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EDITED BY

GEORGE MELVILLE BOLLING
Ohio State University

AURELIO M. ESPINOSA
Stanford University

EDWARD SAPIR
University of Chicago

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A TECHNIQUE FOR THE EXPERIMENTAL INVESTIGATION OF ASSOCIATIVE INTERFERENCE IN ARTIFICIAL LINGUISTIC MATERIAL

BY

ERWIN ALLEN ESPER
Assistant Professor of Psychology, University of Illinois.

LINGUISTIC SOCIETY OF AMERICA
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FOREWORD

The experiments here reported, which were carried out in the Psychological Laboratory of the Ohio State University during the academic year 1921-1922, represent a further attempt in the development of a technique for the experimental investigation of the sensorimotor conditions involved in the process of analogic change in language. My interest in this problem dates from 1917, at which time I first became acquainted with the pioneer work of Thumb and Marbe in this field. The experiment which I reported in the *Psychological Review* in November 1918 was a repetition of the work of Thumb and Marbe; the method employed in the present investigation was suggested by Thumb in 1907. The conception of linguistic change as an experimental problem is one for which Thumb deserves the gratitude of all students of language.

I wish to express my deep sense of obligation to my teachers, George Melville Bolling and Albert P. Weiss. To the former, I owe my interest in language problems ; to the latter, my training in psychological methods as well as guidance and advice throughout this investigation. I am indebted also to Professor Leonard Bloomfield for valuable suggestions in the early stages of this work.

E. A. E.

Ohio State University
January 1925

TABLE OF CONTENTS

I. INTRODUCTION

Aside from changes in the meaning of words, linguistic science has distinguished two main classes of changes in language. The one class is called phonetic change, and includes all those cases where a given sound undergoes a certain modification wherever it occurs under the same phonetic conditions. The other class is called analogic change, and includes all those cases where words or groups of words, associated semantically or formally, become assimilated to each other in form. This second class has been theoretically explained as due to 'associations of ideas' or 'word-associations'. That is, if a word *a* is strongly associated with a word *b*, then it may often happen that the articulation of *a* will be interfered with by the associated word *b*, with a resultant mixture of the two words.

In 1901 the philologist A. Thumb, in collaboration with the psychologist K. Marbe, made the first attempt at an experimental study, in the psychological laboratory, of the conditions underlying analogic change.[1]

Their specific problem was to investigate what characteristics a word-association must have in order to result in an actual analogic change. A list of words was chosen from a number of categories which in the history of the Indo-European languages had shown a strong tendency toward analogic change, with a consequent assimilation in form of the different words of each category to each other. These selected words were used as stimuli in a free-association experiment. The results were as follows: (1) the more frequent a response was (i.e., the larger the number of subjects who gave the same response to a given stimulus word), the shorter was the reaction time; (2) words of a given category were associated predominantly with words of the same category; (3) in all the categories, with the exception of numerals, reciprocal associations were found; (4) numerals were associated predominantly with higher numerals; (5) adjectives were associated predominantly with adjectives of opposed meaning. Further, since the most frequent

1. A. Thumb und K. Marbe: *Experimentelle Untersuchungen ueber die psychologischen Grundlagen der sprachlichen Analogiebildung*, Leipzig, 1901.

associations, which were also those occurring most rapidly, showed a substantial agreement with the courses of analogic change and assimilation revealed in the history of the various Indo-European languages, Thumb concluded that (6) analogic changes result from those associations which predominate in a group of individuals and which occur with the greatest rapidity in the individual members of the group.[2]

Thumb himself regarded this experiment as but a beginning.[3] He believed that very important results might be obtained by extensive studies of various languages; more particularly, by investigating the associational tendencies in a given dialect and comparing these with actually developing analogic changes.

From a behavioristic point of view, we may say that the method of Thumb and Marbe is of value in indicating the interconnections of groups of verbal reactions; and that, by giving a measure (reaction-time and frequency) of the relative strength of these interconnections, it may aid us in predicting what modifications in the verbal reactions are likely to take place. On the conditions under which the interconnections themselves are developed, however, the method throws no light. It necessarily deals always with systems of verbal reactions which have been long and firmly established.[4]

2. Further experiments with similar method, material, and results were reported by Thumb, *Indogermanische Forschungen*, 22. 1-55 (1907), together with a reply to the criticisms of Wundt and others. Oertel, *Am. J. Philology*, 22. 261-267 (1901), reported an experiment with widely diverging method and consequently diverging results, for a discussion of which see the above article by Thumb and also Marbe, *Am. J. Psych.*, 13. 450 f. (1902). The writer in 1917 repeated the experiment of Thumb and Marbe with a large number of subjects, including a group of children and one of uneducated adults (*A Contribution to the Experimental Study of Analogy* in *Psych. Rev.*, 25. 468-487 [1918]). Since the results of this repetition with American subjects were in substantial agreement with those of the German investigation, the range of applicability of the latter was greatly extended.

3. Cf. *Experimentelle Untersuchungen*, pp. 84 ff., and the article cited in the preceeding note.

4. This limitation was recognized by Thumb. Cf. *Experimentelle Untersuchungen*, p. 79: "Aber nehmen wir einmal an, dass die Frage beantwortet wäre, welche Associationen vorhanden waren, und warum sie eine lautliche Wirkung hervorgerufen haben, so müssten wir doch zur Feststellung der Gesetzmässigkeit analogischer Neuerungen auch noch wissen, unter welchen Bedingungen bestimmte Wort- oder Formassociationen überhaupt eintreten. Das sind jedoch Fragen, die von der Sprachwissenschaft allein noch weniger gelöst werden können — aber auch die Psychologie ist in diesen Dingen noch nicht weit gekommen".

II. STATEMENT OF THE PROBLEM

Thumb suggested a new method of investigating the conditions under which analogic changes take place, in the following words : "..... ist es vielleicht möglich, künstlich bei Versuchspersonen Analogiebildungen (Kontaminationen) hervorzurufen ?..... Wenn es gelingen wird, Analogiebildungen experimentell zu erzeugen — natürlich an einem sprachlich völlig neutralen Material, d.h. an künstlichen Lautgebilden —, so werden wir imstande sein, die bis jetzt erkannten Bedingungen des Vorganges in ihrem Wirken qualitativ und quantitativ zu studieren und weiteren Faktoren der Analogiebildung auf die Spur zu kommen." [5] The present series of experiments represents an attempt to develop such a method.

When the problem is approached in this manner, however, its scope becomes ultimately much broader than the original question of the conditions under which analogic changes take place in the historic languages. It becomes a problem of how language reactions become organized into the systems which we call grammatical categories, and how the component reactions of these systems come to be marked by common elements ; in other words, under what conditions the 'associations' which have been held to be responsible for linguistic assimilation are themselves established.

A limitation of such an investigation is at once evident : we can experiment only with subjects who are already possessed of a highly complex and firmly fixed set of language habits ; a 'primitive man' or isolated infants are unfortunately not to be obtained for experimental purposes. This limitation, however, is rather general in psychological experimentation.[6] We can at least expect that the manner in which artificial linguistic material becomes organized into categories

5. *Indogermanische Forschungen*, 22. 48-49 (1907).

6. Dr. A.P. Weiss reminds me that such limitations are not restricted to psychology : " The ideal scientific method, 'to vary only *one* factor while all the other factors remain constant', is only an ideal. What we actually do is to keep as many conditions constant as we can and by repetition and variation try to segregate the relative potencies of the elements (often unknown) of the combination which cannot be physically broken up."

will bear a definite relationship to the tendencies inherent in the speech-habits of the subjects, and that a comparison of the results gained from subjects of widely different language habits may reveal certain uniformities and general laws according to which the organization of language habits takes place. A program of investigation is thus suggested for which the present study aims merely at making a beginning in the development of an adequate technique.

Briefly stated, my problem was to arrange a number of experimental conditions for the learning of artificial linguistic material, and to compare the results under each of these conditions with reference to the development of linguistic categories.

III. METHOD AND APPARATUS

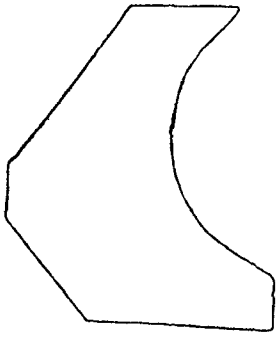
A. General.

The method consisted essentially of joint visual, auditory, and kinesthetic stimulation. The visual stimuli were irregular figures of equal area (6 sq. cm.) and of different colors (red, green, blue, yellow). The auditory stimuli were nonsense syllables, pronounced by the experimenter as the visual stimuli were exposed. The kinesthetic stimuli resulted from the subject's being required to pronounce the nonsense syllables after the experimenter.

B. Apparatus.

The apparatus used for exposing the visual stimuli is a form of tachistoscope designed for this experiment by Dr. A. P. Weiss. It consists of a drum 20.6 cm. in diameter mounted in slots at the top of a wooden frame 1.52 m. in height. On the axle of the drum is a five-pointed starwheel, the points of which are tripped by a trigger on a pulley-wheel. With each revolution of the pulley-wheel, the drum is therefore turned through one-fifth of a revolution. The apparatus is driven by a 1/10 h. p. electric motor. A series of pulleys reduces the rate of the drum to one-fifth revolution every 2.7 seconds. During each of these intervals the drum is in motion approximately 0.7 sec. and at rest 2.0 sec.

The figures which constitute the visual stimuli were cut out of standard (Milton-Bradley) colored papers and mounted in two vertical rows on a continuous paper belt 21.6 cm. in width. This belt was then hung on the drum of the tachistoscope, the figures being so spaced on the belt that with each one-fifth revolution of the drum one figure moves into a given area. The frame of the apparatus was covered with grey cardboard so as to conceal the paper belt except for a window of 22.8 by 12.7 cm. at a height of 1.07 m. above the floor. In the opening thus left was placed, in horizontal grooves, a grey cardboard slide 11.4 by 12.7 cm., which made possible the exposure of either the right or the left vertical row of figures. There is thus an exposure area of 11.4 by 12.7 cm. on either the right or the left side according to the position of the slide. A shutter, also operated by the trigger on the pulley-wheel, closes over the exposure area while the drum and belt are in motion and opens when the next figure is in position.



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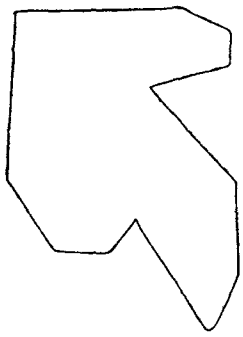

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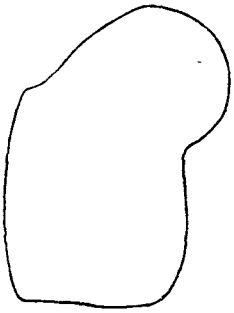

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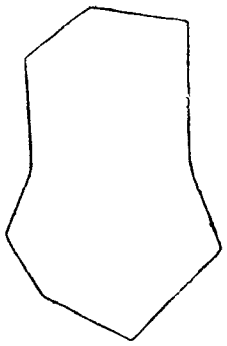


No. 4.

FIGURE 1.

The four shapes used in all experiments, reduced to 1/2 diameter.

The experiment was conducted in a dark-room, the exposure area of the apparatus being illuminated by a daylight bulb. The subject was seated 1.4 m. from the apparatus and directly in front of the exposure area. The experimenter sat at a table to the right and slightly to the rear of the subject, from which position he was able to control the apparatus either by a switch stopping and starting the motor, or by means of a cord which, running through a series of pulleys, controlled an idler-wheel which acted as a belt-tightener. This idler-wheel made it possible to stop the drum without stopping the motor.

C. The Miniature Linguistic Systems.

The visual and auditory stimuli of each experiment constitute together an artificial miniature linguistic system. The shapes of the figures (Fig. 1) were devised with a view to making them unlike any familiar object for which the subject could find a name. Ingenious subjects will of course always find some object with which to compare a nonsense figure, just as they will always contrive to associate a nonsense syllable with some word of actual language. The attempt was made, however, to reduce the possibility of such associations foreign to the experiment. The four shapes (numbered 1, 2, 3, 4) and the four colors (red, green, blue, yellow) made possible 16 combinations. These combinations will be symbolized hereafter by numerals indicating their shape and initial letters indicating their color; thus, 1R = shape No. 1 of red color; 2G = shape No. 2 of green color; etc. In what will be described below as the 'learning series', only 14 of the combinations were used, 2 being omitted (2Y and 4R); while in the 'recognition series' all combinations were used.

For each of the combinations of shape and color, a nonsense name was devised. In the construction of these names only English sounds were used, although the sequence of sounds deviates to some extent from the English system. An especial effort was made to prevent a resemblance of the artificial words to any specific words of actual language. The syllables of the artificial names are correlated in differing degrees in the three experiments with the two factors of color and shape in the figures.

D. The General Experimental Procedure.

In Experiment I, seven subjects were used; in Experiments II and III, eight each. All were undergraduate students in the Ohio State University. No individual acted as subject in more than one of the experiments.

The subject having been seated before the apparatus, the motor (but not the exposure drum) was started and allowed to run while the instructions were given, in order that the subject might become adapted to the sound of the motor. It may be remarked here that the sound of the motor and of the apparatus together did not interfere with the understanding of speech in ordinary conversational tones. The sound of the apparatus, being relatively constant, was actually an advantage, inasmuch as it eliminated disturbing noises arising outside the dark-room.

1. The Learning Series.

The *left* vertical row of figures constituted the learning series, the right row being concealed by the slide. The following instructions were read to each subject :

> This is not an intelligence test. It is an experiment to determine how quickly you can learn the names of certain sacrificial objects in the Morgavian language, a language spoken on the northern slopes of the Himalaya Mountains. As each object is shown, I shall pronounce its name. You will immediately repeat the name after me aloud. If you are not sure of my pronunciation of any word, do not ask for a repetition, but do your best. Each time the series is repeated, try to make your pronunciation more like mine. Do not make any comments until the end of the hour, and do not set yourself any other task than looking at the objects and repeating their names after me. [7]

2. The Recognition Series.

After the learning series had been repeated four times, the drum was stopped, and the slide pushed over so as to expose the right half of the belt. The row of figures on this side of the belt constituted the recognition series, which differed from the learning series in that the figures were in an entirely different order, and in including *all* of the possible 16 combinations of shape and color, while in the learning series 2 combinations (2Y and 4R) had been omitted. These two combinations will be referred to hereafter as the 'unlearned figures'.

The following instructions were now read to the subject:

> I shall now show you the objects in a different order, without pronouncing their names. As soon as you see each object, call out its name in a loud distinct voice. If you are not sure of the name, guess ; but be sure to call out promptly the instant each object is exposed, without waiting to think about it. It is not expected that you will learn the series immediately. Be sure to call out loudly and distinctly. Do not set yourself any other task than calling out the names of the objects as they appear.

7. The reference to 'sacrificial objects' and the 'Morgavian language' is of course fictitious. It was desired to avoid a nonsense setting as far as possible.

The drum having again been started, the experimenter recorded the subject's responses. Those responses which varied from the 'correct' responses (i.e., those taught in the learning series) were recorded as accurately as possible in the symbols of the International Phonetic Association.

After the recognition series had been given once, four repetitions of the learning series were again given in the same way as before; then a recognition series, followed again by four repetitions of the learning series, and so on.

3. The Distribution of the Repetitions.

Each subject appeared on seven different days distributed over a period of two months. The sequence of days was arranged in geometrical progression as follows: 1st day, 2nd day, 4th day, 8th day, 16th day, 32nd day, 62nd day. The recognition series was given after every four repetitions of the learning series, except on the last three days when the total number of repetitions of the learning series became less than four. On the 1st day, 32 repetitions of the learning series were given; on the 2nd day, 16; on the 4th, 8; on the 8th, 4; on the 16th, 2; on the 32nd, 1; on the 62nd, none (only the recognition series being given). On each day after the first, the subjects were given a recognition series to begin with, to test their remembrance of the material from the work of the preceding days. Table I summarizes the distribution of repetitions.

4. The 'Unlearned' Figures.

In each of the three experiments, figures 2Y and 4R with their corresponding names were omitted from the learning series, but included in the recognition series. The subject accordingly never saw these figures or heard their names in the learning series. Whatever responses he made to them when they appeared in the recognition series were necessarily dependent on analogy with the other figures and names which he had been taught. The subjects were not told that there were two more figures in the recognition series than in the learning series. Some subjects, more especially in Experiments II and III, became suspicious after they had reached a certain stage of learning and inquired whether there were not more figures in the recognition series. The invariable reply of the experimenter was that "the recognition series is the same as the learning series except that the objects are in a different order."

TABLE I

Summary of Repetitions, Experiments, I, II, and III.

On the upper horizontal line, *1st*, *2nd*, etc. refer to first day, second day, etc. *L* = learning series; *R* = recognition series. Numerals indicate number of repetitions.

1st	2nd	4th	8th	16th	32nd	62nd
	1R	1R	1R	1R	1R	2R
4L	4L	4L	4L	2L	1L	
1R	1R	1R	1R	1R	1R	
4L	4L	4L				
1R	1R	1R				
4L	4L					
1R	1R					
4L	4L					
1R	1R					
4L						
1R						
4L						
1R						
4L						
1R						
4L						
1R						
Totals 32L,8R	16L,5R	8L,3R	4L,2R	2L,2R	1L,2R	2R

TABLE II

The Material of Experiment I.

Com. = shape-color combination; the numbers refer to the shapes of the figures (see Fig. 1); the letters refer to the colors red, green, blue, and yellow. The two 'unlearned' figures and their names are starred.

Com.	Name	Com.	Name	Com.	Name	Com.	Name
1R	naslij	2R	nasčaw	3R	nasdeg	4R*	naskop*
1G	wečlij	2G	weččaw	3G	wečdeg	4G	wečkop
1B	ʃownlij	2B	ʃowndaw	3B	ʃowndeg	4B	ʃownkop
1Y	rojlij	2Y*	rojčaw*	3Y	rojdeg	4Y	rojkop

TABLE III

THE MATERIAL OF EXPERIMENT II.

Explanation as under Table II, page 14.

Com.	Name	Com.	Name	Com.	Name	Com.	Name
1R	nulgɛn	2R	dojlgɛn	3R	pelgɛn	4R*	wilgɛn*
1G	nugdet	2G	dojgdet	3G	pegdet	4G	wigdet
1B	nuzgub	2B	dojzgub	3B	pezgub	4B	wizgub
1Y	numbow	2Y*	dojmbow*	3Y	pembow	4Y	wimbow

E. THE MATERIAL AND SPECIAL CONDITIONS OF EXPERIMENT I.

The nonsense names assigned to each of the combinations of shape and color in Experiment I are indicated in Table II in the symbols of the International Phonetic Association.[8]

The special conditions of Experiment I, as the table in part shows, are as as follows :

1. The nonsense syllables are correlated throughout with the two factors of shape and color in the figures. For example, to shape No. 1 corresponds the syllable *-liŋ* ; to the color red corresponds the syllable *nas-*.

2. The order of the linguistic elements is color-shape, conforming to the English construction adjective-noun (e. g. ' red square ').

3. Each of the linguistic elements is a natural syllable.

4. The two syllables of each name were spoken by the experimenter with even stress and without pause.

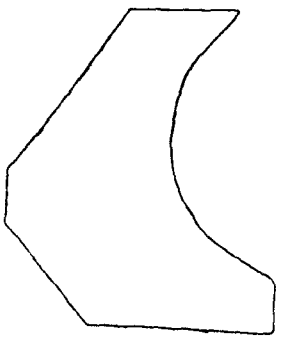
F. THE MATERIAL AND SPECIAL CONDITIONS OF EXPERIMENT II.

Table III will indicate the nonsense names assigned to each of the combinations of shape and color in Experiment II (see footnote 8).

The special conditions of Experiment II are as follows :

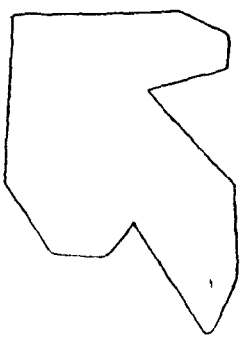
1. Specific sound-sequences are correlated throughout with the two factors of shape and color in the figures. For example, to shape No. 1 corresponds the sound-sequence *nu-* ; to the color red corresponds the sound-sequence *-lgɛn*.

8. The stimuli were of course not presented to the subject in the order of the Table. They were arranged in one order for the learning series and in another order for the recognition series ; in both cases in such a manner that like figures did not follow one another.



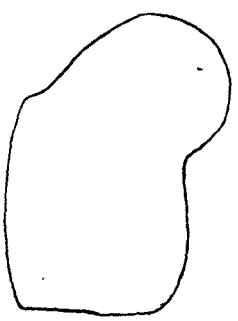
No. 1.

	I	II	III
R	naslitʃ	nulgɛn	čɛlhib
G	wečlitʃ	nugdet	vit
B	ʃownlitʃ	nuzgub	zib
Y	rojlitʃ	numbow	tekbem



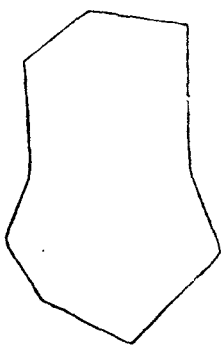
No. 2.

	I	II	III
R	nasčaw	dojlgɛn	nuzgub
G	weččaw	dojgdet	kulren
B	ʃownčaw	dojzgub	sotmitʃ
Y	*rojčaw	*dojmbow	*....



No. 3.

	I	II	III
R	nasdeg	pelgɛn	jowndeg
G	wečdeg	pegdet	awa
B	ʃowndeg	pezgub	faʒa
Y	rojdeg	pembow	jonθim



No. 4.

	I	II	III
R	*naskop	*wilgɛn	*....
G	wečkop	wigdet	ʃɛb
B	ʃownkop	wizgub	wuč
Y	rojkop	wimbow	pel

FIGURE Ia

Showing the names assigned to the figures in Experiments I, II, and III. Figures are reduced one-half. Under each figure, the vertical column at the left indicates the colors, and the Roman numerals at the top refer to the three experiments. The two shape-color combinations which did not occur in the learning series are starred.

TABLE IV

THE MATERIAL OF EXPERIMENT III.

Explanation as under Table II above.

Com.	Name	Com.	Name	Com.	Name	Com.	Name
1R	čɛlhib	2R	nuzgub	3R	jowndeg	4R*	—
1G	vit	2G	kulren	3G	awa	4G	ʃɛb
1B	zib	2B	sotmiŋ	3B	faʒa	4B	wuč
1Y	tekbem	2Y*	—	3Y	jonθim	4Y	pel

2. The order of the linguistic elements is shape-color, *reversing* the English order of adjective-noun.

3. The linguistic elements are not separated by a natural syllable division; e. g. in *nulgɛn* the two elements are *nu-lgɛn*, an impossible syllable division in English.

4. The experimenter pronounced each name without pause, stressing the last syllable.

It will be seen that conditions 2 and 3 of Experiment II greatly lessen the parallelism of our artificial system with the English construction.

G. THE MATERIAL AND SPECIAL CONDITIONS OF EXPERIMENT III.

Table IV will indicate the nonsense names assigned to the combinations of shape and color in Experiment III (see footnote 8).

The special conditions of Experiment III are as follows:

1. No correlation whatever is provided between the visual and the auditory stimuli, except that, since most of the auditory stimuli contain two syllables, a division into two elements corresponding to the two factors of the visual stimuli is suggested. Five of the auditory stimuli, however, contain only one syllable.

2. The experimenter pronounced each name without pause, and in the case of those names containing two syllables stressed the second.

3. Since there is no correlation between visual and auditory stimuli, the names of the other figures provide no pattern for the naming of the two 'unlearned' figures (2Y and 4R).

The material of Experiments I, II, and III may be compared in Figure Ia.

IV. RESULTS

A. The Rates of Learning in Experiments I, II, and III.

In a comparison of the linguistic results of Experiments I, II, and III, it will be important to have a measure of the relative difficulty of the learning under each of these three sets of conditions. In Experiments I and II, where the two visual factors of shape and color are exactly correlated with specific and uniformly recurring sound-sequences, it is also possible to compare the rates and degrees of learning of (1) the syllables corresponding to shape and color, and (2) the names corresponding to the 14 figures of the learning series and those corresponding to the 2 figures which occurred only in the recognition series. By *correct response* is meant a response to a figure substantially identical with the name which was taught to the subject in the learning series, or, in the case of the two figures which did not occur in the learning series, a response showing a correct analysis of the factors of shape and color in accordance with the categories of the linguistic system of the experiment. Many responses have been counted as correct, for the purposes of these comparisons, which deviate phonetically to some extent from the words taught, but which are nevertheless unmistakeable variants of these words. They are due to the subject's misunderstanding of certain sounds in the learning series or his inability to reproduce them exactly in the recognition series, and ultimately are to be referred to three causes: first, some of the sound-sequences of the experimental material differed from very common sequences in English; second, the dialect of some of the subjects differed from that of the experimenter; and third, the unfamiliarity of material made possible confusion between such sounds as voiced and voiceless stops, *m* and *n*, *th* and *f*, etc. Such variant pronunciations were inevitable under the conditions of the experiments, where adult individuals were orally taught unfamiliar material without preliminary training and under definite time restrictions. To eliminate such responses from the tables would, in the writer's opinion, give a distorted picture of the rate of learning.

In the curves of Figures 2 to 7, the upper row of figures along the *x*-axis indicates the cumulative number of repetitions of the

learning series, and the lower row the order of the days on which these series were given, as shown in Table I. The figures along the *y*-axis indicate the percentage of correct responses. In both tables and curves, a value of 100 would mean that, for the recognition series in question, every subject responded correctly to every figure. The first recognition series of each day after the first, and the two series of the 62nd day, are not indicated in the curves, because these were given without additional learning, and hence represent only the degree of retention from the previous days. The percentages for these series are however shown in the tables.

EXPERIMENT I.

Table V and Figures 2, 3, and 4 give the results for Experiment I. Columns I, II, and III of Table V and the curves of Fig. 2 show the rates of learning of the complete names corresponding to the figures, and of the syllables corresponding to shape and to color. The curves show the same general character; a rapid rise during the first day's work, with a falling off in the last series of this day; thereafter, on the second day, a more gradual rise, and, beginning with the fourth day, a levelling off. Noteworthy is the amount of retention on the 62nd day. The two recognition series of this day were given, without additional learning, 30 days after the last previous series. They show practically no losses due to forgetting.

The curve of learning for the shapes rises very rapidly for the first three series of the first day, but thereafter levels off, and on the seventh series is crossed by the curve for color. The relationship between these two curves is however obscured by the responses of one subject who, while responding correctly to the colors, consistently confused the shapes. Fig. 3 shows the curves for shape and color as they appear when the responses of this subject have been eliminated. Here, while the same levelling off of the curve for shape occurs after the third series, with a crossing of the curves on the seventh series, yet in general, in addition to its more rapid initial rise, the curve for shape remains above that for color.

Columns IV and V of Table V and the curves of Fig. 4 show the rates of learning of the names of the 14 figures of the learning series and of the 2 figures which occurred only in the recognition series, respectively. There are no correct responses to the unlearned figures until the fourth series of the first day, but thereafter the curve for these figures rises rapidly, following the general form of the curve

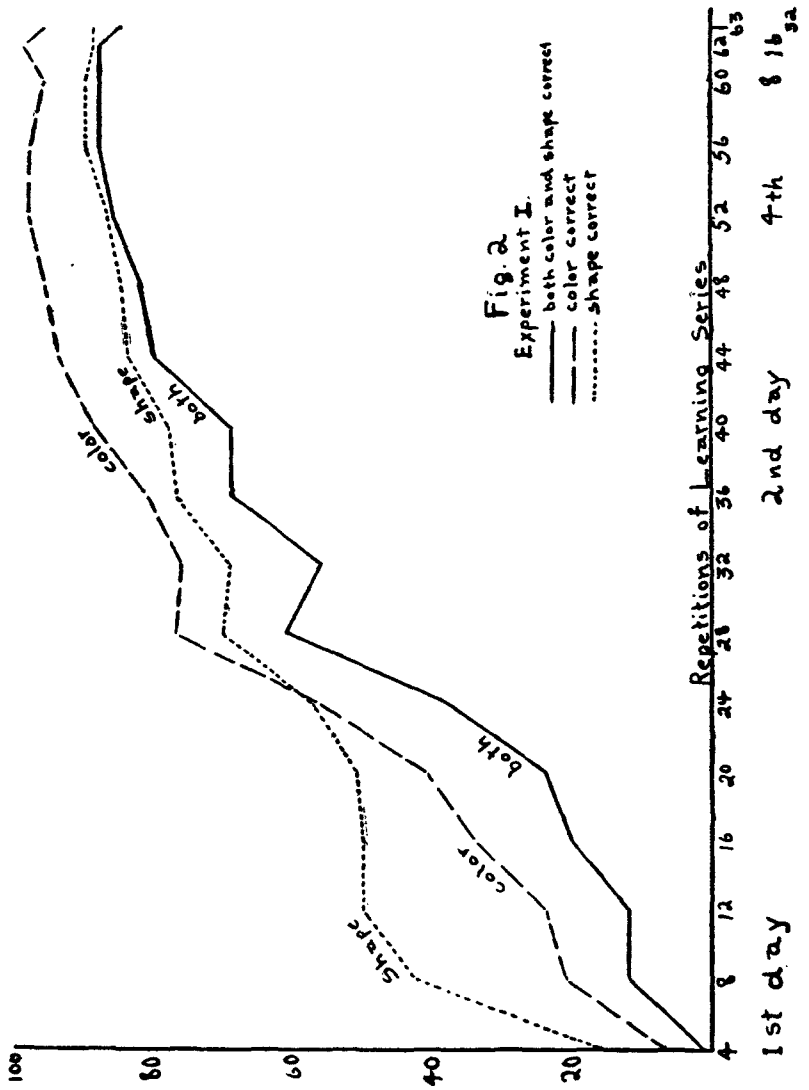
TABLE V

EXPERIMENT I

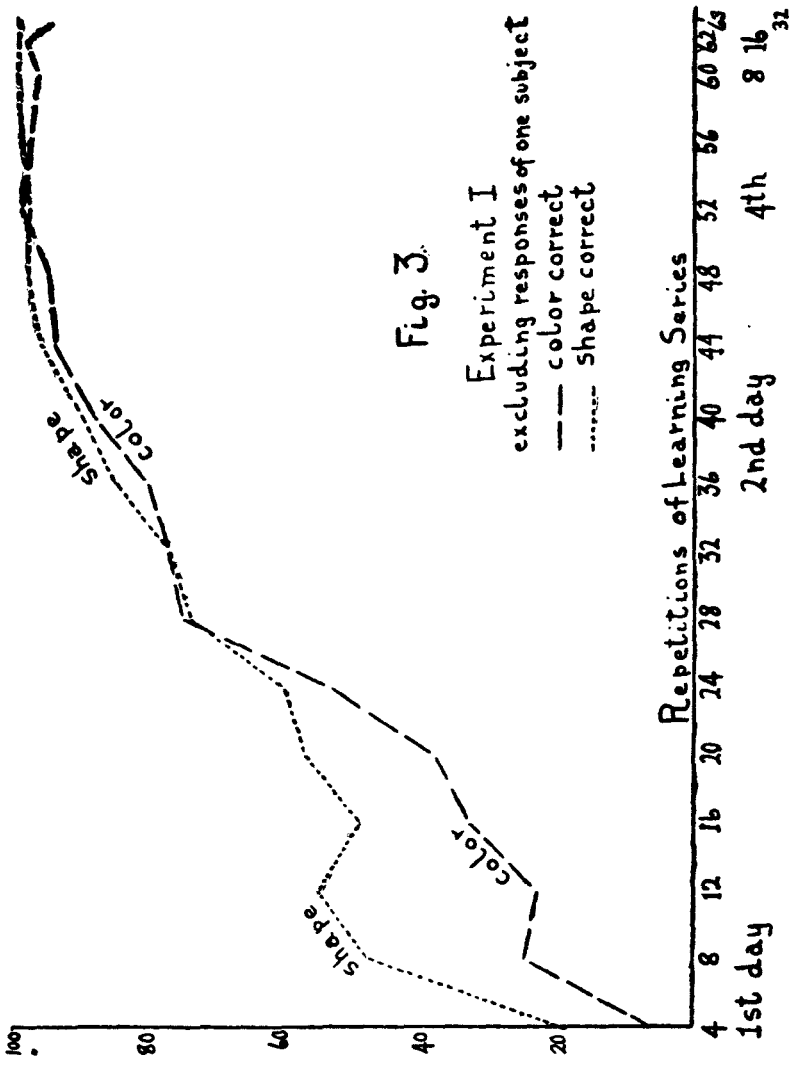
Column I : the percentage of responses correct as to both shape and color (inclusive of the responses to the 2 unlearned figures).
Column II : the percentage of responses correct as to shape.
Column III : the percentage of responses correct as to color.
Column IV : the percentage of correct responses to the 14 learned figures.
Column V : the percentage of correct responses to the 2 unlearned figures.

DAY	SERIES	both I	shape II	color III	learned IV	unlearned V
1st	1	1	16	7	1	0
	2	12	43	21	14	0
	3	12	50	24	14	0
	4	20	50	34	21	7
	5	24	51	41	27	7
	6	38	57	56	41	21
	7	61	70	77	63	43
	8	56	69	76	56	57
2nd	1	48	66	62	52	21
	2	69	77	81	71	50
	3	69	78	89	70	57
	4	80	84	94	82	71
	5	82	85	96	84	71
4th	1	79	84	92	83	57
	2	86	87	98	86	86
	3	88	90	98	90	78
8th	1	82	85	95	83	78
	2	88	90	96	89	78
16th	1	80	88	92	83	64
	2	88	89	99	90	78
32nd	1	82	87	94	85	64
	2	85	89	96	86	78
62nd	1	82	86	94	85	64
	2	88	88	97	88	86

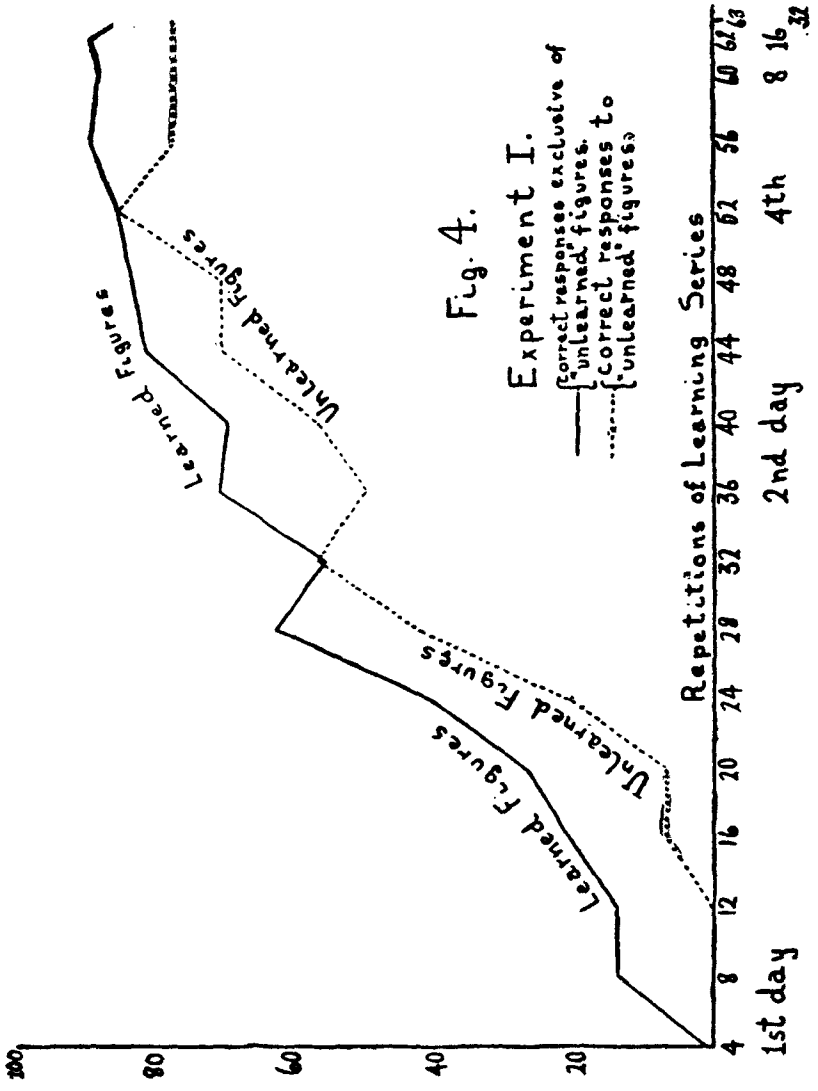
for the learned figures, and reaches its maximum on the first series of the fourth day. It then falls off again, but as the table shows, this maximum is again reached on the 62nd day.



PERCENTAGE OF CORRECT RESPONSES



PERCENTAGE OF CORRECT RESPONSES



PERCENTAGE OF CORRECT RESPONSES

TABLE VI

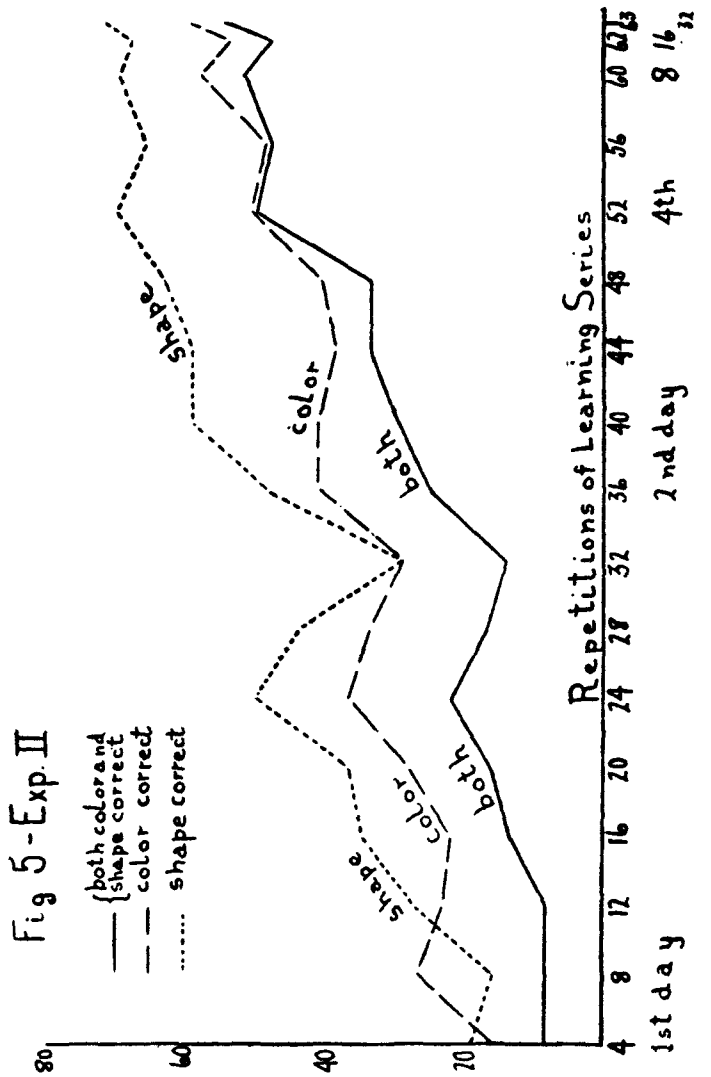
EXPERIMENT II.

Column I : the percentage of responses correct as to both shape and color (inclusive of the responses to the 2 unlearned figures).
Column II : the percentage of responses correct as to shape.
Column III : the percentage of responses correct as to color.
Column IV : the percentage of correct responses to the 14 learned figures.
Column V : the percentage of correct responses to the 2 unlearned figures.

DAY	SERIES	both	shape	color	learned	unlearned
		I	II	III	IV	V
1st	1	8	19	16	9	0
	2	8	16	27	9	0
	3	8	27	23	9	0
	4	13	35	22	15	0
	5	16	37	28	19	0
	6	22	50	37	25	0
	7	17	44	34	19	6
	8	14	29	29	16	0
2nd	1	20	28	31	21	6
	2	25	48	41	29	0
	3	30	59	41	34	6
	4	34	59	39	39	0
	5	34	63	41	39	0
4th	1	27	48	34	29	6
	2	50	70	51	54	19
	3	48	66	49	54	6
8th	1	38	56	43	43	0
	2	52	70	58	59	6
16th	1	41	61	47	47	0
	2	48	68	54	54	6
32nd	1	44	65	53	49	6
	2	55	72	60	61	12
62nd	1	46	62	53	53	0
	2	50	62	55	54	19

EXPERIMENT II.

Table VI and Figures 5 and 6 give the results for Experiment II. Columns I, II, and III of Table VI and the curves of Fig. 5 show the rate of learning of the complete names of the figures and of the sound-sequences corresponding to shape and to color respectively. The three



PERCENTAGE OF CORRECT RESPONSES

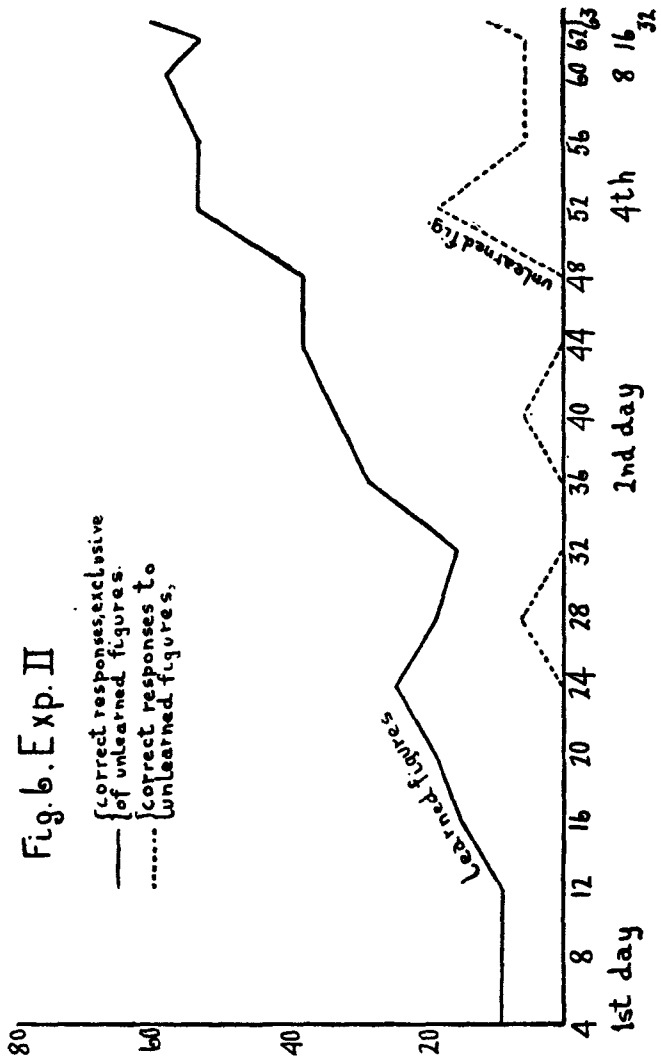


Fig. 6. Exp. II
correct responses, exclusive of unlearned figures.
correct responses to unlearned figures.
learned figures
unlearned fig.
80
60
40
20
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
62
63
8 16/32
1st day
2nd day
4th
Percentage of Correct Responses

TABLE VII

EXPERIMENT III.

The percentage of correct responses to the 14 figures of the learning series.

SERIES	1st day	2nd day	4th day	8th day	16th day	32nd day	62nd day
1	0	19	36	55	51	45	47
2	7	35	57	66	68	62	48
3	8	46	56				
4	13	49					
5	15	51					
6	19						
7	22						
8	23						

curves are, as in Experiment I, roughly similar in configuration. As in Experiment I, the rate of learning of shape is more rapid than that of color, but the difference between these two curves is more pronounced than in Experiment I, as would be expected from the difference in the material. In Experiment II, the sound-sequences corresponding to color were rendered more difficult of learning by the fact that they did not constitute natural syllables.

Columns IV and V of Table VI and the curves of Fig. 6 show the rates of learning of the 14 learned and the 2 unlearned figures respectively. The correct responses to the unlearned figures reach a maximum of 19 percent on the fourth day; this maximum is not again reached until the 62nd day.

EXPERIMENT III.

Table VII and the curve in Fig. 7 show the rate of learning of the names of the 14 figures of the learning series in Experiment III. In this experiment we cannot speak of correct responses to the two figures which occurred only in the recognition series, since the linguistic material provides no correlation between the visual and the auditory stimuli, and hence no phonetic elements corresponding to shape and color. For the same reason, we cannot analyse the responses as being correct in color or in shape.

The curves of learning of the 14 learned figures of each experiment may be compared in Fig. 7. If we compare the speed and extent of learning in the three experiments, Experiment I falls in one class, as being much more rapidly and completely learned, and Experiments II and III fall together in another class with respect to the general level of their curves and the lower degree of learning attained. If however we compare the shapes of the curves, we get a different classification:

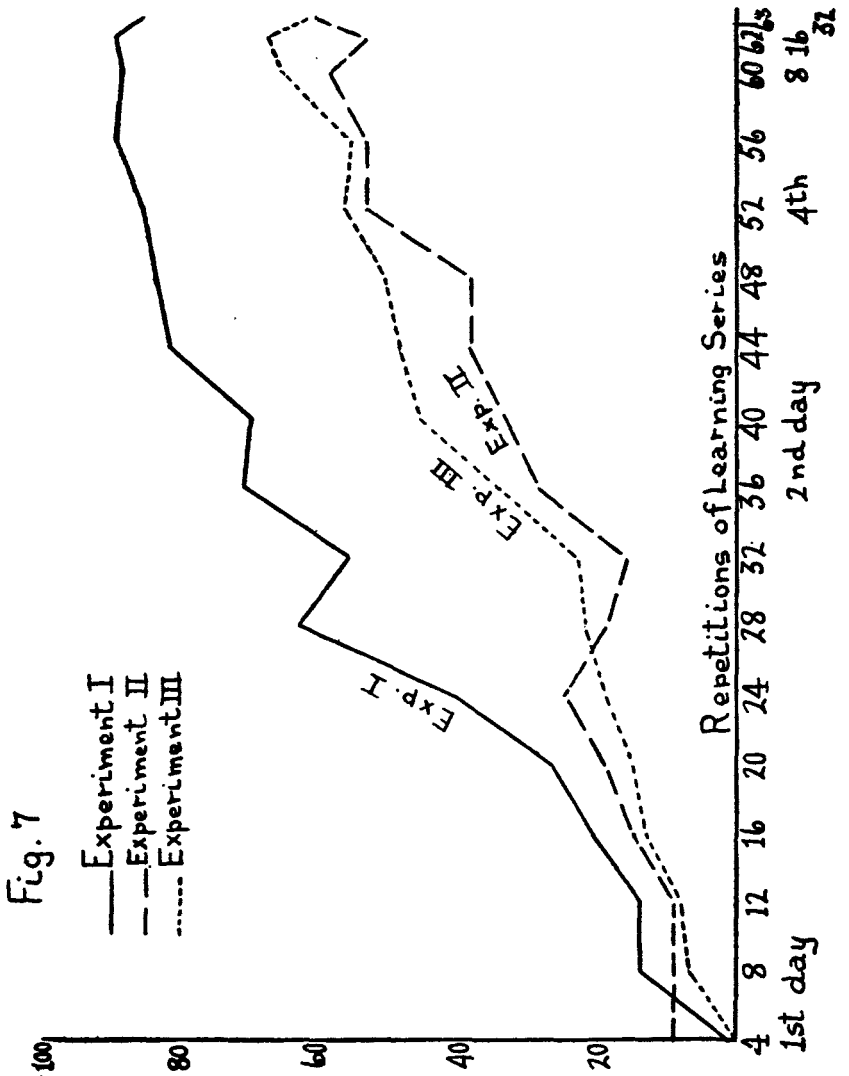


Fig. 7
Experiment I
Experiment II
Experiment III
Exp. I
Exp. II
Exp. III
100
80
60
40
20
4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64
Repetitions of Learning Series
1st day
2nd day
4th
8 16 32
Percentage of Correct Responses

The curve of Experiment III is smoother ; those of Experiments I and II more irregular. This difference reflects the difference in the materials of the three experiments. In Experiment III, we taught dissimilar, uncorrelated names for the figures; learning could accordingly proceed only by the development of separate specific habits for each of the 14 figures. In other words, we are dealing here with 14 separate and distinct elements; we should expect the addition of one after another of these to give a gradually rising curve. In Experiments I and II, on the other hand, we taught linguistic systems exactly correlated with the two variable factors of the visual stimuli. The learning was therefore not of isolated elements but of categories, and hence was of a type which we should expect to be characterized by alternating plateaus and sharp rises. The difference in the rate and degree of learning between Experiments I and II is of course to be explained by the wide deviation of the material of the latter from English speech habits.

RÉSUMÉ OF RATES OF LEARNING IN EXPERIMENTS I, II, AND III.

1. Experiment I showed the most rapid and complete learning ; Experiment II was learned somewhat less rapidly and thoroughly then Experiment III.

2. Learning in Experiments I and II was characterized by alternate plateaus and sharp rises ; in Experiment III, learning proceeded at a more even rate.

3. The retention of the material learned was greater in Experiments I and II than in Experiment III. Of the maximum number of correct responses given on the previous days, the following percentages were given correctly on the 62nd day, 30 days after the last previous series : Experiment I, 98 percent ; Experiment II, 90 percent ; Experiment III, 71 percent.

4. The learning of the two figures which occurred only in the recognition series proceeded at about the same rate as the learning of the other figures in Experiment I, reaching a maximum of 86 percent of correct responses on the fourth day, with no loss in retention in the 30 days which elapsed between the 32nd and the 62nd days. In Experiment II these two figures were only slightly learned; the maximum of correct responses was 19 percent, which was however also retained on the 62nd day.

5. In both Experiment I and Experiment II, the sound-sequences corresponding to shape were learned more rapidly and completely than those corresponding to color.

TABLE VIII.

		nasliŋ	wečiŋ	ʃownliŋ	rojliŋ	nasčaw	weččaw	ʃownčaw	rojčaw*	nasdeg	wečdeg	ʃowndeg	rojdeg	naskop*	wečkop	ʃownkop	rojkop
		1R	1G	1B	1Y	2R	2G	2B	2Y	3R	3G	3B	3Y	4R	4G	4B	4Y
nasliŋ	1R	62		2	2	2			T	2					T		T
wečliŋ	1G	T	59	5	5		6	2			1				3		
ʃownliŋ	1B			74	3			1			T	3				3	T
rojliŋ	1Y	T	2	1	71		2		1				4		2		3
nasčaw	2R	4	T		T	61	T	3		4				T	T		
weččaw	2G	T	5		2	1	66	1		T	1				2		
ʃowńčaw	2B			5	2	2	4	62	T		T	4	T			4	
rojčaw	2Y	T	2	1	12	1	2	5	51	1			2		T		5
nasdeg	3R	3			T	3			T	65		5	2		T		1
wečdeg	3G		1	2	4	T	8			1	51	4	3		7	2	2
ʃowndeg	3B			8	2			2		2		64			T	3	1
rojdeg	3Y		T	T	4					1		T	66	T	2		12
naskop	4R	6		T	T	1				5		T		51	6	7	T
weckop	4G		2		T		5				4	T	1	1	67	1	2
ʃownkop	4B			3	T		T	2			T	7	1		4	64	1
rojkop	4Y		T		6		1						7		1	4	69

THE DISTRIBUTION OF CONVENTIONAL RESPONSES IN EXPERIMENT I.

Vertical column on left indicates names of figures and their shape and color ; upper horizontal row, the responses and the figures to which they correspond. Frequencies are expressed in percentages of total possible number of responses (total presentations). T = trace (1 response). 'Unlearned' figures are starred.

TABLE VIII A

The conventional responses of Experiment I classified according to their color categories. The vertical column on the left indicates the color category of the stimuli; the horizontal row at the top, the color category of the responses. Frequencies are expressed in percentages of total number of presentations.

	nas- (red)	weč- (green)	ʃown- (blue)	roj- (yellow)
nas- (red)	71	2	5	3
weč- (green)	3	74	5	5
ʃown- (blue)	2	3	78	4
roj- (yellow)	2	4	3	79

TABLE VIII B

The conventional responses of Experiment I classified according to their shape categories. The vertical column on the left indicates the shape category of the stimuli; the horizontal row at the top, the shape category of the responses. The numbers of the shapes are indicated in parentheses (see Fig. 1). Frequencies are expressed in percentages of total number of presentations.

	-liŋ (1)	-čaw (2)	-deg (3)	-kop (4)
-liŋ (1)	76	5	3	4
-čaw (2)	10	70	4	5
-deg (3)	7	4	73	9
-kop (4)	6	3	8	74

B. Analysis of the Responses in Experiment I.

Table VIII shows the distribution of the conventional responses of all subjects and for all the recognition series of Experiment I taken together. By 'conventional' responses are meant those responses which conformed to the sound-sequences taught in the learning series. The responses of Table VIII are classified according to their color category in Table VIIIa, and according to their shape category in Table VIIIb.

Table VIIIa shows that there is no strong tendency for any one color category to be confused with a specific other color category. In Table VIIIb, however, we find a rather marked tendency for shape No. 2 to be confused with shape No. 1, and for shapes Nos. 3 and 4 to be confused with each other. It is noteworthy that the omission of two combinations from the learning series does not seem to have influenced the degree of learning of the categories to which these combinations belonged. Thus, a red and a yellow figure were omitted; but the yellow category shows the highest percentage (79) of correct responses. Of the shapes, a No. 2 and a No. 4 were omitted, but the No. 4 category shows the second highest percentage (74) of correct responses.

***

TABLE IX

The Associative Variants in Experiment I.

Column I : the names of the stimuli, with the shape and color indicated in parentheses.

Column II : the responses showing associative interference; in parentheses, the lower-case letters indicate the subjects who gave these responses, and the numerals following these letters indicate the number of occurrences.

Column III : the names to which the interference is most probably to be ascribed, and in parentheses the shape and color to which these names correspond.

I *Stimulus*		II *Variant*		III *Associate*	
naslin̨	(1R)	nasdɛin̨	(s1)	nasdeg	(3R)
»	»	nojlin̨	(s1)	rojlin̨	(1Y)
ſownlin̨	(1B)	ſownslin̨	(s1)	naslin̨	(1R)
rojlin̨	(1Y)	rojslin̨	(r1)	naslin̨	(1R)
nasčaw	(2R)	neččaw	(t1)	weččaw	(2G)
weččaw	(2G)	neččaw	(t1)	nasčaw	(2R)
*rojčaw	(2Y)	čin̨	(v1)	rojlin̨	(1Y)
nasdeg	(3R)	nasdɛin̨	(s1)	naslin̨	(1R)
»	»	nojsdeg	(r1, s1)	rojdeg	(3Y)
»	»	nojdeg	(r1)	»	»
wečdeg	(3G)	načdeg	(x1)	nasdeg	(3R)
ſowndeg	(3B)	rowndeg	(v1)	rojdeg	(3Y)
»	»	ſojdeg	(x1)	»	»
*naskop	(4R)	nojkop	(s1)	rojkop	(4Y)

In Table VIII we find few cases of a strong tendency to react to any figure with the name of any specific other figure. *weččaw* (2G) shows a tendency to be confused chiefly with *wečlin̨* (1G); *ſowndeg* (3B) with *ſownlin̨* (1B); *rojdeg* (3Y) with *rojkop* (4Y); *ſownkop* (4B) with *ſowndeg* (3B). Of the two 'unlearned' figures, **rojčaw* (2Y) is most often confused with *rojlin̨* (1Y); the responses to **naskop* (4R) are more scattered.

Table IX indicates the responses in Experiment I which showed associative interference (column II), together with the figures to which these responses were given (column I) and the associated names to which the interference is most probably to be ascribed (column III). It will be seen at once that the number of such variants is very small, and that no example occurs more than twice.

Most of the examples show interference in the syllable corresponding to color. Thus, *nas-* shows the influence of *roj-* five times (two subjects), appearing as *nojs-* twice and as *noj-* three times ; *nas-* and

weč- show a reciprocal interference in the forms *neččaw*, *načdeg* (two subjects) ; the responses *rowndeg* and *fojdeg* show two different results of an association of *fowndeg* with *rojdeg* (two subjects) ; there are two examples of the carrying over of the medial *s* of *naslin* to other forms, *fownslin* and *rojslin*. In only three cases do the syllables correspond ing to shape show interference ; *nasdɛn* occurs as a response to both *naslin* and *nasdeg* ; *čin*, which occurs as a response to the 'unlearned' figure 2Y (**rojčaw*) shows an interference between *-čaw* and *-lin*.

In general, both the distribution of the conventional responses (Table VIII) and the small number of analogic variants in Experiment I show that the linguistic system remained relatively stable. As was shown in the section on the rate of learning, the material of this experiment was learned very rapidly. Most of the variants of Table IX occurred in the first day's work ; four occurred on the second day, and one on the sixteenth day. The correct responses therefore soon became fixed ; and the possibility of the development of further linguistic categories in the directions suggested by the variant responses of Table IX was obviated by repeated learning.

C. Analysis of the Responses in Experiment II.

Table X shows the distribution of the conventional responses in Experiment II. These responses are classified according to the color categories to which they belong in Table Xa, and according to the shape categories in Table Xb.

Table Xa shows that there is a tendency to react to blue figures with the sound-sequence corresponding to yellow. Table Xb shows a tendency to confuse shapes Nos. 1 and 2, and Nos. 3 and 4.

In Table X we find that in each shape category the red figure shows the highest percentage of correct responses, except in the category of shape No. 4, where 4R was one of the 'unlearned' figures ; here 4Y shows the highest percentage of correct responses. In the color categories, we find that in the red and the green categories, shape No. 3 shows the highest percentage of correct responses, but in the blue and the yellow categories it is shape No. 4.

An examination of the responses incorrect as to either shape or color will reveal certain general tendencies within each category. If we consider those responses to the figures within each *shape* category which are incorrect as to *color* we find that :

a) in the category of shape No. 1, *nulgɛn* (1R) is the most frequent variant color response to *nugdet* (1G), *nuzgub* (1B) and *numbow* (1Y).

*

TABLE X.

		nulgen	nugdet	nuzgub	numbow	dojlgen	dojgdet	dojzgub	dojmbow*	pelgen	pegdet	pezgub	pembow	wilgen*	wigdet	wizgub	wimbow
		1R	1G	1B	1Y	2R	2G	2B	2Y	3R	3G	3B	3Y	4R	4G	4B	4Y
nulgen	1R	37		3	2	5	2			10	3		1				1
nugdet	1G	6	15	6	2	1	8				T						1
nuzgub	1B	4	T	32	T	2	1	1		T		T			T	4	1
numbow	1Y	5	2	1	24	2	T	T		T	T		3	T			6
dojlgen	2R	3		T		50	6	T		8	2		T			T	3
dojgdet	2G	3	1	T	T	2	31	1			2	T	2	T	T		T
dojzgub	2B	T	T	7		4	7	17		1	T		T		T	4	3
*dojmbow	2Y	6		2	2	2	4	T	4	4	T		2		2	2	8
pelgen	3R	T			1	T	T			75	3	T	2			T	T
pegdet	3G	1	2	T			5	1		6	39		8		1	T	1
pezgub	3B			4	1	T	1			3	T	15	9		T	7	4
pembow	3Y		T		T					3	4		36		1	T	10
*wilgen	4R	2		1		3	1			17	1		2	5	4	5	8
wigdet	4G	T			T		4			T	4		1	T	34	4	4
wizgub	4B	T		2		3	T	T		1	T	T	2		3	37	7
wimbow	4Y						T			2	2		8	T	2	3	52

THE DISTRIBUTION OF CONVENTIONAL RESPONSES IN EXPERIMENT II.

Vertical column on left indicates names of figures and their shape and color; upper horizontal row, the responses and the figures to which they correspond. Frequencies are expressed in percentages of total possible number of responses (total presentations). T = trace (1 response). 'Unlearned' figures are starred.

TABLE XA

The conventional responses of Experiment II classified according to their color categories. The vertical column on the left indicates the color category of the stimuli ; the horizontal row at the top, the color category of the responses. Frequencies are expressed in percentages of total number of presentations.

	-lgɛn (red)	-gdet (green)	-zgub (blue)	-mbow (yellow)
-lgɛn (red)	52	5	3	6
-gdet (green)	5	36	4	5
-zgub (blue)	4	3	34	7
-mbow (yellow)	6	4	2	39

TABLE XB

The conventional responses of Experiment II classified according to their shape category. The vertical column on the left indicates the shape category of the stimuli; the horizontal row at the top, the shape category of the responses. The numbers of the shapes are indicated in parentheses (see Fig. 1). Frequencies are expressed in percentages of total number of presentations.

	nu- (1)	doj- (2)	pe- (3)	wi- (4)
nu- (1)	50	8	6	5
doj- (2)	10	48	6	7
pe- (3)	4	4	47	9
wi- (4)	2	4	10	57

b) in the category of shape No. 2, *dojgdet* (2G) is the most frequent variant color response to *dojlgɛn* (2R) and *dojzgub* (2B) ; the responses to **dojmbow* (2Y) are more scattered, but *dojgdet* is among the most frequent.

c) in the category of shape No. 3, *pembow* (3Y) is the most frequent variant color response to *pegdet* (3G) and *pezgub* (3B) and the next most frequent response to *pelgɛn* (3R).

d) in the category of shape No. 4, *wimbow* (4Y) is the most frequent variant color response to **wilgɛn* (4R) and *wizgub* (4B) ; *wimbow* and *wizgub* (4B) are the two most frequent responses to *wigdet* (4G).

Similarly, if we consider those responses to the figures within each *color* category which are incorrect as to *shape* we find that :

a) in the category *red*, *pelgɛn* (3R) is the most frequent variant shape response to *nulgɛn* (1R), *dojlgɛn* (2R), and **wilgɛn* (4R).

b) in the category *green*, *dojgdet* (2G) is the most frequent variant shape response to *nugdet* (1G), *pegdet* (3G). and *wigdet* (4G).

TABLE XI

The Associative Variants in Experiment II.

Explanation as under Table IX, Experiment I.

I *Stimulus*	II *Variant*	III *Associate*
nulgɛn (1R)	nulget (f1)	nugdet (1G)
» »	nulgɛt (a1)	» »
» »	nuldɛn (f1, g1)	» »
» »	nuzgɛn (e3)	nuzgub (1B)
» »	nojlgɛn (c2)	dojlgɛn (2R)
nugdet (1G)	nulget (a1, f3)	nulgɛn (1R)
» »	nuldet (f2, g2, h8)	» »
» »	nuzdet (e4, g1, h4)	nuzgub (1B)
» »	nojgdet (c4, d1, f1)	dojgdet (2G)
» »	dugdet (d1)	» »
nuzgub (1B)	nulgub (f1, h2)	nulgɛn (1R)
» »	nuggub (f1)	nugdet (1G)
» »	nojzgub (d3)	dojzgub (2B)
numbow (1Y)	nulbow (f2, g3, h10)	nulgɛn (1R)
» »	nulgow (f3)	» »
» »	nugdow (d1)	nugdet (1G)
» »	nuzbow (h3)	nuzgub (1B)
dojlgɛn (2R)	dojzgɛn (c1, e1)	dojzgub (2B)
» »	delgɛn (c1)	pelgɛn (3R)
dojgdet (2G)	dojldet (f5, h4)	dojlgɛn (2R)
» »	dojlget (c1, f2)	» »
» »	dojzdet (e5, g7, h4)	dojzgub (2B)
»	nojgdet (d1)	nugdet (1G)
dojzgub (2B)	dojlgub (f1, h2)	dojlgɛn (2R)
» »	dojggub (e3)	dojgdet (2G)
» »	dojgzgub (g1)	» »
» »	nojzgub (d1)	nuzgub (1B)
» »	duzgub (f1)	» »
*dojmbow (2Y)	dojlbow (e1, f9, h8)	dojlgɛn (2R)
» »	dojlgow (f2)	» »
» »	dojgbow (e2)	dojgdet (2G)
» »	dojzbow (e1, h2)	dojzgub (2B)
pelgɛn (3R)	delgɛn (g1)	dojlgɛn (2R)

TABLE XI, continued.

I *Stimulus*	II *Variant*	III *Associate*
pegdet (3G)	pelget (f1, h1)	pelgɛn (3R)
» »	pezget (h1)	pezgub (3B)
» »	pezdet (f1, h7)	» »
» »	pugdet (f1)	nugdet (1G)
pezgub (3B)	pelgub (e1)	pelgɛn (3R)
pembow (3Y)	pelgow (h1)	pelgɛn (3R)
» »	pelbow (h2)	» »
» »	pezbow (f6, h4)	pezgub (3B)
» »	dembow (c1)	dojmbow (2Y)
*wilgɛn (4R)	wiggɛn (c1)	wigdet (4G)
» »	wizgɛn (f14)	wizgub (4B)
» »	wimgɛn (e4, h2)	wimbow (4Y)
wigdet (4G)	wizget (h1)	wizgub (4B)
» »	wizdet (a1)	» »
» »	wimdet (e9, g2)	wimbow(4Y)
wizgub (4B)	wiggub (h2)	wigdet (4G)
» »	wizgzub (d1)	» »
wimbow (4Y)	wigdow (f1)	wigdet (4G)
» »	wizgow (f1)	wizgub (4B)
» »	wizbow (f4)	» »
» »	pimbow (a1, g1)	pembow (3Y)

c) in the category *blue*, *wizgub* (4B) is the most frequent variant shape response to *nuzgub* (1B) and *pezgub* (3B). The most frequent response to *dojzgub* (2B) is *nuzgub* (1B); the next most frequent is again *wizgub*.

d) in the category *yellow*, *wimbow* (4Y) is the most frequent variant shape response to *numbow* (1Y), **dojmbow* (2Y), and *pembow* (3Y).

We should expect, as a result of the above analysis, that any analogic changes in the linguistic system of Experiment II would show definite tendencies within each category.

Table XI indicates the responses in Experiment II which showed associative interference. It will at once be evident that these variants are much more numerous than in Experiment I, and that many of them were given by two or three subjects and by each subject a number of times in spite of repeated learning.

In the category of shape No. 1, the influence of *nulgɛn* (1R) is most marked ; thus we have : for *nugdet* — *nulget, nuldet* ; for *nuzgub* — *nulgub* ; for *numbow* — *nulbow, nulgow*. The influence of *nuzgub, nugdet* is also seen. Association of shape No. 1 (*nu-*) with shape No. 2 (*doj-*) is seen in *nojlgɛn* (for *nulgɛn*) ; *nojgdet, dugdet* (for *nugdet*) ; *nojzgub* (for *nuzgub*).

In the category of shape No. 2, *dojlgɛn* (2R) interferes most strongly with the other forms, although the influence of *dojzgub* (2B) also is evident. Thus we have : for *dojgdet* — *dojldet, dojlget* ; for *dojzgub* — *dojlgub* ; for **dojmbow* — *dojlbow, dojlgow*. Association of shape No. 2 (*doj-*) with shape No. 1 (*nu-*) is seen in *nojgdet* (for *dojgdet*) ; *nojzgub, duzgub* (for *dojzgub*).

In the category of shape No. 3, both *pelgɛn* (3R) and *pezgub* (3B) influence the other forms ; so that we have : *pelget* : *pezget, pezdet* (for *pegdet*) ; *pelgub* (for *pezgub*) ; *pelgow, pelbow* : *pezbow* (for *pembow*). An association of shape No. 3 (*pe-*) with shape No. 1 (*nu-*) is seen in *pugdet* (for *pegdet*) ; and with shape No. 2 (*doj-*) in *delgɛn* (for *pelgɛn*) and *dembow* (for *pembow*).

In the category of shape No. 4, both *wimbow* (4Y) and *wizgub* (4B) influence the other forms. Thus we find : *wimgɛn* : *wizgɛn* (for **wilgɛn*) ; *wimdet* : *wizget, wizdet* (for *wigdet*) ; *wizgow, wizbow* (for *wimbow*). The influence of *wigdet* (4G) is seen in *wiggub, wigzgub* (for *wizgub*). An association of shape No. 4 (*wi-*) with shape No. 3 (*pe-*) is seen in *pimbow* (for *wimbow*).

In general, we find a tendency is modify the non-English syllable divisions of Experiment II in accordance with English speech habits. In the categories of shapes Nos. 1, 2, and 3, this tendency takes the direction of extending the natural syllables *nul-*, *dojl-*, and *pel-*, occurring in *nulgɛn, dojlgɛn, pelgɛn*, respectively, to the other words. These natural syllables thus become semantic units corresponding to shape, while the syllables *-gɛn*, *-det*, *-gub*, *-bow* similarly become semantic units corresponding to color. But *nul-*, *dojl-*, *pel-*, tend to carry with them the following *g* of *nulgɛn*, etc., as for example in the variants *nulgow, dojlget* ; this is no doubt favored by the occurrence of medial *g* also in *nuzgub, dojzgub*, etc. In the category of shape No. 4, **wilgɛn* (4R), being one of the unlearned figures, could not serve as a pattern. Here the syllables *wim-* (*wimbow*) or *wiz-* (*wizgub*) were extended to the other words. These tendencies are seen most clearly in the responses to the unlearned figures, where a 'proportional analogy' was called for. Thus **dojmbow* appears as *dojlbow* ; **wilgɛn* as *wimgɛn, wizgɛn*.

There appears to be a rather strong tendency to assimilate the syllable for shape No. 1 (*nu-*) to that for shape No. 2 (*doj-*), and there is some indication of a reciprocal influence between the two. No definite tendency toward associative modification of the syllables for shapes No. 3 (*pe-*) and No. 4 (*wi-*) appears.

We find, then, in the variant responses of Experiment II certain general tendencies; but it is clear that the processes involved have not gone far enough to permit us to conjecture in what manner the linguistic system would reach an equilibrium. Whether the patterns suggested by the analysis of the conventional responses (pp. 33 ff.) would eventually appear in this system cannot be determined from the material at hand.

D. Analysis of the Responses in Experiment III.

Table XII shows the distribution of the conventional responses in Experiment III. Table XIIa classifies these responses according to the color of the figures to which they correspond, and Table XIIb. according to the shape of the figures. The analysis in the latter two Tables is not of the same kind as in the corresponding Tables of Experiments I and II. In Experiment III the linguistic material is not organized into formal categories, so that there are no sound-sequences corresponding specifically to *red, green, shape No. 1*, etc. Tables XIIa and XIIb only indicate how many times the names of, e.g., red figures were given as responses to red, green, blue, and yellow figures; and how many times the names of figures of, e.g., shape No. 1 were given as responses to figures of shapes Nos. 1, 2, 3, 4.

Table XIIa shows a tendency to confuse the names of red, green, and yellow figures with those of blue figures, and the names of blue figures with those of green figures.

Table XIIb shows a tendency to confuse the names of figures of shape No. 2 with those of shape No. 1, and those of shape No. 3 with shape No. 4.

In Table XII, we find that the figures of shape No. 1 were confused chiefly with figures of the same shape; thus, *vit* (1G) and *zib* (1B) are confused with each other, and *tekbem* (1Y) is confused with *vit* (1G). *čelhib* (1R) shows little confusion.

The figures of shape No. 2 were confused partly with figures of the same shape, partly with figures of shape No. 1 of the same color. Thus, *nuzgub* (2R) is confused with *čelhib* (1R) but also with *sotmip*

TABLE XII.

		čilhib	vit	zib	tekbem	nuzgub	kulren	sotmiŋ	*.....	jowndeg	awa	faʒa	jonθim	*.....	ʃɛb	wuč	pel
		1R	1G	1B	1Y	2R	2G	2B	2Y	3R	3G	3B	3Y	4R	4G	4B	4Y
čilhib	1R	31	T	T	1	T					T	T					
vit	1G		52	14	2		T								T		
zib	1B	T	6	30				T		T	T	1					
tekbem	1Y	3	6	2	23			3		T		T			T		T
nuzgub	2R	5			T	34		3			T		1				
kulren	2G	1	T		2	T	43	4			T		1				
sotmiŋ	2B	1	T	1	T	2	2	17		T		1					
*.....	2Y	T	1	5	11	T		6		T	T	1	1				
jowndeg	3R		T		T	2	1			47	4	3	2			T	1
awa	3G				1	T	2			6	33	6	2		6	2	T
faʒa	3B		T	1							8	36				4	2
jonθim	3Y				2			T		2	5		35				1
*.....	4R	2	1	1		3	3	T		2		1			2	7	T
ʃɛb	4G	T	3	2			T				2	1			45	1	3
wuč	4B	T			T	T					2	T			T	47	2
pel	4Y			T		T		1		T			5			1	51

THE DISTRIBUTION OF CONVENTIONAL RESPONSES IN EXPERIMENT III.

Vertical column on left indicates names of figures and their shape and color ; upper horizontal row, the responses and the figures to which they correspond. Frequencies expressed in percentages of total possible number of responses (total presentations). T = trace (1 response). 'Unlearned' figures are starred.

TABLE XIIA.

The conventional responses of Experiment III classified according to color. The vertical column on the left indicates the color of the stimuli ; the horizontal row at the top indicates the color to which the responses corresponded according to the series as taught. Frequencies are expressed in percentages of total presentations.

	red	green	blue	yellow
red	31	3	4	2
green	2	47	7	3
blue	1	5	35	1
yellow	2	3	5	32

TABLE XIIB

The conventional responses of Experiment III classified according to shape. The vertical column on the left indicates the shape of the stimuli (see Fig. 1); the horizontal row at the top indicates the shapes to which the responses corresponded according to the series as taught. Frequencies are expressed in percentages of total presentations. T = trace (less than 1 percent).

	shape 1	shape 2	shape 3	shape 4
shape No. 1	42	1	1	T
shape No. 2	7	27	2	0
shape No. 3	1	2	46	4
shape No. 4	3	2	3	40

(2B); *kulren* (2G) is confused with *sotmiŋ* (2B); *sotmiŋ* (2B) is confused with *nuzgub* (2R) and *kulren* (2G). The responses to the 'unlearned' figure 2Y show a strong association with 1Y (*tekbem*), and a less strong association with 2B (*sotmiŋ*).

The figures of shape No. 3 were confused chiefly with figures of the same shape. Thus, *jowndeg* (3R) is confused with *awa* (3G) and *faʒa* (3B); *awa* (3G) is confused with *faʒa* (3B) and *jowndeg* (3R), but also with *fɛb* (4G); *faʒa* (3B) is confused with *awa* (3G); *jonθim* (3Y) is confused with *awa* (3G). Thus we find *jowndeg*, *faʒa*, and *jonθim* each confused chiefly with *awa*.

The figures of shape No. 4 were confused partly with figures of the same shape, partly with figures of shape No. 3 (to a less extent with shape No. 1). Thus, the responses to the 'unlearned' figure 4R show an association with 4B (*wuč*); *fɛb* (4G) is confused with *pel* (4Y) but also with *vit* (1G); *wuč* (4B) is confused with *pel* (4Y) and *awa* (3G); *pel* (4Y) is confused with *jonθim* (3Y).

Table XIII indicates the examples of associative interference in Experiment III. The number of these is very small, and the individual forms are neither frequent for a given subject nor common to a number of subjects, with two exceptions.

TABLE XIII

THE ASSOCIATIVE VARIANTS OF EXPERIMENT III.

Explanation as under Table IX, Experiment I. 'Unlearned' figures are starred.

I *Stimulus*		II *Variant*		III *Associate*	
vit	(1G)	zit	(i2)	zib	(1B)
zib	(1B)	vib	(j1,p1).	vit	(1G)
tekbem	(1Y)	čekbem	(i1)	čɛlhib	(1R)
.....	*(2Y)	θim	(o1)	ǰonθim	(3Y)
	»	sotθiŋ	(i1)	sotmiŋ (2B)	-ǰonθim (3Y)
	»	tekpim	(o1)	tekbem (1Y)	-ǰonθim (3Y)
jowndeg	(3R)	jondeg	(j2,k1,q3, p9)	ǰonθim	(3Y)
faʒa	(3B)	aʒa	(q1)	awa	(3G)
ǰonθim	(3Y)	jownθim	(j1)	jowndeg	(3R)
»	»	ǰonθem	(p2)	tekbem	(1Y)

A reciprocal interference of *vit* (1G) and *zib* (1B) is seen in the forms *zit* and *vib*. The response *θim* to the 'unlearned' figure 2Y illustrates a process which it had been expected would find more extensive expression in this experiment; namely, the development of new semantic units from the dissyllabic names of objects which exhibit two variable attributes. Here we see the possibility of *θim* coming to correspond to the attribute *yellow*.

In general, the examples of table XIII show a tendency toward the assimilation of the forms within each shape category to each other.

V. SUMMARY

The problem was that of developing a technique for investigating (1) to what extent and in what manner associative interferences occur in artificial linguistic material, and (2) to what extent and in what manner such interferences tend toward the development of linguistic categories. For this purpose, nonsense figures of four shapes and four colors were presented visually, and nonsense names for the figures were presented orally. A geometrically decreasing number of repetitions was distributed over a geometrical sequence of days, beginning with 32 repetitions on the first day, and ending with 1 repetition on the thirty-second day. A recognition series was given after every four repetitions of the learning series; it was also given (twice) thirty days after the last learning series (62nd day).

Three degrees of correlation between the figures and names were provided in different experiments with different sets of subjects :

Experiment I. — The names consisted of two elements which were exactly correlated with the factors of color and shape in the figures, and which conformed to English speech habits in word order and syllable division (e.g., *nas-liw* = red + shape 1). Under these conditions :

1. Learning was very rapid and there was practically no forgetting 30 days after the last learning.

2. Sound-sequences corresponding to shape were learned more rapidly than sound-sequences corresponding to color.

3. The names of two figures omitted from the learning series but presented in the recognition series were learned (by analogy with the other names and figures) at about the same rate as the names of the other figures.

4. There was a tendency to confuse shapes Nos. 1 and 2, and Nos 3 and 4.

5. The cases of associative interference were very few; no variant form occurs more than once for a given subject, and only one is common to two subjects.

6. No definite tendencies toward the development of further linguistic categories appear.

Experiment II. — The names consisted of two elements which were exactly correlated with the factors of color and shape in the figures, but which deviated from English speech habits in word order and syllable division (e.g., *nu-lgɛn* = shape 1 + red). Under these conditions:

1. Learning was very slow, and the material was incompletely learned, the maximum percentage of correct responses attained (for all subjects taken together) being 61; but of this maximum, 90 percent was retained 30 days after the last learning.

2. Sound-sequences corresponding to shape were learned more rapidly than sound-sequences corresponding to color.

3. The names of two figures omitted from the learning series but presented in the recognition series were learned but slightly (by analogy with the other figures and names).

4. There was a tendency to confuse shapes Nos. 1 and 2, and Nos. 3 and 4; and within each shape and color category, to confuse the names of the figures with the name of a particular figure of the category.

5. There were numerous cases of associative interference; many of these variant forms were given repeatedly by the same subject and were common to two or three subjects.

6. There was a general tendency to modify the non-English syllable division in accordance with English speech habits. This tendency took the form of assimilating the words within each shape category to a particular word of the category (e.g., *nu-gdet* > *nul-det*, *nu-mbow* > *nul-bow*, after *nu-lgɛn*).

7. There was a tendency to assimilate the syllable for shape No. 1 to that for shape No. 2 (e.g., *nulgɛn* > *nojlgɛn*, after *dojlgɛn*). There would thus arise a further linguistic category which would include shapes Nos. 1 and 2, the difference between the two being marked by the initial consonant (e.g., *nojlgɛn : dojlgɛn*).

Experiment III. — The names showed no correlation whatever with the factors of color and shape of the figures, each figure having an entirely different name. Nine of the names were dissyllabic; five were monosyllabic. Under these conditions:

1. Learning was very slow, and the material was incompletely learned, the maximum percentage of correct responses attained (for all subjects taken together) being 68; of this maximum, 71 percent was retained 30 days after last learning.

2. The responses to two figures omitted from the learning series but presented in the recognition series (for naming which the material

of the experiment provided no analogies) were the names of figures either of the same shape but different color, or of the same color but different shape, the name of a particular figure being favored in each case.

3. There was a tendency to confuse shapes Nos. 1 and 2, and Nos. 3 and 4. The names of the figures of shapes Nos. 1 and 3 were however confused chiefly with those of figures of the same shape but different colors.

4. There were very few cases of associative interference, and most of these were given only once by one subject.

5. The cases of associative interference show a slight tendency toward assimilation of the words of each shape category to each other.

VI. CONCLUSION.

The present investigation was designed as a beginning in the development of the optimum technique for the study of associative interferences and the development of linguistic categories in artificial linguistic material. The results obtained during the learning period with three types of material suggest the following points :

1. The names of those figures which are confused with one another during learning tend to interfere with one another so as to produce mixtures of articulation. In other words, when a stimulus tends to evoke either verbal reaction *a* or verbal reaction *b* according to the sensorimotor conditions existing at a given moment, a fluctuation of the sensorimotor conditions during the process of articulation will result in a mixture of the two sequences of articulation.

2. Of the three types of experimental conditions investigated, the strongest tendencies toward associative interference were found when the linguistic material, although exactly correlated with the two factors of the visual stimuli, deviated from English habits of syllable division (Experiment II).

3. The names of figures of a given category tend to be confused with and assimilated to the name of a particular figure of that category. This appears most clearly in Experiments II and III.

4. In further experimental work on this problem it will be necessary to continue the investigation for a long period of time after complete learning of the material. Only from the end-results of a long period of observatican can we draw conclusions as to the regularity and uniformity of the process of associative interference and the resultant development of linguistic categories. While the material described under Experiment II (p. 15) gave the most extensive results during the learning period, it would seem that for a longer period of investigation material of the type of Experiment III (p. 17) would yield the least ambiguous results.

APPENDIX

The Values of the Phonetic Symbols.

The values of the phonetic symbols used in these experiments are those represented by the Middle Western pronunciation of the italicized letters in the following words :

p	*p*et	s	*s*on	ɛ	s*a*t
b	*b*et	ʃ	*sh*un	u	p*u*t
t	*t*ip	z	*z*eal	o	s*o*n
d	*d*ip	ʒ	a*z*ure	ɔ	*o*n
k	*k*id	h	*h*at	a	f*a*ther
g	*g*et	l	*l*ap	aw	h*ou*se
č	*ch*oke	m	*m*an	ow	sh*ow*
ǰ	*j*oke	n	*n*ot	uw	m*oo*n
f	*f*at	ŋ	si*ng*	aj	m*y*
v	*v*at	r	*r*ed	ej	w*ay*
θ	*th*ing	i	p*i*n	oj	b*oy*
ð	*th*is	e	p*e*t	ij	m*ea*n

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