About this PDF

1. The first 4 pages are the Outline I used for my 1999 APA presentation:

   "Learning to Learn" in the 1940s" Gregory Bateson, Harlow Harlow, Robert Yerkes, and Others.

2. The following 34 pages are visual aids prepared originally as Overhead Projector transparencies. I do not remember if all were used; for example, the last 3 are somewhat ancillary and my time may have expired. The visual aids *per se* are not numbered, but they are numbered in the Outline with one exception. Page 2, "A Received View?" consisted of two pages.

3. For a serious examination I suggest putting the visual aid pages in order in a ring binder, to prevent possibly getting them out or order. Then use the Outline to guide your progress through the visual aids.

4. The main focus for me was to emphasize that Bateson's contributions to the concept of "learning to learn" (which Bateson named "Deutero-learning") have been largely overlooked, whereas Harlow has been "lionized." Yet, it might be well argued that Bateson appreciated the intricacies of "learning to learn" well before Harlow did. Harlow deserves full credit for showing that the experimental investigation of "learning to learn" was feasible, whereas Bateson was skeptical whether it could be investigated experimentally, and, of course, Harlow gave the process its most-used name, "Learning Set Formation."

5. Unfortunately, I never prepared a manuscript for possible publication.

6. Finally, for as long as I am able, I am happy to try to answers questions or clarify this PDF. Email me at: rkthomas@uga.edu

Roger K. Thomas
August 27, 2017

Outline: "Learning to learn" in the 1940s: Gregory Bateson, Harry Harlow, Robert Yerkes, and Others." The outline is keyed numerically to overhead transparencies. Titles or descriptions [bracketed] are listed. Boxed text indicates transitions in what will be addressed.

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1. [Title]

Establishing a Context Using Harry Harlow's 1949 Contribution

2. A "Received View?"
3. [Harlow's photograph and biographical sketch]
4. [WGTA drawing and photograph of monkey performing]
5. The first two data graphs presented in Harlow (1949)
6. Harlow specifies his contribution; Harlow iterates his contribution.
7. Harlow (1949a) on the function of learning to learn.

Sampling "Learning to Learn" before Harlow (1949)

8. Learning to learn before Harlow (1949): I
   A. "Formal discipline"
   B. William James (1890)
   C. Thorndike and Woodworth (1901)
9. Learning to learn before Harlow (1949): II
   A. General acceptance despite (?) reactions to "formal discipline"
   B. Example: Ward's (1937) data graph of nonsense syllable list learning.
10. Learning to learn before Harlow (1949): III
    A. Discussed anecdotally among animal psychologists...often with effort to reconcile such discussion with gestalt interpretations
    B. Yerkes will be quoted below as representative, but first...

Robert M. Yerkes' Consideration of "Learning to Learn"

Gregory Bateson's (1942) Consideration of "Learning to Learn"

When did Harlow's "Discovery" of Learning Set Formation Begin?

What Did Harlow and Bateson know about the other and when did they know it?

28. [Title page of ***Science, Philosophy, and Religion***...." (1942)]
29. [Table of Contents of ***Science, Philosophy, and Religion***...]
    A. 28 and 29 suggest the relative obscurity of Bateson's, 1942, Comment.
30. [Cover of Bateson's ***Steps to An Ecology of Mind***...." (1972)]
    A. ***Steps***...raises the potential for recognition of the 1942 commentary.
        (1) Gives it title, "Social Planning and the Concept of Deutero-learning."
    B. ***Steps***...includes new essay titled "The Logical Categories of Learning and Communication" where proto-learning and deutero-learning are renamed Learning I and Learning II, respectively.
        (1) Bateson also postulates an even higher-order, Learning III (he also expressed skepticism regarding the feasibility of experimental investigations of Learning III).
    C. ***Steps***...includes four references to Harlow; two in the above mentioned new essay
        (1) It cited Harlow 's (1949) "set learning" as being among the synonyms for Learning II (other synonyms were "deutero-learning," "learning to learn," and "transfer of learning")." See page 293.
        (2) On pages 294-297, Bateson reviewed ".... four fields of experimentation where Learning II has been carefully recorded."
            a. The first example was a five-paragraph account of Hull (1940).
            b. The second example was a one-paragraph discussion of Harlow's monkey research (quoted fully below)
            c. The third example was a two paragraph discussion of "Bitterman and others" who have studied reversal learning.
            d. The fourth example was a two-paragraph discussion of "experimental neurosis," as described in Pavlov's laboratory, that occurs when the difference between two discriminanda is gradually reduced until the animal can no longer make the discrimination (e.g., starting with a circle versus an ellipse).

> "The second type of Learning II which has been experimentally studied is called "set learning." The concept and term are derived from Harlow and apply to a rather special case of Learning II. Broadly, what Harlow did was to present rhesus monkeys with more or less complex ***gestalten*** or "problems." These the monkey had to solve to get a food reward. Harlow showed that if these problems were of a similar "set," ***i.e.***, contained similar types of logical complexity there was a carry-over of learning from one problem to next. There were, in fact, two orders of contingency patterns involved in Harlow's experiments: first the overall patten instrumentalism (***if*** the monkey solves the problem, ***then*** reinforcement); and second, the contingency patterns logic within the specific problems." (Bateson, 1972, pp. 295-296)

(3) Elsewhere in ***Steps*** ... Bateson cited Harlow twice:

a. An essay titled "A Theory of Schizophrenia" uses the phrase "learn to learn," and Harlow (1949) is cited in a footnote along with Bateson (1942) and Hull (1940). See page 204.

b. An essay titled "Minimal Requirements for a Theory of Schizophrenia" includes Harlow (1949) in a footnote together with Hull (1940). See page 252.

Finally, if time permits, two applications of "learning set formation" research

31. Learning Set Formation and Phylogenetic Comparisons: I
    A. Warren's, 1965, graph
32. Learning Set Formation and Phylogenetic Comparisons: II
    A. [Hodos', 1970, graph as now reinterpreted by Warren, 1974]
33. [Statistical correlations based on comparing species on LS performances and brain indices]

"Learning to learn" in the 1940s: Gregory Bateson, Harry Harlow, Robert Yerkes, and Others

Roger K. Thomas
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Thomas, R. K. (1999, August), "Learning to learn:" Gregory Bateson, Harry Harlow, Robert Yerkes, and Others. Invited presentation in D. A. Dewsbury (Chair), *Animal Cognition in Historical Perspective.* Symposium conducted at the meeting of the American Psychological Association, Boston, MA,

NOTES Added: August 27, 2017

1. **Current email address: rkthomas@uga.edu**

2. **Research by Thomas & Noble (1988) and Bailey & Thomas (1998) raise serious questions regarding the correlations and interpretations reported by Riddell & Corl (1977) in the final visual aid included here. Thomas & Noble (1988)* and Bailey & Thomas (1998)* found excellent learning set performances *in rats* when olfactory discriminanda were used. Please see also the Warren quotation in the next-to-last visual aid here.**

   ***May be accessed at: https://faculty.franklin.uga.edu/rkthomas/**

A "Received" View?

..in the late 1940s he [Harlow] achieved a major conceptual and methodological breakthrough with his discovery of learning sets. (Suomi & LeRoy's, 1982, p. 321)

Harlow's 1949 article, clearly describing for the first time, the concept of learning set formation, is one of the most widely cited articles in the animal behavior literature. (Schrier & Thompson, 1984, p.109)

Harry F. Harlow (1905-1981) is known for discovering the learning set (e.g., learning how to learn) phenomenon...." **(Rumbaugh, 1997, p. 197)**

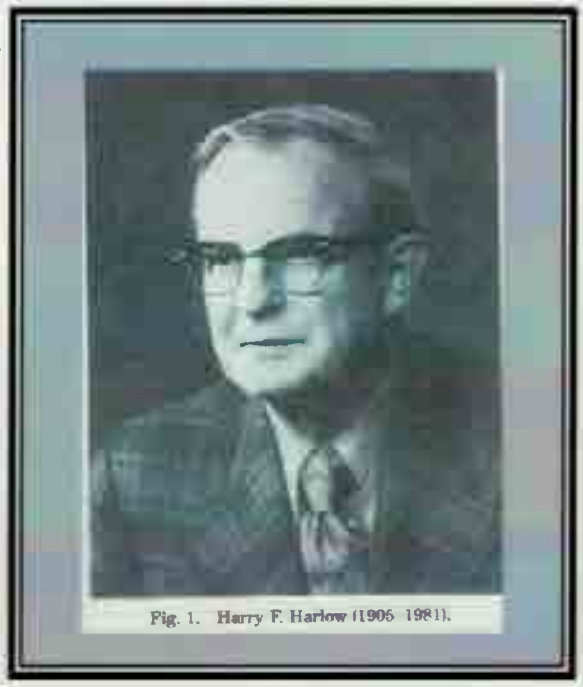

Fig. 1. Harry F. Harlow (1905–1981).

Photo in Suomi & LeRoy (1982)

The term *learning set* denotes *interproblem learning*, the cumulative improvement in performance which occurs when an animal is trained upon many different problems of the same general class. This type of multiple-problem learning was first clearly recognized and described by Harlow (1949). (Warren, 1973, p. 481)

This learning how to learn phenomenon was first demonstrated by Harlow (1949), who called it learning set. (Denny & Ratner, 1970, p. 734)

This phenomenon was first demonstrated by Harlow (1949) and described as the formation of a discrimination "learning set." (Bessemer & Stollnitz, 1971, p. 2)

...in the late 1940s he [Harlow] achieved a major conceptual and methodological breakthrough with his discovery of learning sets. (Suomi & LeRoy's, 1982, p. 321)

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Harry F. Harlow (1905-1981)

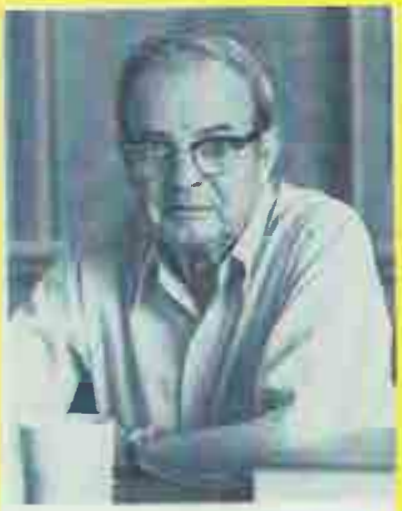
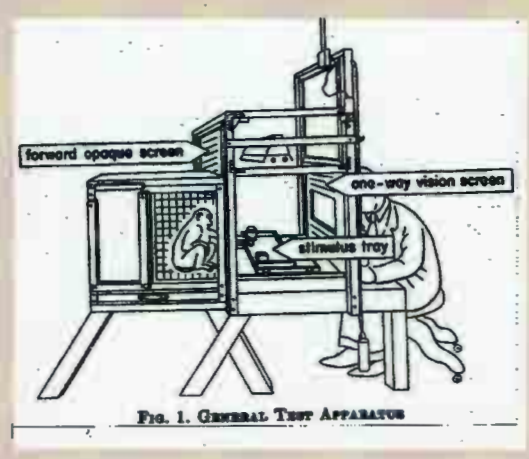


Fig. 4. Harry Harlow in 1978.

- Born in Fairfield, Iowa
- B.A., 1927, Stanford University
- Ph.D., 1930, Stanford University
- Married twice, two children each.
- U. of Wisconsin (1930-1974).
- 300+ Publications.
- Member, National Academy of Science; received National Medal of Science; received APA's Distinguished Scientific Contribution Award (1960) and Gold Medal Award (1973).
- Perhaps best remembered for his work on social attachment in infant monkeys which he developed relatively late in his career, but he was certainly among the most important research investigators in what is today called animal cognition. Learning set formation was only among many fundamental contributions.



This often-reproduced drawing of the Wisconsin General Testing Apparatus, as far as I have determined, first appeared in print in Grandine and Harlow (1948. It appeared also in Harlow's 1949 article.

This photograph of a monkey performing in the WGTA (or its predecessor) was used in Noer and Harlow, 1946

Harlow's first two "real" data graphs, i.e., obtained from experimental results.

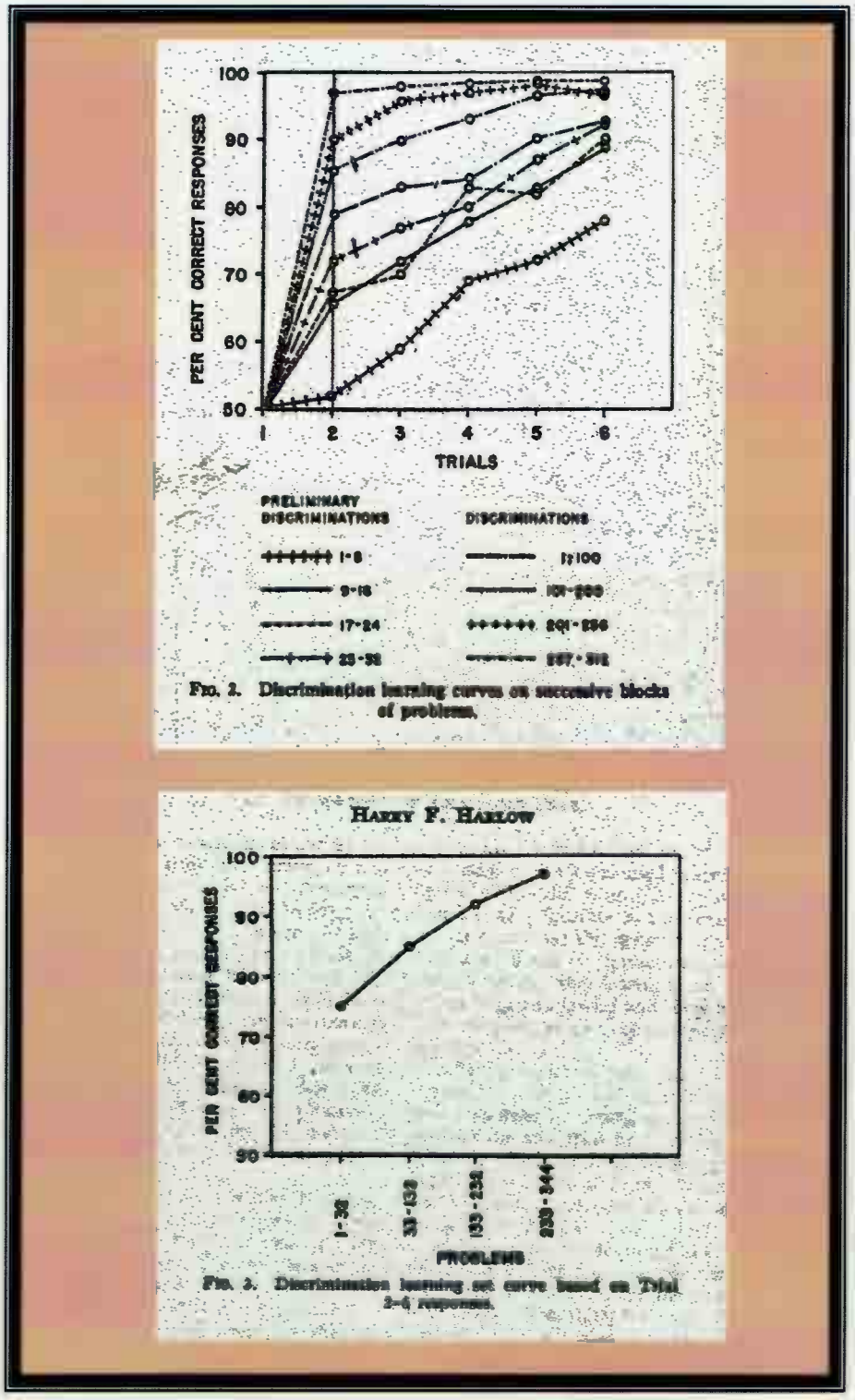


FIG. 2. Discrimination learning curves on successive blocks of problems.

HARRY F. HARLOW

FIG. 3. Discrimination learning set curve based on Trial 2-6 responses.

Harlow specifies his contribution.

Psychologists working with human subjects have long believed in the phenomenon of learning sets and have even used sets as explanatory principles .... These psychologists have not, however, investigated the nature of these learning sets .... we have carried out studies that outline the development and operation of specific learning sets .... (Harlow, 1949, pp. 64-65)

Harlow iterates his contribution.

Transfer of learning between problems within a single class was studied before Pavlov, by Pavlov..., and after Pavlov, but early investigators failed to develop techniques for effective analysis or to recognize the significance of the phenomenon. (Harlow, 1959, p. 494)

Harlow (1949a) on the function of "learning to learn"

Harlow confined most of his remarks about the function of learning set to the monkeys he had studied in his most famous 1949 article. However, he waxed a bit more generally in another article that year titled, "Learning to Think," that was published in *Scientific American* (together with coauthor Margaret Kuenne Harlow).

"We began by pointing out that psychologists have long sought to find in the higher mental processes some organizing mechanism or principle that would explain learning and thinking. We can now suggest such a mechanism: the learning set."

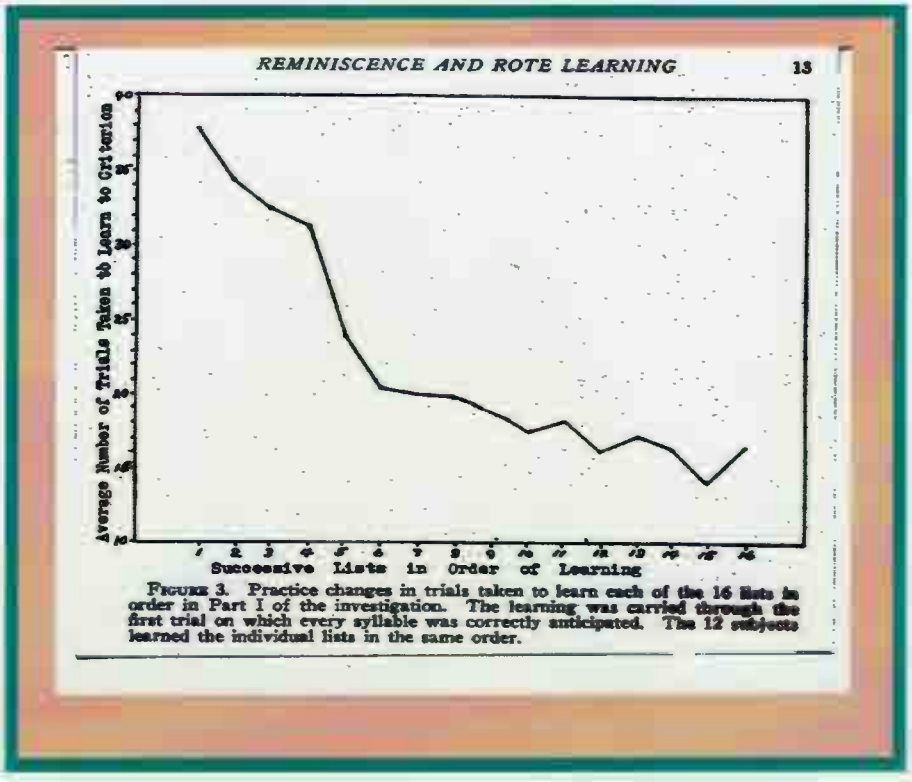
"Learning to learn" before Harlow (1949): I

1. Before there was an experimental psychology, numerous pedagogical theorists advocated "formal discipline" as a way to improve memory and, by implication, improve learning. In brief, learning in one discipline should enhance memory and learning in other disciplines...or put more simply, experience or practice invested in learning some things should benefit learning other things.

2. William James, (1890, Volume I, pp. 664-668) questioned skeptically the alleged benefits of "formal discipline." James reported an experiment in which he and four friends served as the subjects that confirmed his skepticism. Other early psychologists such as Thorndike and Woodworth (1901) also conducted experiments that questioned, even more vigorously, the validity of formal discipline for memory and learning improvement.

"Learning to learn" before Harlow (1949): II

3. Nevertheless, the "learning to learn" phenomenon gained rather general acceptance before Harlow (1949). There was some experimental support, not well developed, in the form of rote learning experiments. Below is a graph from Ward (1937, p. 13) showing improvement in learning over 16 lists of nonsense syllables.



REMINISCENCE AND ROTE LEARNING 13

Average Number of Trials Taken to Learn to Criterion

Successive Lists in Order of Learning

FIGURE 3. Practice changes in trials taken to learn each of the 16 lists in order in Part I of the investigation. The learning was carried through the first trial on which every syllable was correctly anticipated. The 12 subjects learned the individual lists in the same order.

"Learning to learn" before Harlow (1949): III

Several well known animal psychologists, notably Robert M. Yerkes, reported anecdotal evidence of "learning to learn." Related discussions in the literature seem to be permeated with reconciling with gestalt interpretations involving "insight, etc. as presented, for example, by Wolfgang Köhler. Yerkes and the others did not seem to question the validity of learning to learn.

Yerkes will be cited below as representative of the early animal psychologists' views about learning to learn, especially those who studied the behavior of nonhuman primates.

However, before we consider Yerkes....

"Learning to learn" before Harlow (1949): IV

Bateson's and Harlow's contributions would be to elevate the theoretical importance of "learning to learn" and to point the way to the feasibility of its measurement.

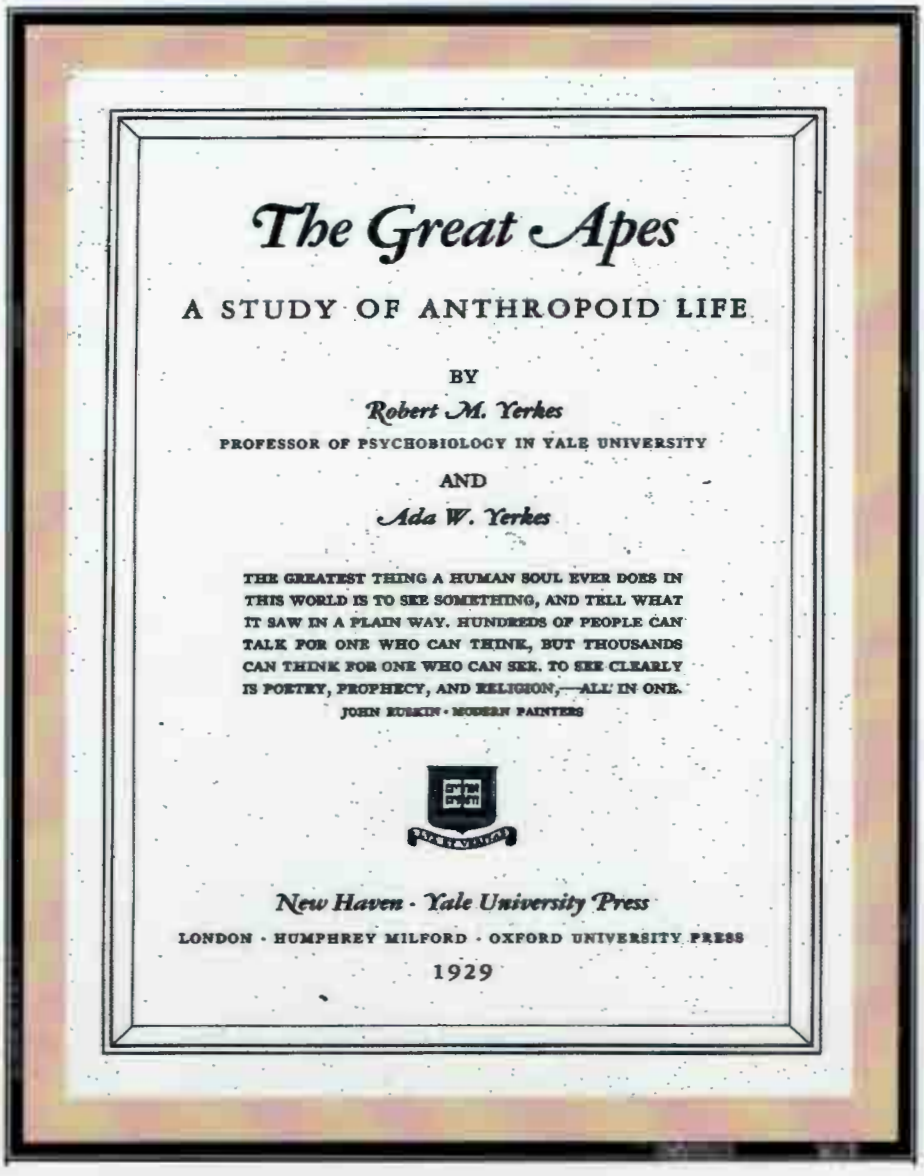
Interestingly, however, Bateson, himself, seemed to think that experiments in "learning to learn," except in limited contexts such as rote learning verbal materials, might not be possible.

Robert Mearns Yerkes (1876-1956)

Robert M. Yerkes, 1876–1956.
Photograph by Dellenbeck, courtesy of the National Academy of Sciences.

- Born and grew up on a farm in Buck County, PA.
- A.B., 1897, Ursinus College (PA), A.B.,1898, Ph.D. 1902, Harvard U.
- Married Ada Watterson (botanist), two children. Co-wrote ***The Great Apes*** (1929) with her.
- **Appointments**: Harvard, 1902-1917; Head, Psychology Department at U. Minnesota (*in absentia*, 1917-1924); U.S. Army, 1917-1924; Yale University, 1924-1944; Founded Yale Anthropoid Experiment Station in Orange Park, FL, 1930, and served as Director until 1941.
- Major R. M. Yerkes led development of Alpha/Beta Tests.
- Used most of his savings to buy Chim and Panzee in 1923, the beginning of his primate behavioral research.
- Eight books, approximately 150 additional publications.
- Named "Dean of Comparative Psychologists" (New York Zoological Society). In his career, Yerkes studied six species of invertebrates as well as frog, turtle, ring-tailed dove, crow, mice, rat, pig, monkey, ape, and human.
- Presidencies: American Psychological Association, American Society of Naturalists.
- Member, National Academy of Science.

The first selection from Yerkes is from:



The Great Apes

A STUDY OF ANTHROPOID LIFE

BY

Robert M. Yerkes

PROFESSOR OF PSYCHOBIOLOGY IN YALE UNIVERSITY

AND

Ada W. Yerkes

THE GREATEST THING A HUMAN SOUL EVER DOES IN THIS WORLD IS TO SEE SOMETHING, AND TELL WHAT IT SAW IN A PLAIN WAY. HUNDREDS OF PEOPLE CAN TALK FOR ONE WHO CAN THINK, BUT THOUSANDS CAN THINK FOR ONE WHO CAN SEE. TO SEE CLEARLY IS POETRY, PROPHECY, AND RELIGION,—ALL IN ONE.

JOHN RUSKIN · MODERN PAINTERS

New Haven · Yale University Press

LONDON · HUMPHREY MILFORD · OXFORD UNIVERSITY PRESS

1929

Robert M. Yerkes' *The Great Apes*, 1929

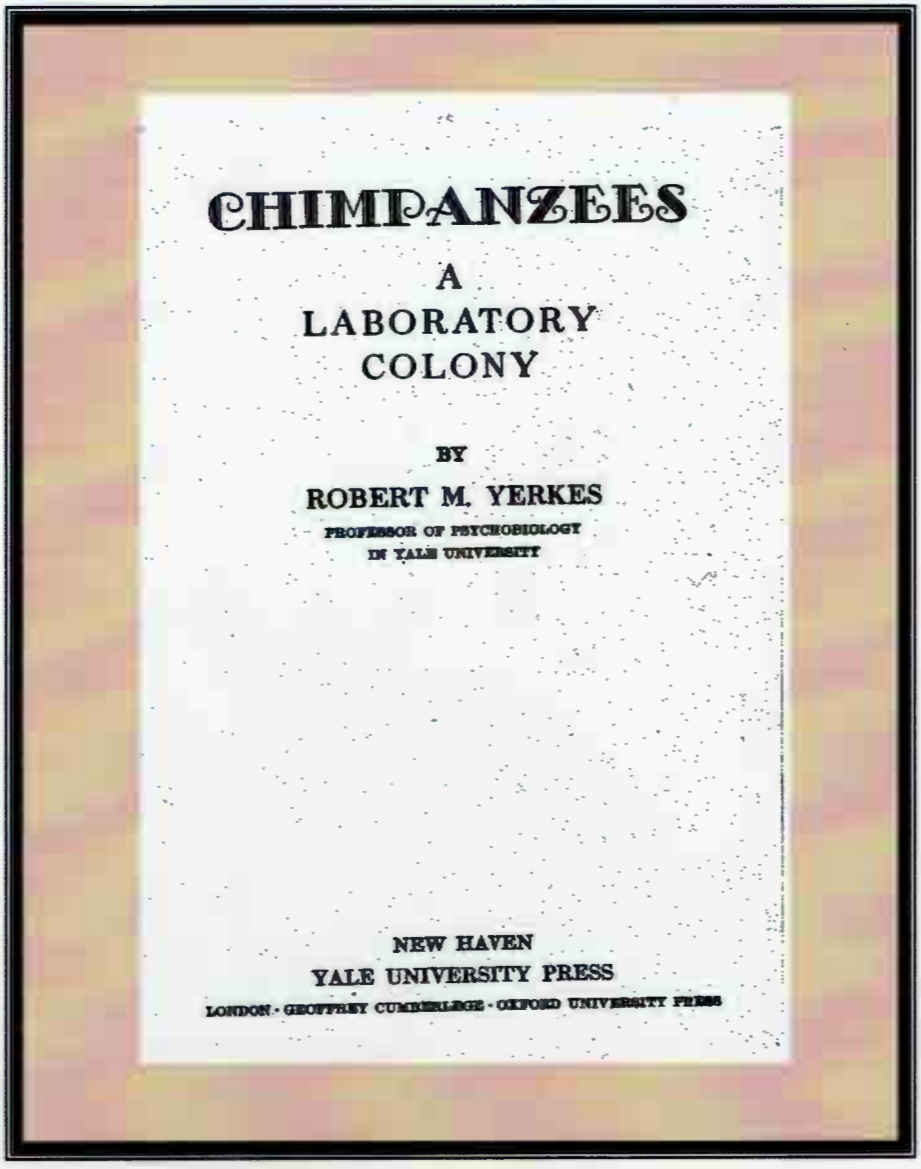
Chapter 30
Intelligence of Chimpanzees: Imaginal Processes

Section: "...Abstraction and Generalization"

Many investigators have noted that ***in the course of weeks or months of experimental work chimpanzees come to exhibit general adaptation, as contrasted with specific habituation.*** This is of such a nature that ***the probability of success in a new type of experiment or in the solution of a new problem is greatly increased.*** It is impossible to describe it more definitely, since ***the behavior has not been analyzed or its conditions discovered.*** That the terms abstraction and generalization are applicable is by no means certain. (p. 372, italics added)

Another illustrative instance of general adaptation appears in spread or transfer of training, from a particular experiment to others which are similar in principle, although differing in perceptual values. The extent to which this occurs in the chimpanzee has never been determined, although the fact of transfer is established. (p. 372, italics added)

The second selection from Yerkes is from:



CHIMPANZEES

A LABORATORY COLONY

BY

ROBERT M. YERKES

PROFESSOR OF PSYCHOBIOLOGY
IN YALE UNIVERSITY

NEW HAVEN
YALE UNIVERSITY PRESS
LONDON · GEOFFREY CUMBERLEGE · OXFORD UNIVERSITY PRESS

Robert M. Yerkes'

Chimpanzees: A Laboratory Colony (1943)

From Chapter 8, "Experience the Teacher"

The curve of improvement of response in such an experiment may seem to indicate that learning occurs gradually. Perhaps this is true. But it seems more, probable from the evidence at hand that instead of slowly learning to discriminate and choose correctly, ***the subject is instead engaged in learning to learn***.... The animal must first of all become familiar with the main features of the situation, including the experimenter.... (p. 130, italics added)

In the chimpanzee, experience may bring about either a specific or a generalized response. ***The individual is able to learn to react appropriately either to a particular set of stimuli or to a relationship such as greater brightness, whatever the situation in which it appears.*** (p. 130, italics added)

Gregory Bateson (1904-1980)

- Born in Grandchester, England
- B.Sc, 1925, Cambridge University
- M.A., 1930, Anthropology, Cambridge University
- Married thrice, first to Margaret Mead from 1936-1950... one child from each marriage.
- Several books authored, coauthored or edited.
- He was a thinker and scholar who was able to integrate anthropology, biology, cybernetics, philosophy, and psychology to mention less than complete list.

Bateson (1942) on "learning to learn."

Now it so happens that in the psychological laboratories there is a common phenomenon of a somewhat higher degree of abstraction or generality than those which the experiments are planned to elucidate....the experimental subject-whether animal or man, becomes a better subject after repeated experiments. He...***learns to learn***. He not only solves the problems set him by the experimenter, where each solving is a piece of simple learning;...he becomes more and more skilled in the solving of problems. (p. 88)

Bateson (1942) on the function of "learning to learn"

The line of argument which we have followed has brought us to a point at which statements about simple learning meet statements about gestalt and contextual structure, and we have reached the hypothesis that "learning to learn" is a synonym for the acquisition of that class of abstract habits of thought with which this paper is concerned; that the states of mind which we call "free-will," instrumental thinking, dominance, passivity, etc., are acquired by a process which we may equate with "learning to learn." (Bateson, 1942, p. 88)

Bateson: proto-learning and deutero-learning.

Let us coin two words, "proto-learning" and "deutero-learning," to avoid the labor of defining operationally all the other terms in the field (transfer of learning, generalization etc.). Let us say that there are two sorts of gradient discernible in all continued learning. The gradient at any point on a simple learning curve (e.g., a curve of rote learning) we shall say chiefly represents rate of proto-learning. If, however, we inflict a series of *similar learning experiments* on the same subject, we shall find that in each successive experiment the subject has a somewhat steeper proto-learning gradient, that he learns somewhat more rapidly. This progressive change in rate of proto-learning, we will call deutero-learning. (p. 89; italics added)

Bateson presented two hypothetical data graphs to suggest how deutro-learning might be assessed.

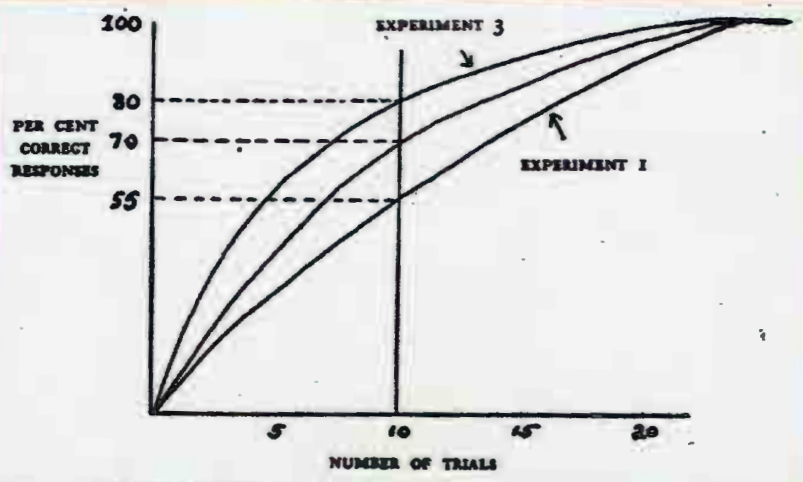


Fig. 1. Three Successive Learning Curves with the same subject, showing increase in rate of learning in successive experiments.

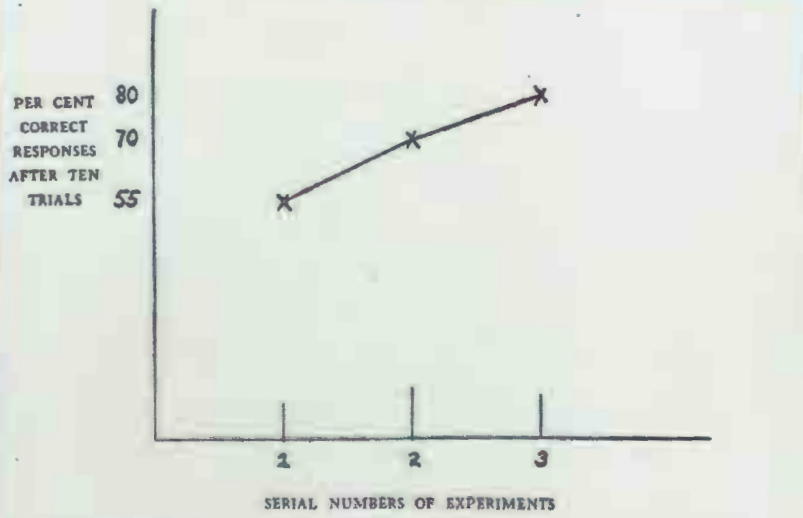
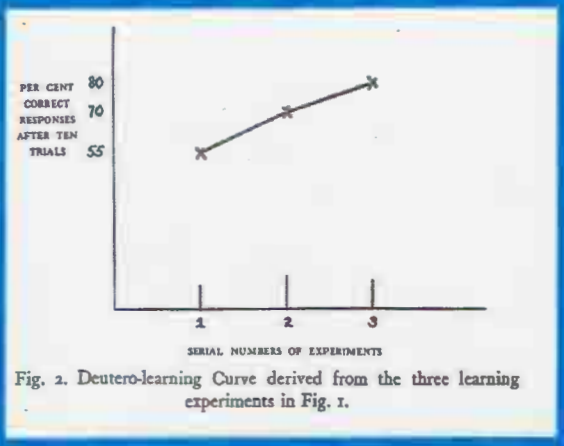


Fig. 2. Deutero-learning Curve derived from the three learning experiments in Fig. 1.

Bateson: Can deutero-learning experiments be done?

In this definition of proto- and deutero-learning, one phrase remains conspicuously vague, the phrase “a series of similar experiments."....Experiments in simple learning are already difficult enough to control and to perform with critical exactness, and experiments in deutero-learning are likely to prove almost impossible. (Bateson, 1942, p. 91)



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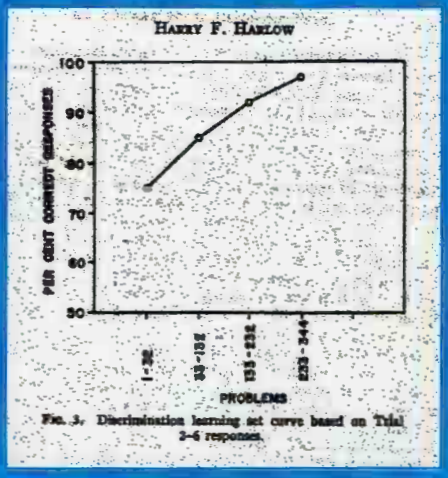

Fig. 3. Discrimination learning set curve based on Trial 2–6 responses.

Bateson's (1942) Fig. 2

Harlow's(1949) Fig. 3

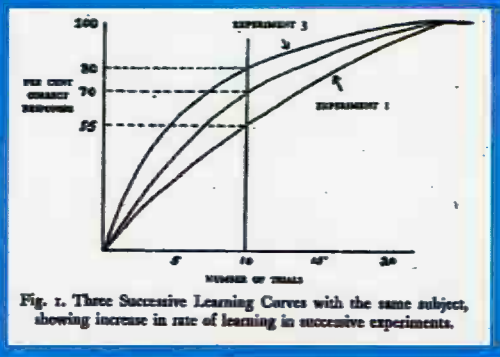

Fig. 1. Three Successive Learning Curves with the same subject, showing increase in rate of learning in successive experiments.

Bateson's (1942) Fig. 1

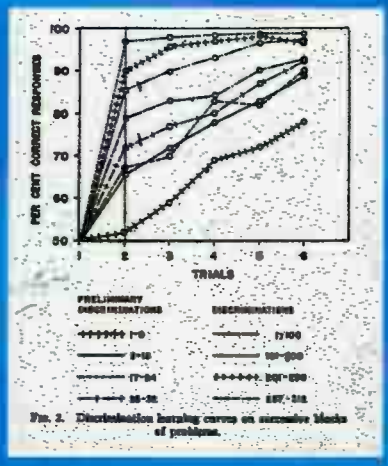

Fig. 2. Discrimination learning curves on successive blocks of problems.

Harlow's (1949) Fig. 2

When did Harlow's "discovery" of learning set begin?

The Journal of General Psychology, 1944, 30, 3-12.

STUDIES IN DISCRIMINATION LEARNING BY MONKEYS: I. THE LEARNING OF DISCRIMINATION SERIES AND THE REVERSAL OF DISCRIMINATION SERIES[*1]

Department of Psychology, University of Wisconsin

H. F. HARLOW

A. INTRODUCTION

Discrimination learning in animals has received widespread attention from psychologists and the various receptive capacities of most common laboratory animals has been studied. Detailed and careful investigation of factors influencing discrimination learning have been made by many investigators—including Fields (1), Klüver (4), Krechevsky (5), Lashley (6), and Spence (8).

Yet, in spite of the vast amount of effort spent on discrimination learning, no systematic attempt has been made to investigate one basic aspect of the general problem—the ability of sub-human animals to form sets or attitudes conducive to extremely rapid acquisition of new discriminative responses. It is a truism that human beings can form discriminations without any reinforcing trials being given, since the set to discriminate has already been established and may be immediately transferred by verbal cues. Whether or not other animals can form homologous sets remains an unsolved problem.

B. PURPOSE

The purpose of the following experiment was to investigate the nature of discrimination learning and reversal of discrimination learning in rhesus monkeys.

C. SUBJECTS

Six monkeys with no previous training on laboratory problems were used as subjects in these investigations. Four subjects, Nos. 50, 51, 52, and 53 were run on all tests but the last. All subjects were fully tamed before training and accustomed to the general experimental situation. In general, the method was adapted from that used and described by Weinstein (10).

[*]Received in the Editorial Office on June 18, 1942.
[*1]This work was supported in part by a grant from the Special Research Fund of the University of Wisconsin for 1940-41.

From another article in 1944 that was received in the editorial office on the same date in 1942. The person in the photograph was not identified...but, presumably, Harry Harlow.

By 1942, Harlow described and was clearly on the brink of introducing learning set formation, but he emphasized contemporary gestalt interpretations. However his use of "shudder quotes" does suggest discomfort with them.

If the monkeys had solved all the problems ***insightfully***, or, in other words, had approached all situations initially with the correct ***"hypothesis"***...the subjects should have made no errors on 50 percent of the trials and one error on the other trials (p. 7; italics added).

He did not see such evidence consistently, but ...

The data do show, however, that immediate or ***insightful*** solution of the problems is occurring in a large percentage of the discriminations. (p. 8; italics added)

Two pages later, Harlow came closest to describing the learning set for the first and only time before 1948/1949, but he continued to speak of gestalt insight learning.

Indeed, once a monkey has solved a preliminary series of discriminations....if the first response is by chance correct, no additional errors will be made. If the first response is by chance incorrect, the error will be corrected on the succeeding trial and no additional errors will be made. In ***gestalt terminology*** the discrimination learning is occurring ***"insightfully."*** (p. 10 italics added)

Finally, five paragraphs later:

....once appropriate ***reaction sets*** have been formed in monkeys, these sets may be ***transferred*** from one pair of discrimination objects to another, making it possible for the subjects to meet a strict criterion for formation of a discrimination with a minimum amount of specific training. (p. 11; first italics added)

Title Page: Book Containing Bateson's Comment (1942)

SCIENCE
PHILOSOPHY
AND
RELIGION

Second Symposium

CONFERENCE ON
SCIENCE, PHILOSOPHY AND RELIGION
IN THEIR RELATION TO THE DEMOCRATIC WAY OF LIFE, INC.
NEW YORK
1942

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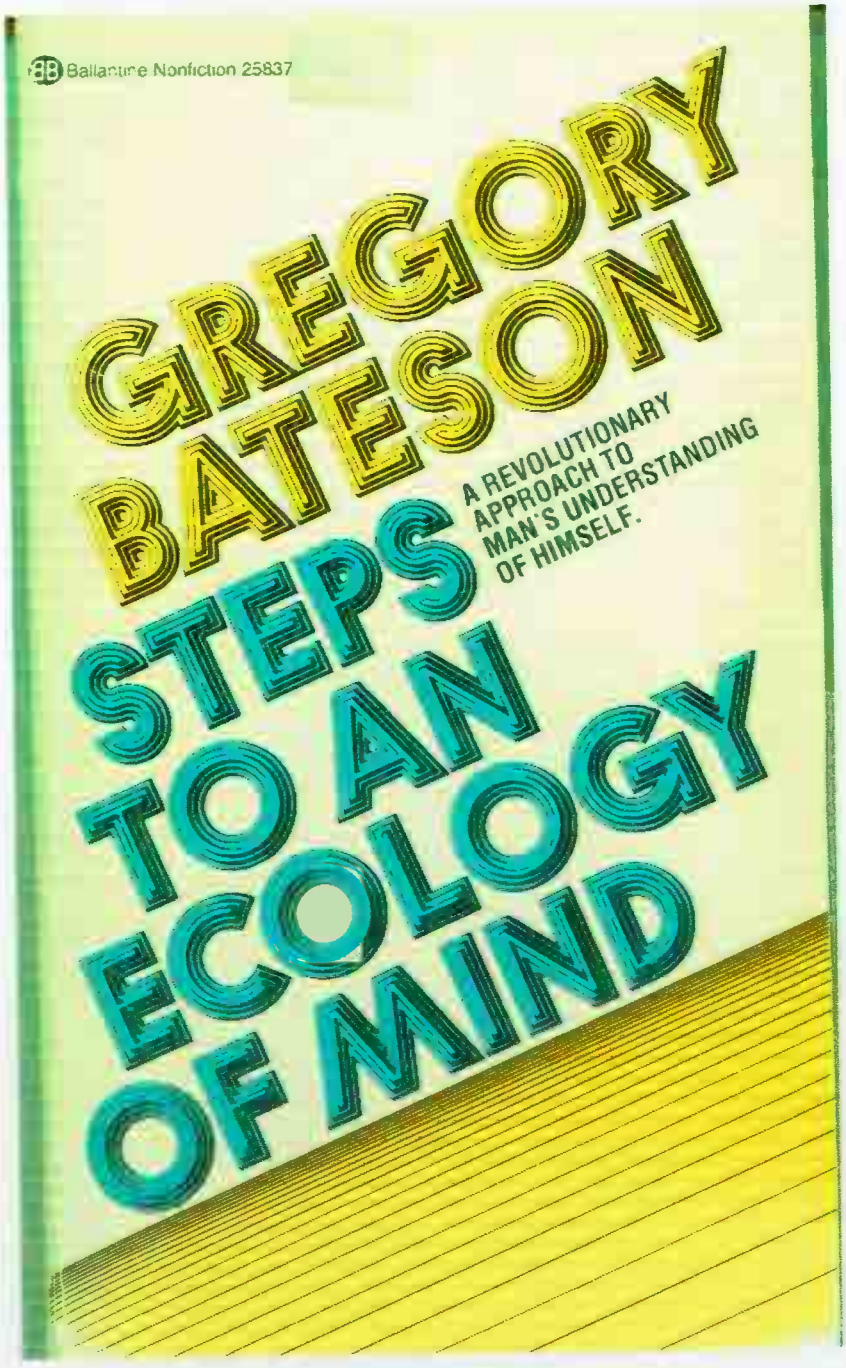
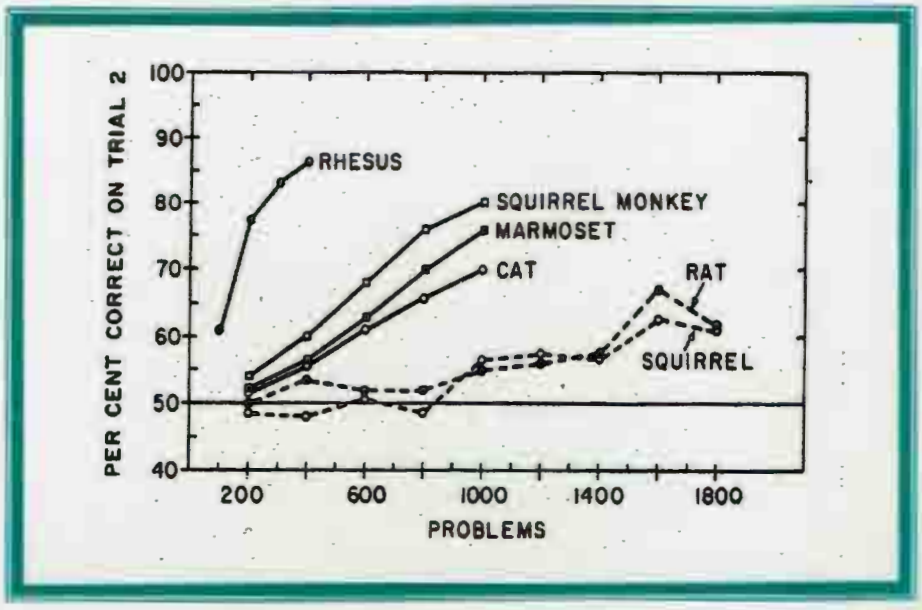

Ballantine Nonfiction 25837
GREGORY BATESON
STEPS TO AN ECOLOGY OF MIND
A REVOLUTIONARY APPROACH TO MAN'S UNDERSTANDING OF HIMSELF.

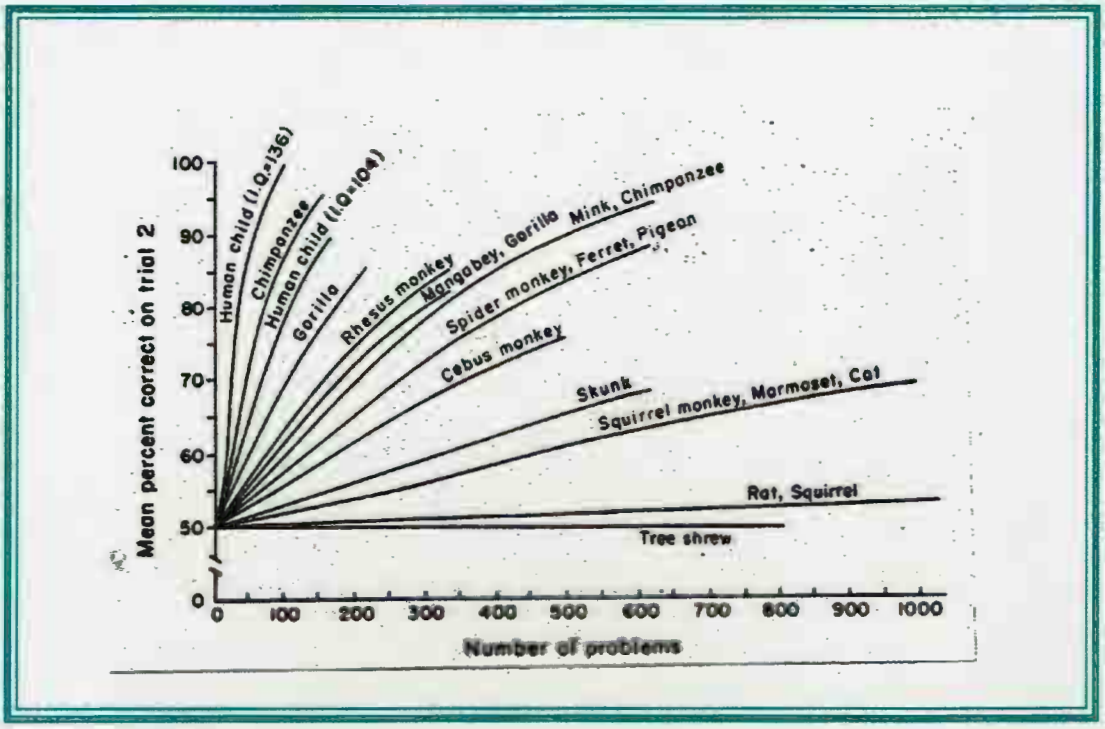
Learning Set Formation and Phylogenetic Comparisons:I

1. Warren (1965) suggested that learning set formation tasks might be used for phylogenetic comparisons of learning ability. His chapter, "Primate Learning in Comparative Perspective" (1965), included the graph below comparing performances of 6 species.



Learning Set Formation & Phylogenetic Comparisons: II

2. Hodos (1970), in his chapter "Evolutionary Interpretation of Neural and Behavioral Studies of Living Vertebrates," expanded upon Warren's graph and compared 16 species.



3. Warren (1974) reproduced Hodos' graph in an article where Warren concluded that ***"...the pattern of interspecies differences shown...probably reveals much more about differences among species in sensitivity to visual cues than learning per se."*** (p. 448)

By then, Warren was aware that studies using sensory modalities more favorable to a species, for example, olfactory for the rat, led to much better performances than those shown above where rats were tested on visual discriminanda.

4. Nevertheless, Riddell and Corl in their article, "Comparative Investigation of the Relationship Between Cerebral Indices and Learning Abilities" (1977) used learning set formation curves (LSF) for 13 species and calculated Spearman coefficients of correlation between the slopes of the LSF curves and three cerebral indices.

The correlation coefficients were:

0.87
0.95
0.98[1]

Riddell and Corl (1977) concluded, "...it is clear that reliable relationships do exist between brain indices and learning ability." (P. 395)[2]

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[1]The 0.98 was associated with Jerison's (1975) "extra neurons index" (N_e) which purports to estimate the number of neurons an average member of a species has beyond the number needed to sustain its vital functions.

[2]It should be noted that this conclusion was based on four learning tasks in addition to LSF.