various phases of concepts and the teaching-learning process. This review of the literature has included what appears to be some of the more significant contributions.

56 Asahel D. Woodruff, Basic Concepts of Teaching (San Francisco, 1961).

57 Ibid., p. vi.
Vocal Pedagogy

This study is concerned with two basic areas of literature. The first, concept formation and learning, has been reviewed in the first section. The remainder of this chapter will present representative contributions to the area of vocal pedagogy. For the purpose of this study the review of the literature in the field of vocal pedagogy will begin with the publication of Victor Alexander Fields' book, *Training the Singing Voice*. Fields attempted to synthesize all the published literature as well as unpublished literature and personal testimonies from singers of his day.

The objectives of his study were

1. To survey and correlate available sources of bibliographic information on methods of training the singing voice.
2. To provide a core of organized information for the use of all teachers of singing.
3. To provide an orientation and background for research in this and related fields.

His book was organized according to concepts of vocal pedagogy, breathing, phonation, resonance, range, dynamics, ear training, diction and interpretation. The methodologies and recommendations of the multitude of writers and singers in the area of voice and vocal teaching were analyzed and classified in the aforementioned areas. The publication of this work was an extremely significant step in vocal pedagogy at the time. However, since its writing there has

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been much experimentation and writing in the field of vocal pedagogy which has not yet been synthesized and correlated. A great many writers approach the teaching of voice by means of basic concepts. While there still exists some disagreement regarding the basic concepts in voice which should be taught (this disagreement lies primarily in the area of priorities of concepts), the greatest area of disagreement still remains that of methodology in the teaching of these concepts.

The following discussion will review some of the more significant representative contributions in the area of vocal pedagogy since the publication of Fields' book.

A work which has been subjected to severe criticism and one which appears to be contrary to what, in general, vocal pedagogues accept is that by Montell. Teachers of voice today may frequently be heard to admonish students to breathe deeply or to relax the body, especially the areas of the throat and jaw. Montell states

Continue to say to yourself--I shall contrive to keep the air out. I shall commence by setting tension. I know that by setting tension my body expands reflexively and provides all the air I require . . .

Montell continually directs the student of singing in vague, non-specific terminology such as

\[\text{59 Marjorie Montell, Montell Vocal Technique (Miami, Florida, 1950).}\]

\[\text{60 Ibid., p. 84.}\]
Direction: Find the tension quickly and at the same time look forward into freedom, or blank. Look (internal vision) as far forward as you can. At first you may not extend the Attention more than a few feet before you; you will be tempted to cling to your body; you will still feel the tension, but uncertain that it will sustain you, alone, with your Attention moving forward.

Continue to look forward as you create freedom out of the endless, unconfined emptiness, or blank.61

The one basic element on which Montell’s theory of singing is based is the "magic spot." It is designated as "the 3/4 inch muscle thickness of the diaphragm which you found directly below the sternum - directly center - between the right and the left rib sections."62

Sergius Kagen’s book entitled On Studying Singing63 is a brief work designed specifically to help the student of singing solve his own problems. It is written in terms which are intended to be understood by the student. Kagen deals primarily with general musicianship, verbal contents (language) and music, vocal technique and repertoire. His basic contention is that the singer must have an image of sound. He states that this "mental image of a sound must, of course, include a most precise mental image of the vowel the singer intends to sing."64

A practical step by step analysis of singing was attempted by Richard DeYoung.65 DeYoung’s book guides one

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61 Ibid., p. 89.
62 Ibid., p. 42.
64 Ibid., p. 57.
through the practice session, the breathing habits, the beginnings of tone and on to personality. "This book combines statements of scientific facts, viewpoints on methods of thinking, and expositions on philosophies of life as they relate to the singer and to the teacher of singing." 66

Trusler and Ehret wrote a programmed approach to singing entitled *Functional Lessons in Singing*. 67 The authors state that "the purpose of this book is to present a functional series of lessons through which students may develop specific vocal and musical abilities with the sounds of the English language." 68 The basic approach to singing used throughout the book is through the correct singing of vowels. Each vowel is presented as to description, execution, faults, and corrections.

One of the most extensive works in the area of vocal singing is that by Van A. Christy entitled *Expressive Singing*. 69 Christy has made a significant contribution, in addition to the beginning voice book and the advanced voice book, in that he has compiled accompanying vocal literature


books. He deals with the basic areas of singing such as posture, breath control, tone and diction. He also presents material related to the finer techniques involved in singing such as legato and sostenuto, agility and flexibility, extension of range and dynamics, intonation, interpretation, stage deportment, program building and memorization. Christy has also included in his works some basic principles and methods related to singing and the teaching of voice. Volume II of his publication includes an extensive listing of selected literature for the voice. This appears to be one of the most complete and self-contained books on vocal teaching which has been published in recent years.

A work which is somewhat lesser known in this country is that by Viktor Fuchs. The intent of Fuchs' book is practical in nature and simple in procedure. He emphasizes the "step by step" approach to singing. "First steps are vitally important... The first lessons are concerned with breathing, opening the mouth, avoiding a stiff chin, and with learning to sing several notes in the middle of the range."71

Frederick Husler and Yvonne Rodd-Marling72 have approached singing primarily from the physiology of the

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71 Ibid., p. 4.
vocal organ. The language of the book is rather technical and factual and omits profuse use of vague, empirical terminology. The authors have, by means of vocal recordings, illustrated some of their contentions regarding the registers of the voice, the concentration of muscle movements in certain tones and the various "functions" such as the "closing functions," and the "falsetto function."

A recent publication in the area of vocal pedagogy which speaks considerably of concepts in voice is that by Cornelius L. Reid. The purpose of the book and vocal pedagogy as an art is summed by by Reid.

... all reference to vocal pedagogy as "voice" training is misleading. The purpose of vocal study is to improve the coordinate relationship between the laryngeal and the pharyngeal muscles responsible for the positioning of the vocal organs as they respond to mental concepts embracing pitch, intensity and the vowel. As all of the muscles of the laryngeal and pharyngeal complex lie beyond the power of volitional control, the only meaningful procedure to be adopted must depend upon a technique of training which will utilize conceptual controls which are known to evoke spontaneous and involuntary bodily reactions.

One of Reid's basic contentions is that "mental" concepts are necessary ingredients in singing.

Voice is a product of function and, except to the degree to which all tone must conform to acoustic laws, has no mechanical function of its own. It is the end result of a coordinative process involving a complex of laryngeal and pharyngeal muscles whose pattern of response occurs as a direct reaction to a mental concept.

74Ibid., p. 2.
75Ibid., p. 1.
D. Ralph Appelman has contributed an extremely technical work which is divided into basic sections. Section one deals with the theory underlying such factors as respiration and phonation. Section two represents the techniques of application including areas such as the linguistic, emotional, social and intellectual elements of interpretation as well as a kinesiologic analysis of speech sounds in singing.

The four objectives of the book as stated by Appelman are

1. . . . to intentionally and directly train the singer's aural awareness of his utterance of the word in song.
2. . . . to describe the scientific theories of vocal pedagogy in a simplified and direct manner.
3. . . . to suggest a phonetic system of teaching voice based upon the International Phonetic Alphabet (IPA).
4. . . . to offer an acoustic model of phonemic utterance that may be accepted as a standard of imitation.77

An advocate of the physiological approach is William Vennard.78 Vennard has attempted to compile all the objective findings regarding the mechanisms of the voice and relate them to singing. He states "there are those teachers who feel that applying science to an art is quackery, but I believe that our only safeguard against the charlatan is

77Ibid., p. vii.
The approach taken by Vennard is similar in technicality to that of Husler and Rodd-Marling. However, Vennard does strive to make some application of the mechanics of the voice to the various areas normally treated in vocal books such as breathing, attack, registration, resonance, vowels and articulation. This work, along with that by Appelman, is possibly the most authoritative and documented vocal book published.

Chapter Summary

It has been the intent of this chapter to present the reader with a general survey of the literature in the areas of concept formation and learning and vocal pedagogy. Those authors and works discussed were those who appeared to be most significant and relevant for the purpose of this study.
CHAPTER III

A THEORY OF CONCEPT FORMATION

The theory of concept formation to be discussed in this chapter is that of Anatol Pikas. Pikas begins his theoretical discourse by stating the problem as it appears to him: "What is the meaning of the diagnostic term abstract behavior, which is sometimes also called conceptual behavior?"

He states "... attempts to interpret data from a pilot study convinced him still more of the need of a theoretical work which would include an analysis of the terms and the fragmentary theories in the field of discussion."

The underlying contention of Pikas regarding concept formation is that the mechanisms involved in concept formation must take into account and "at a central point in the developing theory the existence of memory tracks or storings or, to use a modern expression, memory codes."

In the actual development of his theory Pikas begins by discussing recent explicit approaches to concept formation and thereby presents his own theoretical positions on areas such as types of concepts, coding and recoding, information.

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1 Anatol Pikas, Abstraction and Concept Formation (Cambridge, Massachusetts, 1966).
2 Ibid., p. 1. 3 Ibid., p. 2. 4 Ibid., p. 3.
and misinformation feedback, perception, passive summation, and active search. Further, he treats the proposition regarding the synonymity of concept formation and stimulus generalization and the relationships of concept formation and transfer.

The following discussion is limited to that material which is necessary to adequately present the theory of concept formation as developed by Anatol Pikas.

**Definition of Concept Formation**

In modern literature there appears to be a division among writers regarding the processes involved in concept formation and those involved in concept learning or attainment (Bruner et al. use the term concept attainment in place of concept learning). Pikas quotes Bruner et al. as defining "the act of concept or category formation . . . as the inventive act by which classes are constructed." They state further that "concept formation is essentially the first step en route to attainment."

Pikas states quite explicitly that he considers concept formation to be the more significant of the two areas since it exists as a pre-requisite to concept learning. He states

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that he "regards the originating process (concept formation) as being of the greatest interest."\textsuperscript{7}

The definition of concept formation as stated by T. S. Kendler\textsuperscript{8} is used by Pikas for the development of his theory. That definition is, "Concept formation is taken to imply the acquisition or utilization, or both, of common response to dissimilar stimulus."\textsuperscript{9} Pikas presents the following paradigm which is representative of learning a common response to two stimuli which are not identical:\textsuperscript{10}

![Paradigm of concept formation](image)

Fig. 1--Paradigm of concept formation

The definition of concept formation as given by Kendler is synonymous with the paradigm for concept formation presented. This paradigm serves as a unifying factor in all of the argumentation of Pikas.\textsuperscript{11} Pikas states that "this is likely to be representative of modern approaches to the subject."\textsuperscript{12}

\textsuperscript{7} Pikas, op. cit., p. 119.
\textsuperscript{9} Ibid., p. 447; quoted in Pikas, op. cit., p. 117.
\textsuperscript{10} Pikas, op. cit., p. 138.
\textsuperscript{11} Ibid., p. 118.
\textsuperscript{12} Ibid., p. 117.
Types of Concepts

For the basis of the discussion regarding different types of concepts Pikas uses the concept classification of Bruner et al. According to Bruner et al., concepts may be classified as conjunctive, disjunctive or relational. They are defined as follows:

A conjunctive category is one defined by the joint presence of the appropriate value of several attributes. A typical conjunctive category... may be defined by the conjunction of three figures, redness and circles, i.e. all cards containing three red circles... The disjunctive category may be illustrated by that class of cards... that possess three red circles, or any constituent thereof: three figures, red figures, circles, three red figures, red circles, or three circles...

The relational concept or category is one defined by a specifiable relationship between defining attributes. Thus, we may define as a class all these instances containing the same number of figures and borders, or these cards with fewer figures than borders.13

Pikas then states some theoretical positions regarding these types of concepts and certain other factors. In the first place he contends that conjunctive concepts are the most easily formed or learned. "That conjunctive concepts are more easily learned than disjunctive concepts must be due to the fact that this kind of learning is more natural for the organism and represents a more primitive process."14

In the second place Pikas considers the problem of weighing

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13 Bruner, op. cit., pp. 41-43, cited in Pikas, op. cit., p. 120.

14 Pikas, op. cit., p. 120.
many attributes. The question arises as to why conjunctive concepts are more easily learned or formed and why do they represent the more primitive process? Pikas quotes Bruner et al. regarding this question: "How the strain of weighing many attributes can be reduced?"\textsuperscript{15} Bruner et al. consider two ways: "One is by reduction in the number of attributes considered; the other by a process of combining or recoding attributes into configurations."\textsuperscript{16}

Pikas states that "the first (reduction in number of attributes considered) means to fall back on those attributes most immediately discriminable or to regress to the attributes first formed."\textsuperscript{17} The following example is used to describe the second method of reducing the strain of weighing many attributes:

In coding or categorizing the environment, one builds up an expectancy of all these features being present together. It is this unitary conception that has the configurational or Gestalt property of birdness. . . . When the conception is well enough established, it takes on the property of being able to serve as a discriminable and seemingly irreducible attribute of its own.\textsuperscript{18}

The total process involved in reducing the strain of weighing many attributes and its relation to concept formation

\textsuperscript{15} Bruner, \textit{op. cit.}, p. 45, in Pikas, \textit{op. cit.}, p. 121.

\textsuperscript{16} \textit{Ibid.}

\textsuperscript{17} Pikas, \textit{op. cit.}, p. 121.

\textsuperscript{18} Bruner, \textit{op. cit.}, p. 47, in Pikas, \textit{op. cit.}, p. 121.
is brought into focus by Pikas. He contends that this configuration process, as described by Bruner et al., and the genesis of an "attribute of its own is exactly identical with the genesis of a concept." He states further that "what has been described here (in the example cited above) is the originating process of the concept and is what Bruner et al. called 'the inventive act of concept formation'."

An experimental study by Bruner et al. is cited as the basis for several theoretical propositions regarding the familiarity of concepts. The basic thesis of the experiment by Bruner et al. was

> What does it mean to say that, on the one hand, people escape certain logical errors when they have the guidance of common experience and, on the other, that common experience has the effect of producing certain preferential forms of error? To us, it suggests that much of human reasoning is supported by a kind of thematic process rather than by abstract logic.

Pikas describes the process by which Bruner et al. planned to illustrate the aforementioned thesis:

> To illustrate this thesis, Bruner et al. arranged some "thematic material," with which they compared some WCST-type material, which they called "abstract material." The strict construction with the "abstract material" was also to be found with the "thematic material." The difference was only that the attributes on the cards, which represented two people in interaction, were sex (boy, girl, man, women), dress (daytime clothing, nightdress) and affect (smiling, looking down).

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19Pikas, op. cit., p. 121. 20Ibid.

The results of the comparison were that with abstract material the Ss were relatively indifferent about attributes, while with thematic material there were differences like this, the attribute most "strengthened" being the sex of the adult figure.  

Due to the fact that Bruner et al. were interested primarily in concept attainment the results of the experiment are thus explained in terms of concept attainment:

In the first place, the problem-solver is likely to fall back upon reasonable and familiar hypotheses about the possible groupings. In so doing he may be led into a modified form of successive scanning. 

. . . In the second place, the thematic material will, more readily than abstract material, lead certain attributes to have nonrational criteriality.  

Pikas, however, analyzes the results of the experiment in terms of concept formation.

1. In this view the familiar concepts will be primary and not the familiar hypotheses. This view may be expressed in a self-evident prediction: in sorting tasks the formation of hypotheses is first orientated according to the familiarity of concepts. If all the elements are equally familiar, the familiarity of a hypothesis or a rule will, of course, be marked.

2. It may also be added that the hypotheses whose use is studied in concept attainment are, in the present author's view, themselves concepts and their genesis is thus the story of concept formation.

3. Since hypotheses are synonymous with concepts, we may, of course, also grade them according to familiarity. If we make mistakes in the syllogisms quoted above, it is correct to say we "fall back upon familiar hypotheses," but these are not reasonable hypotheses. If we regard these hypotheses on which we fall back as concepts which are subject to the laws of learning (in the department of concept formation), we may in this case see that there is a rhythmic relation

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22 Pikas, op. cit., p. 122.

between the words "all" and "are" which has been learned in previous situations and which because of its familiarity produce unreasonable effects.24

In summary, regarding types of concepts, it may be said that, of the three types of concepts mentioned, conjunctive concepts are most easily formed and learned. This may be explained, in part, on the basis of familiarity of attributes and the ability of the organism to discriminate those relevant attributes.

Theory of Coding and Recoding

One of the basic premises underlying the concept formation theory under consideration is the cognitive process of coding and recoding. Pikas accepts and uses Hunt's definitions of coding and recoding: "(1) . . . coding is the normal method of information storage, and (2) . . . the function of recoding is to reduce the number of symbols stored in memory at any one time."25

In relation to the ability of organisms to code and recode, Hunt's contention that "man is the most efficient solver of inductive problems known today,"26 serves as the point of departure for Pikas' discussion of coding and recoding. He states:

24 Pikas, op. cit., p. 123.


The question now is, why is man superior in induction and how is this related to memory? . . . the superiority in induction rather than deduction is synonymous in the relevant respects with Bruner et. al.'s conclusion that conjunctive concepts are more easily attained than disjunctive concepts, and furthermore, that if we are to trace the connection between this fact and memory, we must make use of the terms "coding" and "recoding" . . .

According to Pikas, coding and recoding exist in terms of a primary-secondary relationship.

The most primary coding in the memory can probably best defined as a recoding of an original sensory input. It is a question of storing qualitative and individual entities. unique events are received from another medium . . . and are transferred into the code of the organism. What is produced is something which has been called a memory track.

As to the relationship between these recordings of sensory inputs which are called codes Pikas states "if we use the word 'recoding', . . . recodes must be recodings of primary codes." What then is the relationship of coding-recoding to concept formation? Pikas contends,

Since the fundamental definition by Kendler (common response to dissimilar stimuli) presupposes that at least one of the stimuli is stored as a code . . . the relation between codings and codings (or recodings) in the memory must be of great importance for the theory of concept formation.

Pikas establishes the importance of memory by saying that "concept formation is not only 'affected by memory,' but is produced by memory and, we may also say, in memory."

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27 Pikas, op. cit., p. 127.  28 Ibid., pp. 127-128.
29 Ibid., p. 128.  30 Ibid.  31 Ibid.
The relationship of coding and recoding to concept formation may be summarized in the following statement by Pikas:

The most genuine form of recoding also leads us to the boldest hypothesis, namely, that in recoding new codes are created, which are of such nature that they incorporate the common structure of the primary codes which are responsible for their genesis. The phenomenon of concept formation given in the historical definition—"to mind the common and to disregard the particular"—and in the modern formulation—"common response to different stimuli"—would thus be explained by the assumption of a common recoding.\textsuperscript{32}

Throughout the development of his theory of concept formation Pikas used the term "recoding hypothesis" to mean "new formations on the basis primary codes to recodings."\textsuperscript{33}

The theory of coding-recoding is then, in somewhat simpler terminology, a sensory input experienced by an organism and recorded in terms of a primary code. These primary codes combine to form what is called a memory track. From the primary codes the organism recodes which leads to the creation of new codes and a reduction in the number of symbols stored by the organism. It will be seen that this basic premise underlies the further development of this theory.

Concept Formation and Information Feedback

When investigating the relationships of information feedback to concept formation there are several considerations

\textsuperscript{32}Pikas, op. cit., p. 128. \textsuperscript{33}Ibid., p. 129.
which arise. In the first place one must have an operational definition of feedback since it is frequently used to denote a variety of reinforcement techniques. Another problem which arises is the relationship between delay of information feedback, post-feedback interval and effective concept formation. Consideration must also be given to the effect which misinformation has on concept formation.

Pikas gives the following operational definition of the term "feedback":

The operational definition of the term "feedback" has been attenuated in use, so that now it only denotes that a previously presented stimulus or a reaction by the S recurs repeatedly, giving information as to the correctness of the S's responses.\textsuperscript{34}

The two basic problems which become apparent in considering information feedback are (1) delay of informative feedback and (2) post-feedback interval.\textsuperscript{35} Delay of informative feedback may be defined as the "delay in the time between the S's response and the information as to its correctness given by the E (experimenter)."\textsuperscript{36} Pikas defines post-feedback interval as the "delay in the time between the information given by the E as to the correctness of the S's response and the next stimulus."\textsuperscript{37}

Increased latency of reinforcement or stimulus feedback has been found to cause additional errors in the learning of

\[\text{34} \text{Ibid.}, \text{p. 130.}\]
\[\text{35} \text{Ibid.}, \text{p. 129.}\]
\[\text{36} \text{Ibid.}\]
\[\text{37} \text{Ibid.}\]
a concept and to require additional trials in order for the subject to learn or form a given concept. Pikas quotes Sax regarding this problem: "... as the latency in the presentation of a reinforcement is increased, there is a significant increase in the number of trials needed to reach a learning criterion."^8

If the above is true and repeated experiments have supported this, then some consideration should be given to the possibility of an optimal post-feedback interval. Pikas states,

We must reckon on optimal post-feedback intervals: if the post-feedback interval is too long, we have simply to reckon factors of forgetting. The actual fact that post-feedback intervals that are too short impair concept learning is not remarkable at all if we consider that even in common sense observations we speak of the importance of "maturity" or "settlement" in learning.39

He then relates the importance of post-feedback intervals to the actual process of concept formation. Since a certain length of post-feedback interval and IP (information feedback) is necessary this indicates that a process which takes a certain time must take place in the organism. "It is reasonable to imagine that recodings on the basis of primary codes takes time. Since conceptual processes require


^9Pikas, op. cit., p. 131.
time, it is conceivable that it is just a matter of the time which the organic creation of recodings takes.  

What, then, is the relationship of misinformation feedback and concept formation. Misinformation feedback is defined as "feedback signals which were misleading to subjects." In testing the effects of misinformation feedback in one experiment "MF is introduced by presenting feedback signals, ordinarily used to indicate the correctness or incorrectness of the S's response to the given stimulus, which were misleading in a percentage of trials."  

Pikas states that "Goodnow and Postman had found a tendency on the part of experimental groups with low percentages of MF trials to produce errors at a rate below that predicted by a probability-matching hypothesis." Bourne makes the following comment regarding these results:

Ss in concept-learning situations may seek and attain a solution more rational than probability matching; i.e., a solution which maximizes the number of "hits" or trials upon which response and feedback signal correspond.

Pikas analyzes the results of the experiment by stating...

\[ \text{Pikas, op. cit., p. 132.} \quad \text{Ibid.} \quad \text{Ibid.} \]


\[ \text{L. E. Bourne, Jr., "Long-term Effects of Misinformative Feedback upon Concept Identification," Journal of Experimental Psychology, LXV (February, 1963), 139; cited in Pikas, op. cit., p. 133.} \]
percentage is high and does not have this influence (or has only a slight influence) when the MF percentage is low, it is only reasonable to assume that there is a point at which the MF influence tends to cease in a marked fashion and that the position of this point is a function of the complexity of the material.\(^{45}\)

Pikas raises the question as to "what happens at this point with this 'solution more rational than probability matching'?"\(^{46}\) According to Pikas, "a concept has been formed."\(^{47}\) In explaining the above experimental results in terms of the recoding hypothesis Pikas states,

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... \text{a recoding has taken place and a secondary code has been created on the basis of the common structure of the primary codes. This newly created entity offers a certain resistance to the disjunctive elements involved in this misinformation.}\(^{48}\)
\]

In the foregoing discussion Pikas has attempted to explain the phenomenon of newly created entities on the basis of coding and recoding or what he calls recoding hypothesis.

**Perception and Conception**

A comprehensive treatment of concept formation should take into account the relationship between perception and conception. Pikas uses Wohlwill's three dimensions along which perception and conception are related as the basis for his theoretical discussion. These three dimensions are

1. Redundancy: As one proceeds from perception to conception the amount of redundant information required decreases...
2. Selectivity: As one proceeds from perception to conception the amount of irrelevant information that can be tolerated without affecting the response increases.

3. Contiguity: As one proceeds from perception to conception the spatial and temporal separation over which the total information contained in the stimulus field can be integrated increases.

Pikas comments on each of these briefly. "The first two dimensions are a summary of the essence of the information theory approach to concept attainment." Regarding the second dimension Pikas says that "when the concept has once been stabilized, fresh information—which the S also identifies as irrelevant—has less effect. According to the hypotheses on recoding, these recodings constitute a certain resistance to new disjunctive elements." Pikas also contends that "the third dimension in Wohlwill's classification may be just as compatible with recoding and connecting hypotheses."

A reference by Wohlwill is used by Pikas to illustrate the significance of spatial and temporal contiguity in the concept formation task:

Wohlwill (1962) also refers to Davidson's study (1952), which has shown that the opportunity for the

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52 Ibid., p. 136.
S to manipulate the stimulus materials in an object-classification task so as to provide spatial contiguity for the groupings made improves concept formation significantly, and an experiment by Kendler and Kendler (1956), which demonstrated how a certain reasoning task was closely dependent on the temporal sequence in which the steps in the inferential chain were presented.53

Pikas contends that "perception has still not been clearly distinguished in a qualitative sense from conception . . . ."54 He attempts to establish the relationship between perception and conception. He states that "most of the research workers seem to be conscious that all perceptual experiences include previous conceptual experience."55 In explaining the above contention Pikas states "... as soon as a sensory input is interpreted, the interpretations must be related to previously stored material: as soon as an input has a 'meaning' or is taken into account, it is placed in relation to the previous experience."56

Concluding his remarks regarding perception and conception, Pikas states that "... in relation to perception, conception is a more complex, more intellectually demanding, more integrative, etc. activity."57

Passive Summation and Active Search

The basis for the following discussion regarding passive summation and active search and their relationships

54 ibid., p. 136. 55 Ibid., p. 137. 56 Ibid. 57 Ibid.
to concept formation is the following definitive statement concerning "composite photograph" theory. Woodworth explains the composite photograph theory as follows:

"According to the "composite photograph" theory, the features common to a class of objects summate their impressions on the observer, who thus gradually acquires a picture in which the common features stand out strongly, while the variable characteristics are washed out. The observer plays a passive or receptive role, simply letting himself be impressed by the objects."

While it appears that there are no modern advocates of this theory Pikas states that "the psychologist who has done experimental work on these lines is H. A. Podell (1958), in her comparison of the variables passive summation and active search." Podell defines summation and active search as

Summation and inhibition function as in the Composite Photograph process. However, no picture or image is assumed to be required. Summation is defined as a passive concept-formation process which can function when no particular intent to form conceptions is present. . . . In contrast to Summation, the Active Search Process . . . involves the formulation of provisional solutions (hypotheses), which are tested on subsequent examples.

Pikas paraphrases a further contention of Podell in saying that

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59 Pikas, op. cit., p. 141.

active search is characterized by hypothesis testing, which involves both acceptances and rejections, but the probability of permanent rejection following contradiction should be greater than the probability of acceptance following confirmation, because hypotheses concerning common features are confirmed more frequently than those concerning variable features and are never contradicted.61

Pikas contends that both composite photograph and summation are metaphors and in considering "the organic event which is presumed to lie behind concept formation"62 he chooses to use the metaphorical term "melting together." He states further that "the metaphor 'melting together' does not include so far any assumptions as to the underlying mechanisms - these may be recoding or connections of primary codes."63

What does Pikas actually mean by the term "melting together"? He says that what happens in "melting together may also be described as 'normalization' of the content of memory..."64 He illustrates this by mentioning some classical experiments of J. J. Gibson65 which showed how sloping lines tended to be recorded as vertical or horizontal. These phenomena were sometimes called 'the normalization effect' and sometimes the 'adaptation effect'.66

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61Ibid., p. 4.
62Pikas, op. cit., p. 146.
63Ibid.
64Ibid.
Pikas points out that

. . . norms such as verticality and horizontality cannot only be affected by experience but also have their origin in experience, perhaps the genesis of these norms may be advantageously described by concept formation, the mechanism being preliminarily designated as "melting together" and more precise assumptions, such as recoding or connections of primary codes, being emitted.67

While Pikas identifies two mechanisms which may explain his "melting together" theory (recoding and connections between primary codes), it should be clear at this point that he has identified the "recoding hypothesis" as the theory to be used in his explanations of the underlying mechanisms in concept formation.

Summation and Discrimination

The problem which arises regarding summation and discrimination is, "which is more primary . . .?"68 Pikas contends that "if we regard the problem dialectically, we may say definitely that discrimination must precede summation, because we cannot summate if we do not have parts which are discriminated."69

Pikas offers the following solution regarding the question as to which, summation or discrimination, is more primary in concept formation:

The descriptive terms which psychology uses here cannot be detached from their conventional

67 Pikas, op. cit., p. 147.  
68 Ibid.  
69 Ibid.
contexts, from which it follows that summation, according to the definition, presupposes discrimination. An empirical investigation, in which the investigator is not aware of this necessary context of the descriptive terms, may come to mean only a repetition of a logically established relation.\textsuperscript{70}

The investigation, according to Pikas, which most accurately illustrates the problem of the primary relationship between discrimination and summation in concept formation on an empirical basis is that by Rommetveit.\textsuperscript{71}

Rommetveit hypothesizes the three stages in concept formation to be

At first, the defining property acquires perceptual dominance. After that, the functional concept is achieved. Finally the verbal concept is developed as in insight into and symbolic representation of an already established intuitive discriminatory mechanism.\textsuperscript{72, 73}

Pikas states that what is of most interest to him

"... is the transition from the first to the second step. Rommetveit speaks to the 'defining property' in the first stage. Since this stage, like the next, is intuitive in the sense of 'nonverbal' we must ask ourselves to what extent 'defining' refers to a process on the part of the S."\textsuperscript{74} It

\textsuperscript{70}\textit{Ibid.}


\textsuperscript{72}\textit{Ibid.}, p. 115.

\textsuperscript{73}For a brief description of Rommetveit's experimental design see Appendix A.

\textsuperscript{74}Pikas, \textit{op. cit.}, p. 149.
is assumed by Pikas that Rommetveit's use of "defining" refers to an activity where the subject "discriminates," but not "defining" in a sense which presupposes the designation of a class of phenomena since this use of "defining" could be done only by the experimenter. Pikas states that "in testing at this stage, the S will manage only simple comparisons ('similar or not')."

Pikas asks what is now needed, in order to cope with the next test situation, which reveals that the subject has formed a functional (i.e., a nonverbal) concept? According to the recoding hypothesis of Pikas, it may be said "that summation or melting together of the concept-forming features has taken place." Rommetveit, in describing the middle stage as a contrast to the final stage (stage of symbolic representation), says that "the intuitive discriminatory mechanism, furthermore, is described as the end product of passive summation, whereas the reflective symbolic representation is considered an end product of active search."

The question raised by Pikas is whether or not we accordingly have "to take a new discriminatory mechanism into account - an unconscious one - which is secondary in relation to summation?" Regarding this question, Pikas states.

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75 Ibid. 76 Ibid. 77 Ibid. 78 Ibid. 79 Ibid. 80 Ibid.
No discrimination of this kind has been demonstrated in the experiments. But perhaps we may make some guesses as to the reason, why such a conception should crop up. As far as the present author can see, this discrimination is a kind of discrimination which applies to an intuitive (i.e., a nonverbal) decision: an answer to the question "Concept or Not?" Thus it is a matter of an activity after the concept has been formed. The fact that we have difficulty in demonstrating the entry of such a discrimination experimentally is connected with the difficulties in determining exactly when the intuitive (functional) concept has been formed. As long as this experimental problem has not been solved, we have to content ourselves with a rough description: in the intuitive phase of concept formation a reciprocal action takes place between summation and discrimination. What takes place could possibly be called hypothesis testing but then this phrase would mean something other than conscious manipulation of elements often connected with symbolical labels.

A conclusion which may be implicit in the last-mentioned argument is that concept formation and nonverbal concept attainment coincide in the hypothetical design.81

Pikas contends, regarding the primacy of summation or discrimination, that concept formation has been "difficult to investigate experimentally . . . on account of the difficulties of keeping discrimination and summation apart."82 The problem is left at this point with the inference that it is presently impossible to determine which is primary, discrimination or summation.

Concept Formation and Stimulus Generalization

What is the relationship between concept formation and stimulus generalization? To what degree, if any, are they

81 Ibid., pp. 149-150. 82 Ibid., p. 150.
synonymous? These and other questions must be dealt with in order to develop a comprehensive theory of concept formation.

Pikas contends that the definition of stimulus generalization as given by Mednick and Freedman describes the same S-R relation that was evident in Kendler's definition of concept formation. This relationship is discussed by Pikas in terms of primary stimulus generalization and secondary stimulus generalization, drive and stimulus generalization, secondary stimulus generalization and mediation theories and categorization as a determinant in stimulus generalization.

Mednick and Freedman say that "stimulus generalization can be said to occur when a response, previously trained to be elicited by stimulus 0, can also be elicited by test stimulus similar to 0." Kendler's definition of concept formation, which has been used by Pikas, states that "concept formation is taken to imply the acquisition or utilization, or both, of common response to dissimilar stimuli."

The surveys of stimulus generalization research conducted by Pikas have lead him to believe that there is a synonymity between stimulus generalization and concept formation as they have been approached in research. He states:


84 Mednick, op. cit., p. 169; cited in Pikas, op. cit., p. 159.

85 Kendler, op. cit., p. 447; cited in Pikas, op. cit., p. 159.
What indicates, formally but clearly, that there is a synonymity between SG (stimulus generalization) and concept formation is that surveys of SG research include investigations whose designs and material are reckoned in other connections to identify them as investigations of concept formation.\textsuperscript{86}

The surveys and theories on stimulus generalization fall into two groups: (1) those that discuss only a general stimulus generalization variable, and (2) those that discuss two types of stimulus generalization, one of which refers to a more primary and the other to a more secondary process.\textsuperscript{87}

"The phrases 'primary SG' and 'secondary SG' seem to have been coined by Hull (1939) in his attempt to solve the 'stimulus equivalence problem,' which he defined as follows:"\textsuperscript{88}

"How can we account for the fact that a stimulus will sometimes evoke a reaction to what it has never been conditioned, i.e., with which it has never been associated?"\textsuperscript{89}

"Hull's solution distinguished between three distinct principles or mechanisms:"\textsuperscript{90}

(1) The partial physical identity of the stimulus compounds, (2) primary or physiological generalization (Pavlov's irradiation), and (3) secondary or indirect generalization through the arousal of a reaction previously conditioned to the same stimulus continuum.\textsuperscript{91}
Pikas quotes E. J. Gibson regarding primary stimulus generalization and secondary stimulus generalization. Primary stimulus generalization was described "as the 'inability to discriminate' and secondary generalization as 'classifying or categorizing on the part of the organism' - an ability in which similarities and differences are both operative." 92

In the following discussion Pikas deals with the basic differences between primary stimulus generalization and secondary generalization and their relationship to concept formation.

Primary Stimulus Generalization and Concept Formation

The phrase "primary stimulus generalization" was first used by Hull in connection with Pavlov's physiologically conceived "irradiation." 93 However, because of the difficulty of "imagining a concrete irradiation around a 'stimulus trace' (which corresponds to what were earlier referred to as 'primary memory codes'), Hull chose instead the more indefinite phrase 'stimulus continuum'." 94 Hull states,

... when a reaction has been conditioned to the trace of a stimulus, the traces of other stimuli from the same stimulus continuum and adjacent to the first will evoke the reaction with an intensity which decreases as the difference between the stimuli increases... 95


93 Pikas, op. cit., p. 162.  
94 Ibid.

95 Hull, op. cit., p. 10.
Pikas' basic concern is

... with a plastic, non-discrete model on the stimulus side. A natural result of this model is Hull's summation hypothesis, according to which overlapping GSG's (stimulus gradients) originating from two or more points on the same continuum will summate and result in incremented generalization responsiveness in the area of the overlap.96

Pikas considers this to "give indirect support to the 'melting together' approach in concept formation ... ."97

The other approach which conceives of primary stimulus generalization as "inability to discriminate" is mentioned by Pikas but he considers this approach a more remote possibility.98

The most recent approaches in this area, according to Pikas, have been made by Prokasy and Hall. They have suggested "... it is more parsimonious to refer to discrimination or lack of discrimination and to the effects of manipulated variables on discrimination (than to use the label 'stimulus generalization')."99

In speaking of discrimination Pikas quotes Prokasy and Hall regarding "true generalization."

It is our conclusion that the inference that two events are discriminated is something about which the experimenter has little substantial knowledge. That the subject makes the same response to two events may not mean, in two steps, that the events were discriminated and then that the subject generalized. If the

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96 Pikas, op. cit., p. 162. 97 Ibid.
98 Ibid., pp. 162-163.
events were not discriminated, the conclusion that generalization occurred is unwarranted.\textsuperscript{100}

Paraphrasing Pikas' interpretation and reaction to the statement by Prokasy and Hall, he interpreted the final statement (if the events were not discriminated, \textit{etc.}) to mean that, prior to speaking of generalization, the experimenter must have proof that the subject was able to discriminate the stimulus entities before the common response was made. The question Pikas is most interested in is, what are the prerequisite conditions for being able to assume that as a "black box" in a here and now situation, a subject will react "undifferentiatingly to stimuli which previously met with different reactions?"\textsuperscript{101}

Pikas identifies the two possible conditions, disregarding random events: "(1) the organism makes a new reaction which has not occurred before or (2) the organism repeats an old common reaction which was made before discrimination."\textsuperscript{102}

Possibility number one is considered by Pikas to be compatible with his previously stated recoding hypothesis. He states that "what seems to possess the qualifications for a completely new response within the organism is a recoding on the basis of old codes (which, if they are not themselves

\textsuperscript{100}Prokasy and Hall, \textit{op. cit.}, p. 319; cited in Pikas, \textit{op. cit.}, p. 163.

\textsuperscript{101}Pikas, \textit{op. cit.}, pp. 163-164. \textsuperscript{102}\textit{Ibid.}, p. 164.
recodings, are original codings of primary sensory impressions)."103

Pikas then proceeds to determine if the above reasoning can be explained on the basis of recodings. He does this by considering the "most common natural groups of independent variables, namely, drive and genetical processes."104

Drive and stimulus generalization.—Mednick and Freeman state that "... any condition which will increase the drive state will result in increased SG responsiveness."105 Pikas raises the question, "... what is the connection between drive and concept formation?"106 His answer is,

As a component in motivation, drive has a positive effect on concept formation, in the same way as all other cognitive variables which can be used as performance variables. If the intensity of drive is in an optimal relation to the level of concept formation, the effect of the drive is positive; if it falls from the optimal level, the effect is negative. The variables rigidity or overexclusion and overgeneralization or overinclusion ... have often been related to theories of drive effect.

... The most common line of thought is that increased nonspecific drive produces confusion of thought; in this connection some research workers emphasize overgeneralization and others its opposite. In the present author's view a drive model must take into account not only the intensity of the drive but also the time for which the intensity acts. A great intensity for a short time has the effect of an explosion and tends to have a negative effect on the concept formation. The same drive, in the sense of the same energy extended over a long period, may have a positive effect. It is tempting to speculate

103 Ibid., p. 164
104 Ibid.
106 Pikas, op. cit., p. 164.
that, since a high degree of complexity in the conceptual structure requires more time, we may have here a resistance concept also. If we take into account drive intensity, drive tension and resistance, the analogies with the system of electrical units in the building of further models come easily to mind.107

Pikas identifies a point at which he contends that stimulus generalization and concept formation are not synonymous. He states that "since . . . increase of drive is always said to lead to increase of SG, while increase of drive leads to an increase in conceptual performance only if it is related to a certain level, there seems to be sufficient reason for not regarding SG and concept formation as synonyms."108 Further, Pikas differentiates between stimulus generalization and concept formation in the basic nature of the subject's tasks. "In the SG experiments the S's task is to discriminate and failures in this respect are noted as increased SG. In concept formation the task is both to discriminate and to generalize in the sense of 'summarizing' or 'melting together'."109

The discussion of primary stimulus generalization and concept formation is completed as Pikas speaks of the relation between primary stimulus generalization and genetical processes. Pikas found in Mednick and Freedman's survey "that SG is negatively correlated with age."110 In general, "the

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S's task was a discrimination task - 'they were only to respond to the center lamp',\textsuperscript{111} and the young Ss' greater tendency, in comparison with the older Ss, to react to other lamps close by' was, according to the Es, a manifestation of the tendency to generalize.\textsuperscript{112}

Pikas states that, in his opinion,

> The result was due to the fact that the task was to discriminate. . . . If we make SG the performance variable, the correlation between age and SG . . . takes on the same direction as the correlation between concept formation and age. To put it another way, the difference referred to earlier between SG and concept formation is due to the fact that SG is recorded as failures but concept formation as performances.\textsuperscript{113}

Pikas gives the following summary statement regarding primary stimulus generalization and concept formation:

> These comparisons seem to give us one experience: if we consider the SG which could be replaced by non-differentiation as synonymous with concept formation, the terminological chaos is maintained. But tolerating the synonymity between a SG which occurs after the S's discrimination of the relevant stimuli could be assumed to have occurred and concept formation seems not to lead to serious difficulties, because one part of the concept-formation process, viz. discrimination, is already included. Defining concept formation in that way, it is not necessary to emphasize particularly that there is also a similarity between the different stimuli, if we adopt the view that the common response to different stimuli is the criterion for this similarity.\textsuperscript{114}

\textsuperscript{111}For a brief description of Mednick and Freedman's experimental design see Appendix B.

\textsuperscript{112}Mednick and Freedman, op. cit.

\textsuperscript{113}Pikas, op. cit., p. 166.

\textsuperscript{114}Ibid.
Secondary Stimulus Generalization and Mediation Theories as Approaches to Concept Formation

In attempting to establish the relationship between secondary stimulus generalization and mediation theories it is necessary to define mediation processes. Goss defines these processes:

When events A, B and C occur in the sequences A--B--C and A--C, and the probability of the occurrence of C is actually or potentially greater or less when C is preceded by A--B than when C is preceded by A alone, B can be described as a mediating process or event.115

Pikas attempts to determine the relations between mediation and concept formation. Again, he employs the work of Goss which, according to him, will come nearest to answering this question regarding the relations between mediation and concept formation. "... Goss says that mediations are a subgroup in the class of conceptual situations: the other subgroup is the simplest concept-formation tasks, which are 'essentially identical to phenomena more often labeled primary stimulus generalization and response-mediated generalizations'.116

In trying to establish Goss' approach to concept formation, Pikas states that


Goss deals with concept formation situations on an associationistic basis. His point of departure is the explicit statement that there is only one essential difference between conventional paired-associates learning tasks and concept formation tasks in which S-R associations are established by the paired-associates procedure, and this is that, while in conventional paired-associates procedure there are several stimulus members for each response member.\textsuperscript{117}

The basic paradigms of Goss\textsuperscript{118} come from this basic definition, which is approximately the same as Kendler’s paradigm of concept formation.\textsuperscript{119} Pikas states that according to the model or paradigm of Goss (see footnote \textsuperscript{117}) “mediations consist only of namings... this model may be said to include certain sufficient conditions in mediations, while omitting many necessary conditions.”\textsuperscript{120}

Regarding the conditions omitted by the model or paradigm of Goss, Pikas states that

\ldots the fact that common reactions which are not verbal may take place to differentiated stimuli is not included in the model. To put it in a common-sense way, it is self-evident that the individual who has no verbal language may form concepts and the behavior of even the most verbally capable individuals may testify to the occurrence of ideas or concepts which they have no words for.\textsuperscript{121}

Pikas uses Goss’s two-stage paradigm of the relationships possible between initiating stimuli and both mediating

\begin{itemize}
\item \textsuperscript{117}Ibid., pp. 251-252; cited in Pikas, \textit{op. cit.}, p. 169.
\item \textsuperscript{118}For a reproduction of Goss’ paradigms see Appendix C.
\item \textsuperscript{119}Pikas, \textit{op. cit.}, p. 169
\item \textsuperscript{120}Ibid., p. 171.
\item \textsuperscript{121}Ibid.
\end{itemize}
and terminating responses in order to treat the question "how are conceptual entities which are not words to be fitted into a mediation model?" He explains the paradigms or models of Goss on a one-stage and a two-stage basis:

A one-stage paradigm of the same pattern has only initiating stimuli and terminating responses and consists of only four lines. From each of the first two figures a line goes to RVGC and from each of the two others a line goes to Rguz.

On the other hand, the actual two-stage paradigm (see footnote 121) has the following differences from the one-stage paradigm, according to Goss:

First, no responses of naming the component dimensions are present. However, should the common elements of two or more subsets be at the same spatial position, responses of orienting-toward and naming that position might occur and be strengthened. . . . Second, both the common element of members of a subset and the variable features of those members are likely to be made up of a fairly large number of discriminable features, each of which elicits naming responses.

Pikas is primarily interested in the first part of the two-stage paradigm "because the description of what happens when 'two or more subsets are at the same spatial position' is, of course, a representation of a composite-photograph model." According to Pikas, the mediators and their effect on concept formation can be explained by his recoding hypothesis. He states:

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122 See Appendix D for design of this paradigm.
123 Pikas, op. cit., p. 171.
124 Ibid.
126 Pikas, op. cit., p. 172.
If Goss's mediation paradigms are to conform with his general definition of mediation previously quoted, it is necessary to assume that the mediating stimuli and responses which appear are stored codings. . . . But are these codes, which are mediators, primary codes, i. e. unaltered traces of first sensory impressions, or has something happened to them? . . . The interesting question is, how do these mediators arise? The mediation theorists do not deal with this question but we may suggest that they must be conceived of as primary codes, for example, that the primary code of a word is the centre of a complex of connections which constitutes the conceptual mechanism.127

Pikas contends that the major question regarding stimulus generalization, which, according to him, does not appear to have been answered is, "... is there a primary SG mechanism, on the lines suggested by Hull, behind the secondary SG phenomena or could the construction or primary SG be everywhere replaced by non-differentiation?"128 Pikas further contends that the hypothesis of recoding of mediations is a possible answer or explanation for this phenomena, but it "is not to be considered as an exclusive, but only as a competing explanation of the economy of conceptual action."129

Categorization as Determinant in SG-like Behavior

There has been considerable attention given to the function of similarity in concept formation. Pikas states that "concept formation ... is a function of similarity."130 Wallach "distinguished four classes of definitions which

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129 Ibid. 130 Ibid., p. 175.
indicated this similarity by means of (1) common environmental properties, (2) common responses, (3) primary stimulation gradients, and (4) assignment to a common category."\textsuperscript{131}

Pikas "considers that this positively evaluated fourth definition can be paraphrased by saying that concept is determined by similarity and at the same time similarity is determined by concept."\textsuperscript{132} Pikas contends further that "in full agreement with the fundamental paradigm of concept formation we might thus say that, directly a S says that two stimuli are similar, the two objects belong to the same psychological concept."\textsuperscript{133}

From an observation of the research literature there appears some difficulty in dealing theoretically with the term stimulus generalization. Along this line of thought, Nakamura and Kaswan conducted an investigation which "started from the position that in 'SG-like behavior ease of discrimination of stimuli is directly related to categorizability and inversely related to SG'."\textsuperscript{134} Pikas states the following categorization hypothesis which evolved from their studies:

\begin{quote}
... if stimuli to which Ss are instructed to respond can be discriminated and conceptualized
\end{quote}


\textsuperscript{132}Pikas, \textit{op. cit.}, p. 177. \textsuperscript{133}\textit{Ibid.} \textsuperscript{134}\textit{Ibid.}
as belonging to a common class, this will facilitate categorization of these stimuli.\(^\text{135}\), \(^\text{136}\)

In analyzing the results of the experiment by Nakamura and Kaswan, Pikas states:

As is implied in Nakamura and Kaswan's point of departure, these two conditions are to be considered as concepts, which is fully in accordance with the fundamental paradigm of concept formation—the same response to differentiated stimuli. We may also note that these concepts are stored in memory, i.e., coded. . . . the authors have demonstrated what we may call a "condition for concept effectiveness," viz. spatial contiguity of stimuli. But because of fewer errors in the more centered conditions, the "contiguity" might be given a more informative description perhaps "favoring the concept in the center of the contiguity" . . . \(^\text{137}\)

Pikas hypothesizes that the common denominator in the experiment is "concentration toward the center."\(^\text{138}\) However, he makes it clear that further investigation is necessary to adequately examine this common denominator. It will be seen in the following discussion that the hypothesis of "concentration toward the center" is a significant part of his theory.

After reviewing several other experiments Pikas states with somewhat more conviction that "in all other cases the peak of responding was displaced towards the center of the


\(^{136}\)For brief description of experimental design see Appendix E.

\(^{137}\)Pikas, *op. cit.*, p. 178. \(^{138}\)Ibid.
series of given test stimuli. . . . we may note a common
denominator which reveals a tendency which seems to have
some influence in concept formation. . . . the movement is
towards the center of the series.\textsuperscript{139} From a field-theory
approach Pikas describes this field power as "gravitation
towards the center."\textsuperscript{140} Pikas further relates this tendency
toward the center to behavioristic thought stating that "we
may hypothesize that, since frames of reference (like
dimensions) can be considered as concepts and as older con-
cepts by using well-established ones, they also have greater
influence, acting as normalizers. But the question remains,
why does this normalizing move towards the center?"\textsuperscript{141} In
offering a solution to this question Pikas states:

\begin{quote}
  . . . we may reckon on the hypothesis of
summations of gradients, though in a more limited
sense than Hull may have intended, but resisting
the suggestion of replacing primary SG by non-
differentiation. The occurrence of these summations,
together with the centralizing tendencies just re-
vealed, can be used as a framework, to provide an
operational anchorage for the metaphor "melting
together" . . . as a description of concept for-
mation.\textsuperscript{142}
\end{quote}

Pikas states the following as conclusions regarding
stimulus generalization and concept formation:

1. In comparing the definitions of stimulus
generalization (SG) and concept formation which are
to be found in surveys of these subjects, a syn-
onymity could be observed in the beginning. If it

\begin{itemize}
  \item \textsuperscript{139} Pikas, \textit{op. cit.}, p. 180.
  \item \textsuperscript{140} \textsuperscript{ibid.}
  \item \textsuperscript{141} \textsuperscript{ibid.}
  \item \textsuperscript{142} \textsuperscript{ibid.}
\end{itemize}
is presumed that a common response occurs to stimuli which were previously differentiated by the S, the identity of the two paradigms compared could be established and the results obtained in SG research could be considered as furnishing information about concept formation.

2. If the requirement of previous differentiation by the S is not maintained, the consequence is that SG (as well as concept formation) is replaced by "inability to discriminate" and is regarded as an unnecessary construct. This happened in the discussion which did not deal with the possibility that the other alternative would be to establish the synonymity between SG and concept formation.

3. The differences between the two constructs which seemed to exist, on superficial consideration, with drive and genetic development as independent variables, were explainable by the fact that in the experiments SG was recorded as failures but concept formation as performances.

4. Some investigators have made differences between primary SG and secondary SG, the former being most clearly defined by Hull through connotations of "irradiation" and the second being synonymous with meditational processes in general. As the meditational processes, following an old Behavioristic tradition, dealt mainly with verbal mediation, the necessity of taking other mediators into account was pointed out. Further, giving primary SG as a mediating mechanism a more central place and recognizing that mediators must be considered as coded entities, we would expect a fruitful development of the theory.

5. The statements that "similarity" is a matter of private, subjective judgment and that primary SG is a function of similarity (the inverse relation being possible) also form a basis for unifying the SG and concept-formation approaches. As will be remembered, "melting together" was used in the description of the concept-formation processes as a metaphor synonymously with "summation" (both replacing the "composite-photograph" explanation).

In summation Pikas contends that the experiments regarding summation support the "summation of gradients between

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143 The five concluding remarks were taken from the conclusion to stimulus generalization and concept formation, Pikas, op. cit., pp. 181-182.
the points of training stimuli." The interpretation proposed by Pikas regarding this tendency is that "these findings, together with some others, just complete the summation approach: in the middle of the training lamps in a row, in the center of the stimulus words related to a dimension . . . the formation of concepts was intensified."  

Concept Formation and Transfer

In illustrating the relationship between transfer and concept formation Pikas states the following:

Let us assume that we have taught a child to react to the relation "greater than" by using triangles and squares of various sizes and have then noted in a test situation in which circles of various sizes have been used that the child tends to react to the relation "greater than" in this case also.

In this case the child has either (1) learned the concept of magnitude, (2) generalized from one stimulus situation to another or (3) transferred learning from one stimulus situation to another.

Transfer is a significant part in an adequate theory of concept formation. Pikas quotes Shaffer and acknowledges his agreement with Shaffer's statement that "studies of the conditioning favoring concept formation are of limited interest unless they take into account the transfer function of the concepts formed."

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144 Pikas, op. cit., p. 181.  
145 Ibid., p. 182.  
146 Ibid., p. 183.  
147 Ibid.  
Pikas chooses not to discuss the area of positive transfer since as he states it, "the analysis of the similarities between transfer and concept formation would lead to our going over ground that has already been covered." Rather, he chooses to discuss certain transfer problems which cause the greatest hindrances to the development of a well-rounded unifying theory of concept formation. This area he identifies as "negative transfer." He has chosen to deal with negative transfer because "the fundamental paradigms of concept formation and positive transfer could be considered as identical." Thus, the problem area is not positive transfer but negative transfer.

At the outset of the discussion Pikas makes a distinction between transfer and transfer effect. He quotes Woodworth and Schlosberg regarding this distinction:

... transfer means the carrying over of an act or way of acting from one performance to another, whereas transfer effect means the effect of this transfer upon the learning or execution of the second performance. ... A habit of speedy work carried over from a well-learned task to a new one may impede the learning of the latter - a clear case of positive transfer with a negative transfer effect. To call this a case of negative transfer may do no harm, but there are true examples of negative transfer, as when a young man on being released from the army, far from carrying over to civilian life the military habits of promptness and neatness, rebels against them and flies to the other extreme.151

149 Pikas, op. cit., p. 184. 150 ibid., p. 199.

Pikas agrees with this statement on one condition. That is, "if we say that certain phenomena of negative transfer can be eliminated from the discussion by the realization that in these cases 'negative' is to be referred to the teacher's or experimenter's system of values."\(^{152}\)

Much of Pikas's discussion regarding transfer and concept formation is based on three paradigms of Osgood.\(^{153}\) They are

Transfer

**Paradigm A**  
\[ S_1 \rightarrow R_1 \quad S_2 \rightarrow R_1 \quad S_1 \rightarrow R_1 \]

**Paradigm B**  
\[ S_1 \rightarrow R_1 \quad S_1 \rightarrow R_2 \quad S_1 \rightarrow R_1 \]

**Paradigm C**  
\[ S_1 \rightarrow R_1 \quad S_2 \rightarrow R_2 \quad S_1 \rightarrow R_1 \]

Fig. 2--Transfer and concept formation

Regarding Paradigm A, Osgood states that

... the transfer portion of this paradigm will be recognized as nothing other than a symbolic statement of stimulus generalization and the empirical law for this paradigm is: where stimuli are varied and responses are functionally identical, positive transfer and retroactive facilitation are obtained, the magnitude of both increasing as the similarity among the stimulus members increases.\(^{154}\)

\(^{152}\)Pikas, op. cit., p. 185.


\(^{154}\)Osgood, op. cit., pp. 133-134; cited in Pikas, op. cit., pp. 185-186.
Pikas states that this paradigm is synonymous with the basic paradigm on concept formation "with the exception that Osgood has included a test situation, illustrated in the third column, probably in order to show the separate components in the transfer situation."\(^\text{155}\)

Regarding Paradigm B, Osgood states,

\[\ldots\] where stimuli are functionally identical and responses are varied, negative transfer and retroactive inference are obtained, the magnitude of both decreasing as similarity between the responses increases.\(^\text{156}\)

In response to this definition Pikas states that he considers this paradigm to be the center of his discussion and recognizes

\[\ldots\] its structure as being the definition of response generalization. In a certain sense it may be said to be an inversion of the first paradigm. Paradigm B seems to be both a definition of negative transfer and a prediction of the negative transfer effect in the cases in which the paradigm is applicable.\(^\text{157}\)

Regarding Paradigm C, Osgood states,

When both stimulus and response members are simultaneously varied, negative transfer and retroactive inference are obtained, the magnitude of both increasing as the stimulus similarity increases.\(^\text{158}\)

\(^\text{155}\)Pikas, op. cit., p. 186.

\(^\text{156}\)Osgood, op. cit., p. 135; cited in Pikas, op. cit., p. 186.

\(^\text{157}\)Pikas, op. cit., p. 186.

Pikas responds to Paradigm C by stating,

The prediction regarding Paradigm C distorts the symmetry of the system to the advantage of negative transfer. Poffenberger, who put forward these paradigms as early as 1915, reckoned that Paradigm C would give a zero transfer effect, a view which corresponds with the symmetry of Woodworth and Schlosberg's model. The Osgood model could be briefly expressed by saying that a change on the reaction side is a sufficient condition for negative transfer, with the exception, conformably with the transfer and retro-action surface, that, if a change in R is so small that it does not reach the point R, positive or zero transfer may occur. This rule also seems to be applicable to concept formation: the changes on the reaction side counteract the genesis of a stable concept.159

Pikas raises the question as to whether or not the "varying R" in Paradigm C refers to spontaneous changes in R rather than "something which was first presented to the S as a stimulus and was later reinforced."160 If so, "... Paradigm C is really a description of the kind of concept learning which occurs most often: in spite of the fact that the S side varies, it is possible to imagine a random variation of R which is nevertheless understood in a certain sense as varying less than S."161

Stimulus Defined in Reference to Negative Transfer

Regarding the foregoing discussion Pikas considers the necessity for presenting a working definition of the term stimulus. He chooses the definition of "effective stimulus" given by J. J. Gibson as the most appropriate for

159 Pikas, op. cit., p. 187. 160 Ibid. 161 Ibid.
his approach to concept formation. Gibson states that "an effective stimulus . . . is one which arouses receptor activity, or recorded neural impulses, or sense organ adjustments, or overt responses, or verbal judgments - whichever criterion one chooses."\textsuperscript{162}

Pikas makes it clear that he considers insufficient the definition of stimulus as "the material the E (experimenter) manipulates with."\textsuperscript{163} The recoding hypothesis is again referred to as Pikas contends that

We must rely on the organism's remembering or coding the stimuli in order to get this paradigm: if an organism has demonstrated its capacity to give a different response to \( S_1 \) and \( S_2 \) and also to a common response to both of them without either necessarily being present at the same time, at least the absent \( S \) must be a coded \( S \).\textsuperscript{164}

Paradigm B becomes the center of discussion since Pikas considers it to be the most applicable to his particular line of thought, which is a coding model of concept formation. Concerning Paradigm B, Pikas states,

As regards the \( S-R \) interaction, we may begin by stating that a coding of a sensory impression can be considered to be a response of an organism which, after the impression has been received, stores it as an entity which is potentially both stimulus and response. Which it will be depends upon the angle of approach: the event which activates a code is a stimulus for this code and, when the code reacts, it is a response which is interpreted as a stimulus.\textsuperscript{165}


\textsuperscript{163}Pikas, op. cit., p. 188. \textsuperscript{164}Ibid. \textsuperscript{165}Ibid.
Pikas, in considering the above, regards Paradigms A and B as an abstraction

... in which "S" and "R" are not stated but in which only the ratios "many to one" and "one to many" apply. When the varying elements in Paradigm B (the so-called response) appear as stimuli in the next phase and provoke a common response (let us say, in the form of a recoding), Paradigm B is transformed into Paradigm A.166

According to Pikas, when different responses possess similarity, as implied in the above statement, "they form the same dimension, and such a dimension forms a concept."167 What constitutes a class or concept from a logical point of view is a common attribute. Pikas refers to Paradigm B and states that when different responses are made to the same stimulus, the responses all have something in common—"they take place in response to the same stimulus."168

Following this line of thought and referring once again to his recoding hypothesis Pikas states that

From the point of view of psychological mechanics, one more condition is needed: the different responses must act as stimuli and create a common response. Such occurrences are explainable by the recoding hypothesis. From the paradigm point of view, the concept-formation Paradigm A is contained within a Paradigm B sequence. If such recodings following the concept-formation paradigm occur, they must counteract the negative transfer effects in accordance with Osgood's simple model.169

From Osgood's investigation Pikas develops several points.

The purpose of Osgood's investigation was to "resolve the

166 Ibid. 167 Ibid. 168 Ibid. 169 Ibid., pp. 128-129.
similarity paradox in human learning." Pikas raises the following question concerning the paradox:

How does it come about that the similarity between the learning materials on two consecutive occasions, which has a promotive effect on learning (we may say that there is repetition), also produces the greatest negative transfer (we may say that confusion occurs)?

Osgood says that "ordinary learning, then is at once the theoretical condition for maximal interference but obviously the practical condition for maximal facilitation." Pikas states that Osgood's solution to this paradox is his "transfer and retroaction surface." He states further that "what is remarkable about this scheme is the difference between the dimension of stimulus similarity, which varies from 'identity' to 'neutrality,' and the dimension of response, 'varying from functional identity, through neutrality, to direct antagonism.'"

In attempting to summarize the paradox regarding similarities and opposites Pikas states,

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170 ibid., p. 189. 171 ibid.


173 Pikas, op. cit., p. 276, cites Osgood's definition of transfer and retroaction: "When transfer is studied, one is interested in the effect of a specifiable prior activity upon the learning of a given test activity. When retroaction is studied, one is interested in the effect of a specifiable interpolated activity upon the retention of a previously learned activity."

By accentuating the point in a commonsense manner, we may also produce a similarity paradox here: the opposite is more similar than what is less similar. We may say that, if we see a paradox here, it depends on the mixing of logical and psychological frames of reference, i.e., we consider the word "opposite" to have a logical meaning and "similar" to refer to a psychological rating scale shifting from identity to neutrality. The solution would be to give "opposite" a psychological meaning by getting actual "opposite" events judged on such a scale.  

The types of concepts which have natural opposites are given the name "correlative concepts." Pikas contends that the discussion regarding the "place of 'opposites' on similarity continua is valid in so far as we are dealing with words which have natural opposites, i.e., primarily the concepts which Wundt called 'correlative concepts'."  

**Correlative Concepts**

In the area of negative transfer, concepts which have natural opposites are important. The discussion regarding Osgood's work in transfer and retroaction dealt with this type of correlative concepts. Pikas states that "linguistically speaking, these concepts are adjectives with reciprocal relations (e.g., 'big' - 'small'); psychologically they, constitute the perceptual aspect of a dimension which has a substantivized adjective as a label (e.g., 'bigness')."  

Pikas raises the question as to "whether or not the genesis of the correlative concepts can be described in any  

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173 Pikas, op. cit., p. 191.  
176 Ibid.  
177 Ibid.  
178 Ibid., p. 195.
other way than by assumptions of the associationistic verbal mediations . . . ?"\textsuperscript{179} There are two "hypothetical traces" which Pikas discusses. "In the first place, there is the developmental-psychology trace: it may be considered as probable that young children, as opposed to older children, will produce more antonym errors than neutral errors and that free associations will produce more opposite associations."\textsuperscript{180} Pikas contends that the opposites of the correlative concepts "belong together, not because of mutual common associations (which the older children should have more of) but because of their original affinity, which cannot be explained by the number of associations."\textsuperscript{181}

"In the second place, we have the problem of whether or not the originating mechanism of the correlative concepts is to be found in certain spontaneous shift phenomena."\textsuperscript{182} Pikas relates this spontaneous shift to a particular class of phenomena in perception psychology "which have the common characteristic that after a time a certain stimulus passes over into its opposite."\textsuperscript{183} Regarding this spontaneous shift to opposites Pikas states that "in this connection we may bear in mind one general fact: shifting to the opposite has something to do with satiation."\textsuperscript{184} Pikas supports this

\textsuperscript{179}Pikas, op. cit., p. 195. \textsuperscript{180}Ibid. \\
\textsuperscript{181}Ibid., p. 196. \textsuperscript{182}Ibid. \textsuperscript{183}Ibid. \textsuperscript{184}Ibid.
statement with studies by Lambert and Jakovits. These studies "show that continuous repetition of a word results in a decrement in the intensity of its connotative meaning. They describe what took in these continuous repetitions as 'satiation'." Pikas emphasizes that "satiation is a primary process which is worthy of attention." Pikas returns to the example of "true negative transfer" given by Woodworth and Schlosberg (page 41). According to Pikas the example is not a genuine illustration of true negative transfer. He states

The problem of why a young man, being released from the Army, did not carry over to civilian life the military habits of promptness and neatness is a complex problem. But, if we assume that we can cultivate some such primary response as negative transfer is supposed to be, it is most convenient to interpret this "going over to the opposite," as a nonspecific response, the primary driving force behind it being said to be satiation.

Pikas compares Woodworth and Schlosberg's approach to negative transfer with that of Osgood. Osgood defines negative transfer by saying that "negative transfer occurred when the response shifted to its opposite." However, Pikas points out that in Osgood's experiments the shift of

186 Pikas, op. cit., p. 196.
187 Ibid.
188 Ibid., pp. 196-199.
189 Ibid., p. 197.
the response to its opposite "took place primarily in the E's arrangement of the material and secondarily by the S after the reinforcement had been changed and that the transfer effect in the process was by no means negative, owing to the opposites' psychological similarity or proximity to each other." 190

The difference in the definitions was that in Woodworth and Schlosberg's example "the response shifted spontaneously, while in Osgood's experiment the response was changed by external influences." 191 Pikas tends to accept the approach of Woodworth and Schlosberg stating that "it . . . affords a more consistent approach. When the responses are to be changed by external influence, the S-R relations . . . will be more complicated and the negative transfer effect more ambiguous." 192

Pikas further states that the approach of Woodworth and Schlosberg

. . . implies that a single stimulus in the negative transfer paradigm directly initiates different responses instead of their being elicited and reinforced from outside as stimuli. As regards the formation of correlative concepts, however, such a paradigm relation has a special significance: a negative transfer paradigm which is possible owing to satiation may be a link in the genesis of the correlative concepts. 193

The process is described further by Pikas in the following way:

190 Ibid. 191 Ibid. 192 Ibid. 193 Ibid.
First a certain $S$ initiates a primary code which is the $R$ of the organism, on account of intensive repetition of the same $S$, satiation arises in the primary code and produces a new code, which is the opposite or some kind of negative image or the preceding one, or which is also coded. Since the latter code is created from a primary code and not from a recoding, though a recoding of another kind than the present author's recoding hypothesis presented earlier, which assumed the genesis of unifying recodings on the basis of different primary codes.\textsuperscript{194}

In relating satiation to his recoding hypothesis Pikas explains that

As a result of satiation, an "opposite response" occurs which may be considered as recoding. In the next phase, when the two coded responses (the original one and its opposite) occur as stimuli leading to the same response, the conditions of the concept paradigm are fulfilled and the opposites felt (or considered by definition) as psychologically similar. Or, to put it simply, to react with "big" or "little" (= two $R$ or two codes belong together) is to react with the same dimension or concept of "bigness" (= one $R$ or recode to different $S$). We can also say that the correlative concept of "big" is meaningful only in relation to "little"; these are a pair which make "different responses to the same stimulus" and they are a unit which makes "one response to different stimuli."\textsuperscript{195}

The value of this reasoning, according to Pikas, is dependent on its logical correctness and its possible explanatory power.\textsuperscript{196} Again referring to his recoding hypothesis Pikas states that "what he has tried to maintain so far is that the hypothesis of recodings may on account of its unifying connection with the other problems discussed, have a certain explanatory power as regards the great problems

\textsuperscript{194}Ibid. \textsuperscript{195}Ibid., p. 198. \textsuperscript{196}Ibid.
of what happens in the mind of a person who forms a concept.\textsuperscript{197}

In summarizing his discussion regarding concept formation and transfer Pikas states that "as the fundamental paradigms of concept formation and positive transfer could be considered as identical, the present author preferred to concentrate his attention on negative transfer. . . ."\textsuperscript{193} Further, Pikas states,

An analysis of Osgood's theories, on which the discussion was centered, showed great contractions in the paradigm which stated the conditions for negative transfer, and an examination of the investigations which were supposed to demonstrate negative transfer effects yielded a negative result for Osgood's predictions. Assumptions as to the psychological nearness of the opposites were, in the present author's opinion, the best way of resolving the similarity paradox and the most fruitful proofs of alternative hypotheses were to be derived from investigations on reversal shifts.\textsuperscript{199}

Chapter Summary

\underline{Underlying Mechanism}.--According to Pikas, "if research into the mechanism of concept formation is to make any progress in the future, it must start with an assumption that the function of memory tracks or storings or codes must occupy a central position in the working model."\textsuperscript{200} Research in the area of concept formation has given little attention to what Pikas considers to be significant in the underlying mechanism.

\textsuperscript{197}Ibid., pp. 198-199. \hspace{1cm} \textsuperscript{198}Ibid., p. 199. \hspace{1cm} \textsuperscript{199}Ibid. \hspace{1cm} \textsuperscript{200}Ibid., p. 231.
of concept formation; that is, memory codes. Pikas states that "in the literature on concept formation the present author has found practically no mention of the idea that concept formation may be explained by recordings of primary memory codes taking place as a primitive and original process. Such an assumption, however, would appear to form a promising basis for an explanation of the underlying mechanism."201

**Postulates.**--Pikas summarizes his basic arguments by stating the following postulates:

1. **Addition to the fundamental S-R paradigm of concept formation.** If we define concept formation as the 'common response to dissimilar stimuli," we have to assume (a) that these stimuli are perceived or have been perceived as dissimilar by the S and (b) that we may conclude that these stimuli are also perceived as similar, from the fact that the S has given a common response to them.

2. **The choice of definition of "similarity."** The word "similarity" has already been defined in the preceding paragraph. When it is necessary to draw a distinction between "objective similarity" and "subjective similarity," the former is defined by saying that the common response of several Ss to the stimuli under comparison are observable in the external world (in such a way that statistical significance may be considered to exist), while in the latter case it is sufficient that one individual shows a common response to different stimuli.

3. **The necessity of reckoning upon the existence of memory codes.** Since it is possible that a stimulus S2 that has never been previously perceived may be interpreted by the S as an individual phenomenon which is both different from everything else and at the same time in some respects similar to certain stimuli previously perceived, a memory code of S1 must exist in the organism of the S.

4. **The choice of definition of stimulus.** From what has already been said, it is evident that the

201 ibid.
definition of "stimulus" must include the possibility that a memory code may also act as a stimulus.

5. The representative function of the response. Each coding is the organism's response to a stimulus. The code which represents a stimulus in the external world is the internal representation of this stimulus. In its turn this code is a stimulus for other processes, some of which are objectively observable as reactions in the external world. These observable responses are the external representation of the code or codes.

6. The necessity of reckoning upon the existence of nonverbal mediators. It must be considered reasonable to assume that not only codes of verbal symbols but also codes of nonverbal images may act as mediators between different stimuli and the common response.

7. Dimensions, relations, norms and levels of adaptation may be advantageously regarded as functional concepts. Since perception of dimensions, relations, etc. is a function of learning and their common characteristic is that the same response is given to particular and unique events, they fulfill the conditions for the fundamental paradigm of concept formation.

Coding Paradigms of Concept Formation.--In view of the preceding postulates Pikas develops his coding paradigms in relation to classical experiments and examples of concept formation. He states

... the pre-requisite conditions for the first four paradigms are the simplest common features of the fundamental concept paradigm. There are two stimuli that are both objectively different (i.e., observable by other individuals) and subjectively different (i.e., judging by the S's ability to give different responses to these stimuli). Furthermore the S gives an objectively common response to these stimuli, thereby showing that they also have subjective similarity.

Pikas uses five figures to illustrate the divisions between objective stimuli and responses and memory codes. He states that "these figures, both on the input side and on the output side, have a vacant area (oval and rectangle

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202 Ibid., pp. 233, 234.  
203 Ibid., p. 234.
respectively), designed to mark the omission of many of the transmissions in the contact between the external world and the hypothetical sphere of codings and connections.\textsuperscript{204}

The following are descriptive explanations regarding the symbols in the figures:

1. If they are primary codes of the different stimuli $S_1$ and $S_2$, to which the observable response is made, they are denoted as follows:
   a. If no assumptions have been made as to any "common element," the primary code of $S_1$ is denoted by $R_1S_1$ and the primary code of $S_2$ by $R_2S_2$.
   b. If we assume that a "common element" can be distinguished by the $E$ and sooner or later by the $S$ also, the primary code of $S_1$ is denoted by $R_{w_1}^w vE_{v_1}$ and the primary code of $S_2$ by $R_{v_2}^w vE_{v_2}$.

2. It appears that in the paradigm we must take into account other primary codes which perform a mediating function in the production of "the common response to dissimilar stimuli." These may be, on the one hand, previously stored codes and, on the other, codes of events which go on at the same time as $S_1$ and $S_2$. Since these mediating primary codes in the paradigms are codes of entities which can be reproduced by the $S$ (for example, a word) or selected or designated amongst other entities by some kind of behavior (for example, by point out a certain color in a response situation), they are also mediators to the objectively observable representative behavior. In order to distinguish them from other mediators (for example, a recode), they have been given the subscript $s_y$. In order to indicate that these $s_y$ codes were elicited by different stimuli in the external world than the $S_1$ and $S_2$ in the standing relation - two to one - they are indicated by an arrow with a broken line (---).

Where we assume the existence of secondary codes or recordings of previously mentioned primary codes this is denoted by a double prime (') instead of a single one ('). For the sake of simplicity we take account here only of recordings of different primary codes in the current phase thus designated by $R"S"$.\textsuperscript{205}

\textsuperscript{204}Ibid.\textsuperscript{205}Ibid., pp. 234-235.
The Fundamental Connectionistic Models.—In order to illustrate the fundamental connectionistic paradigm Pikas uses Hull's description of how a child learns the concept of "dog." "The assumptions are that on different occasions the child has seen different dogs, a collie (S₁) and a terrier (S₂), and heard them called 'dog'."²⁰⁶ The codes which Pikas takes into account from Hull's example are:

1. The primary code of the visual stimulus "collie" (R₁S₁).
2. The primary code of the visual stimulus "terrier" (R₂S₂).
3. The primary code of the stimulus word "dog" (R₃S₃).²⁰⁷

Figure 3 illustrates the relations of these codes:

Fig. 3—The fundamental connectionistic paradigm

Pikas's explanation of this fundamental connectionistic paradigm is as follows:

The reason why the different stimuli here lead to a common response is that the codes of these stimuli are connected with a common mediating code. The

²⁰⁶Ibid., p. 236. ²⁰⁷Ibid. ²⁰⁸Ibid.
response "dog" observable in the surrounding world must be assumed to be coded and, in order that one of the stimuli may elicit this response, this code must be used. The connection between codes of visual stimuli of dogs and the code of the word "dog" appears as a function of temporal contiguity.\[209\]

Pikas contends that this paradigm is sufficient in explaining concept formation if we limit ourselves to the simple preconditions which call for "the connection of the codes of stimuli with a mediating code which is capable of eliciting an observable common response."\[210\] The problem arises, however, in trying to explain "that other stimuli which the S has not previously perceived may elicit the same response."\[211\] This paradigm is not sufficient for explaining this phenomenon.

This being the case with the aforementioned paradigm Pikas "considers a case in which both common and differentiated reactions to the outer world can be recorded or systematically observed."\[212\] In Figure 4 "(R_cS_c)sy and (R_tS_t)sy denote the primary codes of the words 'collie' and 'terrier' respectively, and R_1 and R_2 the corresponding words uttered by the child."\[213\]

Pikas states that the underlying mechanisms are the same in Figure 3 as in Figure 4 and can not provide an adequate solution "to the problem why all dogs or all collies or all

\[209\text{Ibid.}\quad 210\text{Ibid., p. 237.}\quad 211\text{Ibid.}\quad 212\text{Ibid.}\quad 213\text{Ibid.}\]
terriers not previously experienced may be called by their right generic names." According to Pikas, when taking primary codes into account, "the only advance here may be that we have a basic scheme for locating 'failures': if a response does not occur in accordance with the scheme, either a primary code or a connection may be missing."  

**Concept formation as a one-to-one relation.**—In Figure 5, Pikas deals with the problem of "identifying" and non-identifying" attributes. He assumes that there are two different stimuli—$S_1$, which has the attributes $w$, $a$, and $x$ and $S_2$, which has the attributes $y$, $a$ and $z$. These attributes, according to Pikas, are all well known concepts and there already exist separate codes for them. This is shown in Figure 5.

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Pikas explains this paradigm in the following way:

In testing the common response, the S points out or indicates by some other selective behavior the right attribute from amongst the alternatives given by the E. In a case like this we need not imagine any verbal connecting link. The previously coded attributes or, as the present author prefers to call them, the finished concepts are manifested directly in selective behavior. If the attribute \( a \) is pointed out in the external world, the code \( R_a S_a \) corresponding to \( a \) was the steering code in the organism on that occasion. Since the previously coded attributes fulfill the same function as, for example, the word "dog" in the first paradigm, this function is denoted by the subscript \( sy \).

It is easy to see that in such a case \( S_1 \) and \( S_2 \) will lead to the same \( R \), because they contain a common element. This leads us in fact to nothing less than the conclusion that \( R \) is really a response to a single cue or attribute \( (a) \); the rest \( (w, x, y, z) \) are simply distractors. Thus the fundamental paradigm of concept formation could be reduced to a single S-R connection.\(^{218}\)

In comparing paradigm II to paradigm I \( a \) and \( b \), Pikas contends that they "agree well, if we restrict ourselves to the fact that \( R \) was a response to one label ('dog'). It does

\(^{217}\)Ibid., p. 239.  \(^{218}\)Ibid.
not agree if we say that this label, as the organism's response, connected the different stimuli \(S_1\) and \(S_2\) or, to put it more correctly, their primary codes."\(^{219}\) The "one response to several different stimuli" which Pikas is considering "presupposes only a 'learned connection' in paradigm Ia and Ib: nothing has been said about any attribute common to the two codes."\(^{220}\) The real difference between paradigms Ia and Ib and paradigm II is that "in paradigms Ia and Ib, the common element consists only of a label: in paradigm II, the common element is to be found in the stimuli, like other elements, already arranged and clearly coded (and moreover often connected with codes that may be used as symbols)."\(^{221}\)

Pikas further contends that the common element in \(S_1\) and \(S_2\) in paradigm II is clearly laid out and it is the task of the subject to "discover" it. If, Pikas states, we assume "that the primary codes of \(S_1\) and \(S_2\) have common elements also in paradigms Ia and Ib,"\(^{222}\) then the subject's task is to "invent" them.

The inventive act of concept formation.--Pikas's primary concern is with the act of concept formation. Those involved primarily in the area of concept attainment were most concerned with "why" a certain attribute is discovered rather than "how" it is discovered. Pikas states that his interest is in the inventive act of concept formation.\(^{223}\) The

\(^{219}\) Ibid.  
\(^{220}\) Ibid., pp. 239-240.  
\(^{221}\) Ibid., p. 240  
\(^{222}\) Ibid.  
\(^{223}\) Ibid.
question, in this regard, which Pikas proposes to answer is, "why is the common element in Hull's Chinese letters distinguished and why does it become equivalent to the feature constituting the concept?" His immediate answer to this question is

... that it must be dependent on the fact that it has a quality which the particular features do not have, namely, that it is repeated. The common trait appears in preference to the particular features simply owing to the greater frequency of the occasions on which it can be learned. In this connection concept formation may appear as a discrimination task. 

Pikas has constructed a model of the course of events in Hull's experiment in learning Chinese letters.

Fig. 6—Concept formation with gradual learning of the common trait.

The following is an analysis of the paradigm according to Pikas:

In choosing notations for the traits, the same letters have been used as in the reconstruction of the attainment paradigm using known elements. In

\[224\text{ Ibid., p. 241.}\]  \[225\text{ Ibid.}\]  \[226\text{ Ibid.}\]
order to mark the fact that they do not in the begin-
ing appear to the S as separate features and that we cannot as yet know whether it is at all possible to distinguish them in the initial primary codes, they have been placed within square brackets.

What we can be certain of is that the common trait appears after a certain frequency and the proof of this is that, on the presentation of a fresh stimulus \( S_j \), which has not been previously perceived and which contains the same common elements as \( S_1 \) and \( S_2 \), the same response as \( S_1 \) and \( S_2 \) can be elicited.

Thus it is the frequency of recurrence of a certain element or trait in an unchanged state, while the other elements vary, that results in this element forming a concept. Here we may also say that there is in fact one \( R \) to one \( S \), as soon as this \( S \) has occurred consistently a sufficient number of times. Hull's experiment also relies on a symbol (Li), with which the common element is connected, because they always occur together. In describing the selection of the concept-constituting element by frequency of recurrence, it is, as has been previously mentioned, by no means necessary to resort to such an intermediate link. What is important thus far is that it was the activity of the memory that made possible the appearance of the feature constituting the concept.

The assumption behind the argument so far has been that the concept-constituting elements were completely identical.\(^{227}\)

In concluding his discussion on concept formation as a one-to-one relation Pikas states "we might say than an 'element' (or 'trait' or 'cue' or 'attribute') need not be an identical element but may be a structure, which, on the one hand, is accessible in principle in an objective stimulus and, on the other, must be found in some form in the primary code of this stimulus."\(^{228}\) He states further that "as regards the structure of this element (or perhaps we should rather say 'trait') in the primary code in the sphere of hypothetical

\(^{227}\)Ibid., pp. 241-242.  \(^{228}\)Ibid., pp. 242-243.
constructions, its hypothetical existence is dependent precisely on the fact that a 'common response' is given to 'dissimilar stimuli'.

Concept formation through generalization.—Pikas has established earlier in his theoretical discourse the relationship between stimulus generalization and concept formation. He concentrates on stimulus generalization as it occurs in the area of mediating generalizations. Figure 7 consists of a paradigm constructed on the bases of Lipton and Blanton's experiment.

![Diagram](image)

Fig. 7—An example of a mediated generalization and a "partial concept-formation" paradigm.

Pikas's description of the selected parts of the experiment is as follows:

To the first stimulus which consisted of a complete circle a symbol YEM was conditioned. An electric shock was applied, so that YEM elicited a GSR reaction. When the stimulus CEP, to which a

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229 Ibid., p. 233.  
230 Ibid.  
231 Ibid., p. 244.
semicircle was conditioned, was presented to the S, it elicited a GSR reaction (though not as strong as that elicited by YEM), in spite of the fact that an electric shock was not applied either with CEF or with the semicircle. The experiment, which was performed with a large number of controls, shows quite clearly that it is the similarity between the complete circle and the semicircle that is the cause of the mediation. This similarity is primarily objective, i.e. it can be expressed in rules which can be shared by several individuals. The subjective similarity is defined by the similarity of the observable responses. The relation between the two similarities has also been demonstrated here, even though it has not been so precisely determined as in psychophysical experiments (and is not, of course, represented by so simple a relationships as that indicated by in the diagram).

In analyzing the paradigm Pikas states that

As regards the objectively observable variables, the above paradigm differs from those previously discussed in that the response to different stimuli is by no means identical or common. ... In this connection a reasonable hypothesis is that we may re-word the fundamental paradigm of concept formation, so that "common response" is replaced by "small variation in output" compared with the larger variation in input, which, however, requires a common basis of comparison, and makes the definition still wider which perhaps simultaneously reduces the possibilities of explaining the underlying mechanism.

If we continue on the present lines, with SG as an explanation of conceptual actions, we have to note that, if a SG paradigm is drawn up in this way, SG appears to take the place of the connection (sometimes also called the association), which in this case can also be interpreted as a function of spatial contiguity. Stimulus generalization may then remain as an auxiliary, by which connectionists explain the relation of a common response to similar stimuli. We may also say that connectionism, supplemented by the assumption of the SG mechanism in a connecting position, is the real two-to-one alternative among the explanations of conceptual phenomena. In saying this, we conceive only of a connection between primary codes, ... but of no common element between them.

\[232\] Ibid.
\[233\] Ibid., pp. 244-245.
Pikas contends that this paradigm would be quite different if it were designed in terms of the psychologists who choose to replace stimulus generalization by nondifferentiation. Pikas states that "sometimes nondifferentiation must also be thought of as a one-to-one alternative which has nothing to do with concept formation, because the organism has never at any time distinguished between the different stimuli concerned."\(^{234}\) The nondifferentiation in which Pikas is interested "is that which appears in relation to two stimuli to which the S has previously given different responses."\(^{235}\) According to Pikas

\[\ldots\] nondifferentiation like this must be synonymous with "response to a common element or structure," which in its turn, means that it is placed on a par with an approach which, according to the previous discussions, is an explanatory hypothesis for concept formation and, as such, a rival hypothesis to stimulus generalization.\(^{236}\)

Various possibilities of recoding.—In concluding his general summary concerning his theory of concept formation, Pikas discusses the possibilities of his recoding hypothesis. He states that his "approach is to try to apply the construct of recoding as an explanatory hypothesis at a fairly primitive stage of concept formation, defined as an 'inventive act'."\(^{237}\) In brief form Pikas's contentions regarding his recoding hypothesis are:

1. The use of the term "recode" presupposes the occurrence of primary codes which are recoded.

\(^{234}\)Ibid., p. 245. \(^{235}\)Ibid. \(^{236}\)Ibid. \(^{237}\)Ibid.
2. The material of the recodes or secondary codes is the content of the primary codes.238

Regarding the above statements Pikas says "we may be permitted to use the existence of recodes as a hypothetical construct, in order to investigate its validity in relation to other hypothetical constructs. We must . . . refrain from assuming the existence of codes in the brain."239 Pikas does, however, contend that

. . . It is still possible that the permanent and independent entity whose functions are noted down by external observation, so that "recoding," as distinct from "connecting," may be justified as a descriptive term, may, in the advances made in neurology prove to be, in some sense, permanently established connections.240

On the basis of his survey of studies in concept formation Pikas summarizes what the different alternatives are to the assumptions regarding recoding as an explanatory hypothesis of conceptual behavior."241

1. As a general guiding line, we may say that, wherever connections between primary codes (through SG, temporal or spatial contiguity and/or the use of primary codes, e.g. words, as mediators) does not seem to be the most parsimonious explanation, the existence of recoding in one form or another may be interpolated.

2. We may also say that the one-to-one alternative which involved the appearance of the common concept-constituting feature in the different stimuli was already a description of recoding in a general sense if we use it to describe all changes in the functions of later codings. However, such a use of the term would be too wide.

238 Ibid., pp. 245-246. 239 Ibid., p. 246. 240 Ibid. 241 Ibid.
3. In conformity with what he has already written, Pikas recommends that the word "recoding" should be used in cases in which the emergence of a new code is hypothesized, on the basis of the contents of primary codes of the first sensory input. This definition must include, at least to begin with, the possibility that recoding consists of changes in the primary codes as a result of external influences.

4. The recoding hypothesis had not been used, on the whole, as an explanatory construct of the inventive act of concept formation. Therefore, there are no direct experiments regarding the distinguishing of changes in the primary codes from the pure recoding alternative, i.e., the origin of new entities. There are some arguments in favor of the recoding alternative which amount to saying that it seems to be less ambiguous.

a. In the first place, a recoding hypothesis which is based on changes in the primary codes must leave a fairly large and indefinite scope for the influence of a new sensory input directly to a particular code. The original content of this primary code is certainly still of importance but the code will have the character of a variable transitional phase. This results in what seems to be an important disadvantage of this hypothesis: if we wish to avoid the picture of perception as a "perceptual jumble," we must make a supplementary assumption that only some of the primary codes are changed, an assumption which in its turn requires supporting reasons. We must be able to explain that there are in the memory potentially accessible codes of unique events with their particularities intact, alongside concepts which were formed as a result of these unique events.

b. As the carrier of the conceptual content, the recoding hypothesis has a more refined alternative, which does not give rise to these difficulties. If we assume that recodes or secondary codes have been created as new entities properly so called (and not merely in the sense of "having been changed"), the existence of concept-carrying entities (recodes) is quite compatible with the simultaneous existence of entities which are the carriers of unique events (primary codes), without our needing to conceive of conceptual behavior as a complicated aggregate of connections between codes.
or to make it dependent on mediating (usually verbal) primary codes.\textsuperscript{242}

However, Pikas states that these arguments "are by no means sufficient to eliminate a changing-of-primary-code-alternative within the recoding hypothesis."\textsuperscript{243} For this particular reason Pikas has refrained from giving a schematic diagram of any particular recoding paradigm. He does, however, state that "for the present Figure 8 illustrates satisfactorily the two forms of recoding."\textsuperscript{244}

![Diagram](image)

\textbf{Fig. 8—Tentative recoding paradigm}\textsuperscript{245}

In conclusion, Pikas states that it is not, at present, possible to prove the tenability of the recoding hypothesis. He says that "at the moment, no empirical results seem to exist that bear directly on this point..."\textsuperscript{246} He does

\begin{itemize}
\item \textsuperscript{242}Ibid., p. 247.
\item \textsuperscript{243}Ibid.
\item \textsuperscript{244}Ibid.
\item \textsuperscript{245}Ibid., p. 248.
\item \textsuperscript{246}Figure 8 adapted from paradigm on concept formation with gradual learning of the common trait. The adaptations made from suggested changes by Pikas, p. 248.
\end{itemize}
contend, however, that the recoding hypothesis offers a better explanation of the existing fragmentary theories of concept formation.\textsuperscript{247}

\textsuperscript{247}Ibid., p. 248.
CHAPTER IV

A THEORY OF CONCEPT LEARNING

The theory of concept learning to be presented in this chapter is that taken from Concept Learning: An Information Processing Problem, by Earl B. Hunt. The area of concept learning, according to Hunt, is treated from a "problem oriented point of view." The remainder of this chapter shall be given to a synthesis of Hunt's theory of concept learning in the specific areas of (1) the nature of concept learning, (2) an analysis of the problem, (3) concept learning and basic learning, (4) stimulus organization, (5) memory and concept learning, (6) strategies of concept learning, (7) artificial intelligence, (8) an information-processing model of concept learning, and (9) concept learning by artificial intelligence.

The Nature of Concept Learning

Hunt's initial step in the development of his theory consists of defining and discussing the nature of concept learning. For a definition of the term "concept" Hunt uses that in Webster's dictionary.

2Ibid., p. vii.
concept: 1. A thought, an opinion. 2. Philós. A mental image of a thing formed by a generalization from particulars; also, an idea of what a thing in general is to be.\(^3\)

The second definition is the one with which Hunt is concerned. He states:

The ability to think in terms of abstractions is one of the most powerful tools man possesses. It is literally true that we never step into the same river twice; every situation is in some sense unique. Yet we manage to order our experience into coherent categories by defining a given situation as a member of that collection of situations for which responses x, y, etc. are appropriate. We classify. Classification is not a passive process. Tests must be made to determine whether the present situation contains certain elements or whether it can be described in a particular way. The results of these tests provide the information we use to guide the classifying act.\(^4\)

The development of these aforementioned rules for testing, according to Hunt, is the fundamental purpose of his research.\(^5\)

**Concept Learning Defined**

In defining concept learning, Hunt rewords Kendler's definition of concept formation\(^6\) and states that concept learning is the "acquisition or utilization, or both, of a common identifying response to dissimilar stimuli."\(^7\)

Further, Hunt states that "acquisition of a response involves both the capacity to distinguish situations in which

\(^3\)Ibid., p. 1. \(^4\)Ibid. \(^5\)Ibid.

\(^6\)Kendler's definition is "acquisition or utilization, or both, of a common response to dissimilar stimuli."

\(^7\)Hunt, *op. cit.*, p. 2.
the response is appropriate and the capacity to make the response. Concept learning and use refers only to the identification step." 8

The question is raised as to whether or not discrimination and concept learning would both fit the previously mentioned definition of concept learning. Or, "if we think of the utilization of a name as a response, such acts as learning to call particular animals 'dogs' will be classified as concept learning. . . . We certainly wish to include the learning of the use of names as an example of concept learning." 9

Discrimination, however, might be represented in an experiment where a "psychologist trains a rat to jump toward circles and away from triangles." 10 The question here, according to Hunt, is whether or not the rat has learned a concept of triangularity. Hunt, at this point, chooses to make a distinction between "two classes of behavior, discrimination and concept learning." 11 He states that "as it is used in this monograph, concept learning is defined as a term which applies to any situation in which a subject learns to make an identifying response to members of a set of not completely identical stimuli, subject to the following restrictions:" 12

8 Ibid. 9 Ibid. 10 Ibid. 11 Ibid. 12 Ibid., p. 6.
1. The subject must, conceivably, be able to instruct a human to apply the classification rule. The subject is not allowed to use examples during the course of this instruction.

2. The rule to be learned must be one that can be applied to any appropriate stimulus regardless of the context in which the stimulus appears.

3. The rule must be deterministic; once a given stimulus is completely described it must be uniquely classifiable.13

Hunt states that these three restrictions have eliminated "the study of infrahuman organisms, . . . almost all the so-called perceptual learning phenomena, and . . . the learning of many rules (e. g., weather prediction) by which we lead our stochastically categorized lives."14 According to Hunt, there is a large class of interesting phenomena which these restrictions have not eliminated. He states that "to point out a few examples, medical diagnosis, decoding, and taxonomy are all cases of concept learning. All forms of behavior in which the use of a name is learned will be included under the rubric 'concept learning'."15

As to the basic objective, Hunt declares his purpose to be the presentation of a "unified picture of current research and thought on the topic of concept learning."16

Concept Learning and Basic Learning

According to Hunt, "no single universally accepted 'basic' learning theory exists."17 In relation to concept

13Ibid., p. 7.  
14Ibid.  
15Ibid.  
16Ibid.  
17Ibid., p. 47.
learning and basic learning Hunt deals only with specific attempts to extend learning theories to concept learning.\textsuperscript{18}

In the area of basic learning Hunt recognizes two broad classes specifically related to the conditioning of responses:

1. One school . . . postulates a continually strengthening bond between the stimulus trace of an object (the object's internal representation in the subject) and a response. Since several responses may be conditioned, with varying degrees of strength, to a particular stimulus, responses compete for evocation. Changes in their relative strength are the result of changes in habit strength or the connection between the stimulus and the response.

2. Another approach conceives of the stimulus as being equivalent to an abstract set of elements. Each element is conditioned to one of the possible responses: the probability of occurrence of a particular response is equal to the proportion of elements conditioned to it. A second assumption is that on each stimulus presentation some proportion of the total population of stimulus elements is sampled (i.e., chosen at random). All elements in the sample are then conditioned to the response that is actually made. This sampling process places learning into the model via "all or none" conditioning of responses to basic stimulus elements. . . . Although conditioning of each element is on an all-or-none basis, if the sample size is small relative to the number of elements in the set representing the stimulus, the probability of a particular response will change slowly. This change will give the appearance of a continuously increasing learning curve, especially if data from several subjects are averaged.\textsuperscript{19}

Hunt contends that "concept learning can be studied without reference to a basic learning theory."\textsuperscript{20} The S-R theories, about which Hunt has been speaking, cannot on a

\textsuperscript{18} Ibid. \hfill \textsuperscript{19} Ibid., p. 48 \hfill \textsuperscript{20} Ibid., p. 49.
strictly logical basis, be generalized beyond the laboratory situations in which they have been tested.  

Stimulus trace and generalization models.--As a basis for some discussion Hunt uses the research of Eleanor Gibson which deals primarily with generalization. Gibson's work, according to Hunt, was concerned with the role of stimulus and response generalization during the learning of paired associates. Hunt describes a paired associate experiment in the following way:

In the paired associate experiment the subjects observe a sequence of stimuli. These may be nonsense syllables, English words or pictures. When a particular stimulus is presented, the subject is supposed to make a designated response. The subject may be required to recite the letters VEK whenever the letters RUZ are presented. If he fails to do this or recites an incorrect response, he is corrected. Within a given experiment, several such pairings are learned. The entire set of pairings constitutes a list. A trial occurs when a list is presented to the subject. Normally the order of items within a trial is changed at random. The experiment continues until either a given degree of performance is reached (e.g., x successive trials without an error) or until a fixed number of trials have occurred. The time between trials may be varied. Trials on one list may be interspersed with or followed by trials on a second list.

Gibson claimed, according to Hunt, "that the basic problem facing the subject is to learn to make a discrimination between

21 Ibid.


different items on the same and different lists. When the subject has difficulty in discriminating it is due to stimulus generalization between the various items either on the same list or different lists. Hunt states,

The result of stimulus generalization is that the act of conditioning a particular response to stimulus A increases the probability that it will be given upon presentation of some similar stimulus A'. This tendency is decreased if A and A' appear in markedly different lists, thus permitting the discrimination between them on the basis of cues from the overall stimulus context.

Gibson used the term gradient of generalization to denote the tendency of a particular response to generalize to a different stimulus. Hunt states that "this gradient was assumed to arise from some underlying continuum of stimulus similarity. Actually, the continuum of stimulus similarity is applicable to the stimulus trace, or internal representation of the stimulus within the learner, and not to the stimulus itself."

The following are summary statements regarding the results of Gibson's experiment and certain conclusions by Hunt:

1. Empirically, . . . the learning of two lists in a paired associates experiment results in poorer performance on the individual lists.
2. Gibson . . . deduced that interference arose from the learning of an identical response to dissimilar stimuli or from learning of dissimilar responses to identical stimuli.
3. In concept learning, all members of a denotation must be paired with the same response, the name whose concept is to be learned. Suppose we think of the denotation as a paired associates list of

\[ \text{Ibid.} \] \[ \text{Ibid.} \] \[ \text{Ibid.} \]
stimuli. If the stimuli within this list have similar traces, the concept-learning problem should be easy. But, if (some of) the stimuli on the list are similar to the stimuli on a second list (the denotation of another name), learning will be difficult.

4. The same effect (mentioned in 3 above) can be seen if we start with a stimulus sampling model. Similarity can be interpreted as the presence of overlapping sets of stimulus cues. When a concept is learned, the cues whose presence is relevant to a particular naming response will be conditioned to the response. Irrelevant cues will be randomly paired with this response.

5. Random pairing (of irrelevant cues mentioned in 4 above) may cause interference if two concepts are to be learned. Every time a member of the denotation of the first concept is presented some of the relevant cues will be conditioned to the appropriate name. These cues will eventually be biased toward being conditioned to the required naming response. Irrelevant cues will not be so biased. But, if there are a large number of cues which are shared with stimuli in the denotation of a second name, and if the shared cues are relevant in the second concept-learning situation, the supposedly irrelevant cues will be conditioned to an inappropriate naming response, the second name. The probability of the correct name's being given will be a joint function of the size of the set of relevant and of the set of shared cues.27

Hunt discusses the work of Baum 28, 29 regarding the contentions made by Gibson. Baum expanded Gibson's argument concerning the relationships between relevant and irrelevant cues in a concept learning situation. The following is a summation of the conclusions of Baum's experiments and relevant statements by Hunt:

27 Ibid., pp. 54-55.


29 For a brief description of Baum's experiment see Hunt, op. cit., p. 55.
1. Baum concluded that high intralist (intradation) similarity should facilitate concept learning; high interlist (interdenotation) similarity should inhibit it.

2. The stimuli in Baum's experiment fell into three broad classes; drawings of concrete objects, drawings of abstract patterns, and drawings of a specific number of things. Baum, according to Hunt, found that subjects first learned concepts based on the presence of concrete objects of a given type, then the concepts based on the presence of abstract forms, and finally the concepts of numbers.

3. Hunt states that Heidbreder (who originated this particular procedure used by Baum) concluded that the arrangement of learning hierarchy (mentioned in 2 above) was because of the greater perceptual accessibility of concrete objects. Heidbreder, according to Hunt, felt that concept learning was to be seen as a special example of perception. Baum, however, maintained that the data could better be explained by Gibson's generalization hypothesis.

4. Baum analyzed errors made by subjects and found that the denotations of the concept most difficult to learn contained stimuli which subjects frequently interchanged. For instance, the responses appropriate to form "a" were more likely to be given to form "b", and vice versa, than were similar confusions between concepts based on concrete objects.30

Another concept-learning approach to which Hunt gives attention is that of Welch. Welch's concept learning model was based on the idea of the direct conditioning of a response to a stimulus trace.31 According to Hunt, Welch "assumed that any stimulus object was represented, inside the subject, by a neural condition which was isomorphic with the stimulus. This neural trace (s) . . . was assumed to change progressively

30Hunt, op. cit., pp. 55-56

with time."  The particular nature of this change is not clear but Hunt indicates that Welch "evidently meant some sort of fading procedure." Hunt states that Welch postulated

... that when a naming response was made it was conditioned to all elements of all previously presented stimulus compounds which were present inside the subject at the time of the response. Since criterial elements (i.e., those elements which defined instances as members of a concept) would be present on all occurrences of a naming response, they would eventually acquire sufficient response strength to evoke the naming response.

In addition to the direct conditioning of a response to a stimulus trace, Welch also "used this model in studies of the learning of hierarchial concepts. Hierarchial concepts define sets whose elements are also concepts (e.g., collie-dog-animal)." According to Hunt, Welch contended that "since a higher order concept is further removed from the direct 'stimulus trace' of its instances of higher order concepts on the average have less common elements, they should be more difficult to learn." This contention has been supported not only by experiments of Welch, but by

32Hunt, op. cit., p. 56.  33Ibid.

34Hunt states that this term rather than "stimulus trace" was used to indicate that the neural representation of the instance contained elements which were isomorphic with various molecular elements of the stimulus. The nature of the transformation was never made clear. In particular, which relations between stimulus elements would be represented in the stimulus trace? If we knew this we could specify or at least limit, the class of transformations which create the stimulus trace.

35Hunt, op. cit., p. 56.  36Ibid.  37Ibid., p. 57.
experiments of Kendler and Vinberg. Hunt states that "if a basic instance elicits a well-learned response which in turn produces stimulus elements which are criterial for another response (a higher-order concept), learning of higher-order concepts should be easier."^{39}

Hunt states that "Welch's assumption of a neurological correlate for s is unnecessary and probably not advisable."^{40}

Regarding Welch's stimulus-trace approach to concept learning Hunt states:

An analysis which considers only conditioning to stimulus elements does not seem suited for explanation of concept-learning situations in which no element of the stimulus is perfectly correlated with the presence or absence of a particular name. This situation can occur if the concept to be learned is a conjunction or a disjunction of two stimulus elements (e.g., red and triangle). A stimulus trace theory can handle this situation by introducing a postulate concerning cues which result from a particular combination of stimulus elements. Unless the rules for forming such patterns are specified, this amplification of the basic theory destroys much of its attractive simplicity. It would seem also that such a postulate would have to predict rather slow learning. If the element combinations involve conjunctions, and therefore imperfect stimulus element-response correlations, concept learning is certainly neither impossible nor difficult.^{41}

There have, however, according to Hunt, been a series of experiments which have shown more rapid learning when the criterial values of each relevant dimension are perfectly


^{39}Hunt, op. cit., p. 57.  
^{40}Ibid.  
^{41}Ibid.
correlated with the naming response. Even though significantly harder, a true conjunctive concept is not extremely difficult to learn." 42

A Cue-Conditioning Model

Hunt states that "Restle 43 (1955, 1957, 1958; Bourne and Restle, 1959) has presented a comprehensive model of discrimination learning based on the 'all-or-none' stimulus sampling model of conditioning." 44 He states further that "their analysis is the most complete derivation of concept learning from a theory of stimulus sampling and conditioning to elementary cues," 45 and he uses their analysis as a basis for discussion. The concept learning problem of Bourne and Restle 46 is rather simple in structure and may be briefly and non-specifically described in the following manner:

Stimuli are specified by binary dimensions, each dimension indicating the presence or absence of a particular set of cues. In a two-choice problem, each dimension is either relevant (in the

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42 Ibid., pp. 57-58.
44 Hunt, op. cit., p. 58.
45 Ibid.
sense that one of its values is always associated with the appropriate name) or irrelevant. Thus the discovery of any one of the relevant dimensions transmits sufficient information for the subject to make the appropriate discrimination. In a four-choice problem . . . the more conventional conjunctive concept analysis is used. Four names are used. Each is associated with one of the four combinations of values of two binary dimensions. In this problem it is possible to add redundancy by introducing a new dimension which may be substituted for one of the two original relevant dimensions. 47

For the purpose of this study it is not necessary to go into a detailed analysis of the mathematical relationships in Bourne and Restle's studies, but rather, the general implications for concept learning from the studies and relevant evaluations by Hunt will be given.

1. Bourne and Restle used a variation of the stimulus trace argument to account for the effects of delay in reinforcement. Hunt states that they found that the number of elements in a sample of stimulus elements chosen decays exponentially with the time since the stimulus was presented.

2. However, regarding the results mentioned in number one above, more recent research is sufficient to question this. In a study by Bourne, the stimulus presentation was terminated by the response. The onset of the next stimulus occurred at a constant time period after the response. The "informative feedback" (reinforcement) signal occurred at an experimenter-determined point within the constant interstimulus interval. Increasing the time between response and signal decreased the time between the signal and the onset of the next stimulus. It was found that subjects made more errors when the signal-next stimulus period was shortened. Learning was not affected by increasing the response signal period if the signal next stimulus period was held constant.

3. In a logical problem solving study (subjects had to decode the PS1 apparatus) it was found that the subjects clearly displayed information-seeking

47 Hunt, op. cit., p. 58.
behavior in their responses. Blatt, along this same line reported a change in physiological measures of arousal when the subject's responses changed from information seeking to the testing of complex hypotheses. Hunt states that since the PSI apparatus is an inductive reasoning problem amenable to description in terms of symbolic logic, it has a good deal of apparent commonality with concept learning.

The preceding have been summary statements regarding the results of experimental research conducted in the area of stimulus discrimination or cue conditioning.

An All-or-None Model

In the area of stimulus sampling, many theorists have held to the belief that the conditioning of stimuli to responses is a gradual process. The probability that a conditioned response will be given increases gradually with each successive learning trial is explanatory of the gradual process. Hunt states that "this gradual conditioning was first seriously questioned by the findings from a series of experiments on paired associates learning." Rock began the research into "all-or-none" learning but it was applied

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49 Hunt, op. cit., pp. 62-68.

50 Ibid., p. 66.

to a concept learning situation by Bower. Hunt records Bower's statement regarding the "all-or-none" model:

The basic notion of the model is the assumption that each stimulus item and its correct response become associated on an all-or-none basis. . . . If the item (stimulus response pair) is not conditioned. . . . the probability that the subject will guess correctly is 1/N (N is the number of response alternatives). . . . The single parameter of the theory is the learning rate constant (c) which represents the probability that an unconditioned item becomes conditioned as the result of a single reinforced trial.

The all-or-none model assumes that the probability that a stimulus response pair is learned on a given trial is not dependent on the number of previous reinforcements the subject has received for making the correct response to the particular stimulus. Hunt states "as learning trials are continued, an all-or-none learner does not gradually decrease his probability of making an error." Bower and Ginsberg, according to Hunt, tested the ability of the all-or-none model to describe the data from concept learning experiments. The following are descriptions by Hunt of the experiments of Bower and Ginsberg:

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53 Ibid., pp. 35-35; cited in Hunt, op. cit., p. 67.

54 Hunt, op. cit., p. 67.  
55 Bower, op. cit.

56 R. Ginsberg, Address given at Western Psychological Association 1962 meeting, Symposium on concept learning, (1962); cited in Hunt, op. cit., p. 68.

57 Hunt, op. cit., p. 68.
In Bower's experiments college students learned two choice concepts based on stimuli with binary dimensions. The experiments were very similar to Bourne and Restle's (1959) two-choice problem. Logically, the problem was exactly the same. In the experimental procedure Bower permitted the subjects ample time to view each stimulus item, but they were not forced to do so. In a typical experiment the stimuli were five-letter clusters of consonants, constructed by choosing different combinations containing one of two letters from each of five pairs of letters. The model was confirmed in a striking manner. Bower's data were consistent with the hypothesis that each subject responded randomly until, on a stochastically determined trial, "something happened," the concept was learned, and from then on the subject made no errors. Of course, the model does not tell us what happened.

Ginsberg's (1962) experiments are by no means repetitions of Bower's. She used five-year-old children instead of college students as subjects. The concept her subjects learned was based on a property of sets of objects rather than on a property of objects. Finally, in her procedure the subjects practiced using the concept in a more specific way than do subjects in the normal cue-conditioning experiments. She showed the children three sets of objects in each display, and asked that they indicate which set "did not belong." Two of the sets contained the same number of objects, whereas the third, the "did not belong" set, contained a different number of objects. . . . She indicated . . . that her results are very much the same (as Bower's). These results are simply that the all-or-none model provides a very good description of the data. The subjects responded randomly until they began a long series of errorless trials, thus indicating that they had learned the concept. 58

Regarding the results of the experiments by Bower and Ginsberg, Hunt states that "there are no obvious artifacts in the experimental procedure which favor spurious confirmation of the many predictions of the all-or-none model.

... As it has been presented the model makes no assumption concerning the process of concept learning.\textsuperscript{59}

In the case of Bower's stimuli, five letter consonant clusters, it is clear that they are made up of at least five elements (the letters) to which the subject can respond differentially. Hunt states that "there is, however, a conceptually simple process which will lead to all-or-none learning in Bower's experiments."\textsuperscript{60} He further states:

Once Bower's subjects learned which letters were relevant, the concept-learning problem was trivial. A given name was always associated with the presence of a particular letter and never with its absence. In other words, Bower's subjects had to notice a sufficient and necessary property for assigning an object to a denotation before they could solve the problem. If we assume that subjects noticed a few stimulus properties at random, each time an object was presented ... and that once a relevant stimulus item was noticed, the problem was solved, we have specified a process that leads to all-or-none learning.\textsuperscript{61}

Hunt contends also that "this process emphasizes the perceptual aspect of concept learning, the establishment of a relevant description, and de-emphasizes the problem of manipulating symbols to state a concept using the terms of the relevant description."\textsuperscript{62}

From the results of the experiments of Bowers and Ginsberg, Hunt concludes that the idea that all-or-none learning occurs in a situation in which "restructuring"

\begin{flushright}
\textsuperscript{59}\textsuperscript{Hunt, op. cit., p. 69.} \hspace{1cm} \textsuperscript{60}\textsuperscript{Ibid.} \\
\textsuperscript{61}\textsuperscript{Ibid., pp. 69-70.} \hspace{1cm} \textsuperscript{62}\textsuperscript{Ibid., p. 70.}
\end{flushright}
(finding the appropriate way to look at the stimulus) is very important. 63

In concluding his discussion of research into all-or-none learning theory Hunt states that "the all-or-none model is clearly applicable to a set of experiments which we suggest may be defined by the relative importance of the perceptual and deductive phases of concept learning." 64

Mediating Responses

The complex mental processes of humans involve more than simple S-R bonds between physically present stimuli and the overt response. 65 According to Hunt,

The mediating response explanation begins with the assumption that responses produce stimuli, which may serve as cues for further responses. When a stimulus is presented, its image in the organism is presumed to evoke certain previously learned responses. These provide the stimuli which evoke another response, and so on. The chain of stimuli and responses, or some part of the chain, may consist of overt and covert responses. In concept learning the chain is ended with the occurrence of the overt naming response. 66

Hunt contends that this chain need not end with the occurrence of the overt naming response. "In the use of concepts, the naming response would be an important cue to further action. ... The analysis of speech in terms of S-R learning theory stresses this role of the overt response." 67 The following example of S-R chains is given by Hunt:

63 Ibid. 64 Ibid., p. 71. 65 Ibid. 66 Ibid. 67 Ibid., p. 72.
Any stimulus will have a tendency to evoke several competing responses. The occurrence of one of these competing responses, to the exclusion of others, will affect the probability of obtaining a given response later in the chain. Concept learning can be seen as a problem in strengthening the links of covert S-R chains which lead to the appropriate naming response. For instance, training a subject to say "vegetable" to the stimuli "carrots, peas, and cabbage," and "mineral" to "gold, silver, lead," should aid in learning that the "food" can be applied to the first set of words and not to the second. Learning could also proceed the other way, with "vegetable" becoming a response to be conditioned to the previously learned response-produced stimulus, "food." Notice that the logical characteristics of objects which distinguish food and not-food are not considered. Instead, the grouping is seen as being based on the evocation, for each object in the class "food," of a chain of responses that terminate in a common overt response.68

In this particular analysis of S-R chains "the mediating responses were pictured as competing for evocation at different points in the chain."69

Hunt gives some attention to the mediating response position developed by Kendler and Kendler.70 Their position . . . suggests that the mediating response should not be conceived of as "naming" at all; instead, it can be thought of as a response that orients the learner toward a particular aspect (dimension) of the stimulus. The stimuli for the orienting response would be derived from the general experimental situation and not from the particular object to be categorized.71

68 Ibid., p. 73.

69 Ibid.


71 Hunt, op. cit., p. 73.
Hunt's evaluation of this position on mediating responses and the idea of orienting responses is:

This interpretation of a mediating response is particularly interesting, since it avoids a puzzling paradox. How is the initial selection of some aspect of attention to be made? If we think of the mediating response as being a response to the object to be categorized, we are forced to say that the learner scans all aspects of the object and then selects one as his focus of attention. If we hypothesize an orienting response, initiated by the experimental situation, the decision for selection takes place before the stimulus is presented. Thus we avoid the paradox of saying that, after observing x and y a "subconscious decision," whatever that is, is made to attend only to y.\textsuperscript{72}

Continuing along the line of mediating responses Hunt discusses further the idea of orienting response stating that "since the orienting response hypothesis appears to be the hypothesis which represents the least amplification on the basis of S-R position, we shall discuss it first."\textsuperscript{73}

Orienting Responses and Reversal Shifts

Hunt states that "the most impressive evidence for the orienting response hypothesis is its ability to account for the behavior of subjects in a particular transfer situation known as reversal shift."\textsuperscript{74} The experimental design for the study of orienting responses and reversal shift was

The subject is required to solve two concept-learning problems in which stimuli have binary dimensions. The first problem is a simple two-choice discrimination - using binary dimensions - with one

\textsuperscript{72}Ibid. \textsuperscript{73}Ibid. \textsuperscript{74}Ibid., p. 74.
relevant dimension. The second problem requires either reversal or nonreversal shift. In the reversal shift condition the "correct" (or approach, or positive) instances all contain the binary value of the dimension which was relevant in the first problem and which was associated with negative instances. In the nonreversal condition the discrimination is based on a previously irrelevant dimension. For instance, if the first task required that the subject learn that triangles, regardless of size, were "positive" and circles were "negative," the reversal shift problem would have circles as "positive" and triangles as "negative." In the nonreversal condition, small objects might be "positive" and large ones "negative." 

According to Hunt, if concept learning stems from the connection of a naming response (this is the development of habit strength) to the element which was most frequently associated with the response, the reversal shift condition should be more difficult since it would necessitate connecting a naming response to stimulus elements which had never been paired with the response. This would also require that the naming response tendency connected to the (now negative) instances be extinguished. However, in the nonreversal shift condition, the learned habit strength would not have a perfect inverse correlation to the correct answer, so learning in this condition should not be as difficult.

However, the opposite of this is true for human adults. Hunt states that it was found that the reversal learning problem was considerably easier. This was true even during the early stages of the second problem when the

\[75 \text{Ibid.}\]  
\[76 \text{Ibid.}\]
negative transfer effects on reversal learning should be at a maximum."

Hunt records the analysis made by Kendler and D'Amato.\textsuperscript{78}

Kendler and D'Amato concluded that the subject was learning two responses: a mediating (orienting) response to attend to a particular dimension, and an overt response to identify an instance as positive when a particular value appeared in that dimension. The first response should be learned to a greater habit strength since it was reinforced on presentation of both positive and negative instances. Although the nature of the mediating response was not clear (it could be either a physical orientation toward a stimulus dimension or a subvocalized designation of a particular dimension as important), the utility of a mediating response as an explanation seemed quite attractive.\textsuperscript{79}

Hunt discusses various other studies conducted in the area of mediating responses which concluded approximately the same results. Regarding the orienting responses, Hunt states that

> Learning to orient ourselves toward a particular dimension should be an important determinant of learning. Any condition which makes learning of the mediating response difficult should make concept learning more difficult. Once the mediating response is learned, however, it should exert no further effect on the solution of subsequent problems.\textsuperscript{80}

In summary Hunt states that "... an S-R theory, amplified by mediating responses, appears to explain

\textsuperscript{77}\textit{Ibid.}


\textsuperscript{79}Hunt, \textit{op. cit.}, p. 75.

\textsuperscript{80}\textit{Ibid.}
satisfactorily the process of learning and transfer of
concepts based on simple discrimination. 81 He further
contends that "a language-mediated theory of an orienting
response seems more compatible with the data than a physical
orientation theory." 82

Verbal Concept Learning

In studies of verbal concept learning the term "medi-
ating response" is used to refer to verbal responses. Hunt
states that "in verbal concept-learning studies it is often
suggested that the pairing is not between the stimulus and
overt response, but between the stimulus produced by a
(previously learned) mediating response and the overt re-
response." 83 According to Hunt,

... this is particularly true if the stimuli on
which the concept is based can be considered to have
had responses learned to them. In a sense, such
previously learned responses could be considered the
meaning of the object, and conditioning may refer to
conditioning a response to a certain meaning. 84

Hunt uses the following S-R pairings to illustrate the
theory of mediating responses:

There is little doubt that the following
stimulus-response pairings:
beet-gax
cabbage-gax
corn-gax
amethyst-roq
onyx-roq
granite-roq

81 Ibid., pp. 77-78.
82 Ibid.
83 Ibid., p. 76.
84 Ibid.
present a list that is easier to learn than the following list:

beet-gax
amethyst-gax
cabbage-gax
corn-roq
onyx-roq
granite-roq

The reason that the first list is easier to learn is because the stimuli to which "gax" is to be conditioned have in common the previously conditioned response of "food."

There appear to be differences among theorists regarding the nature of the mediating response. However, Hunt states that these differences "will often be irrelevant to the question of mediation in concept learning... All mediating response hypotheses (except the orienting response hypothesis Hunt just discussed) assume that each object in a concept-learning experiment evokes cues which were conditioned to it before concept learning was begun." According to Hunt, "the subject has to locate a set of cues which are elicited by the members of the denotation and which, if they are learned as cues for the naming response, will provide adequate discriminations." The subject must bring the relevant cues and the necessary response into association with one another. "It may be said that the mediated stimulus (or the mediating response, since the two are identical) is the 'meaning of the concept'."  

85 Ibid., pp. 78-79.  
86 Ibid., p. 79.  
87 Ibid., p. 80.  
88 Ibid.
Hunt uses Reed's experiments as a basis for further discussion in mediation. The experimental design of Reed's experiments was as follows:

In Reed's experimental situation, the subjects had to learn concepts based on sets of four words. Each set of words was placed on a card (so that the card was, in our terminology, the object to be categorized and the words on it its description). A nonsense syllable was designated as the correct response. Thus the appropriate responses might be

- (apple, stone, hat, emperor) - guz
- (fox, rose temple, eagle) - jok
- (moose, town, rose, turnip) - guz

Reed paired a given response with a set of words which contained, as one of its members, an example of a concept in colloquial English. This is illustrated in the foregoing example, where "guz" is paired with two sets of words, each containing the name of a food. The mediating response account of Reed's basic experiment is that the "key" words in each object set of words elicited a common mediating response and response-produced stimulus (e.g., "food"), and that this stimulus was then conditioned to the naming response.90

There are three basic ways a subject might respond to the nonsense syllables: (1) he might respond with the learned mediating response and response-produced stimulus (e.g., food) as mentioned in the experimental design, (2) he could learn the pairings by rote, or (3) he could respond to an inappropriate aspect of the stimulus, such as the first letter in the first word.91

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Reed defined rote learning as "inconsistent" and it is obvious that he meant that the learning of inappropriate stimulus cues to be considered "inconsistent." However, learning by discovering the English language concept was considered to be "consistent."\(^9^2\) The experimental design by which Reed conducted his studies regarding "consistent" and "inconsistent" learning was

In most of his experiments, forty-two cards were divided into the denotations of seven concepts, in the manner described. A single trial consisted of the presentation of all forty-two objects, one at a time, in the manner of a paired associates experiment. In addition to recording errors in naming, Reed encouraged his subjects to state their understanding of the concept. This information allowed him to divide subjects into two groups, depending on whether they learned a consistent or inconsistent concept.\(^9^3\)

The observations from Reed's experiments are discussed by Hunt as follows:

1. Concept learning took place far more rapidly than comparable learning of paired associates in which stimuli and responses were nonsense syllables.
2. The improvement was most striking if the subjects were learning a consistent concept, less striking (but still large) if they were learning an inconsistent concept.
3. The difference in speed of learning could be further increased, relative to paired associate learning, if subjects were given instructions that emphasized the possibility of using a common mediating response.
4. When subjects learned consistent concepts there was practically no decrement in performance after intervals up to 6 weeks.
5. In the paired-associates task, increasing the length of a list increased the difficulty of the task. When Reed increased the length of his lists (but kept the number of concepts constant), \(\ldots\) he did not find a comparable increase. For consistent concepts,

\(^{9^2}\)Ibid., p. 81 \(^{9^3}\)Ibid.
increasing the length of the list from 42-60 items did no harm, although decreasing it from 42-21 did make the task easier.

6. Increasing the list length did make the task more difficult for subjects who were learning inconsistent concepts.

7. Most important, increasing the list length increased the frequency of occurrence of consistent concepts. It is as if the increase in the number of stimuli increased the chance for the correct mediating response to occur.94

In another series of experiments Reed95 attempted to determine the effects of inhibiting the occurrence of the mediating response. Reed's experimental design was

In one condition he added irrelevant words to the set of words on the cards. In another condition, he added words that were partially relevant. For instance, suppose that all seven cards in one denotation contained somewhere an example of the English language concept "food." In Reed's final condition, four of the seven cards might also contain an example of "stones."96

Hunt states that in evaluating the results of his studies "Reed found that the presence of partially relevant information slowed learning, since subjects might fixate on a partially correct answer."97

Hunt is critical of Reed's work on methodological grounds stating that "although the idea of a mediating response is central to his argument, Reed did not obtain careful measures of the extent to which different stimuli shared common

94 Ibid., pp. 81-82.
95 H. B. Reed, "The Influence of the Complexity of the Stimuli," Journal of Experimental Psychology, XXXVI (June, 1946), 252-261; cited in Hunt, op. cit., p. 82.
96 Hunt, op. cit., p. 82 97 Ibid.
mediating responses. Thus, one of his most crucial variables was left uncontrolled."[^98]

In studying the effects of response dominance, as it is related to mediating responses, Hunt uses the work of Mednick and Freedman.[^99]

Their subjects first learned a paired associates list of twelve items. Four of the items in one of the two lists used were paired with responses for which the word "white" had high response dominance. The other list, which contained the same stimulus items, did not pair these four items with responses with a common dominant response. However, it did pair a different set of four items with response words to which the word "soft" was response dominant. Finally, each list contained four items which were never paired with response words with a common dominant response. After the subjects had learned the paired associates list, they learned the same twelve stimuli as a verbal concept-learning list with a nonsense syllable as the name. The three four-item sets discussed were specified denotations of each of three concepts. According to the mediating response analysis, the concept to whose instances a common dominant response had been "facilitated" should be easier to learn.[^100]

According to Hunt the study did confirm this hypothesis. In another study Freedman and Mednick[^101] investigated the variance of the dominant response when measured over members

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[^98]: Ibid., p. 83.


[^100]: Hunt, op. cit., p. 85.

of a set of stimuli to which a name is learned. Hunt, in this regard, states:

Consider the case in which the appropriate mediating response has high dominance for some instances in the training set and very low dominance for others. The mediating response should occur to some instances of the training set, which would place the appropriate mediated stimuli in close temporal contiguity with both the naming response and the other instances of the training set. This contiguity should lead to an increase in both (a) the conditioning of the overt naming response to the stimuli produced by the mediating response and (b) the conditioning of the mediating response to the other members of the training set. A high-variance concept list would be easier to learn than a low-variance list, provided the mean level of each list was the same.\textsuperscript{102}

This prediction was, according to Hunt, "confirmed for verbal concept-learning lists equated for mean response dominance of the appropriate mediating response."\textsuperscript{103} The question which Hunt deals with, regarding this issue, is, how does the correct mediating response become dominant for the low-dominance items in the high-variance list? Freedman and Mednick suggest that "the high response dominance instance quickly places the correct response in contiguity with the other relevant concept instances. This tends to polarize responses to the relevant instances and results in rapid attainment of the HV (high variance) concept."\textsuperscript{104}

\textsuperscript{102}Hunt, \textit{op. cit.}, p. 85. \textsuperscript{103}Ibid. \textsuperscript{104}Ibid., p. 85; citing Freedman and Mednick, \textit{op. cit.}, p. 465.
Regarding the idea of polarization, Hunt states that it loosely "suggests that subjects have some method of manipulating the mediating response."\textsuperscript{105} Hunt further contends that this indicates a strict contiguity interpretation. "If the mediating response is conditioned to the low-dominance items by temporal contiguity, learning should also be facilitated by placing all instances of a single concept together when the list of stimuli used in training contains examples of several different concepts."\textsuperscript{106}

In concluding his remarks regarding mediating responses Hunt states that "the need for a mediating response analysis of concept learning has been confirmed."\textsuperscript{107} Again, Hunt poses a question as to whether or not concept learning can be explained with the S-R model, amplified by mediating responses. He maintains further that a strong case can be made for this model but contends that there remain a few unanswered questions. He states that

Introduction of mediating responses, unless they are rigorously specified, can destroy the predictive power of the S-R formulation. \ldots If this is so, the resulting theory is bound to be weak. It will only be able to predict for simple situations, and even then the predictions will have to be based on inequalities. What is required is a theory of mediated generalization rich enough to make detailed predictions.\textsuperscript{108}

There is, according to Hunt, no reason why such a generalization theory could not be developed. "The only

\begin{footnotes}
\item[\textsuperscript{105}] Hunt, op. cit., p. 85. \\
\item[\textsuperscript{106}] Ibid. \\
\item[\textsuperscript{107}] Ibid., p. 88. \\
\item[\textsuperscript{108}] Ibid.
\end{footnotes}
qualification is that it would have to be developed within
the framework of a quantitative theory of direct S-R
learning. . . . It is clear that future mediating response
models should stress quantification more than past ones
have."¹⁰⁹

Stimulus Internalization and Coding:
A Problem in S-R Theories

The stimulus trace is an important consideration in
attempts to mechanize concept learning. Hunt states that
"for either a biological or a mechanical concept learner,
categorizations must be based on an internal representation
of an external object."¹¹⁰ The question as yet unanswered
is whether the "transformation that creates the representation
is a 'parallel' one which produces elements to which response
strengths are associated, or whether it is in itself subject
to learning during a particular concept learning task."¹¹¹

Hunt states that Shepard, Hovland, and Jenkins¹¹² have
conducted studies in this area. In analyzing the work of
Shepard et al., Hunt states that "the implication is that
subjects are searching for some sort of maximally efficient
decoding scheme. In doing so they are involved in two pro-
cedures, locating relevant channels of information and

¹⁰⁹Ibid., p. 89. ¹¹⁰Ibid. ¹¹¹Ibid.

¹¹²R. N. Shepard, C. I. Hovland, and H. M. Jenkins,
"Learning and Memorization of Classifications," Psychological
Monographs, LXXV (1961), Number 13, cited in Hunt,
developing procedures to utilize these channels. \textsuperscript{113} Relating to the question of whether or not the subject builds up habit strength or learns on an all-or-none basis, Hunt states that this decoding scheme "implies an active, hypothesis-forming subject rather than one who is passively building up response strength or adapting to and conditioning passively received cues." \textsuperscript{114}

**Evaluation of Learning Theory Approach**

In summarizing the learning theorist's attempt to explain concept learning on the basis of S-R learning theory, Hunt emphasizes the following conclusions:

1. Learning theorists had originally hoped to devise a concept-learning model which treated complex categorizations as a specialization of discrimination learning. This proved impossible. Some form of mediating response had to be introduced into the analysis of concept learning in the human adult.

2. The mediation hypothesis is not adequate. Some form of mediation is certainly necessary in any analysis of concept learning. There appear to be two major flaws in a theory which introduces nothing else. Paradoxically, these two objections are somewhat inconsistent. (1) Unrestricted introduction of a mediating response into an S-R chain leaves the theorist in the uncomfortable position of being able to explain everything while predicting nothing. (2) There is almost no behavior that could not be "analyzed" as being compatible with an S-R theory (or a theory of cue conditioning and adaptation) if the theorist is allowed to introduce new mediating links or to vary habit family hierarchies.

3. Hunt states that perhaps a more fruitful approach would be a redefinition of the response.

\textsuperscript{113}Hunt, *op. cit.*, p. 93. \textsuperscript{114}Ibid.
Is it unreasonable to assume that an adult human has learned several large "information processing units" which are specifically designed for the manipulation of an internally represented, symbolically coded environment? By using them the human could construct an internal model of the environment, one that could be used to predict external events. In an extended learning theory model these routines would be considered as responses. As such they would be held accountable to the laws of learning. Presumably they could be broken down into smaller more unitary S-R connections. This should not be done, because the smaller responses would not occur in isolation in the adult. The stimulus of having completed one step in an information processing procedure should be a sufficient stimulus to elicit the occurrence of the next step. Only at a very few "choice points" would the stimuli arising from the results of information processing be examined before determining further responses.

Building such a model requires vastly different techniques than those used in conventional S-R psychology. Responses can only be thought of as complex transformations on input data. Since the transformations provide varying stimuli, the rules for assembling strings of transformations must be stated. Here S-R or other conventional learning theories may help. We might find, however, that an S-R model could not provide enough flexibility in the application of these transformations. In fact, there may be learned transformations used to decide what transformations to use next. Learning itself may be a problem-solving situation.115

Hunt further states that in the area of research, responses must be identified first and foremost. He contends that

Responses or transformations may exist in canonical form in four areas: the recognition and internalization of the stimuli to be categorized, the retention of information from previous experience, development and testing of hypotheses, and the evaluation of possible alternative arrangements of responses as a result of stimuli from previous executions of the current arrangement.116

115 Ibid., pp. 93-95. 116 Ibid., p. 96.
Stimulus Organization

The Problem of Subjective Definition

Within the area of learning theory there exists the problem of adequately defining a stimulus. Learning, of course, occurs within the organism. Hunt states that people, pigeons and even rats "do not learn to response to a particular physical object, they learn to respond to their internal representation of that object." 117

Hunt's definition of stimulus is similar to that of Restle. 118 Restle "proposed viewing the stimulus as a collection of possible aspects, some of which were noticed by the subject at any one time." 119 The problem arises in the development of a stimulus definition by the experimenter and his assumption that the subjects will perceive the stimulus in the same way. However, Hunt contends that this "assumption is not always justifiable. How humans will structure any particular stimulus is an unresolved problem of perception." 120 Allport 121 has concluded that "one of the most important aspects of perception is the subject's

117 Ibid., p. 103.


119 Ibid., cited in Hunt., op. cit., p. 103.

120 F. H. Allport, Theories of Perception and the Concept of Structure (New York, 1957); cited in Hunt, op. cit., 121 Ibid.
choice of a structure. By 'choosing a structure' Allport meant essentially what we have called 'selecting a descriptive process'. In a given stimulus situation there will exist a variety of ways a subject might describe a physical stimulus. Bruner has proposed the idea that a subject "first receives a few tentative, prominent cues from his environment. The subject used these cues to establish a tentative structure. The structure becomes more and more detailed as more important information is obtained. At all times future perception is under the partial control of present perception."

The problem arising here is that if tentative structures are inaccurate, concept learning could be hindered. Hunt states that "a subject might be led to an irrelevant description of the objects to be categorized because that description was consistent with his tentative structuring of the overall situation." While the tentative structuring of a situation by a subject or his perception of the situation is an important consideration, Hunt contends that "how much, and in what way in a particular situation, is extremely difficult to predict. This is particularly true when the relevant organization of stimuli requires a great deal of abstraction."

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122 Ibid.
124 Ibid., cited in Hunt, op. cit., p. 106.
125 Hunt, op. cit., p. 107.
126 Ibid.
It is Hunt's opinion that most of the time an experimenter can predict the manner in which subjects will perceive stimuli such as geometric patterns or nonsense syllables. However, the problem is that this procedure introduces artistic judgment into what actually should be scientific procedure.\textsuperscript{127} Hunt states that the only way to solve this problem is for experimenters to use extremely thorough pre-test procedures to insure that they and the subjects agree on the definition of the formal description of the stimuli.

\textit{Variations in Dimensions and Values}

It is generally agreed upon that the more complex the stimuli in a concept learning situation, the more difficult the task will be.\textsuperscript{128} A number of studies have been conducted in the area of cue-conditioning experiments. The problems of these studies have been rather simple, usually involving the discovery of only one or two cues whose presence or absence was an infallible predictor of the appropriate response.\textsuperscript{129} However, even in these relatively simple experiments the subjects made many errors. In explaining the frequency of these errors Hunt contends that the major difficulty in these experiments was not in the subject's manipulation of defined symbols, but in their discovering them.\textsuperscript{130} In the experimental design the subject would make his response and

\textsuperscript{127}\textit{Ibid.} \hspace{1cm} \textsuperscript{128}\textit{Ibid.}, p. 111. \hspace{1cm} \textsuperscript{129}\textit{Ibid.}, p. 113. \hspace{1cm} \textsuperscript{130}\textit{Ibid.}
then the stimulus would be removed. The next stimulus was presented five seconds later, which would have placed a time pressure on the subject. There was no opportunity to re-examine a stimulus to determine the reason for their error. Hunt states that when a subject tried to respond quickly, he may have felt he would have to prepare himself to notice only a few dimensions (or cues) on each trial. If, according to Hunt, these happened to be relevant dimensions, he could solve the problem easily. However, if the dimensions were not relevant the subject could categorize with no better than chance accuracy. The subject must begin to notice relevant dimensions before he can solve the problem.\textsuperscript{131}

In the area of more complex concept learning situations it has been established from research studies that "there is a linear increase in the total number of errors as the number of irrelevant dimensions is increased. . . ."\textsuperscript{132} Another finding regarding the problem of relevant and irrelevant dimensions is that "if a human subject can learn to capitalize on the redundancy relations between particular dimensions he can reduce the number of dimensions he must scan. He may use the known value of one dimension to predict the value of dimensions redundant to it."\textsuperscript{133}

It has also been found that increasing the number of redundant relevant dimensions made the concept-learning task

\textsuperscript{131} Ibid. \hfill \textsuperscript{132} Ibid., p. 114. \hfill \textsuperscript{133} Ibid.
easier. Further, if there existed a large number of irrelevant dimensions, the number of errors could be reduced by increasing the number of relevant dimensions.\textsuperscript{134} It has also been concluded from experiments that if a subject is required to state, verbally or written, a given concept rather than simply identify or recognize the concept, he must demonstrate greater abstracting ability.\textsuperscript{135}

**Stimulus Identification**

The relationship of stimulus identification to concept learning is stated by Hunt in the following paragraph:

Stimulus identification is certainly a part of concept learning. Errors in the identification and description of objects to be categorized are bound to influence the deductive processes, just as errors in the transmission of a message will effect the receiver's ability to use the information it contained. Any failure of the subject to perceive or remember correctly cannot be repaired by later deductions. Is it possible that the effects of stimulus complexity on concept learning are, at least in part, due to difficulties in creating veridical internal codes to represent the stimuli to be categorized? If so, effects parallel to those observed in concept learning should occur in studies of stimulus identification which do not require that subjects abstract a concept from the stimuli.\textsuperscript{136}

Hunt uses a code word model\textsuperscript{137} to explain stimulus identification problems. "The code word model suggests that, at any one time, a concept learner can partition the stimulus universe into as many 'equivalence classes' as he has code
words. Hunt states further that the learner could try various partitions (class divisions) until he found "one such that any subset of his partition was either a subset of the denotation of the name whose concept was to be learned or a subset of the complement of the denotation. In this case his partition could be related to a relevant description of the stimulus universe."\textsuperscript{139} If, according to Hunt, the stimulus universe is large compared to the number of code words (which happens when the number of dimensions are increased) the learner must try a larger set of partitions, resulting in a more difficult concept learning task.\textsuperscript{140}

The code word model is largely conjectural and is offered by Hunt as a bridge between stimulus identification and concept learning.

**Stimulus Structure**

The discussion thus far has assumed that the subject knows and uses the experimenter's definition of the stimulus. The following discussion refers to the processes by which a subject structures his stimulus, both visual and nonvisual. Hunt describes Attneave's\textsuperscript{141} analysis of visual perception and extends it to the problem of stimulus structure.

\textsuperscript{138}Ibid., p. 122. \textsuperscript{139}Ibid. \textsuperscript{140}Ibid., pp. 122-123.

Imagine a stimulus image represented by a matrix of (not necessarily binary) points. Each point has a value that corresponds to a sensation received along some psychophysical dimension. For convenience, think of only one sensory mode's being represented on the matrix. This is not necessary; different areas of the matrix could correspond to visual, olfactory, auditory, and tactile sensations. If there are \( n \) (any number) points on the matrix, all of them the result of independent stimulation of the sense organs, and \( v \) different values per point, there are \( v^n \) possible states of the matrix. So long as the points are, in fact, completely independent, \( n \) tests are required to determine the state of the matrix at any given time. However, if the \( n \) points are not independent, it will be possible to predict the value of some points when the values of others are known.

Atneave suggested that perception is the process of making such a prediction. In the perceptual process, relations between points on the matrix are determined so that less than \( n \) tests can be used to describe the matrix. The tests consist of examining the points whose value cannot be predicted from a knowledge of the value of other points. After these points have been tested, a prediction is made of the values of the remaining points. Perception then is seen as a two-stage process. In the learning phase the perceiver locates points that transmit the most information (i.e., are least predictable) about the stimulus and determines how the values of these points are related to the values of predictable points. In the application state the perceiver will guess the state of the matrix after examining a few points.\(^{142}\)

Hunt states that "the usefulness of a decision rule depends directly on the accuracy of the predictions it makes; inversely on the number of points which must be scanned, the complexity of the rule, and the accuracy required."\(^ {143}\) The particular class of perceptual decision rules which Hunt deals with is that described as "template matching."

According to Hunt, "the subject is assumed to have a large

\(^{142}\)Ibid., p. 125.  \(^{143}\)Ibid.
set of templates that can be fitted to any subarea of the projection matrix. Each template requires certain information before it can be fitted."\textsuperscript{144} Hunt gives the following example: "The template for equilateral triangles requires that two vertices of the triangle be located. A maximally efficient rule would apply just one template to the entire projection matrix, using only a single sensory point to anchor the template, and do all this without any major loss in information."\textsuperscript{145}

There are two components involved in the cost of applying a template: (1) the cost of testing the matrix to determine the input values for the template, and (2) the cost of testing to determine what template to apply.\textsuperscript{146}

Hunt explains that the latter cost can be reduced if the subject can determine, before testing, that the correct template is a member of a relatively small set of possible templates. The subject can determine this by predicting, from his knowledge of the template which is applicable in one area of the matrix, what templates might apply to another.\textsuperscript{147} Hunt illustrates this process by supposing "we know that we are looking either at a picture of a baseball player or a violinist. If we see that the man is wearing a ballplayer's\textsuperscript{146} Ibid., p. 126.\textsuperscript{147} Ibid.

\textsuperscript{144} Ibid., pp. 125-126.\textsuperscript{145} Ibid., pp. 125-126.\textsuperscript{146} Ibid., p. 126.\textsuperscript{147} Ibid.
cap, why test to discriminate between a bass violin or cello in his hand?"\textsuperscript{148, 149}

Perceptual models such as this are, according to Hunt, relevant to concept learning "since they suggest ways in which a description of the stimuli can be obtained."\textsuperscript{150}

There appears to be a relation between the number of dimensions required in the definition of a stimulus and the difficulty in applying a template. Hunt states,

If we equate the number of regions requiring separate templates to dimensions and the number of templates which may be applied within a given region to values, the order of difficulty of learning types of concepts varies with the number of dimensions and values needed to define stimulus objects.\textsuperscript{151}

When a subject is viewing a matrix of stimuli he frequently scans certain parts of the stimulus and infers as to the whole. Hunt states that "the scanning analysis of perception" is essentially expressed by Bruner\textsuperscript{152} as, "perception is viewed as an act of inferring wholes from usually valid cues obtained from parts of the stimulus."\textsuperscript{153} The steps in perception, according to Bruner, are,

\textsuperscript{148}\textit{Ibid.}

\textsuperscript{149}For a more detailed discussion of templates see Hunt, \textit{op. cit.}, p. 126.

\textsuperscript{150}\textit{Ibid.}, p. 126. \hfill \textsuperscript{151}\textit{Ibid.}, p. 128.


\textsuperscript{153}Bruner, \textit{op. cit.}, cited in Hunt, \textit{op. cit.}, p. 129.
1. The first step in perception is a primitive categorization of the stimulus by identifying a set of possible precepts.

2. This set can be used as the basis of future "guesses" about object identity.

3. After each guess, specific tests can be carried out to validate it.

4. The information obtained from these tests will prescribe a smaller set of possible objects.

5. Finally, when sufficient information is obtained to select a set consisting of only one object, a precept of the object is formed. At any stage a wrong guess could be accepted, since validation would not be complete.\(^{154}\)

Hunt poses the question as to "what would happen if the stimuli from which a concept was to be learned could be fitted by a few highly overlearned templates?"\(^{155}\) The following solution is offered:

If these templates lead to erroneous perception of irrelevant dimensions there would be no effect. But if they lead to misperception of relevant dimensions, learning would be retarded. In particular, concept learning should be slower than the learning of informationally identical concepts based on less familiar stimuli. In the latter case subjects would be forced to apply templates to more localized regions of the projection matrix, thus abstracting more information about the stimulus. . . . this finer analysis, whereas it leads to a more complex description, is more likely to lead to a relevant one. On the other hand, if the internal correlations between the applicability of templates in different regions were related to the structures of the concept, a template-matching scheme which accentuated the correlation would aid in concept learning.\(^{156}\)

Another consideration regarding errors in template matching is that "Ss may assume, erroneously, that certain dimensions are bound to be relevant."\(^{157}\) While the preceding

\(^{154}\) Hunt, op. cit., p. 129.  
\(^{155}\) Ibid., p. 130.  
\(^{156}\) Ibid.  
\(^{157}\) Ibid., p. 131.
are indications from studies conducted in the area of stimulus structure (and its relation to perception) Hunt states that "more direct tests are needed before the relation between perception and concept learning can be understood."  

**Memory and Concept Learning**

In order to adequately establish the relation of memory to concept learning the role of data storage in problem solving must be considered. In a problem solving situation, a person "receives information from his environment, makes calculations, and selects a response. The 'environment' (the experimenter, if you will) evaluates the response and as appropriate, rewards or punishes the problem solver."

According to Hunt, the problem solver is primarily interested in improving his performance until he can maximize reward and minimize punishment. The key to this is the maintaining of some sort of record of his past experience. To be of value this record must contain necessary information which is readily accessible.

Hunt states that human memory is of an associative type.

The internal (neurological) correlates of stimulus trace are assumed to be attached to each other, so that activation of part of the compound of nerve firing which occurred when the stimulus was originally presented will lead to the activation of the remainder of the compound. Thus the stimulus can be re-created, piece by piece.

\[158\text{Ibid.}\]  
\[159\text{Ibid., p. 137.}\]  
\[160\text{Ibid.}\]
Forgetting is explained by Hunt as the result of interfering stimulus traces being introjected. This disrupts the sequence of firing which is necessary to re-create the original stimulus from its parts. Hunt further contends that "within this framework it is possible to develop a model that introduces ideas of fading and interchange of elements (confusions) during forgetting."\(^{161}\)

It is also noted by Hunt that the major objection to the association process is that memory is not a passive phenomenon. Bartlett\(^{162}\) contends that memory is an active reconstruction process. The subject first recalls the particular item to be recalled as a vague idea or scheme and then the details are filled in, partly from memory and partly from reasoning what the event or item to be recalled must have been. Hunt maintains that association and reconstruction are not necessarily exclusive. "Memory may operate in stages; at recall associations in memory may be searched to provide alternative reconstructions of the past event. These reconstructions could undergo a private screening before being made public."\(^{163}\) There are, according to Hunt, no well developed theories regarding the role of memory in concept

\(^{161}\)Ibid., p. 138.

\(^{162}\)F. C. Bartlett, Remembering (Cambridge, 1932); cited in Hunt, op. cit., p. 138.

\(^{163}\)Hunt, op. cit., p. 138.
learning. Several considerations which have apparent relationships with concept learning are discussed by Hunt.

**Techniques for Remembering Hypotheses**

In reviewing the results of experimentation in the area of hypothesis selecting techniques which may be employed by subjects:

1. One is the technique of using each identification of an object's name to evaluate every possible hypothesis. In the early stages of the problem this strategy (simultaneous scanning) forces the subject to keep track of an impossibly large number of hypotheses. One alternative is to evaluate only a few of the possible hypotheses at each trial.

2. A second and more efficient alternative makes use of the fact that (in the experiments) only conjunctive concepts (were used) and the subjects knew this. Therefore, they knew that the correct concept had to be the intersection of the sets of descriptive statements which applied to all objects in the denotation of the name (each positive instance). The required intersection could be found by taking, as a trial hypothesis, the intersection of the sets of descriptive statements applicable to successive pairs of positive instances.\(^{164}\)

Hunt states that he does not claim that the subjects actually formulated their strategy in such an analytic manner. He contends only "that they either knew or discovered the very simple operational procedure which the foregoing analysis implies."\(^{165}\) The following example is given to illustrate this contention:

... suppose the subjects were asked to find a cue using stimuli that varied in form, size, and color. Furthermore, suppose the correct answer is

\(^{164}\)Ibid., p. 140.  \(^{165}\)Ibid., p. 141.
"form-triangle." If the first positive instance is a big red triangle, and the second positive instance, a big blue triangle, the answer must be either big, triangle, or big and triangle.166

Hunt states that "there is a strategy for selecting objects (focusing) which will lead the subject to the correct answer with a minimum information retention requirement."167

First the subject must locate one positive instance. The next object chosen should differ from this instance in the value of only one dimension. If this change produces a negative instance, the changed dimension must be relevant. Otherwise the dimension must be irrelevant. In the previous example, if big red triangles and big blue triangles were both positive instances, color could not be relevant. But if big red triangles were positive and big red circles negative, form would have to be relevant. The appropriate values within these dimensions can be established by reference to any previously located positive instance.168

In summarizing, Hunt states that it is doubtful that a general statement regarding the place of memory in induction can be made except on an individual basis since the importance of information storage in concept learning varies with the individual subject's strategies.

Memory for Specific Information

In order to determine the effect of memory on concept learning, Hunt states that the appropriate test "is not whether the subject can recall or recognize a particular object, but rather whether or not he can make use of information it transmitted about the concept."169 According

166 Ibid. 167 Ibid. 168 Ibid. 169 Ibid., p. 144.
to Hunt, this criterion presents certain problems. Just because a subject's hypothesis at a given time agrees with the class membership of a particular object present at a given time does not assure that he has remembered it.

The subject can make a guess which might be consistent with any particular previously presented piece of information. If the subjects were choosing hypotheses at random, without regard to previously presented data, his choice would not be affected by the location of prior instances in the training series.\(^{170}\)

Hunt states further that if the location of a particular instance, as related to those instances presented before it or those intervening between it and the point at which the subject offers his hypothesis, influences the tendency of the subject to offer hypotheses which are consistent with this instance, it can be inferred that there was some memory for the information it transmitted.

In studies dealing with memory in specific concept learning situations the results have shown both primary and recency effects in the retention of information during concept learning. In general subjects tended to retain information from either the first or most recently presented stimulus. However, these results could, according to Hunt, occur even if memory was not used at all. He states, "if subjects scanned the objects in some systematic order, a few dimensions at each instance, their ability to evaluate hypotheses about a given dimension would be a function of the location

\(^{170}\text{ibid.}\)
of instances transmitting information about that dimension in the training series.\textsuperscript{171} It was further found that subjects tend to have biases toward using particular dimensions in their answers. In summary, Hunt states that "evidently memory for specific negative instances does play a part in concept learning. Just how large a part it plays will depend upon the current hypothesis the subject holds and how he attained it."\textsuperscript{172}

**Strategies, Hypotheses and Memory**

It has been found that "conjunctive concepts, the most frequently encountered type in the literature on concept learning, are particularly affected by the choice of strategy which the concept learner makes."\textsuperscript{173} Hunt states that conjunctive concept learning problems may be solved by the focusing on repeated intersections of the description of positive instances. Since any particular positive instance will contain all the elements of the correct statement of the concept, memory of specific past instances is not necessary. The subject must merely rely on memory to tell him "which dimensions have never changed over previously presented positive instances and what the constant value of each of these dimensions was."\textsuperscript{174} The constant value of each of

\textsuperscript{171}``Ibid., p. 147.\textsuperscript{172}``Ibid., p. 148.\textsuperscript{173}``Ibid.\textsuperscript{174}``Ibid.
these dimensions must be available so that the concept learner can perceive a "change in the 'focus' or set of previously constant dimensions when one occurs." When focusing the subject must keep track of the constant value (state) of the variables.

The task of keeping track of the current state of several variables was investigated by Yntema and Meuser. Hunt describes their research in the following way:

In their experiments objects (designated by letters) would have attributes (designated by the class names of nouns in English), each of which can change its state independently. For instance, there might be two objects, A and B, with three attributes—stone, animal, and direction—in each. The subject has to record a series of messages (e.g., "animal of A is fox, "stone of B is ruby") and, at aperiodic intervals, must respond to questions about the current state of a variable (e.g., "What is the stone of A?"). The task becomes one of keeping track of the current state of N x A variables which have various degrees of interrelation.

Hunt states that "applied to the learning of conjunctive concepts through the information presented on positive instances, we can think of the focus as being the object, the . . . dimensions within it as being attributes of the object." In most concept learning studies there will be

175 Ibid., p. 148.
177 Hunt, op. cit., p. 149.
178 Ibid.
seven or fewer dimensions in the focus. Hunt states that this number drops quickly as concept learning progresses. The results of Yntema and Meuser's research indicate that it is relatively easy for a subject to keep track of the current state of the variables defined by seven or fewer attributes of a single object. Other indications from the research in this area are discussed by Hunt.

1. ... the probability of an error in identifying a state of a variable increases with an increase in the number of messages since the last message about that variable. If we regard each instance as a message, but positive instances only as messages about the variable of interest, we would expect that interspersing positive and negative instances within a concept-learning task would make it harder to keep track of the current focus, thus interfering with concept learning.

2. ... keeping track of 6 objects, each with the same attribute, is much more difficult than keeping track of six different attributes of the same object although the number of variables is the same in each case. They showed that this is so because, in the latter case, we can identify the current state of each variable if we know only which states are active. If we are trying to remember which of six "animal" states are active in variable one, it is not too much help to know that one active state is "dog," if the "dog" state can appear in any variable. But if we know that the state "dog" is active, and that there is only one variable which has as its state the names of animals, the question is answered.179

Hunt translates this finding to concept learning situations.

Suppose that the objects to be categorized are described in such a way that each dimension can have the same values. The memory requirements of the focusing strategy will be increased. The learner must remember what values appear in the

179 Ibid.
focus and which values are assigned to which dimensions. This suggests a possible interaction between difficulty of learning, type of stimuli, and successive versus simultaneous presentation of objects in concept learning.\textsuperscript{180}

According to Hunt, any concept is essentially a union of one or more sets of descriptive statements which are applicable to the objects to be categorized. Each conjunction (a concept is always expressible by a disjunction of conjunctions) has its own focus or set of dimensions. Therefore the concept learner has then to keep track of a particular set of foci. The task then becomes one of making modifications within each of these foci. As the number of foci increase the number of variables will also increase. Hunt states that "this makes the memory task much more difficult since, not surprisingly, the more variables to which the subject must respond, the more errors he is likely to make."\textsuperscript{181} Hunt further states that the same dimensions may be contained in two or more foci, with the same or different values. The concept learner must thus keep track of variables with common states. Yntema and Meuser's research suggests that the particular "form of the correct answer will interact with memory requirements to determine problem difficulty. The amount of this effect should be controllable by altering the extent to which different foci contain the same dimensions, or dimensions which have the same values."\textsuperscript{182} In addition, "there may

\textsuperscript{180}Ibid., p. 150. \textsuperscript{181}Ibid. \textsuperscript{182}Ibid.
also be nonmemory aspects of conjunctive and disjunctive problems which make them differentially difficult for subjects. It may be that the problems imposed by focusing are so great in disjunctive concept learning that the subjects adopt a new strategy." In summarizing this section, Hunt states that "whether an analysis of a focusing strategy in concept-learning as a task involving keeping track of several variables is fruitful will depend on future research."

**Patterning, Description and Memory**

"Miller has suggested that recording stimuli into a few symbols is a method that humans use to increase their capacity to retain information. The limiting factor on human information capability is evidently not the amount of information per symbol, but rather the number of symbols to be stored." Miller, Galanter and Pribram contend that coding in memory is more important if the information to be retained is to be used in later induction, such as concept learning. According to Hunt, the function of recoding is

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the reduction in the number of symbols stored in memory at any given time. These symbols, in order to be used, must contain information relevant to the concept. It is possible that at the time of presentation the concept learner may not know what this relevant information is. Hunt assumes that the subject recodes so that he can store information he believes is relevant at the particular time the object is presented. In the event that the hypothesis is wrong, the information the subject has stored may be of no use to him. When he later changes to a relevant description, it will possibly be difficult for him to use earlier information.

Regarding the focusing strategy Hunt states that

\[ \ldots \text{if the concept learner has a relevant description and can utilize a focusing strategy, the problem of recoding will not be crucial. Some recoding may take place. Specifically, we would expect that only the value of dimensions within the focus would be stored. So long as this rule is followed, at least all relevant dimensions will be included within the stored information.} \]

The problem in learning conjunctive concepts comes, according to Hunt, when the concept learner under-intersects resulting in the storing of only part of the focus and loss of vital information. In conclusion, Hunt states that focusing will not work well if there are only a few positive instances. Another important consideration is the subject's style of cognitive behavior. According to Hunt, "even when focusing

\[ \text{\footnote{Hunt, \textit{op. cit.}, p. 152.}} \]
is both appropriate and easy, not all individuals utilize it as a strategy. 189

Recovery of Specific Items of Information

Hunt proposed earlier in this discussion of memory and concept learning a "scanning" alternative to a focusing strategy. He contends that since there are usually a large number of hypotheses in the beginning stages of concept learning the scanning procedure which involves evaluation of all of these hypotheses is not feasible. If, however, the subject chooses repeated samples of a few hypotheses, he will eventually choose the correct answer. The subject can reduce the chances of selecting erroneous hypotheses if he is able to retain some information about previously presented instances. He will be making his selection on the basis of more information. The question posed by Hunt is with regard to what form such information is stored. He states,

To evaluate a newly developed hypothesis, the concept learner must first decide what evidence he needs and then whether or not he has it. The first step is not a memory task; the second step does not require that the learner "remember" in toto a particular instance. Instead, he has to search his memory to see whether or not a particular subset of descriptive elements has or has not occurred jointly with a particular naming response. For instance, suppose that a subject in a concept-learning experiment develops the hypothesis that "all red stars are in the class of Alpha." To evaluate his hypothesis he must search his memory, however conceived, to determine whether there is any representation of an object to which the descriptive statement

189 Ibid., p. 153.
"has a red star" and the name "not-Alpha" can both be applied.\textsuperscript{190}

Experimental support has been given to Shepard's\textsuperscript{191} "micromechanical" model of memory during recognition which Hunt extends to the use of stored information. Hunt states that in Shepard's model a particular stimulus is represented internally by a set of elements. When the subject experiences a stimulus a set of "activated" trace elements is associated with its internal representation. Upon removal of the stimulus the activated trace elements become deactivated on a gradual basis or may "migrate" to other internal representations. Hunt states that

The probability that an element will transfer from one representation to another is specified, as is the probability of deactivation. In recognition, the unbiased probability that a given stimulus will be responded to as an "old" stimulus is proportional to the number of activated trace elements in its internal representation.\textsuperscript{192}

In order to apply this model to concept learning Hunt states that the task must be slightly changed. In Shepard's model the stimulus elements were in essence elements of the description of the object. The value of each dimension as well as the class name allocated to each object are assumed

\textsuperscript{190}Ibid.


\textsuperscript{192}Hunt, \textit{op. cit.}, pp. 153-154.
to be stimulus elements. Hunt states that "during hypothesis evaluation a search will be conducted to see whether or not certain combinations of elements can be found. For example, a hypothesis could be evaluated by asking 'Is there any case in which the name GLYMPH was (was not) associated with a red object'?" Hunt contends that if memory assumes this role in performing simultaneous scanning strategy, it is necessary that the search of memory be organized. The use of proper search techniques to retrieve information will be as important as the proper coding in storing it. This assumption, according to Hunt, has received some support from research. Other indications from research in this area are

Accuracy of report on a particular dimension could be increased by giving the subjects a "set" (in a psychological, not logical, sense) to report a dimension. The set could be induced either before or after the stimuli had been presented. . . . This suggests that a constant amount of information is stored, more than the subject can recall. But at any one time there may be a limit to the amount of information that can be reported. Accuracy of report along a particular dimension (i.e., about stimulus elements thought to be important in evaluation of a particular hypothesis) could be obtained by biasing the subject's method of searching his memory.

Sperling found that if the instruction to report occurred very soon (fractions of a second) after the stimulus presentation ended, the report of a single attribute was almost perfect. This

\[193\textit{Ibid.}, p. 154.\]
\[194\textit{Ibid.}, p. 154.\]

result indicated that memory was nearly complete. When the instruction to report was delayed, however, memory accuracy, estimated from the sampled attributes, dropped until it was approximately equal to the number of stimulus elements that could be reported in the free recall situation. In addition, if the visual field was changed immediately after the stimulus had been presented, the estimated number of stimulus elements in memory decreased. Sperling interpreted his results as indicating that information storage consisted of a sensory image and a symbol storage phase. During the period immediately after stimulus presentation an image would normally be present. By concentrating his attention upon this image, the subject could select a limited number of stimulus elements to store; the information so selected would be available for later retrieval.\footnote{\textsuperscript{196}}

Hunt contends that during the time intervals between the presentation of the stimulus and hypothesis selection and change the length of time would normally be sufficient so that the changes made in hypotheses would have to be made entirely on symbol-storage memory. In the Lawrence\footnote{\textsuperscript{197}} studies, Hunt states that the intervals were similar to those which would be found in hypothesis evaluation during concept learning. The symbols stored might be reviewed by the subject periodically as to their relevance, as defined at the review time. They might then be reselected for retention. Hunt states that "a model for information retention could be developed in which the probability of retaining particular

\footnote{\textsuperscript{196}}Hunt, op. cit., p. 155.

Information would be a function both of that information's relevance to the hypothesis in force at the time it was stored and of its relevance to later hypotheses.  

According to Hunt, such a model exists only as an idea and the development of it will involve solutions to factors such as stimulus elements and patterning.

Conclusion

Hunt contends that there is little doubt that concept learning is affected by memory. "How and how much will be determined by the strategy of inductive reasoning used by the learner. This, in turn, will be a function of task requirements and individual differences. The focusing and scanning techniques of concept attainment make quite different use of retained information."  

It is proposed by Hunt that there must be more precise studies within this area. He does state that "any adequate model of the role of information retention in complex mental processes will have to take into account the phenomenon of recoding."  

Strategies of Concept Learning

Plans, Totes, and Functions

In approaching a concept learning problem the learner will most likely move according to a plan. Hunt states that  

the learner cannot state his decisions before he actually begins the problem. That which he can state, however, is the rules which he plans to use in arriving at a decision. Hunt states that "these are computing rules, analogous to functions in mathematics. They take as their argument the information the environment provides and produce as their value the new decision rule. The learner can even have rules for changing his rules."\textsuperscript{201}

According to Miller, Galanter, and Pribram\textsuperscript{202} most, if not all, human behavior is organized by plans. Plans of behavior consists of four stages: "a test to determine differences between the present and desired state of affairs, an operation to reduce these differences, a second test, and finally an exit when no differences exist. The entire cycle is a 'TOTE unit' (an acronym for test, operate, test, exit)."\textsuperscript{203}

In applying the TOTE unit to concept learning Hunt states that the test phase corresponds to the checking of the current hypothesis against data already known. The operating phase is the subject's strategy. Hunt calls it an "hypothesis-computing function." He states further that "if the first test reveals that the current hypothesis is not compatible

\textsuperscript{201} Ibid., p. 160.
\textsuperscript{202} Miller et al., op. cit., cited in Hunt, op. cit., p. 160.
\textsuperscript{203} Hunt, op. cit., p. 161.
with known data, this function is activated. Its inputs are the current hypothesis and the information that this hypothesis led to a certain type of error. The value of the function is the new hypothesis, which will be tested in the second test phase.\(^{204}\) When the subject chooses a particular hypothesis-computing function, he has specified a strategy. This constitutes a TOTE unit.

TOTE units may be compounded but, according to Hunt, in most studies of concept learning only one or two TOTE units are needed for analysis. Hunt specifies the general form of a TOTE unit for developing hypotheses as shown in Figure 9.\(^{205}\)

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204 ibid.  
205 ibid., p. 162.
On a higher level, one can analyze the changes in the subject's actions as he gains experience in concept learning. The TOTE unit for evaluating strategies is shown in Figure 10.206

![Diagram]

Fig. 10—TOTE unit for evaluating strategies

In order to align the operations of Figure 10 with traditional terminology in psychology, Hunt states that it represents "an attempt to assemble maximally efficient discriminations and responses which serve as the test and operating phases of the unit depicted."207

The value of a TOTE analysis "orients our thinking in a somewhat different way than does the more familiar S-R analysis. In the TOTE framework the function of the components is stressed. We are continually forced to ask:

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206 Ibid., p. 163.  
207 Ibid., p. 162.
"What is this step for? - 'What characteristics must it have?'" Hunt states that in applying this to concept learning, it may simply be said that concepts can be learned by humans. The learning of concepts requires the subject to execute particular tasks, which, in turn, require mechanisms with particular performance characteristics. Hunt concludes that humans must, therefore, possess such mechanisms.

Requirements of a Strategy

Hunt defines strategy as "a plan for arriving at a pre-defined goal at minimum cost." The goal in concept learning, Hunt contends, "is the attainment of a definition of a concept which provides a satisfactory decision rule for assigning names to objects." The term satisfaction is used regarding the decision rule because, according to Hunt, it would be impossible to obtain a perfect decision rule. "A perfect decision rule would cost nothing to obtain, cost nothing to apply, and never lead to an erroneous decision."

Hunt states that the cost of obtaining a concept may be stated by determining how many objects must be shown to the learner before he can develop the correct hypothesis. The concept learner can minimize the number by extracting "all available information from an object when it is presented. He should also extract all information from pairs of objects.

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208 Ibid.
209 Ibid., p. 163.
210 Ibid.
211 Ibid.
triplets, etc. Minimizing the number of objects of known set memberships which the learner must observe will maximize the amount of computing and data storage which the learner must expend on each object.\textsuperscript{212} In general, a categorization rule may be described by the accuracy with which it permits the learner to assign objects to the correct denotation. Hunt contends that this is not, however, an adequate criterion.

In summary, Hunt states that "the appropriate strategy can be determined only with reference to the cost functions involved. These, in turn, are defined by the requirements of the problem and the capabilities of the problem solver. . . . The solution should be chosen that will make the most efficient use of available facilities."\textsuperscript{213}

**Individual Differences Among Adults**

When a concept learner is faced with a concept learning problem he must be able to make abstract or descriptive statements regarding the objects. He must, according to Hunt, be able to perform logical operations on the sets defined by the statements. The difficulty of the concept problem depends on the individual's ability to perform these basic operations. Hunt states that "we have no proof that all humans can perform all operations. To the extent that they cannot, their strategies must be different."\textsuperscript{214}

\textsuperscript{212}Ibid., p. 164.  \textsuperscript{213}Ibid.  \textsuperscript{214}Ibid., p. 165.
Developmental Stages and Concept Learning

The ability to think and respond in abstract terms normally increases from childhood to adulthood. "The level of abstraction of which the concept learner is capable will determine the descriptions of stimulus objects which are available to him."\textsuperscript{215} He states further that

The idea that more operations become available with increasing age fits well with the point that the effective strategies of concept learning must be those which rely on operations and tests at which the concept learner is particularly skilled. Any TOTE analysis of behavior during concept learning will be particularly sensitive to this sort of individual difference.\textsuperscript{216}

Information and Reward

Hunt identifies two decision problems which face the concept learner. "Given his current state of knowledge (i.e., hypotheses), how should he classify a particular object? Given the information that his current hypothesis is incorrect, how should he modify it?"\textsuperscript{217}

The classification at first glance may appear to be trivial. If, in a concept learning situation, the concept learner has only one hypothesis and "if the punishments for misclassification are symmetrical, regardless of the classification made and the one that was correct, he ought to always follow his favored hypothesis."\textsuperscript{218} The situation is

\textsuperscript{215}Ibid., p. 167.  
\textsuperscript{216}Ibid., p. 168.  
\textsuperscript{217}Ibid., p. 169.  
\textsuperscript{218}Ibid.
not frequently this simple. Hunt states that "in most practical cases . . . payoffs are not symmetrical. They depend on the compatibility of the action which will be taken on the basis of the classification with the action that is required by the true state of nature."\textsuperscript{219}

There is also the consideration that the learner might have more than one hypothesis. Hunt contends this general problem can be pictured by a probability and payoff matrix. In such a matrix, "each course of action is weighted by the faith we have in the hypotheses that recommend it and the strength with which they make their recommendations. . . . The resulting weights can be used to establish estimates of the probability that different classifications are correct. These estimates must be combined with the effects of different combinations of naming response and correct classification before a decision can be reached."\textsuperscript{220}

Hunt states that when a known concept is absent, classification is a more risky problem in decision making. He contends that "at least two alternatives exist, and the probability of either one being correct can be estimated (more or less accurately). Payoffs for various contingencies must be specified. Even so, the solution to such decision-making problems . . . is not always clear."\textsuperscript{221}

Reward considerations, Hunt maintains, may not only have effect on the use of current hypotheses but may also affect

\textsuperscript{219}\textit{Ibid.} \hspace{1em} \textsuperscript{220}\textit{Ibid.} \hspace{1em} \textsuperscript{221}\textit{Ibid.}, p. 170.
the choice of hypotheses and even hypotheses generating strategies. "Strategies can be chosen to bias errors toward inclusive in or exclusive from a particular class." The following example is given by Hunt:

As a simple example, suppose a child, new to the country life, notices that in the universe of insects yellow things that buzz are bees. On his first day in the country, he never encounters a yellow object that does not buzz or a buzzing object that is not yellow. He cannot distinguish between three possible concepts for the name "bee," yellow objects, buzzing objects, both at once, or either. If he can only remember a limited number of hypotheses at a time, he should, to be safe, retain the disjunctive hypotheses. Although he will call some butterflies bees, at least he will not be stung.\(^{223}\)

Hunt states that the matter is made more complex by the fact that the payoff for classification should reflect the value of the information which may be attained from each classification, even if it is wrong. "If there are more than two possible classifications, the only way to make a direct test of the membership of an object in a particular class is to assign it to that class."\(^{224}\)

Another situational variable, in addition to reward contingencies, is the logical form of the concept to be learned. This will have some effect on the choice of an appropriate strategy. In the normal situation the concept learner will not know what the logical form of the answer is. Hunt states that some strategies which are useful in solving conjunctive concept learning problems are not effective in

\(^{222}\)Ibid. \(^{223}\)Ibid., pp. 170-171. \(^{224}\)Ibid., p. 171.
solving disjunctive problems. Hunt defines conjunctive concepts "by the union of the descriptive statements that are common to every positive instance (members of the denotation). Negative instances are useful to prove that some subset of the descriptive statements in this set is not, by itself, a sufficient statement of the concept."\(^{225}\) The positive focusing strategy, Hunt maintains, extracts information only from positive instances. "This is not a foolish procedure. It can be shown that positive instances, on the average, eliminate more plausible hypotheses than do negative instances during the learning of a conjunctive concept."\(^{226}\)

Positive focusing is not, however, a suitable strategy for learning disjunctive concepts. In disjunctive concepts there may be no descriptive element which is common to all positive instances. Hunt contends that it may still be possible to develop a disjunctive concept by a variant of focusing on positive instances. "What the learner must do is develop a trial set of several conjunctive concepts, the union of which defines the disjunctive concept."\(^{227}\)

They rely on a comparison of positive and negative instances. If there are two instances, differing only in the value of one dimension, and one is and one is not an object to which a name is applicable, that dimension is relevant to the concept of the name. If there is a small number of relevant dimensions relative to the total number of dimensions, the concept may be defined by noting values which never appear on negative instances, a "double negation" as it were. (In an extreme case

\(^{225}\)Ibid. \(^{226}\)Ibid. \(^{227}\)Ibid.
the complement of the denotation may have as its associated concept a conjunctive statement.) This strategy involves concentrating attention on negative instances.\textsuperscript{228}

Hunt states that

Knowledge of the type of correct answer is useful in determining a strategy for concept learning. The efficient learner must be alert for cues indicating with which type of concept he is faced. Such cases may occur before he has sufficient information to define the concept itself.\textsuperscript{229}

The example given by Hunt states that there may be two positive instances which have no descriptive elements in common and this is indicative that the concept to be learned is disjunctive. The learner must still discover the answer.

The concept learner may not always have control over object production. If he does, however, he can produce the desired sequence. He states that "such control should be particularly useful in disjunctive concept learning, since the learner could make the desired contrasts between positive and negative instances without relying on memory of the features presented at some time in the past."\textsuperscript{230} Hunt states further that "although the learner may not be able to control the choice of objects to be categorized, he can make use of knowledge about how the choice is made."\textsuperscript{231}

The situation is similar to a problem of induction as used by a statistician. He starts with a hypothesis about the distribution of objects in a universe. Hunt states the "correction of the statement must be determined by observing a sample."

\textsuperscript{228}\textit{Ibid.} \hspace{1em} \textsuperscript{229}\textit{Ibid.} \hspace{1em} \textsuperscript{230}\textit{Ibid.} \hspace{1em} \textsuperscript{231}\textit{Ibid.}
A biased sample will do providing that the bias is known. Hunt uses the following example to illustrate the task of a concept learner trying to determine the truth of a statement:

Russian women are scientists and/or mother heroins and Russian women are either scientists or mother heroins can be used to illustrate this point. If the sample of Russian women that he observed was drawn randomly from the entire population, we would expect that, assuming the truth of the inclusive disjunctive statement, eventually a woman who was both a scientist and a mother heroine would be encountered. If the sample was drawn from Russian women attending a moving picture, it might be argued that the absence of any such person was not evidence to discriminate between the two hypotheses. A person who was both a scientist and a mother heroine would be too busy to go to the movies.

Preference for Positively Stated Inferences

In general humans exhibit a preference in concept learning situations for positive instances. Experimental support has been given to the fact that "humans cannot easily evaluate negatively stated inferences." Hunt states that it will probably be found that whereas humans can learn from negative instances, they normally do not. An ancillary role of negative instances, either to establish a contrast class or to check hypotheses derived from positive instances, may be a vital part of the strategy of efficient concept learning.

Strategy Preferences Designed to Discover Certain Types of Answers

"If strategies are appropriate descriptions of human concept learning, we would expect them to be revealed by

\[\text{\cite{232} Ibid.} \quad \text{\cite{233} Ibid., p. 173.} \quad \text{\cite{234} Ibid., p. 175.} \quad \text{\cite{235} Ibid., p. 176.}\]
the differential difficulty of experimental situations designed to support them.\footnote{Ibid., p. 176.} Seymore\footnote{R. Seymore, "Strategies in the Utilization of Information," unpublished doctoral dissertation, (1954), Harvard University; cited in Hunt, op. cit., p. 176.} conducted a series of relevant experiments involving the following:

Harvard graduate students learned a conjunctive concept under the simultaneous presentation-subject controlled selection technique used in the Bruner et. al. experiment just cited (in which Seymour had participated as an experimenter). In one condition - ordered presentation - instances were arranged so that each pattern differed from the one next to it in just one value of one dimension. In the second condition - random presentation - patterns were placed in front of the subject without regard to the nature of the neighboring patterns. Seymour argued that the ordered condition would favor the adoption of an efficient focusing strategy, since the next instance required by a focuser would be available without extensive searching. An analysis of instances chosen for identification did show more focusing in the ordered condition. In this condition subjects learned the concept in fewer choices.\footnote{Hunt, op. cit., p. 177.}

The implications from Seymour's studies are given by Hunt:

Seymour's study indicates that human concept learners can, within limits, adopt a strategy which is suited to a particular task. It also affirms the belief that the extent to which the experimental situation supports focusing is related to the difficulty subjects will have with a problem. But this cannot be the only factor determining difficulty, since not all subjects use a focusing strategy correctly at all.\footnote{Ibid.}

Hunt states that in focusing, memory, problem type and strategy interact. Focusing strategies are normally directed
toward the discovery of conjunctions. In case the problem has a disjunctive answer, Hunt states there will be no unique focus, which is common to all instances. In this situation disjunctive problems will be unusually difficult. Again, it should be stated that research suggests that individuals prefer conjunctive answers.

Bruner\textsuperscript{240} contends that when faced with disjunctive problems, the learner will adopt varying strategies. Hunt states:

What subjects did do was to adopt strategies “appropriate” for conjunctive problems. They would either offer hypotheses based on elements found in positive instances or, if there were no completely common elements, the elements that appeared in most of the positive instances. Such a hypothesis will define a set of objects included in, but not identical to, the set of positive instances. Another strategy observed was an attempt by subjects to find a positive instance and then contrast it to a negative instance, taking as their hypothesis the values of the positive instance which were changed. This strategy, adequate for conjunctive concepts, will define the answer only if the positive instance used in the contrast contains within its description the union of all descriptive statements used in the definition of the concept. In some concept-learning problems (for example, exclusive disjunctions) this cannot happen.\textsuperscript{241}

Hunt mentions two other possible strategies which a learner may use:

One is a form of scanning using negative instances. The complement of the denotation of a disjunctive concept is identical to the set of objects defined by the conjunction of the complements of all descriptive elements relevant to the disjunctive

\textsuperscript{240}Bruner, \textit{op. cit.}; cited in Hunt, \textit{op. cit.}, p. 179.

\textsuperscript{241}Hunt, \textit{op. cit.}, p. 179.
concept. In other words, the concept could be defined by what nonexamples are not. This definition involves a double negation . . . which subjects had great difficulty in evaluating. When concept-learning tasks are based on such statements, they are extremely difficult to learn. . . . This strategy would be particularly appropriate if only a few descriptive elements were used to define the stimuli. In the limiting case, if there were only two values per dimension, the complement of the denotation becomes a simple conjunction. For instance, if we are classifying strings of letters, each letter a capital or small letter, then "A or B" is equivalent to "not a and b.

Finally, there is a strategy, conditional focusing, which utilizes positive instances to define a disjunctive concept. Given a set of positive instances, count the descriptive statement which is most frequently applicable to them. Check against a set of negative instances to see if this statement can ever be applied. If not, this statement is one of the elements of the disjunctive answer. If the statement can be applied to any negative instances, consider only the subset of instances (both positive and negative) to which it can be applied. Repeat this procedure within the subset, recursively, until a conjunction of descriptive statements is obtained which never can be applied to negative instances. This conjunction becomes an element of the disjunctive answer. Then continue the procedure on all unclassified instances. An answer is obtained when all positive instances are included within the hypothesis.

In summary, Hunt contends that when a subject is given a test problem solvable either by conjunctive or disjunctive answers, differences will appear. Some subjects using the focusing technique will first discover the conjunctive concept (this will be discovered by the common element strategy). Other subjects who use the negative scanning strategy will discover the disjunctive concept first. They

242 Ibid., pp. 179-18.
will attend to the "absence" of certain descriptive elements in negative instances.

Chapter Summary

Hunt raises the question as to what is actually learned when a problem is solved. He grants that a specific concept is learned but contends that this may be the least valuable factor over a long period of time. Experimentation is cited by Hunt which suggests that "information-processing techniques" might be learned. This reverts back to the previous discussion of the TOTE units (test to determine the difference between current knowledge and the desired state, operate to reduce these differences, and then test again). "One of the things the subject might learn is what to do when the current strategy fails. Learning to select TOTES is similar to 'learning to learn'."

In the TOTE analysis any transfer study is a study of inductive problem solving, or perhaps concept learning. The objects are problems which can be described by their physical structures and by the feedback (e.g., success or failure of a particular observation) received when a strategy is applied to them. By observing this feedback, the concept learner could develop concepts to define the types of problems on which particular strategies will work. Often his experience will not be sufficient to permit him to learn an unequivocal concept about problems. Therefore he will have to guess about the "best" strategy to try; at some time this guess may lead him into an incorrect classification. This would be revealed by an incorrect choice of a strategy.244

243 Ibid., p. 185.  
244 Ibid.
Hunt is proposing that learning can be thought of as a case in inductive problem solving. He feels that this interpretation will likely be the most fruitful in the production of research.

The theory of concept learning proposed by Earl B. Hunt, as it pertains to human concept learning, has been discussed in the foregoing pages. It should be noted that Hunt does include within his theoretical discussion chapters on "Artificial Intelligence," "An Information Processing Model," and "Concept Formation by Artificial Intelligence." However, these chapters are oriented directly in the area of conceptual thinking and mechanistic simulation. Since these discussions do not relate directly to the basic purpose of this study they have not been analyzed and discussed.245

245 If the reader is interested in these areas of discussion he is referred to Hunt, _op. cit._, Chapters Seven, Eight and Nine, pp. 189-272.
CHAPTER V

AN ANALYSIS OF HUNT’S THEORY OF CONCEPT LEARNING
AND PIKAS’S THEORY OF CONCEPT FORMATION
REGARDING AREAS OF COMPATIBILITY
AND INCOMPATIBILITY

This discussion will constitute an analysis of the theory of concept learning by Earl B. Hunt and the theory of concept formation by Anatol Pikas in terms of compatibility and incompatibility. Those areas which are discussed by one writer and not discussed by the other will be noted. Since the two writers are dealing with areas which are different yet related, a definition of each area is in order.

Definitions

Pikas defines concept formation as "the acquisition or utilization, or both, of common response to dissimilar stimulus."¹ He contends that concept formation is basically the first en route to concept learning or concept attainment.

Hunt defines concept learning as "a mental image of a thing formed by a generalization from particulars."² He


states further that only a rewording of Kendler's definition of concept formation ("the acquisition or utilization, or both, of a common response to dissimilar stimuli") is needed in order to define the process of concept learning. The definition must contain the word "identifying" and should read, "the acquisition or utilization, or both, of a common identifying response to dissimilar stimuli." 3

Hunt contends that "acquisition of a response involves both the capacity to distinguish situations in which the response is appropriate and capacity to make the response. Concept learning and use refers only to the identification step." 4

Types of Concepts

There is, as discussed by Pikas and Hunt, no incompatibility as to the basic types of concepts. Hunt states that "it will probably be found that whereas humans can learn from negative instances, they normally do not." 5 Hunt identifies and discusses conjunctive and disjunctive concepts. He contends that in a conjunctive concept learning situation, the presence of a cue is normally a perfect predictor of the appropriateness of a given naming response. However, in a disjunctive concept learning situation the absence of a cue "is not a perfect predictor of the inappropriateness of the same response." 6

3 Ibid., p. 2.  
4 Ibid., p. 3.  
5 Ibid., p. 71.  
6 Ibid.
Pikas uses Bruner et al's concept classifications. They are conjunctive, disjunctive, and relational. Pikas emphasizes the fact that conjunctive concepts are more easily learned. This is because "this kind of learning is more natural for the organism and represents a more primitive process." The conjunctive concept possesses, according to Pikas, an attribute (s) of its own. This may be stated in Hunt's terminology as possessing positively stated inferences. Hunt states that organisms prefer positive instances or, in other words, concepts which possess similarities.

It is the basic contention of Hunt and Pikas, as well as most other writers in this area, that conjunctive concepts are more easily learned than disjunctive concepts. It should be noted here that Hunt makes no mention of relational concepts. Pikas gives little attention to this type of concept but rather concentrates on conjunctive and disjunctive concepts. Types of concepts may be considered to be an area of compatibility between the two theories under discussion.

Coding and Recoding

Both Hunt and Pikas maintain the necessity for some type of coding and/or recoding process. In the first place Hunt contends that the stimulus trace is a significant

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8 Pikas, op. cit., p. 120.
factor in concept learning situations. He states that "categorizations must be based on an internal representation of an external object." The "implication is that subjects are searching for some sort of maximally efficient decoding scheme. In doing so they are involved in two procedures, locating relevant channels of information and developing procedures to utilize these channels."

Hunt states that coding is the normal method of information storage and that recoding is the process of combining symbols to reduce the number stored at any one time. In order for an individual to increase his capacity to retain information he must, according to Hunt, increase not the amount of information per symbol, but rather increase the number of symbols to be stored. The function of recoding is the reduction in the number of symbols stored at any given time. These symbols, in order to be used, must contain information relevant to the concept. Hunt assumes that the subject recodes so that he can store information he believes is relevant at the particular time the object is presented. In the event that the hypothesis is wrong, the information the subject has stored may not be of any use to him. When he later changes to a relevant description it will possibly be difficult for him to use earlier information. In recoding and storing of information Hunt states that a problem might

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9 Hunt, op. cit., p. 89. 10 Ibid., p. 93.
occur if the concept learner under-intersects and stores only a part of the focus and loses vital information.

Hunt uses a code word model to explain stimulus identification problems. This appears to be compatible with his theory of the functions of codes and recodes. "The code word model suggests, at any one time, a concept learner can partition the stimulus universe into as many 'equivalence classes' as he has code words."\(^{11}\) He states that the learner could try various partitions (class divisions) until he found "one such that any subset of his partition was either a subset of the denotation of the name whose concept was to be learned or a subset of the complement of the denotation. In this case his partition could be related to a relevant description of the stimulus universe."\(^{12}\) If, according to Hunt, the stimulus universe is large compared to the number of code words (which happens when the number of dimensions is increased) the learner must try a larger set of patterns, resulting in a more difficult concept learning task.

Pikas approaches the function of recoding through the following question: How can the strain of weighing many attributes be reduced? He quotes Bruner et al. as considering two basic ways: "One is by the reduction in the number of attributes considered; the other by a process of combining or recoding attributes into configurations."\(^{13}\)

\(^{11}\)Ibid., p. 122.

\(^{12}\)Ibid.
According to Pikas, the first method would involve use of those attributes which are most immediately discriminable or to regress to the first formed attributes. Regarding the second method he states:

In coding or categorizing the environment, one builds up an expectancy of all these features being present together. It is this unitary conception that has the configurational or Gestalt property of birdness. . . . When the conception is well enough established, it takes on the property of being able to serve as a discriminable and seemingly irreducible attribute of its own.14

Pikas uses Hunt's definitions of coding and recoding (previously cited) as the bases for discussion. He agrees with Hunt that coding is the normal method of information storage. Further, he states that "the most primary coding can probably be best defined as a recording of an original sensory input."15 According to Pikas, the concept learner receives unique events which are transferred into the code (or the particular method of information storage) of the organism. This results in what is often called a memory track. This is compatible with Hunt's statement regarding the stimulus trace.

As has been stated Hunt maintains that recoding is the process of combining symbols to reduce the number stored at any one time. Pikas contends that coding and recoding exist as a primary-secondary relationship. Recoding refers to the process whereby an organism recodes the primary codes and

14 Bruner, op. cit., p. 47; cited in Pikas, op. cit., p. 121.

creates new codes which incorporate the common structure of the primary codes. He states that concept formation, defined as a common response to different stimuli, "would thus be explained by the assumptions of a common recoding."16

Pikas's theory of coding-recoding is then, in simpler terminology, a sensory input experienced by an organism and recoded in terms of a primary code. These primary codes combine to form what is called a memory track. From the primary codes the organism recodes which leads to the creation of new codes and the reduction in the number of symbols stored by the organism.

It is quite evident that there is considerable agreement regarding the basic function of codes and recodes. It should be noted, however, that whereas Hunt discusses coding and recoding in terms of their relationship to the act of concept learning, Pikas uses them to develop his entire theory of concept formation. Throughout the development of his theory of concept formation Pikas refers to his "recoding hypothesis." This is not to be taken necessarily as an area of incompatibility but rather as a matter of degree of emphasis. It should also be pointed out that since concept formation is considered, by Pikas, to be the originating process of a concept, coding and recoding should be more significant than in the actual process of concept learning.

16 Pikas, op. cit., p. 128.
Stimulus Generalization

Hunt contends that "the result of stimulus generalization is that the act of conditioning a particular response to stimulus 'A' increases the probability that it will be given upon presentation of some similar stimulus A'. This tendency of stimulus generalization will decrease if A and A' appear in markedly different lists. . . ."\(^1\) The stimulus generalization gradient, according to Hunt, arises out of the continuum of stimulus similarity which may be traced back to the original stimulus trace (the internal representation of the stimulus within the learner). Similarity is defined by Hunt as the presence of overlapping sets of stimulus cues. If the stimuli on a list (such as a paired-associates list) have similar traces, the concept learning problem should be easy. But, Hunt contends, if some of the stimuli on the list are similar to the stimuli on the second list (which has the denotation of another name), learning will be more difficult. In essence, difficulty in discrimination, according to Hunt, is due to stimulus generalization.

Pikas maintains that the definition of stimulus generalization as given by Mednick and Freedman\(^2\) describes the same

\(^{17}\)Hunt, *op. cit.*, p. 53.

S-R relation that was evident in Kendler's\textsuperscript{19} definition of concept formation. Pikas concludes, as a result of his surveys of stimulus generalization research, that there is a synonymity. This is compatible with Hunt's contention that stimulus generalization results in the increased probability that a response conditioned to a particular stimulus will be given to similar stimuli. Pikas approaches stimulus generalization from a basic concern "with a plastic, non-discrete model on the stimulus side. A natural result of this model ... (is that) overlapping GSGs (stimulus gradients) originating from two or more points on the same continuum will summate and result in incremented generalization responsiveness in the area of the overlap."\textsuperscript{20}

The effect of drive on stimulus generalization is discussed briefly by Pikas. He contends that "increased non-specific drive produces confusion of thought."\textsuperscript{21} It is at this point that stimulus generalization increases.

Pikas further maintains that in the area of stimulus generalization the problem of summation of gradient (or what Pikas sometimes calls melting together) must be considered. Experimental research in the area supports the assumption that "in all ... cases the peak of responding


\textsuperscript{20}Pikas, op. cit., p. 162.

\textsuperscript{21}Ibid., p. 165.
was displaced towards the center of a series of given test stimuli. . . .”22, 23 Pikas further relates this tendency toward the center to behavioristic thought stating that “we may hypothesize that, since frames of reference (like dimensions) can be considered as concepts and as older concepts by using well-established ones, they also have greater influence, acting as normalizers. . . .”24

Hunt's approach to stimulus generalization represents a rather restricted definitive statement regarding the nature of stimulus generalization and concept learning, whereas Pikas treats the area somewhat more specifically. However, there appears to be no specific areas of incompatibility but rather each author has approached the area from slightly different vantage points.

Mediating Responses

Hunt states that

The mediating response explanation begins with the assumption that responses produce stimuli, which may serve as cues for further responses. When a stimulus is presented, its image in the organism is presumed to evoke certain previously learned responses. These provide the stimuli which evoke another response, and so on.25

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22 Ibid., p. 180.

23 For an example of this type of experimental design see Chapter III, p. 74.


In concept learning, this chain of events is usually considered to end with the occurrence of the overt naming response. The naming response could be an important cue to further action, according to Hunt, and need not end with the overt naming response. Within the chain any stimulus will tend to evoke several competing responses. When one of these responses occurs, to the exclusion of the others, this will affect the probability of obtaining a given response later in the chain.  

In the area of verbal concept learning, Hunt maintains that "mediating response" refers to verbal responses. "In verbal concept learning studies it is often suggested that the pairing is not between the stimulus and overt response, but between the stimulus produced by a (previously learned) mediating response and the overt response." These previously learned responses may be considered to be the meaning of the object and conditioning may actually be the conditioning of a response to a certain meaning. Hunt uses the following S-R pairings to illustrate the theory of mediating responses:

26 For an example see Chapter IV, p. 133.

27 Hunt, op. cit., p. 78.

28 For further discussion see Chapter IV, pp. 136-143.
There is little doubt that the following stimulus-response pairings:

- beet-gax
- cabbage-gax
- corn-gax
- amethyst-roq
- onyx-roq
- granite-roq

present a list that is easier to learn than the following list:

- beet-gax
- amethyst-gax
- cabbage-gax
- corn-roq
- onyx-roq
- granite-roq

The first list is easier to learn because the stimuli to which "gax" is to be conditioned have in common the previously conditioned response of "food."

A type of mediating response which Hunt discusses is that which he calls "orienting responses." In a concept learning situation the learner selects some factor of a concept and attends to this factor. Hunt states that a question which arises here is how is this initial selection made. It has been hypothesized that an orienting response, initiated by the experimental situation, influences the selection before the stimulus is presented. This function may be seen best through the relationship of orienting responses and reversal shifts. Hunt explains reversal shifts by stating that "if the first task required that the subject learns that triangles, regardless of size, were 'positive' and circles were 'negative,' the reversal shift problem would have circles

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29Hunt, *op. cit.*, pp. 78-79.
as 'positive' and triangles as 'negative'. In the reversal shift experiments it was found that reversal learning problems were learned very easily.

Regarding this problem, Hunt states Kendler and D'Amato's conclusion that "the subject was learning two responses: a mediating (orienting) response to attend to a particular dimension and an overt response to identify an instance as positive when a particular value appeared in that dimension." Hunt concludes that learning to orient ourselves toward a particular dimension should be an important condition of learning.

Hunt states that "all mediating response hypotheses (except the orienting response hypothesis) assume that each object in a concept learning experiment evokes cues which were conditioned to it before concept learning was begun." The subject must "locate a set of cues which are selected by the members of the denotation and which, if they are learned as cues for the naming response, will provide adequate discriminations." The subject must bring the relevant cues and the necessary response into association with each other.

30 Ibid., p. 74.
32 Ibid., p. 173.
33 Ibid., p. 79.
34 Ibid., p. 80.
According to Hunt, the mediated stimulus or the mediating response (since the two are identical) is the meaning of the concept.

Another related area which Hunt discusses is response dominance and mediating response. In mediating response analysis, it was found that a concept that had a common dominant response which had been facilitated was more easily learned. The variance of the dominant response when measured over members of a set of stimuli to which a name is learned is illustrated by Hunt.

Consider the case in which the appropriate mediating response has high dominance for some instances in the training set and very low dominance for others. The mediating response should occur to some instances of the training set, which would place the appropriate mediated stimuli in close temporal contiguity with both the naming response and the other instances of the training set. This contiguity should lead to an increase in both (a) the conditioning of the overt naming response to the stimuli produced by the mediating response and (b) the conditioning of the mediating response to the other members of the training set. A high-variance concept list would be easier to learn than a low-variance list, provided the mean level of each list was the same.35

This prediction was "confirmed for verbal concept learning lists equated for mean response dominance of the appropriate mediating response."36

Hunt contends that even with the mediating hypothesis, S-R theory has difficulty in explaining concept learning. He states that "some form of mediation is certainly necessary in

35Ibid., p. 85. 36Ibid.
any analysis of concept learning."37 He identifies two major flaws in this theory which appear to be somewhat inconsistent: (1) unrestricted introduction of a mediating response into an S-R chain leaves the theorist in an uncomfortable position of being able to explain every thing while predicting nothing. (2) There is almost no behavior that could not be "analyzed" as being compatible with an S-R theory . . . if the theorist is allowed to introduce new mediating links or to vary habit family hierarchies.38

In summary, Hunt maintains that

. . . an S-R theory, amplified by mediating responses, appears to explain satisfactorily the process of learning and transfer of concepts in simple discriminations. . . . A language-mediated theory of an orienting response seems more compatible with the data than a physical orientation theory.39

Pikas approaches mediation theories from the standpoint of their relationship to stimulus generalization. Goss's work is used as the basis for his discussion. Goss defines the mediation process in the following manner: "When events A, B and C occur in the sequences A -- B -- C and A -- C, and the probability of the occurrence of C is actually or potentially greater or less when C is preceded by A alone, B can be described as a mediating process or event."40

37 Ibid., p. 93. 38 Ibid. 39 Ibid., pp. 77-78.


41 Ibid.
The relation between mediation and concept formation is stated by Pikas as he quotes Goss. "... Mediations are a subgroup in a class of conceptual situations: the other subgroup is the simplest concept-formation tasks, which are essentially identical to phenomena more often labeled primary stimulus generalization and response-mediated generalizations." Pikas uses the model or paradigm of Goss and states that the model includes only those mediations which consist of namings. "This model may be said to include certain sufficient conditions in mediations, while omitting many necessary conditions." Regarding the conditions omitted by the model or paradigm, Pikas states that

... the fact that common reactions which are not verbal may take place to differentiated stimuli is not included in the model. To put it in a commonsense way, it is self-evident that the individual who has no verbal language may form concepts and the behavior of even the most verbally capable individuals may testify to the occurrence of ideas or concepts which they have no words for.

Pikas contends that mediators and their effect on concept formation can be explained by his recoding hypothesis. He states,

If Goss's mediation paradigms are to conform with his general definition of mediation previously quoted, it is necessary to assume that the mediating

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42 Goss, op. cit., p. 250.
43 For a more detailed description of the paradigm see Appendix C.
44 Pikas, op. cit., p. 171.
45 Ibid.
stimuli and responses which appear are stored codings. . . . But are these codes, which are mediators, primary codes, i. e. unaltered traces of first sensory impressions, or has something happened to them? . . . the interesting question is, how do these mediators arise? The mediation theorists do not deal with this question but we may suggest that they must be conceived of as primary codes, for example, that the primary code of a word is the centre of a complex of connections which constitutes the conceptual mechanism.46

It is suggested by Pikas that the hypothesis of recoding of mediations is a possible explanation for the phenomena of primary stimulus generalization mechanisms. He states, however, that it "is not to be considered as an exclusive, but only as a competing explanation of the economy of conceptual action."47

Here again the situation is one of emphasis rather than disagreement. Hunt concentrates on chain reactions formed by mediators, verbal mediators and response dominance. Pikas emphasizes the relationship between mediating response and stimulus generalization, but the contentions made regarding mediating responses are similar to those discussed by Hunt. There is, however, one area which Hunt deals with which is unique to his theory. This is the area of "orienting responses." Hunt contends, however, that orienting responses are mediating responses which direct an organism's attention to a particular factor of a concept. It is difficult to evaluate this in terms of Pikas's theory, since he does not

46 Ibid. 47 Ibid., p. 173.
treat the area. The same problem exists regarding Pikas's contention that the hypothesis of recoding of mediations may be used to explain the stimulus generalization mechanisms. As has been shown, however, the treatment of these areas does not, in itself, represent areas of incompatibility.

**Information Feedback**

Hunt treats the area of information feedback from the standpoint of information and reward. He contends that, in a concept learning situation where the concept learner has to choose between several possible hypotheses as being the correct hypothesis for the solution of the concept problem, reward will not only have an effect on the use of current hypotheses but may also affect the choice of hypotheses and even the strategies the learner will use in generating hypotheses about concepts. Another term which Hunt uses and which appears to be part of information feedback is "payoff." By "payoff" it appears that Hunt is speaking of the probability that one hypothesis, as opposed to another hypothesis, has of being the correct hypothesis.

According to Hunt, the payoff for classification should reflect the value of the information which may be attained from each classification, even if it is wrong. He states "if there are more than two possible classifications, the only way to make a direct test of the membership of an object in a particular class is to assign it to that class."\(^\text{48}\)

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\(^{48}\)Hunt, *op. cit.*, p. 171.
Pikas deals with three basic areas of information feedback: delay of information feedback, post-feedback intervals and misinformative feedback. Research has shown that increased latency of reinforcement or stimulus feedback causes additional errors in the learning of a concept and requires additional trials in order for the subject to learn or form a given concept.\textsuperscript{49} Regarding the post-feedback intervals Pikas contends that there is logically an optimum post-feedback interval. Intervals which are too short or too long hinder concept formation. Since a certain length of post-feedback interval is necessary, this indicates that a process which takes time must take place in the learner. Pikas relates this to his basic recoding hypothesis stating that "it is reasonable to imagine that recodings on the basis of primary codes takes time. Since conceptual processes require time, it is conceivable that it is just a matter of the time which the organic creation of recodings takes."\textsuperscript{50} Pikas indicates that this optimal post-feedback interval is, as yet, undetermined.

In the area of feedback Pikas deals with the effects of misinformation feedback. He contends that misinformation feedback has an influence on concept attainment when the misinformation feedback per cent is high and does not have this influence (or has only a slight influence) when

\textsuperscript{49}Pikas, \textit{op. cit.}, p. 129. \textsuperscript{50}\textit{Ibid.}, p. 132.
misinformation feedback per cent is low. He assumes that there is a point at which the misinformation feedback influence tends to cease in a marked fashion and that the position of this point is a function of the complexity of the material.51

The approaches of these two authors is considerably different. Pikas uses current research in the area to establish the effects of information feedback on concept formation while Hunt approaches it from the standpoint of the concept learner being rewarded or reinforced by his knowledge that he has made a correct response.

The one area where there may be some appearance of disagreement is that regarding the signal-next stimulus period discussed by Hunt. When applied to the results of delay of information feedback as discussed by Pikas it is seen to be approximately the same. According to Hunt, errors increase as the signal-next stimulus period is shortened which implies that the length of time since the stimulus and response and subsequent reinforcement is increased.

Again it may be said that Hunt and Pikas do not appear to have areas of disagreement. This may be true because they discuss information feedback from different standpoints. While it would be difficult to establish, from their discussions, positive areas of agreement it can hardly be said that the two theories are incompatible in this area.

51Ibid., p. 133.
Stimulus Organization and Structure

It is generally agreed upon that the more complex the stimuli in a concept learning situation, the more difficult the task will be. In simple cue conditioning experiments the subjects will have time to notice only a few dimensions. If, according to Hunt, the dimensions noticed are relevant dimensions, the problem could be solved easily. However, if the dimensions are not relevant the subject could categorize with no better than chance accuracy.

In more complex concept learning situations research studies have established "that there is a linear increase in the total number of errors as the number of irrelevant dimensions is increased." Also, "if a human subject can learn to capitalize on the redundancy relations between particular dimensions he can reduce the number of dimensions he must scan. He may use the known value of one dimension to predict the value of dimensions redundant to it." A third finding is that increasing the number of redundant dimensions makes the concept learning task easier. It has been shown from experimental studies that the better the subject can state, verbally or written, a given concept, the more abstracting ability he possesses.

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52 Hunt, op. cit., p. 111.  
53 Ibid., p. 114.  
54 Ibid.  
55 Ibid.
Our perception plays a significant role in our stimulus structuring. Perception is basically a two-step procedure:

In the learning phase the perceiver locates points that transmit the most information about the stimulus and determine how the values of these points are related to the values of predictable points. In the application state the perceiver will guess the state of the matrix after examining a few points.55

Bruner56 proposes that the subject

...first receives a few tentative, prominent cues from his environment. The subject uses these cues to establish a tentative structure. The structure becomes more and more detailed as more important information is obtained. At all times future perception is under the partial control of present perception.57

Hunt states that the problem arising here is that if tentative structures are inaccurate this might hinder concept learning. He contends that "a subject might be led to an irrelevant description of the objects to be categorized because that description was consistent with his tentative structuring of the overall situations."58

In perceiving and predicting "usefulness of a decision rule depends directly on the accuracy of the predictions it makes: inversely on the number of points which must be scanned, the complexity of the rule, and the accuracy required."59 The class of perceptual rules Hunt deals with

55Ibid., p. 125. 56Bruner, op. cit.
are described as "template matching." Hunt states that "the subject is assumed to have a large set of templates that can be fitted to any subarea of the projection matrix. Each template requires certain information before it can be fitted."\textsuperscript{60, 61}

There are two components involved in the cost of applying templates: (1) The cost of testing the matrix to determine the input values for the templates and (2) the cost of testing to determine what template to apply.\textsuperscript{62} If the subject can determine, before testing, that the correct template is a member of a relatively small set of possible templates, the latter cost can be reduced. The subject can determine this by predicting, from his knowledge of the template which is applicable in one area of the matrix, what template might apply to another.\textsuperscript{63}

There is, according to Hunt, a relation between the number of dimensions required in the definition of a stimulus and the difficulty in applying a template. When a subject is viewing a matrix of stimuli he will frequently scan certain parts of the stimulus and infer as to the whole.

\textsuperscript{60}Ibid.

\textsuperscript{61}For an example of template matching see Chapter IV, p. 154.

\textsuperscript{62}Hunt, op. cit., p. 126.

\textsuperscript{63}For an example of this process see Chapter IV, p. 155.
Bruner is quoted by Hunt as stating that "perception is viewed as an act of inferring wholes from usually valid visual cues obtained from parts of the stimulus."64

Pikas approaches the problem of stimulus complexity in the same manner as Hunt. He states that research has indicated that the greater the number of relevant dimensions the easier the concept formation task. Also, according to Pikas, the increase in irrelevant dimensions increases the difficulty of the concept formation problem. This situation seems to apply both to concept formation and concept learning.

In the area of perception and stimulus organization and structuring, Pikas maintains that the problem solver uses a modified form of scanning the attributes and then falls back on those hypotheses which are most familiar to him. He does contend, however, that (specifically in sorting tasks) the formation of hypotheses is first orientated according to the familiarity of concepts. Further, he maintains that hypotheses are themselves concepts. Hunt is basically in agreement with the scanning practice and the use of familiar hypotheses. He also contends that the subject will locate points that transmit the most information about the stimulus matrix.

Pikas contends that concept formation must take into account the relationship perception has to it. He uses

64Bruner, op. cit.; cited in Hunt, op. cit., p. 129.
Wohwill's\textsuperscript{65} three dimensions along which conceptualization and perception are related as the basis for his discussion. The three dimensions are:

1. Redundancy: As one proceeds from perception to conception the amount of redundant information required decreases. . . .

2. Selectivity: As one proceeds from perception to conception the amount of irrelevant information that can be tolerated without affecting the response increases. . . .

3. Contiguity: As one proceeds from perception to conception the spatial and temporal separation over which the total information contained in the stimulus field can be integrated increases.\textsuperscript{66}

According to Pikas, the first two dimensions constitute the essence of the information theory approach to concept attainment. Regarding the second dimension "when the concept has once been stabilized, fresh information—which the subject also identifies as relevant—has less effect. According to the hypotheses on recoding, these recodings constitute a certain resistance to new disjunctive elements."\textsuperscript{67}

This approach is considerably different, especially in terminology, from that of Hunt. Hunt deals in the area of template matching while Pikas treats the area from the standpoint of the differences between perception and conception. However, that which Pikas has stated has been supported by research in the field. This may also be stated regarding Hunt's contentions.

\textsuperscript{65}Wohwill, \textit{op. cit.}, p. 98; cited in Pikas, \textit{op. cit.}, p. 135.

\textsuperscript{66}Ibid.

\textsuperscript{67}Pikas, \textit{op. cit.}, pp. 135-136.
In summary, it may be stated that Hunt approaches the areas of stimulus structure and perception in a more detailed manner than Pikas. Hunt emphasizes the concept-learner's use of a prediction rule as a result of what he perceives. It is possible that this prediction rule is influenced by past experience and could be related to the significance which Pikas places on past experience. The basic difference between Pikas and Hunt with regard to perception and conception is one of emphasis. Pikas emphasizes the relationship of perception to previously stored material (or experiences) and his recoding hypothesis. Hunt emphasizes the subject's use of perceptual rules or templates which the subject may apply to various concept learning situations. It should be noted, however, that templates can be regarded as products of experience on the part of the learner and could possibly fit in the theoretical framework of Pikas. The difference appears, then, to be one of emphasis rather than one of disagreement or incompatibility.

Memory, Concept Learning, and Concept Formation

Hunt maintains that human memory is of an associative type.

The internal (neurological) correlates of stimulus traces are assumed to be attached to each other, so that activation of part of the compound of nerve firing which occurred when the stimulus was originally presented will lead to the activation of the remainder of the compound. Thus the stimulus can be re-created, piece by piece.\(^{68}\)

\(^{68}\) Hunt, op. cit., p. 137.
According to Hunt, "memory may operate in stages: at recall association in memory may be searched to provide alternative reconstruction of the past event. These reconstructions could undergo a private screening before being made public." 69

In studies dealing with memory in concept learning situations the results have shown both primacy and recency effects in the retention of information. Subjects tended to remember or retain information from either the first or most recently presented stimulus. These results could, however, occur even if memory was not used at all. Hunt states "if subjects scanned the objects in some systematic order, a few dimensions at each instance, their ability to evaluate hypotheses about a given dimension would be a function of the location of instances transmitting information about that dimension in the training series." 70

Pikas uses memory as a significant factor in his theory of concept formation. His underlying contention is that the mechanisms involved in concept formation must take into account and "at a central point in the developing theory the existence of memory tracks or storings, or, to use a modern expression, memory codes." 71 The concept of memory or information storage is a necessary factor in Pikas's theory. His

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69 Hunt, op. cit., p. 137.  
70 Ibid., p. 147.  
71 Pikas, op. cit., p. 3.
reencoding hypothesis is based on the ability of the subject to store information in the form of a code and then recall and assimilate information in reencoding to reduce the number of symbols stored in memory. He states that "concept formation is not only affected by memory but is produced by memory and, we may also say, in memory."\(^7\)

As can be seen Pikas and Hunt are in basic agreement with regard to the role of memory in concept formation and concept learning. Both contend that memory is related to the original storing of data by the stimulus traces. Pikas does not deal with the primacy and recency concept which Hunt mentions but one cannot assume that they are in disagreement because of this fact.

Other Areas

There are a few areas which are treated by one or the other writer but not both. The major area to which Hunt gives emphasis is that of TOTES.\(^7\) Hunt contends that in approaching a concept learning situation the learner cannot state his decisions before he makes them but he can state the rules which he plans to use in arriving at a decision. He states that "there are computing rules, analogous to functions in mathematics. They take as their argument the

\(^7\)Ibid., p. 128.

\(^7\)For a detailed discussion of TOTES see Chapter IV, pp. 172-175.
information the environment provides and produce as their value the new decision rule. The learner can even have rules for changing his rules."74

According to Hunt, our plans of behavior consist of four stages which are, in essence, the TOTE unit: "a test to determine differences between the present and desired state of affairs, an operation to reduce these differences, a second test, and finally an exit when no differences exist. The entire cycle is a TOTE unit (an acronym for test, operate, test, exit)."75

In applying the TOTE unit to concept learning Hunt states that the test phase corresponds to the checking of the current hypotheses against data already known. The operating phase is the subject's strategy. Hunt calls it an "hypotheses-computing function." He states further that "if the first test reveals that the current hypothesis is not compatible with known data, this function is activated. Its inputs are the current hypotheses and the information that this hypothesis led to a certain type error. The value of the function is the new hypothesis, which will be tested in the second test phase."76

74Hunt, op. cit., p. 160  
75Ibid., p. 161.
76Ibid.
77A model of the TOTE unit may be seen in Chapter IV, pp. 174-175.
The value of the TOTE analysis, according to Hunt, is that it orients our thought process. In the TOTE framework the function of the components is stressed. A person is forced to determine what a particular step is for or what characteristics must it have.

Hunt is actually describing an active process in which the individual seeks the correct answer in a concept learning situation. This has a slightly different inclination than the related area discussed by Pikas. In the area of concept formation Pikas refers to the active process of identifying and organizing conceptual factors. The TOTE unit is, however, more compatible with the basic processes involved in concept learning than those in concept formation. There is no disagreement regarding the processes but rather treatment of a process which may be specifically related to concept formation.

There are several areas discussed by Pikas which are not treated by Hunt. These are the areas of summation and discrimination, definition of stimulus and correlation concepts. Pikas does not appear to state any particular position on the relationship of summation and discrimination. He contends rather, that the primacy of summation or discrimination has made concept formation difficult to investigate experimentally because of the problem of keeping these two factors separated. He infers that it is presently impossible to determine the relationship of the two.\footnote{Pikas, \textit{op. cit.}, p. 150.}
Regarding the area of stimulus, Pikas makes it clear that he considers insufficient the definition of stimulus as "the material the E (experimenter) manipulates with." He proceeds to place certain restrictions on the use of stimuli. There is no problem here regarding compatibility of theories.

Pikas discusses a type of concept which has been given the name "correlative concepts." These are defined as concepts which have natural opposites. This is discussed by Hunt also, but the term correlation concept is not used. Rather, it is treated as negative transfer. The function of the correlation concept or negative transfer is, as discussed by Hunt and Pikas, compatible.

Chapter Summary

In conclusion, it should be noted that there appear differing terminology and differing approaches but as far as the basic theoretical relationships between Pikas's theory of concept formation and Hunt's theory of concept learning, the data included in the past three chapters should be sufficient to establish that the two theories, as far as a practical working relationship with each other is concerned, are compatible.

79 Ibid., p. 188.
80 These restrictions are included in Chapter III, pp. 87-91.
A THEORETICAL STRUCTURE UNDERLYING A CONCEPTUAL APPROACH TO TEACHING

The following discourse consists of a theoretical structure underlying a conceptual approach to teaching. The major contention of this study is that a conceptual approach to teaching a given body of information can be beneficial to both teacher and student. Learning should be facilitated if the relevant information is condensed to a minimum number of major concepts. The concentration of teacher and student on a few major concepts, as opposed to concentration on all the individual component factors or on isolated techniques, should increase the student's capacity for retaining information. Vital to the learning of concepts is the process of reducing a vast amount of information to a unifying concept. In studies regarding concept formation and concept learning it has been found that students create symbols to represent given concepts. It has also been found that it is not the amount of information per concept or symbol which limits the student, but rather, the number of concepts or symbols which must be learned or formed.

A conceptual approach to teaching should be beneficial to both teacher and student in at least the following ways:
1. In a conceptual approach to teaching the teacher is not bound to the conventional approach of presenting to the student an organized, factual discussion of a body of information. The basic proposition here is that concepts are not taught; they are formed and learned on an individual basis. Concept formation and learning are not the results of an external structuring of a set of descriptive factors or attributes. Rather, it is the individual perception and internal structuring which determine how a concept will be formed or learned by a student. The contention is that the teacher should become involved in conceptual problem solving encounters along with the student rather than attempt to teach the student a teacher-defined concept. There should be a combined effort on the part of teacher and student as they, together, engage in the process of forming and learning a concept.

2. A conceptual approach to teaching should provide the student with learning experiences in inquiry, out of which he should develop certain fundamental questions. From an encounter with these fundamental questions the student should become involved in forming a conceptual structure. This particular conceptual structure may give rise to certain postulates or propositions, regarding the concept, out of which the student should be able to identify certain problems. In the formation and learning of a given concept he must become involved in discovering the various relationships between
the descriptive factors of a concept as well as the interrelationships between various concepts. It may be more appropriate to say that a concept is individually experienced rather than taught.

3. In a conceptual approach to teaching the student has a maximum opportunity to identify and define questions and to solve problems independently. The student is provided with a variety of independent learning and problem solving experiences. As has been previously stated, the formation and learning of a concept is an individual process which is dependent on at least two factors: the student's past experiences and present perceptions. Independent concept formation and learning experiences can be transferred beyond the immediate learning experience to new and different problem encounters. Conceptual teaching aids the student in being able to solve future problems, on the basis of past conceptual experience, without the constant supervision or guidance of a teacher. The student is provided with the maximum opportunity to become independent of the teacher in his own thought processes.

Levels of Intellectual Activity in Conceptual Teaching

There are at least three identifiable levels of intellectual activity in concept formation and concept learning. They are (1) acceptance of conceptual information, (2) conceptual information seeking, and (3) conceptual hypothesis testing.
Each of these levels of intellectual activity or thought processes requires a particular type of behavior on the part of the teacher and the student. It is possible that a student will function intellectually as a result of the combination of these levels. The level at which a student functions is, however, dependent on the thought processes of the teacher.

The first level, that in which the student merely receives conceptual information, is to be considered the least desirable. It may be considered the lowest form of conceptual thought. Concepts may be formed and learned by the student through the process of teacher instruction. However, there are several disadvantages to functioning at this conceptual level.

When conceptual teaching and learning is approached in this manner it usually amounts to no more than a teacher-defined concept presented as a set of irrefutable facts to the student who is then expected to memorize the concept and its various attributes.

When concepts are presented in this manner there is little, if any, opportunity for the student to develop the ability for independent conceptual learning. The student who is forced to accept a set of facts regarding a given concept is not afforded the opportunity to actively involve in problem solving encounters. He will tend to remain dependent on the teacher.
Concepts which are presented in this manner are limited as to their transferability to other learning situations. One of the significant advantages of higher levels of conceptual teaching and learning should be that of transferring a previously learned concept to a new or similar learning experience. When there is a significant degree of overlapping and inter-relatedness between concepts, as is the case in vocal concepts, the ability to transfer previously learned concepts can greatly facilitate learning.

When concepts are presented in this manner student interest tends to be minimal. Students are being presented with information which they may not consider relevant and which is totally teacher-defined and teacher-oriented. Research in concept formation and concept learning indicates that student interest is minimal in this approach.

Concepts which are presented in this manner offer the least incentive for student verification. One of the important factors in conceptual learning should be the verification or testing of one's hypotheses regarding a given concept. If concepts, as defined by the teacher, are presented as indisputable facts there is little need for the student to question these concepts. Thus, there will be little, if any, attempt to actively test and verify information given by the teacher.

The second level of intellectual functioning, that of conceptual information seeking, affords the student greater opportunity for independent thought. Research in concept
formation and concept learning has revealed that, as compared to the first level discussed, greater interest is normally evident. Also, the student may have opportunities to independently seek information regarding a given concept. The most significant problem, if restricted to this level of intellectual activity, is that it affords no opportunity for the verification or confirmation of information gathered concerning a given concept. Conceptual teaching is limited, often times, to a combination of the first and second levels of intellectual activity. The student may be taught a given concept and encouraged to study and eventually memorize a set of facts related to the concept. This will not suffice in conceptual learning.

The third and highest level of intellectual activity, with regard to concepts, is that of conceptual hypothesis testing. The first level, that of acceptance of conceptual information, may be by-passed when functioning at this level. There are advantages of teacher and student intellectual activity on this level:

1. The student has not only the opportunity to independently seek information regarding a concept but also has the opportunity to verify his information by some testing procedure.

2. As the student gathers information regarding a given concept he is able to transform that information into tentative hypotheses which he can test as to their validity.
3. As the student is involved in testing his tentative hypotheses he is also screening and omitting information which he identifies as irrelevant to the concept. Thus, he decreases the number of conceptual attributes to which he must attend, simplifying the conceptual structure and thereby facilitating conceptual learning.

4. As the student transforms the information regarding a concept into hypotheses for testing he more easily comprehends the common elements of different concepts. This should facilitate further conceptual learning, especially when the concepts are interrelated and dependent. In this way, the student will be more capable of transferring overlapping information and concepts to other learning encounters.

5. After sufficient hypothesis testing regarding a concept, it may be determined whether student has formed and learned the concept on the basis of his ability to consistently perform the concept.

A major objective in a conceptual approach to teaching is, therefore, the development of a student who is capable of deriving questions out of inquiry, forming conceptual structures, theorizing certain propositions regarding the conceptual structures, and arriving at relevant problems and solutions.

The following discussion deals with a set of theoretical propositions regarding a conceptual approach to teaching. The reader should be mindful that at least two objectives of
this conceptual approach to teaching are (1) maximum efficiency and effectiveness in both concept formation and concept learning and (2) the development of student ability to form and learn concepts independently within the problem solving frame of reference.

There are three major areas of consideration in the development of a theoretical structure underlying a conceptual approach to teaching which are discussed in the following paragraphs: they are (1) the thought processes or mental activity of the teacher, (2) the actual presentation of the concept, and (3) the relationship between student and teacher.

Thought Processes of the Teacher

The teacher's thought processes or mental activities are significant factors in creating an environment for conceptual learning. Teacher thought, directly or indirectly, elicits student thought. The type of thought processes the student engages in is dependent to a great degree on the type of thought processes in which the teacher engages. The teacher who approaches conceptual teaching on the first level of intellectual activity, that of presentation and acceptance of conceptual information, will tend to be a limiting agent in the student's conceptual problem solving development. Whereas the teacher who approaches conceptual teaching on levels two and three, those of information seeking and hypothesis testing, should maximize the possibilities of
student thought on those levels. There are certain thought processes on the part of the teacher which would tend to be conducive to creating higher levels of conceptual thinking on the part of the student. It is proposed that the teacher should engage in thought processes similar to the following:

1. The teacher should demonstrate that he is involved in cognitive processes of inquiry. The student, in conceptual learning, must function within the basic framework of inquiry. In order to function in the area of higher order conceptual learning the student must seek information regarding concepts, and then analyze and verify this information with regard to conceptual appropriateness. The mental set of the student (or his preparedness for a particular activity) is a vital factor in this process. The student who perceives his teacher as one who is continually seeking and inquiring will be inclined to imitate this behavior. Teacher and student may find it beneficial to inquire in cooperative effort. This should offer added incentive or motivation for the student.

2. The mental activity of the teacher should involve exploration. This is similar to inquiry but includes certain other connotations. Inquiry involves the identification of certain questions and the initial process of forming a conceptual structure; exploration involves not only these factors, but also the deriving of certain theoretical propositions and the experimentation with the problems arising
out of these theoretical proportions. As has already been implied, a teacher should not teach a student a concept. When a teacher introduces a student to an abstract concept, both teacher and student should seek information regarding the concept; or, in other words, they should seek the defining attributes of the concept. This should not be the end of the cooperative effort. Student and teacher further engage in the formation and testing of certain tentative hypotheses regarding the concept. The student who has been involved in this intellectual activity will tend to (1) be more interested in the problem at hand, (2) learn the concept more efficiently and effectively, and (3) be capable of transferring this conceptual knowledge to other problem encounters.

It should be recognized that this is similar to the educational idea termed the discovery method which is predominant at this time. The point must be reiterated, however, that one of the value dimensions of the exploratory approach is the guiding and, it is hoped, motivating force of teacher-exploration on the student.

3. The third characteristic of the teacher's thought processes which should be conducive to conceptual teaching is that of freedom of thought. Freedom of thought involves at least the following benefits: (1) The teacher should tend to be more receptive to new and perhaps better ideas, even though the ideas may originate with the student; (2) The
teacher should tend to be more flexible in his teaching. All students cannot be taught efficiently and effectively in the same manner. Flexibility in teaching should be especially beneficial in vocal teaching, which is the major concern of this study, where the teacher-student ratio is one-to-one; (3) The teacher should feel more freedom to experiment with new teaching approaches which might ultimately benefit the area of teaching and the effectiveness of his own personal teaching methodology; and, (4) The student and teacher should experience greater rapport with the student's awareness that the teacher is open and responsive to new thoughts and ideas.

4. A fourth proposition regarding the mental activity or thought processes of the teacher in a conceptual approach to teaching is related to his basic teaching attitude. By teaching attitude is meant the teaching structure out of which he approaches teaching. The teacher should be oriented toward a teaching structure of guidance. There are many approaches to teaching, such as authoritarian, laissez-faire, and discovery method, which are currently being used. The guidance structure can be significant in conceptual teaching. The mental activity of the teacher is, in a sense, an indication of what the mental activity of the student is likely to be. The learning of concepts should be maximized in efficiency and effectiveness when the teacher serves in the capacity of guiding students into conceptual experiences.
It was previously stated that concepts are least efficiently learned when they are taught as a set of facts. This may be taken a step further. Concepts should be experienced on an individual, personal basis. This involves the problems of individual perception which is discussed in a later section. Suffice it to state here that the teacher's role in concept formation and learning should be that of guiding the student into meaningful conceptual experiences. The actual process by which this is achieved is discussed in detail in a following section. The purpose of this discussion is to establish the importance of a teacher's teaching attitude. It should not approach the extreme of the authoritarian approach nor the laissez-faire approach. It should consist of guidance of a student within the framework of his own individual experiences, perceptions and capabilities.

5. The teacher's mental activity or thought processes should involve what may be called perceptive thinking. In conjunction with what has been stated regarding inquiry, exploration, freedom of thought and orientation toward guidance, it may be said that perceptive thinking involves elements of all of these. Benefits from perceptive thinking on the part of the teacher are (a) The teacher should be more sensitive regarding the personal interests of students; (b) The teacher should be more perceptive regarding the individual needs of students; (c) The teacher should be able to determine, in a more efficient way, the teaching approach
which would be most effective with each student; and, (d) The teacher should be better able to communicate with the student in terms of the student's own unique perceptions.

These are not intended to exhaust the areas of mental activity or thought processes on the part of the teacher which may be conducive to creating an effective environment for conceptual learning. These are, however, representative of the types of mental activity or thought processes which are under consideration and which have been proposed. Needless to say, the typical authoritarian, fact presenting approach is not a part of these thought processes. It should also be stated that teaching, involving the mental activity or thought processes previously discussed, is not easy. It requires more of the teacher than the student. It should, however, be the most rewarding to the teacher and the most beneficial to the student.

Presentation of Concepts

A second area which presents problems in conceptual teaching is the actual introduction or presentation of a given concept or set of concepts to the student. This section deals with problems such as whether or not a concept can be taught, what are the conditions for teaching concepts, and what teacher behavior is most conducive to concept learning.

Some thought processes of the teacher in conceptual teaching have been discussed. These processes are significant
in creating an intellectual atmosphere for conceptual learning. However, a theoretical structure for conceptual teaching must also include certain theoretical propositions regarding the processes by which a student forms a concept and subsequent teacher-student involvement with the concept. The following are considerations which should be given to the conceptual learning situation.

1. A concept should not be presented structurally to a student in the same way a teacher has formed the concept.

A basic problem in the conceptual teaching is the tendency on the part of the teacher to analyze and form a concept and then instruct the student as to the component attributes of the concept. This problem has been previously mentioned but it may prove beneficial to mention the specific disadvantages of teaching what might be considered a teacher-defined concept.

One disadvantage of this approach is that it may virtually eliminate independent inquiry and hypothesis testing on the part of the student. This would be no more than that which is so predominant in today's classrooms where a teacher tells a student or group of students about a particular area of concern.

Also, a factual presentation of a teacher-defined concept will tend to negate independent problem solving on the part of the student. It is granted that relatively effective learning and performance results may be accomplished
under the constant supervision of a teacher. What happens when the student is no longer a student and the teacher has long since been forgotten? Will the student be capable of identifying, analyzing and solving his own problems, whether they be conceptual problems or otherwise?

A further problem, in the presentation of teacher-defined concepts, is that the individual, unique perceptions of the student are ignored. Conceptual learning, at its highest, is an individual process. The actual formation and learning of a concept depends, in great part, on the particular way an individual student perceives a conceptual structure. Even if a student were to memorize a teacher-defined concept, it cannot be assumed that either the concept or the verbal descriptions of the concept have the same meanings to both teacher and student. More will be stated regarding the role of perception in concept formation and learning.

Finally, the presentation of teacher-defined concepts tends to reduce conceptual teaching to no more than a factual presentation. It must not be assumed that facts are inherently bad. In consideration of the ultimate objective of conceptual teaching, that of developing a student capable of inquiry, analyzation and solution of problems independently, it must be contended that mere presentation of a body of facts will not suffice in the attainment of this objective.
It is proposed, then, that the teacher refrain from instructing a student or teaching a student about a concept which, possibly, only the teacher has actually experienced.

What then are some of the propositions concerning the presentation of a concept which will tend to facilitate conceptual learning? Some of these positively stated implications are

2. A concept should be identified in terms of the unifying attribute (sometimes called the dominant attribute) or what may be called the key to the concept.

   a. A concept will normally possess a dominant attribute which represents the summation of the concept. It is virtually impossible to attend to all the attributes of a given concept each time the concept is encountered.

   b. A student, in forming and learning a concept, will tend to discriminate the attribute which is most accurately representative of the total concept. This attribute is often spoken of as the dominant trait, the unifying factor or attribute or even the "key" to the concept. The actual process, however, is one of summatizing all the attributes of the concept, usually by scanning the attributes, and arriving at some mental description of the concept which is, supposedly, inclusive of the relevant attributes previously scanned. The tendency in concept learning is to "melt together" all the attributes of a concept and arrive at a basic descriptive
focus of the concept or what has previously been called the dominant trait or key to the concept. The student will, then, create by some means (the means are not clear nor the process) an internal symbol for the total concept. Upon recall or possibly external presentation of this symbol the concept would be remembered by the student. It must be remembered that this immediately preceding discussion is basically theoretical in nature. However, it is sufficient to merit the next consideration.

c. The unifying attribute (dominant trait, attribute or key to the concept) should be determined as a result of cooperative teacher-student inquiry.

In the first place it has been proposed that focusing on the dominant attribute will facilitate the formation and learning of a concept. In the second place, it has been proposed that teacher and student perceptions will most likely be different. Therefore, in order for the teacher and student to benefit from the dominant attribute of a concept, the dominant attribute must have a commonality of meaning between teacher and student. This would necessitate a cooperative inquiry on the part of teacher and student. This brings us to the final proposition.

d. Joint discrimination of the dominant attribute or key to the concept by teacher and student should simplify the formation and learning of a concept and
thus facilitate efficient and effective concept formation and concept learning. The significance of this proposition has been discussed in preceding paragraphs. This does, however, give rise to some problems which are worthy of future study. These problems will be discussed in the final chapter.

3. Another proposition regarding the presentation of concepts is that a concept should be presented as a whole rather than concentrating on component attributes or parts of the concept.

This proposition is similar to the previous one but does offer some unique problems.

a. It has been found in research on concept learning and concept formation that concentration or focusing on isolated attributes or parts of a concept tend to cause the students to fixate on these isolated attributes. Thus, a total picture or image of the concept is not gained. This practice may be witnessed quite often in the classroom and especially in the vocal studio. The real concern of a learning situation may actually consist of an over-arching or under-lying concept which is broad and inclusive in scope. However, because of the difficulty in correct conceptual teaching, or various other reasons, the learning situation is quickly restricted to the abstraction and discussion of isolated parts of the concept or even to isolated,
unrelated facts. Concept presentation is facilitated when concepts are approached in terms of the total concept. Failure to present concepts as wholes leads to the following problem.

b. The tendency toward isolation of conceptual parts may cause the student difficulty in identifying a dominant or unifying attribute and in the creation of a symbol which is adequately representative of that concept. In order to discriminate an attribute or key to the concept it is necessary to give appropriate consideration to all the relevant attributes. Failure to do so normally hinders concept formation and concept learning and leads to so called errors in concept formation and learning. Adequate concept formation and concept learning is dependent, in part, on the opportunity and ability of the student to perceive a concept as a whole. The teacher's role, as has been discussed, is vital in this regard. Problems are also created regarding future conceptual learning if concepts are not presented as wholes. This is illustrated in the following proposition.

c. Concentration on isolated attributes or parts of a concept will tend to make succeeding conceptual learning more difficult. In a given academic area concepts usually possess a high degree of interrelatedness and dependence. When concepts are interrelated
and dependent on one another the correct formation and learning of one concept should facilitate the formation of other concepts. If, however, the initial concept is not correctly formed and learned this would, of course, be a hindering factor in the formation and learning of related concepts. It is, therefore, most expedient to approach the presentation of concepts as wholes.

4. A fourth consideration in constructing a theoretical structure for conceptual teaching is that the sequence in which concepts are presented should be student-oriented sequence.

In most classrooms or private vocal studios the sequence with which a body of information is presented is teacher-determined. While the following considerations may not be pragmatic in nature, especially in a classroom situation, they are significant in conceptual learning situations. It should be noted that in a vocal studio situation where the teacher-student ratio is one-to-one these propositions are as practical as using a single sequence of teaching for all students.

a. In the first place, it is virtually impossible to identify or determine a correct sequence of presentation in any academic discipline. There are ultimately too many factors to consider: the teacher as an individual, the students as many individuals and the environment of the classroom are but a few.
b. In the second place, it is significant in a sequential conceptual presentation that the individual student see some justification or rationale for a particular sequential approach. This does, of course, present many problems in a classroom situation. Can a class of students be approached in such a way that each individual student sees justification or rationale for the particular sequential approach? The answer is, of course, no if one restricts the classroom teaching to the conventional, authoritarian, lecture-type approach. This is a problem area which has been identified but it is not within the scope of this study to resolve the problem. This proposition is, however, especially relevant to the private vocal studio. The following proposition is related to the one under consideration.

c. The sequential conceptual approach is ultimately dependent on the individual student. This has, of course, already been implied. While only indications have been given for resolution of the classroom problem (see the discussion regarding thought processes of the teacher), it should be evident that there really exists no significant problem to this proposition in the private vocal studio, which is the primary concern of this study. Since the sequential conceptual approach is dependent primarily on the individual student the following proposition is appropriate.
d. The following are representative criteria for determining a given sequence of concept presentation:

**Simplicity of presentation.**--The simplest approach is usually the most efficient and effective approach in concept formation and concept learning. The objective in concept formation and learning is to reduce the complexity of the concept in order to expedite formation and learning.

**The rationale of the sequence.**--Another factor which has been mentioned but should be reiterated is that the student must see some justification or rationale for the sequential presentation.

**The progression of the sequence.**--A third criterion is that of the sequential progression. There are, of course, sequences in any discipline which would not represent a logical progression.

**Individual student consideration.**--A final criterion is that of individual student considerations. In a learning situation, such as the vocal studio, each student will have his own unique problems, interests, experiences and so forth. These must be considered in determining the most effective conceptual sequence. It may be felt that entirely too much attention has been given to the sequence of conceptual presentation. This is, however, a significant factor in concept formation and concept learning and, as has been discussed,
involves many related areas such as consideration for the individual student. Not only is the sequence of conceptual presentation important in concept formation and concept learning, the rate of conceptual progress is also important. This is explained in the following proposal.

5. The rate with which a teacher introduces succeeding concepts to a student should be relative to the rate of formation and learning of the individual student. At first glance, this may not appear to possess a great deal of significance. It is, however, certainly comparable with the previous proposition regarding the sequence of conceptual presentation.

   a. In the first place, there is no fixed-rate of concept formation or concept learning which applies to all students. This, of course, can be said of any type of learning encounter. It should be stated again that conceptual learning is an individual process and opportunity to demonstrate this individuality is vital to concept formation and concept learning.

   b. A given concept should be correctly formed and adequately learned before progressing to a second concept. This is especially true when the concepts are interrelated and dependent. The correct formation and learning of one concept would then facilitate the formation and learning of succeeding concepts. This
proposition is, however, compatible with the proposition that conceptual learning situations should be made as simple as possible. The more complex a conceptual learning situation the longer it takes to form and learn a concept and the greater tendency there is toward errors in formation.

c. The criterion for determining if a student has formed and learned a concept is his ability to consistently perform the concept. Performance of a concept may be stated in other ways such as one's ability to explain the concept or demonstrate the concept. Performance of a concept is especially applicable to vocal teaching.

d. When a student is guided by a teacher in inquiry, exploration and verification of concepts he will normally progress at a self-determined rate. It should be remembered that this is not a recommendation for a \textit{laissez-faire} approach to teaching. Rather, it is a proposition regarding the validity of student-determined rates of progress. It is granted that learning may appear to progress more slowly using this concept of teaching. This is, however, most probably a temporary state. Students must become oriented to this approach to teaching and learning in order for it to be most effective.

The vocal studio, where the teacher-student ratio is one-to-one, provides an ideal environment for this
approach. The problem of whether or not one can teach a class of students and still provide opportunity for individual rates of progress is at least a theoretical possibility. It is not, however, within the scope of authoritarian or teacher-defined approaches to teaching.

e. Concepts correctly formed and adequately learned, especially when they are related to performance, become habits of behavior capable of being elicited by external presentation or individual recall of the representative symbol for the concept.

One of the phenomena of conceptual learning is the ability to condense a multi-faceted concept into a single unifying symbol. Adequately learned concepts tend to evoke an appropriate behavioral response with a minimum of mental activity. Thus, when a given concept is correctly formed and adequately learned the student is better prepared to encounter a new concept. The new concept, under these conditions, will present the least amount of learning interference. The following proposition is related to this contention.

f. Introduction of a new concept or new information prior to the correct formation and adequate learning of a concept being studied will tend to frustrate the student and hinder both the learning of the original concept and new concept. This is related to the statement regarding the need for simplicity in
conceptual presentation. Early in the process of concept formation and concept learning, when the concept is not firmly established, introduction of a new concept or additional information serves in the function of interfering stimuli. Research in concept formation and concept learning indicate that this condition produces frustration and the tendency toward errors in concept formation and concept learning.

In general, it has been proposed that conceptual teaching be based primarily on the individual student being considered.

6. A further proposition regarding the presentation of concepts is that concepts which have been previously formed and learned should be reviewed periodically.

   a. As has been stated, when a student forms and learns a concept he creates a symbol which is representative of that particular concept.

   b. By means of symbol recall the student will, possibly unwittingly, evaluate his concepts periodically. This is especially true when a student is constantly using a given set of concepts such as in vocal performance. During this evaluation of concepts the concepts may go through certain revisions. During the process of revision the student may select some symbols or concepts for retention and mentally discard others. Whether or not he retains certain information
regarding a concept is the result of the information's perceived relevance to the problem in question at the time it was stored and its relevance to later problems encountered by the student. Review of concepts on the part of the teacher and student should facilitate the student's retention of the appropriate attributes of the concept from which the student created his representative symbol. This is simply a part of learning theory and applies not only to conceptual learning but other types of learning also. It is, however, a significant factor in the theoretical structure of teaching concepts.

7. Another consideration regarding a conceptual approach to teaching is one which is an outgrowth of the discussion concerning the teacher's thought processes. That is, a teacher should serve primarily in a guidance capacity in conceptual teaching. Much has already been said regarding this proposition. There are, however, other relevant considerations.

a. In the first place it is important that the student be guided into an encounter or experience with a given concept. The conventional approach of presenting information to students is not the most advantageous approach for teaching concepts.

b. In the second place, it is vitally important that the student be allowed intellectual freedom and
opportunity for self-expression in conceptual learning. Students should be provided not only the opportunity for creative thought but be encouraged to express themselves freely regarding their thought.

c. And finally, as has already been suggested, the teacher should inquire and explore concepts along with the student. This is beneficial in creating student interest and in establishing a rapport with the student which is conducive to further conceptual learning.

8. By way of a final theoretical proposition it is theorized that in presenting concepts to students, teachers should be mindful regarding the problem of individual perceptions of the students. Attention has already been directed to perception as a significant factor in conceptual learning. The following considerations are offered in this regard:

a. The individual student's unique perceptions will determine how he will respond to a given conceptual presentation. By respond is meant how he will receive, interpret, form and learn the concept.

b. Concepts are virtually impossible to teach by the use of word meanings. The problem arising here is that of attempting to verbalize a concept to another person. It goes without saying that words have different meanings to different people. The student may not perceive a verbal description of a concept in the same way that the teacher intends it. This is why so much emphasis
has been placed on providing opportunity for the student to experience a concept. Combine the problem of verbal meanings with the frequently used vagueness of vocal expressions and the problem is made even more complex. The formation should grow out of the student's own experiences and perceptions.

c. A teacher should not assume that a word or a verbalized concept means the same thing to a student as it does to him, or that all students will perceive a verbalized concept with like meanings and understandings.

d. Finally, the value of guiding students into individual experiences with concepts is reiterated in light of this proposition. The entire discussion regarding the teacher and presentation of concepts has been oriented in this direction.

The preceding have been theoretical propositions underlying a conceptual approach to teaching. The first section was given to the discussion of the teacher's thought processes or mental activity which would be most conducive to conceptual learning. The immediately preceding discussion has consisted of a set of theoretical propositions regarding the actual presentation of a concept to a student. Neither of these discussions should be taken to be exhaustive in scope. There are undoubtedly other considerations which were not mentioned. These are, however, the most significant considerations
in view of the research in concept formation and concept learning.

Teacher-Student Relationship

Another area underlying the theoretical structure of conceptual teaching, in addition to the thought processes of the teacher and the actual presentation of concepts, is one relative to the relationship between student and teacher. Inferences have been made concerning this teacher-student relationship in the previous discussions. The following discussion is, however, directed more to these considerations which are significant in developing a personal rapport between teacher and student which will maximize the environment for conceptual learning. The ultimate basis for this type of rapport, in addition to the considerations already discussed, revolves around the conditions which make for effective communication between teacher and student. There are numerous considerations which are relevant to teacher-student communication in conceptual teaching and learning.

Many of the considerations relevant to teacher-student communication tend to cluster around the contention that each student should be regarded as an individual. It seems as though this has been stated several times prior to this. It is, however, a significant factor in communication. Several propositions have already been made regarding this contention. Some of these are: (1) Concepts are formed and learned on an individual basis; (2) There should be a joint approach to
inquiry and exploration of concepts; (3) The problems of a student's individual perceptions should be considered; and (4) The teacher should serve in a guidance capacity with the student.

There are several other considerations which are related to this proposition which may, at first glance, appear to be trivial. However, it has been indicated by the research in concept formation and concept learning that these are significant considerations.

1. Teacher-student communication depends to a great extent on what may be termed a commonality of experience. This simply means that the more experiences the teacher and student have had in common the more likely they will be able to communicate in terms of common perceptions. Other practical considerations in this vein are

a. The teacher should strive to know a student on a personal basis.

b. The teacher should strive to understand a student's problems.

c. The teacher should strive to demonstrate a genuine interest in the student, above and beyond the professional interest.

d. The teacher should demonstrate confidence in the student, his ideas, and his abilities.

e. The student should feel that his teacher is always available to him. A student will, many times,
need what is called information feedback. These times may not always be at the given class hour or voice lesson time. The student should feel free to call upon his teacher. The teacher, of course, is the one who does or does not create this feeling in the student.

If the student is convinced of the teacher's interest and concern for him as an individual this, in itself, should serve to break down barriers to open and free communication.

The reason so much emphasis is being placed on teacher-student communication should be evident. Virtually all that has been stated previously is ultimately dependent on the level of communication between teacher and student.

2. Related to the area of communication but worthy of separate treatment is the theoretical proposition that students should never be subjected to threat or unreasonable amounts of external stress.

a. There are no circumstances in which threat may be justified as part of the teaching-learning process, especially in conceptual learning. Research indicates that concept formation and concept learning are significantly hindered under conditions of perceived threat. The more difficult or complex the concept the more adverse effect threat tends to have on it. A teacher should never subject a student to any circumstance which is threatening or which may be perceived as threatening. The teacher should be careful of these situations which
are not actually threatening but which may be perceived as threatening by the student. This is another argument supporting the previous contention that a teacher should be knowledgeable regarding the experiences, interests and capabilities of his students. This knowledge should give some insight into what situations the student might perceive as threatening.

There are probably few teachers who would intentionally threaten a student. There are, however, many teachers who, sometimes unwittingly, use indirect methods of threat. These indirect threats are often disguised under headings of motivation and stimulation. Such indirect methods of threat may be found in forms such as pressure regarding grades, threat of dismissing an individual as a vocal student, extreme expectation regarding a student's progress or performance, embarrassment of students in the presence of others, or other similar methods of threat. These are, it is assumed, intended to be methods of teaching which will motivate or stimulate a student to work harder and faster. Research in concept formation and concept learning does not, however, support this assumption. Threat or perceived threat has been found to hinder concept formation and concept learning.

3. An area which is somewhat related to threat is that of external stress. External stress refers to pressure from
people or conditions other than the individual involved. This is not to be confused with drive which is normally considered to originate from within the individual. There is a point at which external stress can be frustrating and debilitating to the student. A teacher who forces a student to progress at a teacher-defined progression rate or who subjects the student to undue stress may hinder effective conceptual learning. It is, of course, impossible to determine in advance the amount of external stress which would be most effective for a given student. The better the teacher knows the individual student the more insight he should have regarding the degree of external stress which may be effective in conceptual learning.

Summary Regarding Theoretical Structure

The following discussion has consisted of a set of theoretical propositions, all of which have been indicated in the research in concept formation and concept learning, underlying a conceptual approach to teaching. Attention has been directed to three major areas of concern: (1) the thought processes or mental activity of the teacher, (2) the actual presentation of the concept by the teacher and subsequent reception by the student, and (3) the relationship between teacher and student which appears to be most conducive to conceptual learning.

The intent of this study has been the construction of a set of theoretical propositions, regarding a conceptual
approach to teaching, broad enough in scope that a teacher could arrive at some basic guidelines for a conceptual approach to teaching in any academic discipline. The major concern of this study is, however, in the area of vocal teaching.

Vocal teaching has, for many years, been limited primarily to the teaching of techniques in singing such as techniques of respiration, phonation, resonance, range and dynamics. There is, however, a significant difference between techniques in voice and concepts in voice. In order to present the reader with an accurate contrast between techniques and concepts, a general discussion of the areas of techniques of respiration, phonation, resonance, range and dynamics will be given. It is theorized here, however, that these vocal techniques can be effectively condensed to a minimum number of vocal concepts and that a conceptual approach to teaching within the framework of the previous theoretical propositions should facilitate conceptual learning and performance in vocal singing.

Vocal Techniques

The vocal techniques included here are discussed within the following framework:

1. Definition of the technique.

2. Factors regarding the technique or teaching of the technique on which vocal pedagogues in general agree.
3. The basic problem areas related to the technique.

The techniques of vocal singing included here constitute those vocal functions which normally lie within the framework identified by many vocal pedagogues as the motor, the vibrator and the resonators. The motor, in this case, is generally considered to be the singing breath; the vibrator is regarded as the vocal cords or vocal folds; and the resonators are generally regarded as the head resonators, chest resonators and nasal resonators. These terms may vary somewhat depending on the individual writer. The five basic techniques discussed here are:

1. The technique of respiration.
2. The technique of phonation.
3. The technique of resonance.
4. The technique of range.
5. The technique of dynamics.

The Technique of Respiration

Respiration or breathing may be defined as "the act or process of drawing air into the lungs for oxygenating and purifying the blood, and its subsequent exhalation."¹ Correct breathing is one of the necessary functions which must be performed by the singer. Trusler states that ". . .

controlled breathing is the foundation of singing." There are teachers of singing who contend that breathing is the single most important factor in the production of the singing voice.

Other writers in the area of vocal pedagogy, such as William Vennard, contend that it is unnecessary to spend a great deal of time teaching a student to breathe properly as he sings. Vennard states, "It (breathing) is primary in importance, but it is easy to understand and can be practiced without the aid of a teacher."

The American Academy of Teachers of Singing are agreed on the following statements regarding breathing in the singing process:

1. Believes in teaching the pupil how to breathe.
2. Believes that the correct practice of singing in itself tends to develop and establish the mastery of the breath.
3. Believes that the singer should stand comfortably erect, with the chest medium high, and with a feeling of flexibility and well being.
4. Favors the method of breathing which is known scientifically as "Diaphragmatic-Costal," colloquially as deep breathing.
5. Believes that in inhalation the upper abdomen expands, owing to the descent of the diaphragm, and the ribs expand; in exhalation the abdomen tenses and contracts, owing to the pressure of the abdominal muscles and to the gradual ascent of the diaphragm and the ribs contract. Thus, the greatest observable effect in both

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inhalation and exhalation is at the sides and in the region of the waist-line.

6. Believes that either the mouth or the nose may be used in inhalation.

7. Recommends the daily practice of calisthenics or setting-up exercises.4

The discussion of the technique of breathing may be treated in two major areas: posture for breathing and physiological factors involved in breathing.

One of the major factors in correct breathing for singing is that of posture. It should be noted at the outset that there is not a single postural state which is best for all singers. However, there are some guidelines of which the beginning student of singing should be cognizant. The basic postural position which should be taught to the beginning student of singing involves the following:

1. The head should be held erect, but not rigid.
2. The shoulders should remain in a natural, relaxed but not slumped position.
3. The chest should be carried high in the frontal position and expanded in the under-arm regions.
4. The back should remain straight so as to align the head, chest and pelvis.

Figure 11 illustrates graphically the correct postural position for the upper torso.5 The side view illustrates the erect postural position desired for singing. The dotted lines indicate the chest and back expansion during inhalation. The frontal view illustrates the shoulder and arm position desired


5Illustration taken from Trusler, op. cit., p. 3.
Fig. 11—Postural position of torso

for singing. The dotted lines indicate the expansion which occurs in the rib cage during inhalation.

The position of the lower limbs is also important. The legs should remain straight but not in a locked position at the knee area. It can be beneficial to the singer to place one foot slightly in front of the other. This makes it possible to shift body weight from one foot to the other aiding the student in maintaining a relatively relaxed postural position.

It should be noted that in the teaching of the breathing process and the correct posture for breathing the teacher should concentrate not so much on the physiology of a student’s posture (even though he must know and understand these factors) but on the objectives of the postural position.

Vennard states

It helps to imagine that you are a marionette, hanging from strings, one attached to the top of your head and one attached to the top of your breast bone. This keeps the head erect and lifts the chest,
allowing the pelvis just to "hang" in position. Imagine that the strings pull you a little toward the audience.6

With some imagination one can visualize or sense the major objectives of this postural approach; they are a feeling of expansion, freedom of bodily movement and the ability to control and use the breath.

**Diaphragmatic-Costal Breathing**

There are two basic types of breathing. They are diaphragmatic-costal and clavicular or chest breathing. There is a tendency for beginning singers to indulge in clavicular breathing. This process of breathing is evidenced by inability on the part of the singer to sing long phrases, and by inadequate control over the breath which he has.

The diaphragmatic-costal type of breathing is the most efficient method of breathing for singing. This type of breathing involves primarily the function of the intercostal and diaphragmatic muscles.

The intercostal or rib muscles are between the ribs and consist of internal and external intercostals. The function of the external intercostals is to pull the ribs upward toward the backbone by their contraction. The external intercostal muscles are inspiratory in function since their movement increases both diameters of the thorax. The internal intercostals serve the opposite function of the

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external intercostals. Their action involves the pulling of the ribs down again in the process of exhalation.

There are a number of other less significant muscles in the rib cage and back areas which are involved in breathing. However, these muscles have little or no relationship to the cognitive processes of the individual and therefore will not be discussed.\(^7\)

The muscle playing the most significant part in the breathing process is the diaphragm. It is considered by some to be a muscle of the belly, serving as the "ceiling of the belly."\(^8\)

The diaphragm is most frequently described as a dome-shaped muscle which separates the chest and stomach cavities. Figure 12 shows a cut-away illustration of the diaphragm.\(^9\)

When inhalation occurs the diaphragm tends to flatten and move downward, pressing against the viscera which results in the outward protrusion of the belly. The position of the diaphragm during deep inhalation is illustrated by the broken line in Figure 12.

There remain several belly muscles which have some function in the breathing process but, as was true in the

\(^7\)For a detailed discussion of these muscles the reader is referred to Vennard, \textit{op. cit.}, p. 23.

\(^8\)Ibid., p. 24.

\(^9\)Figure 12 taken from Christy, \textit{op. cit.}, p. 29.
case of the less important rib cage muscles, these are not significant in the conceptual approach to teaching correct breathing since they are involuntary in nature.  

Vennard summarizes correct breathing as "in, down, and out." The air is taken in through the nose and mouth, down into the lungs which then cause the thorax to expand outward.

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10. For a discussion of these belly muscles and other muscles involuntary in nature which are involved in the singing process see Vennard, op. cit., pp. 24-26.

11. Vennard, op. cit., p. 27.
Christy states that there are four basic phases involved in the breathing process as used by the singer. They are inhalation, suspension, exhalation, and recovery. In the process of inhalation, Christy mentions several factors which should be noted here. In the first place the chest, as a postural position, should be raised to a high position prior to inhalation. The chest is not raised by the inhalation process. Further, Christy maintains that a yawn position of the throat be established while inhaling. The process of inhaling while maintaining a yawn position aids in the relaxation of the throat and all phonation muscles. While learning the correct process of inhalation the student should also learn to take and control a deep, full breath. Christy recommends that the student be guided in practicing full, deep breathing exercises without singing.

Christy further states that after one has completed inhalation there should occur a "hold" in the diaphragm muscle around the waist-line, with a consequent firming of the belly wall. He states, "After inhalation there is a sensation as if breath were continuing to be taken in when suspension starts. This feeling holds the air column in balance, moving neither in nor out, until the attack."\(^{12}\)

The third phase in breathing according to Christy is exhalation. This phase, which is also the process of

\(^{12}\)Christy, _op. cit._, p. 31.
phonation will be discussed in a separate section. Suffice it to state here that exhalation or phonation is the process by which the singer conserves his breath, producing enough breath flow for a steady, legato singing tone.

Christy states that recovery is the final phase in the breathing process. He says, "Recovery is primarily physical—a moment, no matter how brief, of relaxation in the breath control muscles and larynx before the new phrase is attacked."  

The student of singing must become proficient in the correct process of respiration or breathing for singing to the extent that he inhales and exhales as a matter of habit rather than by concentrated effort. It will be seen later how this method of approaching breathing is related to the student's formation and learning of the concept of breathing.

The Technique of Phonation

Phonation may be defined as the

... act or process of generating vocal sound; it is the inception of vocal tone at its point of production in the larynx. ... Phonation is the vibratory activity of the vocal cords so as to produce pulsations sufficiently rapid to cause the sensation of tone.  

Good vocal tone or correct phonation depends on the coordinative functioning of the following:

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13 Ibid., p. 32.
14 Fields, op. cit., p. 98.
1. Controlled breath.

2. A larynx whose normal position, neither locally raised or lowered, is insured by correct inhalation, and allows freedom of action of the tongue to which it is attached.

3. Vocal cords in unhindered vibration. These three produce a fundamental tone proportionately reinforced by --

4. The resonance chambers of the chest and the head (mouth and nasal cavities), and issuing through

5. a free throat;

6. Tongue, palate, lips, and jaw, all freely active in pronouncing without rigidity, and with no locally specialized effort for supposed aid to the tone.

This tone, easy flowing, smooth, permits every variety of expression in singing. Its inception, following inhalation is the attack; that is, the immediate application of breath to the vocal cords, after pitch and vowel adjustment of the whole apparatus.15

The vibrator, which actually is the origin of tone, is housed in the larynx and called by a variety of names, such as vocal cords, vocal folds, vocal bands and so on. In the actual phonation process these vocal folds come together and offer resistance to the passage of air (breath) through them. The air forced through the vocal folds causes them to vibrate. Vennard states that as the air escapes through the vocal folds "compression waves at audible frequencies are created which travel through the atmosphere at a speed of 1100 feet per second. It is the elasticity of air that determines this speed, not the flow of breath. That which travels is not air, but energy from released air pressure."16

15 Christy, op. cit., p. 39.

16 Vennard, op. cit., p. 38.
The process of phonation begins with the inhalation of sufficient breath for a given passage to be sung. The air is directed by use of the breathing muscles (previously discussed) through or past the vocal folds or glottis which offers a certain resistance to the air pressure inducing glottal vibrations, thereby focusing the energy of the tone. This vocal tone is then formed and projected by use of the resonators.

The phonating process originates in the larynx or voice box which, according to Fields,\textsuperscript{17} consists of five basic structural elements: "(1) a ring-shaped (cricoid) cartilage; (2) a pair of small ladle-shaped (arytenoid) cartilages; (3) a shield-shaped (thyroid) cartilage; (4) a pair of vocal cords (thyro-arytenoid muscles or folds); and (5) a U-shaped (hyoid) bone.\textsuperscript{18}

The one basic physiological factor which plays an important part in the phonation process is that of tension or rigidity in the vocal mechanism. This will be discussed in more detail regarding the concept of resonance. It is, however, necessary in correct phonation that the physical locations involved in phonation be appropriately used during phonation. Posture is an important consideration and may be discussed with the inclusive meaning of pertaining to all the physiological factors in the phonation process. Of special

\textsuperscript{17}Fields, \textit{op. cit.} \hspace{1cm} \textsuperscript{18}\textit{Ibid.}, p. 124.
significance in phonation are the laryngeal positions, the throat position (including the uvula), the palate and tongue positions, the shoulder and chest positions, the head position and the rib position. Common faults with regard to these physiological aspects include such things as the fluctuation (up and down) of the larynx during the phonation of high or low tones, the closed throat and low-hanging uvula, the attempt to focus the tone on either the hard or soft palates and the rigid placement of the tongue. Problems arising regarding phonation from such practices as the drooping or sagging shoulders, the sunken chest position, the lowered rib cage and various inappropriate head positions have been mentioned prior to this. It is, however, necessary to establish the relationship between posture and phonation. The incorrect physical position of any of these factors mentioned could create undue tension and rigidity of tone primarily in the laryngeal area. The technique of phonation will be discussed further with regard to its relationship to resonance.

The Technique of Resonance

By definition "resonance is the intensification and enrichment of a musical tone by means of supplementary vibrator. It is also the result of synchronous vibrations that blend with the initial pulsations issuing from a generator of sound. . . . the effect of resonance is to
increase the initial tone or to change its quality or both."\textsuperscript{19}

The generator of the sound (the phonation process) has already been discussed. One can hardly separate these two processes. Many of the factors which adversely affected the process of phonation also affect the process of resonation. Fields contends that "the process of phonation and resonation are related to each other as cause and effect. The line of demarcation between the two is not clearly made."\textsuperscript{20} It will, therefore, be necessary to repeat some of the statements made regarding the concept of phonation.

There continues to be some disagreement among vocal authorities regarding the function of the various resonators. Many vocal authorities consider the basic resonators to be the mouth, head and chest.

Christy contends that the major controversy regarding the resonators lies in the area of the function of the head and chest resonators. There is, according to Christy, little disagreement that the "character and force of resonance are changed by shape and size of mouth and pharynx space and by relaxing or tensing the tongue and surfaces of the pharynx and the soft palate."\textsuperscript{21} Although there is considerable

\textsuperscript{19}Fields, \textit{op. cit.}, p. 129. \textsuperscript{20}\textit{Ibid.}, p. 144.

\textsuperscript{21}Christy, \textit{op. cit.}, p. 46.
disagreement regarding these resonators, Christy maintains that "authorities . . . generally agree that the singer normally should experience a sensation of head and nose vibration or resonance in order to achieve balanced tone, and that some feeling of sympathetic chest resonance is desirable for the low compass."\(^{22}\) He further contends that it is not really important whether or not the head and chest are actually resonators. The real value in singing is in feeling the forward projection and hum of the nasal area and the vital tone in balanced resonance.

Contrary to what many teachers of singing taught in past years (some even today), there is no support for the concept that a given tone resonates in a single area, such as the "head tone" concept.\(^{23}\)

Vennard discusses two theories of vocal resonance: the Helmholtz and Wheatstone theory, which reduces resonance to the vibration of the glottal lips, producing a series of partials (the first being the fundamental) which are reinforced by the cavities above the glottis (this is called the overtone theory of vowels), and the Scripture theory, which contends that not overtones but a series of puffs is produced by the larynx. According to this theory the larynx is relatively unimportant. Its function is like that of the vibrator of a reed instrument whose function is to set

\(^{22}\)Ibid., p. 47. \(^{23}\)Ibid.
into vibration a column of air. The power and beauty of the tone are products of the resonators.\(^{24}\)

The principles which Vennard uses as a basis for understanding resonance are

1. Any resonator is a secondary vibrator.
2. The vocal resonator is a column of air. It is not a sounding board of some sort, as comparisons with stringed instruments would make it.
3. The shape of the resonator is not only complex, but highly variable. Thus it may vibrate as a whole or in any of its parts.\(^{25}\)

The Resonators

The three categories of resonators, as has been stated, are the chest, mouth, and head. It should be noted here, since there is considerable disagreement regarding the chest and head as resonators, that the value of thinking in terms of the chest and head as resonators where tone can be consciously directed is limited to that of imagery.

The chest.—The term "chest resonance" is frequently used in vocal teaching. While it may be psychologically helpful to use this terminology in trying to convince a singer to use the totality of his resonating powers, the fact is that the chest is not, by definition, a resonator. It is neither a cavity where air may vibrate nor is it a sounding board. More will be said regarding the chest as a resonator.

\(^{24}\) Vennard, op. cit., p. 81  \(^{25}\) Ibid.
The mouth.—The mouth is the location where the tonal product of the larynx is changed to an understandable vowel sound. Vennard maintains that the function of the mouth "is to shape the tone into words. . . ." 26

Although it is not always grouped with the mouth as a resonator the pharynx will be discussed in conjunction with the mouth. The pharynx is divided into three sections: the laryngo-pharynx, the oro-pharynx, and the naso-pharynx. The pharynx is subject to voluntary control and Vennard states that there is probably more agreement that the pharynx must be open and free from tension as possible than any other concept of singing. Vennard contends that the pharynx is constantly interacting with the mouth and "... we must think of one highly complex and variable 'buccopharyngeal' resonator." 27

The head.—Both the laryngo-pharynx and the oro-pharynx have been mentioned with regard to the mouth as a resonator. The naso-pharynx is here discussed within the framework of the head as a resonator. The naso-pharynx may be closed off by lifting or arching the soft palate. Vennard contends that due to its physical nature the naso-pharynx is a poor resonator for either improving or building tone.

For many years teachers of singing instructed students to place or throw or direct their voice into the head and

26. Ibid., p. 93.  
27. Ibid., p. 92.
specifically into the sinus pockets. The purpose of this practice was to achieve head resonance. It is now known that "the sound vibrations cannot be directed at all. They enter every nook and cranny possible, and also set all the bones into vibration."\textsuperscript{28} Although there are those who continue to maintain that the sinus cavities are sources of resonance, Vennard contends that experimental evidence does not support this theory. He states, "to dispose finally of the idea that these tiny air spaces, with their minute openings into the other resonators, could be of any value other than as indicators to the singer himself, let me quote a typical scientific authority, Schaeffer:"

\begin{quote}
It is very unlikely that the paranasal sinuses exert any influence upon vocalization. The ostia of the sinuses are so small and not infrequently encroached upon by neighboring parts that one naturally wonders how the chambers can have any modifying influence on the sound waves. Moreover, the great variations in the size and arrangement of the sinuses would preclude any constancy of influence. The theory that the paranasal sinuses impart resonance to the voice must doubtless be abandoned.\textsuperscript{30}
\end{quote}

The two resonators, according to Vennard, which create all the differences possible in tone quality are the mouth and the throat. The chest and the head cavities have no effect on the resonance of the tone.

A word should be stated regarding the psychological value of "placing" the voice although, scientifically, it

\begin{flushright}
\textsuperscript{28}\emph{Ibid.}, p. 94. \textsuperscript{29}\emph{Ibid.}, p. 96. \textsuperscript{30}\emph{Ibid.}
\end{flushright}
cannot be placed. The correct upper-register tones of the singer "feel" as though they are being directed and resonated in the cavities of the head, and as Vennard states, they take on the sensation of "up" and "forward." The lower, richer tones are thought of in terms of chest vibrations and "down" and "back." Vennard states that "it is better to admit the validity of imagery as a teaching aid, although one should avoid the pitfall of literalism and not make the mistake of locating the placement in terms of anatomy."  

**Unrestricted Phonation and Resonation**

The technical aspects and physiological factors which are a part of phonation and resonation have been discussed. There are, however, several other considerations regarding phonation and resonation which should be mentioned. The major objective of the vocal teacher or the student of singing with regard to phonation and resonance should be the production of a singing tone which is free from undue tension, a tone which possesses tonal vitality, a tone which possesses the correct tone color for the given voice and individual singer, and a tone which resonates to its greatest potential.

**Tonal freedom and vitality.**—With regard to tonal freedom and vitality, Christy contends that the student should, during his practice sessions, consistently ask the following questions: 

(a) Does it feel easy in the throat? 
(b) Does

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It is necessary for tonal freedom and vitality that the singing mechanism be as free as possible from any factor which would hinder its natural unrestricted flow of sound. Or, to state it another way, the singer is constantly striving to reduce tension in the vocal organs. Christy identifies four basic types of tension which the singer must avoid:

1. Phlegmatic thought tension. A tone which is allowed to "stand still" in mental development always becomes less interesting to the listener and probably more tense. A sustained tone, unless a monotonous effect is desired, should be developed in thought concept to more and more beauty, freedom, and emotional significance until released. Continual mental development of the tone is the best guarantee of flexible and free vocalization.

2. Articulation tension. The jaw, lips, and tongue are articulating organs that are never "set" or held in one position but should move flexibly, continuously, not only from consonant to consonant, and syllable to syllable, but also to a slight degree in the singing of a sustained vowel.

3. Throat tension. It frequently takes months of patient study under the supervision of a competent teacher, first, for the pupil to become conscious of small degrees of tension in the larynx, pharynx, tongue base, and neck muscles and, second, to habitualize a free, relaxed, spontaneous tonal production.

4. Body and breath tension. This type of tension is caused by a rigid chest and diaphragm, and by clavicular (chest) breathing. It often is induced by nervous, inadequate inhalation, the fundamental cause of which is fear. It is basic that students learn to take time to inhale in a relaxed manner, and to maintain a flexible expansive posture to guarantee proper control of breath energy.

The voice which is produced with a minimum of restriction or tension should possess most if not all of the following capabilities:

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32 Christy, op. cit., p. 40. 33 Ibid., p. 41.
1. The voice should be capable of performing with considerable ease legato and staccato passages.
2. The voice should be consistent in timbre from the lower extremities of range to the higher extremities of range.
3. The voice which is free from tension may be used for longer periods of time without apparent fatigue.
4. The voice should be capable of expressing extreme changes in dynamic levels without losing its consistency of tone.
5. The voice should be capable of expressing variations in timbre which may be necessitated by particular songs or passages within certain songs.

**Tone Color**

Tone color involves the production of vocal tone from the extremely sombre or even dark tone to the most penetrating bright tone. It is necessary that a student of singing develop the ability to produce variations in tonal color which are compatible with the moods of the music which is being performed. One can sense and hear quickly the inability of a singer to change tonal color. The variation in color of voice is one of the most important expression media of the voice. Christy contends that "the most vital element of expression in singing is tone color."  

Ability to vary tone color with mood is not an inborn capability. The student must be taught the effectiveness of this use in vocal singing. One of the most important considerations in achieving correct tone color is a clear understanding of the text as well as the mood construction.

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34 Ibid., p. 44.
found in the rhythm, harmony, melodic line, and dynamic markings of the composer.

Another technique of singing which is certainly related to the techniques of breathing, phonation, and resonation is the technique of range.

The Technique of Range

Range in vocal singing may be defined "as the number of frequency changes possible between the lowest and highest pitches of the voice."35 The range of voices, both trained and untrained, varies from slightly over one octave to between three and four octaves. Voices which exceed two octaves normally encounter different "registers." There is still much controversy over the term and meaning of "register." Ideas regarding vocal registers vary from those who contend there is but one register (the total compass of the voice) to those who maintain as many as four registers. Christy contends that there are, according to scientific findings, only two registers, which he identifies as the lower (for low and loud tones) and the upper (or falsetto). According to Christy, lyric and coloratura sopranos normally use the upper registers and basses the lower. Tenors and altos use both and have the problem of smoothing the two registers. There are, however, many vocal teachers who maintain that a singer possesses a chest (low) voice, a middle

35Fields, op. cit., p. 147.
voice, and a head (high) voice. Even those who contend that three separate registers exist in the singing voice are usually agreed upon that "the vocal line should be uninterrupted from the bottom to the top and that head resonance should be blended with chest resonance in the lower and middle ranges. . . ."36

Although science would establish only two registers (one for high voices and one for low voices) the actual empirical findings regarding the singing voice are convincing that most singers are forced to make vocal adjustments (sometimes called registration adjustments) as the voice moves from the lower range (or registration) to the middle position of the voice (or middle register) into the higher range of the voice (often called head voice or upper register).

Whether or not one holds to the two register theory or the three register theory for each voice it is generally agreed that each note in the singer's total range should contain a balance of resonance qualities and be blended in quality throughout the range. Christy contends that when "breaks" occur in a singer's voice it is "due to not making gradual adjustments of mouth space, breath energy, and resonation quality."37

Vennard maintains that the idealistic approach is that of one register. "The voice, if possible, should produce

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36 Christy, op. cit., p. 73.  
37 Ibid., p. 75.
all the pitches of which it is capable smoothly and consistently without 'breaks' or 'holes' or radical changes of technic." He does, however, contend that the realistic approach is that of three registers. "If one goes by the facts of vocal experience, be they ideal or not, one recognizes distinct qualities of tone, produced by distinct adjustments of the larynx, without recourse to which the full potential of the voice cannot be sung."^  

Vennard identifies the three registers in the male voice as normal or chest, head, and falsetto. In the woman's voice they are identified as chest, middle, and head. Although there is some disagreement regarding these registration classifications there is considerably more controversy over the specific area of the male falsetto. Vocal teachers vary in their concept of falsetto from the contention that it should never be used to the contention that a male's upper range consists of reinforced falsetto tones. It is not likely that this controversy will be resolved any time soon.

The problem of extending one's singing range is a complicated one. There are nearly as many techniques for range extension as there are teachers of singing. It will be necessary, therefore, to speak of range extension in terms of generalizations rather than specific techniques.

The major problem in extending the range of the male voice is, as would be expected, the proper development of

\[^38\text{Vennard, op. cit., p. 69.} \quad ^39\text{Ibid.}\]
the head voice or high voice. It is certainly true that the lower range can be extended but this does not normally produce as many problems as the high voice. The one concept that may be generally agreed upon is that this upper voice of the male should be a vital, sonorous, ringing, and projected tone produced with as much ease and flexibility as possible. Many statements could be made in the area of personal opinions and many writers in the field could be quoted regarding methodology for the attainment of the male head voice. This would, however, be of no significant value in this discussion.

The low voice presents problems to singers of all voice classifications. The problem is not so much one of singing the lower tones but rather one of blending the tone quality of the low voice to those tones produced in the middle and high registers. Some of the problems evident in the lower tones are breathy tones, edgy or sharp tones, forced tones which lose their focus, and improperly supported tones.

In summary, it may be stated that the teacher and student should strive for the extension of vocal range and the unification of tone quality from the lowest tone to the highest tone. This is, of course, usually a tedious and lengthy process.

The Technique of Dynamics

"In the physical sciences, dynamic refers to physical force, power or energy. In acoustics it refers to the
relative intensity or force producing a sound. In musical science it relates to the variation of volume, quantity or power of musical sounds."\(^{40}\)

Christy states that the beginning student of singing is certainly not aware of the monotonous inadequacy of his dynamic variation and contends that "awareness" is the first step in correcting this problem.

One of the first problems arising in the area of vocal dynamics is defining what is a good, full tone as opposed to a weak, inadequate tone. This problem, it appears, has no resolution. It is usually a matter of taste and opinion.

The dynamic range of the human lies, technically, within the range of pianissimo to fortissimo. This is, of course, a relative comparison. Tones which are soft must, however, possess qualities of resonance, undertone, intensity, and projection. It is more difficult to maintain these characteristics of tone when one is singing softly than when one is singing loudly. Christy contends that a soft tone demands "the same qualities of resonance, vowel quality and throat adjustment as the more dramatic tone, only breath energy and mouth opening are reduced."\(^{41}\)

Another characteristic of good tone, which varies from pianissimo to fortissimo, is freedom. The tone must be

\(^{40}\)Fields, op. cit., p. 166.

\(^{41}\)Christy, op. cit., p. 85.
unrestricted. (Tension and restriction of tone have already been discussed). Christy contends that the development of an extensive fortissimo is dependent on "full utilization of resonance capabilities and increased motive force (breath pressure)."\textsuperscript{42} The full fortissimo tone must be produced by using total breath pressure and total resonation.

There are numerous techniques, espoused by teachers and writers in the area of vocal singing, for the development of ability to use extremes in dynamic range. These may be found in any vocal pedagogy text. The limits and purpose of this discourse do not permit their inclusion here. Suffice it to state here that the student of singing must be taught to use effectively the variation in dynamic levels. Discrete and effective changes from one dynamic level to another increase the excitement and pleasure of listening to the human voice.

The purpose of the immediately preceding discussion has been to acquaint the reader, in a very general sense, with five basic areas or techniques of vocal singing. In order for the discussion on vocal concepts to be perceived with the greatest degree of clarity and understanding, it was necessary that the reader receive some technical orientation regarding these techniques of singing.

An underlying contention of this study has been, of course, that a given discipline can be taught in terms of

\textsuperscript{42}\textit{Ibid.}, p. 86.
basic concepts and that a conceptual approach to teaching is superior to what may be called a factual approach or a technique approach. The benefits of conceptual teaching, to both teacher and student, have been previously discussed.

It has been proposed that a given discipline should be condensed to a minimum number of basic concepts. In order for the reader to better comprehend the contrast between a technique approach and a conceptual approach to the teaching of voice, the multiplicity of factors which may be considered as component parts of the techniques previously discussed have been condensed to three major vocal concepts.

Vocal Concepts

Perhaps it will clarify matters if these areas which are not included in this section will be stated first. In the first place, this report is not intended to be a methodological approach to conceptual teaching. The theoretical structure has already been proposed out of which an individual teacher can determine his own approach to conceptual teaching. Further, this is not intended to be an exhaustive study of the possible concepts in vocal singing. It would be virtually impossible to set down an indisputable list of vocal concepts which should be taught. The vocal concepts which are encountered will, ultimately, be relative to the individual teacher and student.

There will, however, be an attempt to present a set of three major concepts which are considered to be inclusive
of all the factors which are necessary in the production of the singing voice. What constitutes a concept in voice? It is the contention of this study that concepts are broad, inclusive statements which serve in the function of unifying a variety of conceptual factors, attributes or secondary concepts, if one chooses to call them this.

The following concepts to be presented, in theoretical framework, are to be considered concepts which support the one unifying concept in vocal singing. This single unifying concept is stated thusly: The unifying concept in vocal singing is the production of a correctly executed vocal tone which is representative of the maximum efforts and capabilities of a given student.

The unifying concept theorized here could, then, be symbolized by the single verbal descriptive of TONE. One can immediately recognize that there are literally hundreds of isolated factors or "things" which a student must master in order to be able to perform vocally in such a way that it may be assumed that he understands and has learned the underlying structure of this concept. It is proposed here that these isolated factors or "things" which a student must learn are component parts of the three concepts to be presented. The three major concepts in voice are theorized as

1. The singing breath is the originating force of the vocal tone and the total respiration process (inhalation
and exhalation) should create the sensation of free and unrestricted breath flow.

2. The vocal tone produced should possess the qualities of physiological and psychological freedom and release.

3. The vocal tone should be representative of the free and full resonating powers of the individual and should be projected with clarity of voice and naturalness of vocal production.

In order to clarify the conceptual relationships between the techniques of respiration, phonation, resonance, range and dynamics and their component factors previously discussed and the three major concepts which have been theorized, a model is shown in Figure 13.

The three major concepts are presented as being inclusive of all the relevant factors or techniques necessary in the teaching of vocal singing. It is suggested that the techniques of respiration, phonation, resonance, range and dynamics become verbal symbols for a group of secondary or supportive concepts. The relationships between these secondary concepts and the three major concepts are shown by the continuous and broken lines. The continuous line signifies a primary relationship and the broken line signifies a secondary relationship. Primary relationships may be considered to exist between two areas which are dependent upon one another for existence. Secondary relationships may be considered to exist between areas which are, under normal
Fig. 13—A conceptual structure of three vocal concepts

43The three major concepts are presented in abbreviated form here.
circumstances, related to each other in that the presence of one affects (improves or possibly hinders) the performance of the other.

The five vocal techniques, which have been designated as verbal symbols for secondary concepts, have a multitude of component factors. Some of these are shown in the model. All of these factors, and possibly more, are involved in the singing process. It should be noted that the interrelatedness of the three major concepts and the five secondary concepts is shown by the continuous line which connects them.

The purpose of this model is to show that vocal teaching can be reduced to a minimum number of concepts and can be approached within the previously proposed theoretical structure for conceptual teaching.

The three major concepts (unrestricted breath flow, physiological and psychological freedom and release, full and natural resonating power produced with clarity of voice), the five secondary concepts or verbal symbols (respiration, phonation, resonance, range, dynamical), and the many component factors shown as parts of the secondary concepts or verbal symbols are ultimately supportive of the unifying concept in vocal singing signified by the verbal descriptive TONE.

It is proposed that vocal teaching should originate at the top of the model, with the unifying concept of TONE, and progress through the model to the three major concepts,
the five secondary concepts and then to those component factors deemed necessary. This is, of course, not the generally accepted method. Most vocal pedagogy texts begin by compartmentalizing and discussing all the factors related to a particular area such as breathing or phonation. Actual studio teaching is too often begun by isolating a few problem areas, such as head resonance or posture, or even the mouth position. If one were to identify the starting point of this type approach on the conceptual model, it would tend to be located at the bottom of the model, with the component factors. Vocal teachers may begin with these isolated component factors and then try to progress towards the secondary and major concepts. Research in concept formation and concept learning indicates, however, that this is not the most efficient or effective approach.

It can readily be seen that each of these three major concepts are supportive of the unifying concept previously stated. It should also be noted that each of the three concepts is supportive of the other concepts. Thus, the learning of any given concept should facilitate the learning of any one of the others. A further word regarding the three major concepts and their relationship to the five vocal techniques is in order.

Concept I

The singing breath is the originating force of the vocal tone and the total respiration process (inhalation and
exhalation) should create the sensation of free and unrestricted breath flow.

Breathing is a natural phenomenon which occurs correctly if left unhindered. In the act of producing the singing voice, however, there is necessity for greater control of the breath flow. The technical or technique approach to the teaching of correct breathing or respiration tends to isolate certain factors in breathing such as the function of the diaphragmatic muscle or the abdominal press (contraction or abdominal muscles) or other such factors. In conceptual teaching, isolation of a factor or factors which are relevant to a particular concern tends to cause the student to fixate on one particular facet of the concept. Vocal teachers have been known to summate their teaching of many of the techniques in vocal production to a single area of focus. In the area of respiration this might be illustrated by admonitions from vocal teachers to "take a deep breath" or "lift the chest." While these may be valid considerations in the vocal respiration process they are only parts of a total process. Extreme concentration on any one facet tends to reduce vocal teaching to a set of gimmicks. This, of course, cannot possibly give the student a comprehensive, unifying view of the singing process.

Within the conceptual approach to teaching, attention is directed to the unifying function of a concept and the cognitive image or symbol of the student regarding that
concept. Many of the minutia instructions which require much of the lesson time will become insignificant within the framework of conceptual teaching. Progress may appear to be slower at first, but the student should actually learn the significant concepts of vocal singing more quickly and certainly more effectively than if vocal teaching is restricted to focus on certain isolated factors of singing which seem to be the sources of the student's problems.

Figure 13 illustrates graphically the relationship between the three major concepts and the vocal techniques. Regarding Concept I, it may be seen that the techniques of respiration and phonation exist in a primary relationship. This actually means that respiration and phonation are dependent on the concept of unrestricted breath flow. It may also be seen that the techniques of resonance, range, and dynamics exist in a secondary relationship to Concept I, which means that resonance, range and dynamics are not necessarily dependent on Concept I, but are affected by it.

Concept II

The vocal tone produced should possess the qualities of physiological and psychological freedom and release.

One of the major problems in vocal teaching is tension or restriction in the voice. This tension or restriction is normally quite evident in the quality of the voice and the physical appearance. The reason physiological and
psychological freedom and release are discussed together is
the fact that even though tension and restriction normally
demonstrate themselves physically, the origin is frequently
psychological. This may be stated another way in saying
that the student must possess a mental set or mental pre-
paredness toward singing. The student who performs before
others normally undergoes considerable stress and anxiety.
These, in turn, tend to emerge in the form of physical tension
and restriction in the singing voice.

One can easily see the relationship between this vocal
concept and the others previously mentioned. They are inter-
related and dependent. By approaching concepts in this
manner one can maximize the potential for transfer of learning.
Another value in learning concepts which are interrelated,
such as these being presented, is that they are also over-
lapping. The student who, for example, adequately learns
the concept regarding freedom of breath flow should be able
to transfer this image of freedom to other areas of singing,
most all of which necessitates some type of freedom.

Figure 13 reveals that the techniques of resonance and
range exist in a primary relationship with Concept II. That
is to say that the resonance of one's voice and the develop-
ment of an extended range is directly related to physiological
and psychological freedom and release in vocal singing. Res-
piration, phonation, and dynamics are certainly related but in
a secondary relationship. The relative effectiveness of the
process of respiration, correct phonation and development of ability to use vocal dynamics is dependent, in part, on Concept II.

Concept III

The vocal tone should be representative of the free and full resonating powers of the individual and should be projected with clarity of voice and naturalness of vocal production.

Vocal resonance is, of course, related to the previously discussed concepts. Physiologists contend that if the voice is produced correctly and freely the voice should resonate in every available resonance area. Resonance then becomes a conjunctive problem between freedom in the various areas of vocal production and the student's mental concept of resonance. This concept also involves such component factors as diction, articulation and vowel production. The voice can, by use of unnatural resonance, inadequate motor or breath power, extreme tension or a number of other ways be falsified. The intent of this concept is that the singing voice should represent the natural voice of the student, fully resonated and naturally executed.

Figure 13 shows that the techniques of phonation, resonance and dynamics exist in a primary relationship with Concept III. These include, of course, the natural phonation of the voice, the freely resonating voice and the vocal control of dynamics. Related in a secondary function are the
techniques of respiration and range. These are, of course, significant factors in the production of a full and naturally resonated voice.

The intent of this discussion has not been the exhaustive proposal of a set of vocal concepts. The three concepts should be accepted as representative of the types of conceptual areas of study which are needed by the vocal student. It is proposed, however, that any factor in singing can be learned as an essential component factor of one of these three concepts. The concepts merely serve as a unifying symbol for the multitude of factors involved in the singing process.

It should be stated further that the presentation of these major concepts and secondary concepts in the form of a model (Figure 13) was given only as an indication of the process involved in reducing a body of information to an inclusive set of major concepts which would unify and present the broad, major objectives of a given discipline. Ultimately, the individual teacher will determine the concepts which he considers necessary to the teaching of any given subject. This study has, however, presented a set of theoretical propositions which, according to theories of concept formation and concept learning, will maximize efficient and effective conceptual learning.
Chapter Summary

The intent of this chapter has been fourfold.

1. A theoretical structure underlying a conceptual approach to teaching has been proposed. Attention has been given to three basic areas: (1) the thought processes of the teacher, (2) the actual presentation of concepts, and (3) the relationship between the teacher and student.

2. Five selected vocal techniques were discussed in terms of (1) definition of the technique, (2) factors regarding the technique on which vocal pedagogues in general agree, and (3) the basic problem areas related to the technique. Further attention was given to the contrasting relationship between vocal techniques and vocal concepts.

3. Three major vocal concepts were presented as representative vocal concepts designed to be inclusive of the factors involved in the singing process. The concepts are

   (1) The singing breath is the originating force of the vocal tone and the total respiration process (inhalation and exhalation) should create the sensation of free and unrestricted breath flow.

   (2) The vocal tone produced should possess the qualities of physiological and psychological freedom and release.

   (3) The vocal tone should be representative of the free and full resonating powers of the individual
and should be projected with clarity of voice and naturalness of vocal production.

4. A conceptual model was presented as representative of the process involved in reducing a body of information to a set of inclusive and unifying concepts. The model included a single unifying concept, three major concepts, five secondary concepts and a number of component factors.

An attempt has been made to present a theoretical structure for conceptual teaching such that any teacher, in any given academic discipline, could arrive at his own theory of conceptual teaching.

Problems for Further Study

In a theoretical study there are usually a number of problem areas which arise. An attempt has been made to identify some of these areas which appear to be worthy of further study, but do not lie within the scope of this immediate study.

The following problems have been identified:

1. Is there a relationship between a particular type of cognitive thought process on the part of the teacher and the subsequent cognitive thought process on the part of the student? It has been proposed in this study that a relationship does exist.

2. If the dominant attribute or key to a concept is so vital to expediting concept formation and concept learning,
what are these dominant attributes of a given set of concepts or how can they be determined? Are they relative to the individual student?

3. Further study should be directed in the area of identifying major concepts in all academic disciplines and, as has been the contention of this study, the development of optimal methods for teaching these concepts.

4. It may be beneficial to try to determine, possibly in a longitudinal approach, the relative effectiveness of technique approaches and conceptual approaches to teaching voice.

5. Further study seems to be warranted in the area of trying to determine what thought processes are involved in forming and learning an abstract vocal concept, or any concept.

These are illustrative of the types of problems which need further investigation in the areas of concept formation, concept learning and conceptual teaching. There are, most assuredly, many more problem areas which arise as an outgrowth of a theoretical study of this nature.
The material in Rommetveit's experiments consisted of stylized drawings of a "cup and saucer" in which height, roundness or bowedness were varied in a systematic fashion and formed the cues or distractors amongst which the Ss, according to the instructions, were to seek the "good figures" which also yielded small sums of money, mounted on an apparatus which served as a wheel of fortune.

The test procedures by which Rommetveit was able to distinguish the three levels mentioned were as follows:

(1) The recognition test, in which the S had to point out, from among nine figures, the one which he felt was most similar to the one he had just seen.
(2) The learning tests, in which the E investigated whether the S had achieved a functional concept, i.e. whether the S could distinguish differences between "good" and "bad" figures without on that account being able to verbalize the differences.
(3) Description of "good" and "bad" characteristics.

An especially valuable result of this study was that Rommetveit was also able by these three test procedures to establish a definite, predicted, ranking order between them, i.e. that the recognition test could be completed before the learning test, for which the criteria were achieved before the verbal description could be given.1

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APPENDIX B

The experimental design of Mednick and Freedman is described as follows:

Stimulus 0 is provided by the middle lamp in a series of lamps (usually 7 or 11). The S is instructed to react as rapidly as possible when this lamp is switched on. After a training run, in which only the middle lamp is lit, the E begins to switch on other lamps, one at a time. The generalization gradient (GSG) is measured by the S's error reactions to lamps which are nearest to Stimulus 0.

Pikas states that

In the SG experiments the S's task is to discriminate and failures in this respect are noted as increased SG. In concept formation the task is both to discriminate and to generalize in the sense of "summarizing" or "melting together". . . . The experimental material in their investigation was the series of lamps described . . . and the age-range of the Ss was from 7 to 12 years. The Ss' task was a discrimination task--"they were only to respond to the center lamp" and the young "Ss' greater tendency, in comparison with the older Ss, to react also to other lamps close by" was, according to the Es, a manifestation of the tendency to generalize.2

Goss illustrates primary stimulus generalizations with one-stage paradigms and mediating responses and stimuli with two-stage paradigms. Goss gives the following example as the simplest case of possible sets of stimuli containing complete orthogonal combinations:

Fig. 14--Goss's two-stage paradigm of some of the relationships possible between initiating stimuli and mediating responses, between mediating stimuli and mediating responses, between mediating stimuli and terminating responses and between initiating stimuli and terminating responses.3

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APPENDIX D

The first subpattern represents relationships in which responses of naming the dimensions occur. These are the associations between initiating stimuli and $R_x$, $R_y$. The second subpattern represents responses of naming the specific values along the dimensions. The responses of these associations are $R_{x1}$ for $x_1$, $R_{x2}$ for $x_2$, $R_{y1}$ for $y_1$ and $R_{y2}$ for $y_2$.

\[ \begin{align*}
&\text{Snakes} \rightarrow R_{\text{Sword}} \rightarrow R_{\text{Two Curves}} \\
&\text{Lines} \rightarrow R_{\text{VEC}} \\
&\text{Sword} \rightarrow R_{\text{GUZ}} \\
\end{align*} \]

Fig. 15—Goss's two-stage paradigm of the relationships possible between initiating stimuli, which consist of two different common elements and variable features, and both mediating and terminating responses and also between mediating stimuli and terminating responses.

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4 Goss, op. cit., p. 171; cited in Pikas, op. cit., p. 171.

APPENDIX E

... if stimuli to which Ss are instructed to respond can be discriminated and conceptualized as belonging to a common class, this will facilitate categorization of these stimuli.

The experimental material with which they illustrated this hypothesis consisted of the now classical horizontal row of 11 lamps (see Appendix B of this study for the design of the classical experiment with lamps), but the Ss were instructed to react according to two conditions. In condition 5-6-7 the Ss (psychology students) were instructed to react only when lamps nos. 5, 6, and 7 were switched on. In condition 3-6-9 they were to react when the corresponding lamps were switched on. Nakamura and Kaswan's hypotheses were directly connected with this experimental order:

Because of the spatial contiguity of Lights 5-6-7, Ss are expected to identify each as belonging to a group of three, thus facilitating categorization of these lights as positive. No such grouping is likely to be discerned in Lights 3-6-9, so that categorization of these lights should be more difficult.

Furthermore they predicted, in opposition to Hull's summation hypothesis, that under the conditions of present experiment, the gradient summation hypothesis would predict approximately the same number of errors to Lights 4 and 8 in both Cond. 5-6-7 and 3-6-9. If, however, spatial contiguity facilitates categorization, fewer errors to these lights would be expected in 5-6-7 than in 3-6-9.

Empirical confirmation of these predictions was obtained, categorization of lights 3-6-9 was more difficult, as measured by reaction-time latencies, and fewer errors occurred in the 5-6-7 condition to lights nos. 4 and 8, as compared with the 3-6-9 condition.6

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