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PREFACE

The experiments reported in this monograph represent an extension of the experimental investigation of associative interference initiated abroad by Thumb and Marbe in 1901, and in this country by Esper in 1918.

The experiments were performed in the Psychological Laboratory of the Ohio State University during the academic years 1929-30 and 1930-31.

I wish to express my great indebtedness to Professor E. A. Esper of the University of Washington, both for arousing my interest in this problem, and for training in the necessary techniques; and to the late Professor A. P. Weiss of the Ohio State University for his guidance and cooperation both in the experiments themselves and in the preparation of the manuscript.

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I. HISTORICAL INTRODUCTION

Whenever the form of a word is altered by virtue of the influence exerted upon it by another word or group of words, the process is known as analogic change. Illustrative of this action is a frequent change in the pronunciation of the word *height*. Probably because of the influence of such words as *width*, *length*, *breadth*, and *depth*, [haitθ] is often spoken instead of [hait]. The recognition of the importance of this type of linguistic change has led linguists to make such historical surveys of its occurrence as that of the levelling of the singular and plural forms of OE strong verbs to a single form. Wyld¹ 205 describes the changes in such verbs: 'The changes in the forms of Strong Verbs since the OE period have been determined partly by normal sound change, and partly by the action of analogy working in various ways. The results of the latter factor have been (a) the levelling out of what proved to be an unnecessary variety of forms. . .'

While linguists have commonly attributed analogic change to the interference of associated words, it was not until 1901 that this explanation was subjected to experimental proof. At that time (1901), Thumb and Marbe selected 60 German words from those categories which in the history of the Indo-European languages had shown marked tendencies toward analogic change. These words were used as stimuli in an association test. From an analysis of the responses and the response time to each stimulus word the conclusion was reached that analogic change results from those associations which are common to a large portion of the group and which are given most rapidly by the individual members of the group. Using a similar technique, Esper (No. 1) verified these results with a larger and more diverse group of American subjects.

Adopting a suggestion made by Thumb, Esper (No. 2) investigated the nature and the process of analogic change within an artificial lin-

1. The works of the author are to be found in the bibliography, page 6.

guistic system which he taught to different groups of subjects. He found (1) that those words which were most confused during learning were most subject to associative interference later; and (2) that generally one member of each category attracted the remaining members of that category to it.

Wolfe, following the artificial language technique used by Esper, attempted to determine how the associative organization of a linguistic system would be affected by the formation of a corresponding set of manual habits. Although no relationship between these two variables was found, the conclusion of Thumb and Marbe regarding the relationship of association and analogic change was verified under entirely different experimental conditions.

Whatever may be the ultimate cause of analogic change, all of the works quoted would bear out the statement that such change occurs under conditions of strong association between words or groups of words, and that such association is indicative of at least potential analogic change. Whether or not the change actually occurs is a function of other factors as well as association.

II. PURPOSE

The purpose of all these studies may be summarized as an attempt to discover, first, the sensori-neuro-motor conditions of the individual which underlie the process of associative interference in language, and second, those factors in the language itself which are particularly favorable to the development of analogic change. These are simply two phases of the same fundamental problem, problems of the second type being reducible to some aspect of the sensori-neuro-motor conditions of the individual using the language.

The purpose of the present experiments has been primarily of the latter type : to determine some of the relationships existing between the types of linguistic structure involved and the susceptibility of the language to analogic change. Specifically, two types of language were investigated. The first was a systematic language involving a one-to-one correspondence between the stimulus variables and the linguistic elements which designated them. The second differed from this in the direction of being less systematic. Basically it, too, involved a perfect correlation of stimulus variables and linguistic elements. But into this systematic pattern a number of variants were introduced, thus producing an unsystematic or heterogeneous language. A comparison could then be made of the action of associative interference in these two types of linguistic structure.

III. METHOD

GENERAL :

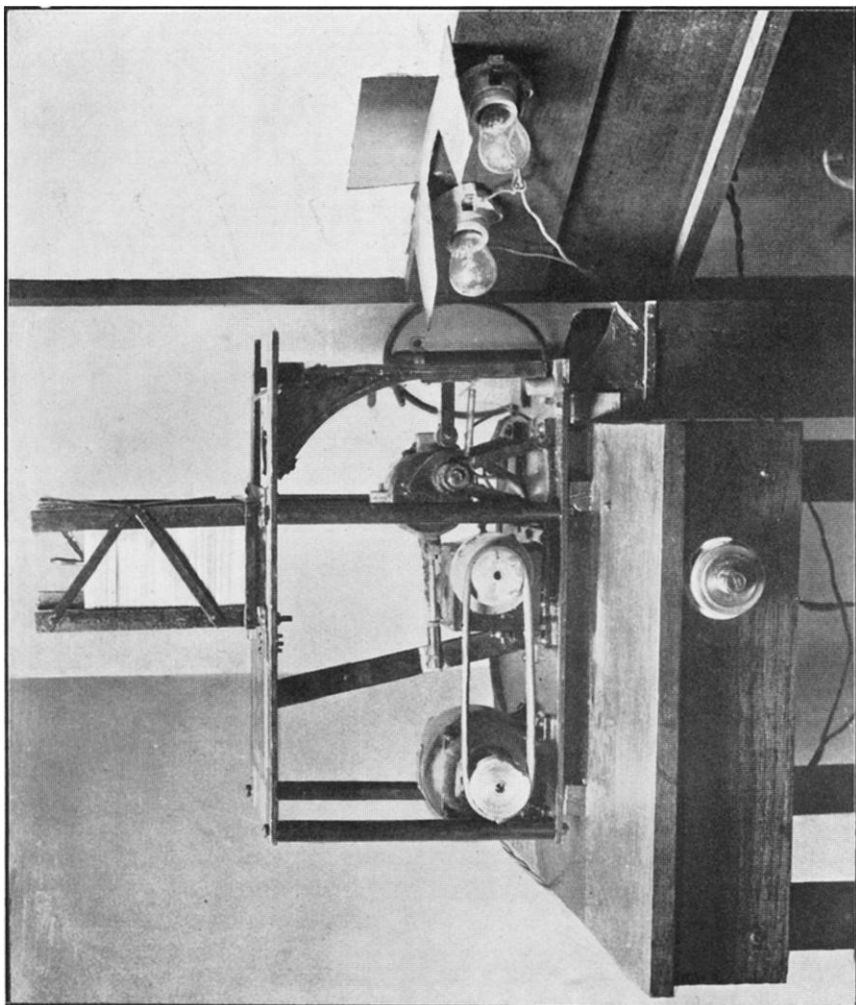
Briefly, the experimental technique was to teach to a group of subjects an artificial language in which nonsense names were applied to nonsense figures. The learning method consisted of joint visual, auditory, and kinesthetic stimulation. When the subjects had learned the material to the point of satisfying an arbitrary criterion they continued to use the language, but without ever hearing it from anyone other than themselves. The errors made in naming the figures, both during and after the learning period, were compared with the associations within the linguistic system.

APPARATUS :

The nonsense figures, whose names comprised the language to be learned, were printed on gray fiber cards, four by five inches in size. These cards were presented serially to the subject by means of an exposure apparatus, the bradyscope¹, shown in Figure 1. Cards stacked into a hopper are presented serially for any desired time and at any desired rate. The cards already exposed are automatically restacked into another hopper in the same order in which they were presented. This allowed them to be shown to the next subject without change of order. By simply stacking the cards properly they could be presented in any order desired. The interval between successive cards and the time of exposure of each were independently variable. A cam on the bradyscope completed the electrical circuit to two ten-watt lights which illuminated the figure for the desired exposure time. The cards were always at rest when they were seen by the subject. Cards were removed from the exposure window and new ones placed there automatically and in the dark. By using low illumination no difficulty was experienced with after images or with adaptation.

The stimulus figures used were made up from the varying arrangements of a geometric jigsaw puzzle. Approximately 50 such figures were presented to a group of judges who were instructed to select

1. See Gulliksen, No. 3 of Bibliography.



THE BRADYSCOPE.

those which were most meaningless to them. The four figures used were those most frequently chosen in this way. Similarly a list of approximately 100 nonsense syllables was presented to a group of subjects and their associations recorded. The syllables which became the elements of the linguistic system used were those which had the fewest and most widely varying associates. Thus the interference of previously acquired linguistic habits or associations was avoided by using material as nearly meaningless as could be obtained. While the names used were nonsense names, the speech sounds and the syllable division were those of normal American English. Similarly the combinations of sounds were all such as occur in English. All syllables were of the type consonant-vowel-consonant. The names of the figures consisted of two such syllables with the accent on the second.

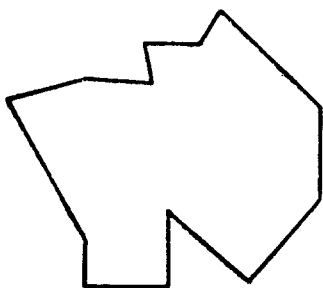
The four spatial forms used each occurred in four different sizes. There were thus 16 distinct figures. The sizes of each form were in the ratios of 1, 4, 9, and 16. The forms used, together with the names given to each are shown in Figure 2. As different names were given to the figures in the two experiments, these will later be given separately for each of the two.

The general plan of the experimental room and the relationships of subject, experimenter, and apparatus are shown in Figure 3. Except for the illumination of the stimulus figures, as mentioned before, the experimental room was dark.

EXPERIMENTAL METHOD :

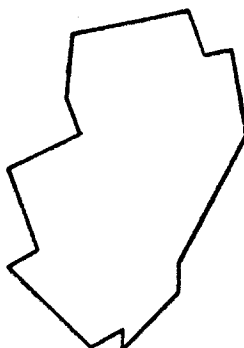
The subjects used (12 in Experiment I, and 8 in Experiment II) were all volunteers from the elementary psychology classes. All of them except one were of American birth. While most of them had taken some courses in one or more foreign languages, none had studied linguistics, nor was any one informed of the nature or purpose of the experiments. While they naturally tried to guess the reason for the experiments, their guesses were all either that it was simply in order to plot learning curves, or that it was in the nature of an abstraction and generalization experiment. The subjects were, then, quite unaware of the purpose of the study.

The procedure followed throughout the entire experiment was as follows. The subjects were instructed to appear individually at a given hour five days a week. The first day on which they came these directions were read :



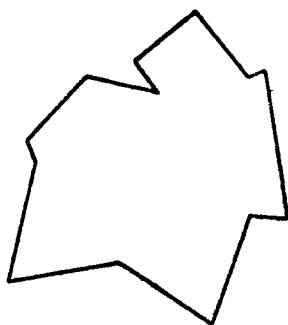
FORM A

	EXP I	EXP. II
SIZE 1	<i>ludnas</i>	<i>vuskof</i>
SIZE 2	<i>grėnas</i>	<i>naspof</i>
SIZE 3	<i>sebnas</i>	<i>zinpof</i>
SIZE 4	<i>pofnas</i>	<i>tavpof</i>



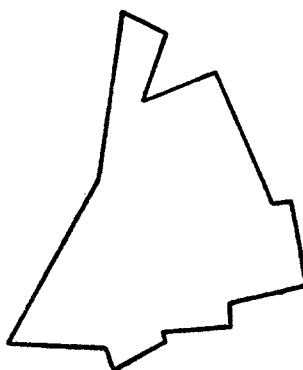
FORM B

	EXP. I	EXP. II
SIZE 1	<i>ludzig</i>	<i>sebvus</i>
SIZE 2	<i>grėzig</i>	<i>sebnas</i>
SIZE 3	<i>sebzig</i>	<i>zigseb</i>
SIZE 4	<i>pofzig</i>	<i>tavseb</i>



FORM C

	EXP. I	EXP. II
SIZE 1	<i>ludtav</i>	<i>vusgrė</i>
SIZE 2	<i>grėtav</i>	<i>nasgrė</i>
SIZE 3	<i>sebtav</i>	<i>ziggrė</i>
SIZE 4	<i>poftav</i>	<i>tavgrė</i>



FORM D

	EXP. I	EXP. II
SIZE 1	<i>ludvus</i>	<i>vuslud</i>
SIZE 2	<i>grėvus</i>	<i>neslud</i>
SIZE 3	<i>sebvus</i>	<i>ziglod</i>
SIZE 4	<i>pofvus</i>	<i>tavlud</i>

FIGURE 2. THE FOUR FORMS USED AS STIMULUS FIGURES.

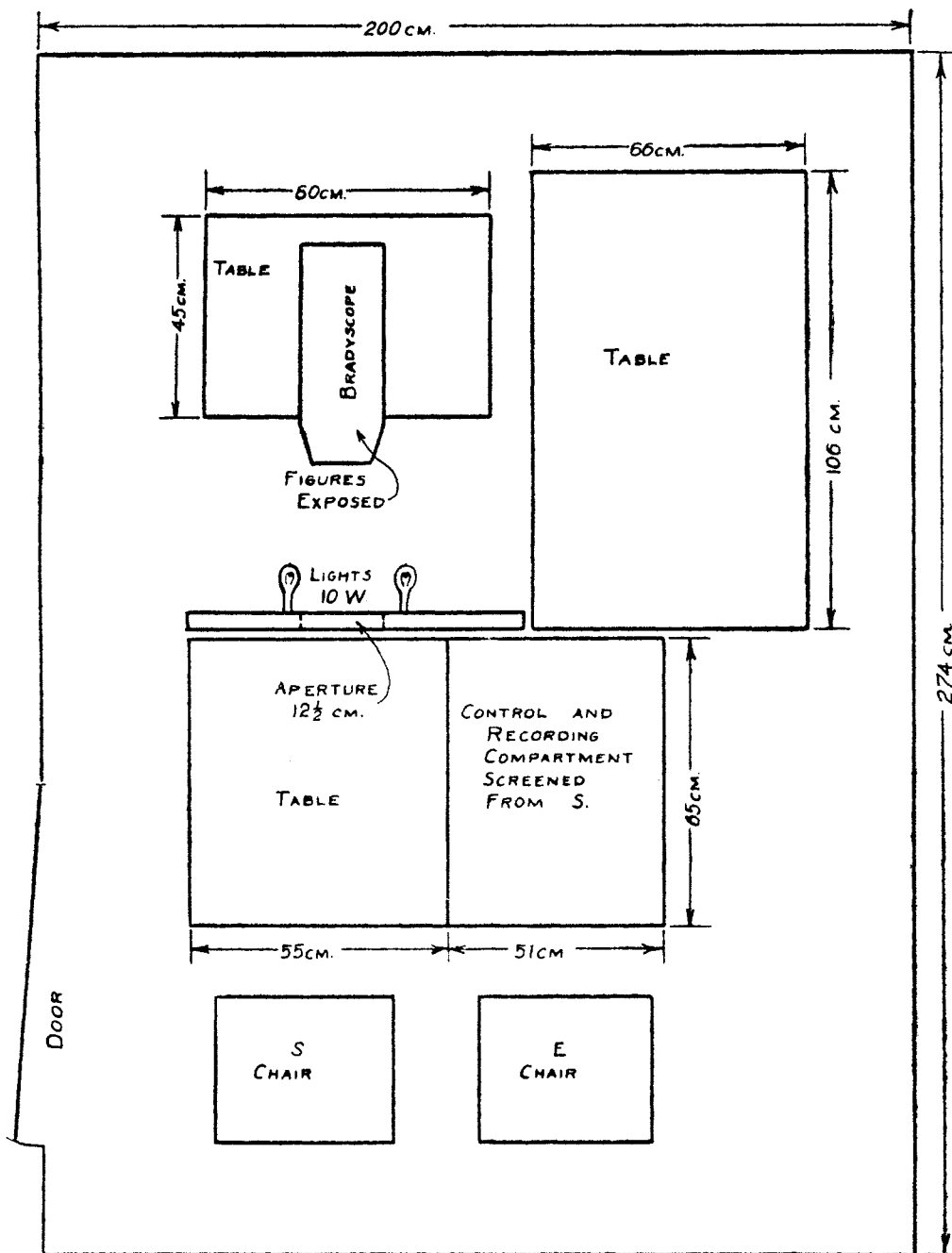


FIGURE 3. ARRANGEMENT OF THE EXPERIMENTAL ROOM.

You are to come to this room every school day at . . . o'clock. When you come, knock, and then come in if you are told to do so. If your knock receives no answer, you will know that the previous subject is still here, so wait until he leaves.

It is important that you be regular in attendance. So do not miss any day unless it is absolutely impossible for you to come.

It is important that you do not rehearse the material that I am going to teach you outside of the experimental time. So I am going to ask you as far as possible not to think of, and certainly not to discuss, this material at any time outside of your daily experimental period. [The subject's promise was secured.]

At the conclusion of the experiment I shall be glad to explain anything that you may care to ask concerning the nature or purpose of this experiment. But I would rather not talk about it until after the experiment is over.

After making sure that these instructions were understood, the following directions were read :

I am going to teach you the names of a number of figures that you have probably never seen before. In order to find out now whether you will have any difficulty with these names I will pronounce them one at a time. Will you watch my lips and then say the names over after me. Try to say them exactly as I do.

The names of the figures were then read over, allowing the subject to watch the experimenter pronounce them. In order to determine whether or not the subject would have any difficulty in pronouncing them correctly he was asked to repeat them. If he could do this readily, the next name was read. Those names which presented any difficulty were practised until all could be given correctly.

The following day the experiment began. The subject was instructed as follows :

Now I am going to show you the figures. Watch the window in front of you where the light appears. As each figure is shown, I shall call out its name. Then I want you to name it after me. [A speaking tube connected to Ediphone headphones to facilitate hearing the subject's responses was then adjusted so that the subject could speak into it comfortably without having his vision obstructed.] After a while, when I say 'Call them out', you are to name the figures as they appear without my prompting. Try to give a name to each figure even if you are not sure what the correct name is. Speak loudly and distinctly.

The subject was then shown two series of figures while the names were pronounced by the experimenter. A series of figures consisted of the presentation of all 16 figures arranged in chance order. The order of presentation depended upon the order of withdrawal of cards from a box in which they were shuffled. The arrangement was then a chance one. The subject never saw the same order of presentation

twice, as nine new series were made up each day. A series presented while the experimenter pronounced the names will hereafter be called a learning or L series. One given to test the subject's learning, unaccompanied by the experimenter's naming, will be called a recognition or R series. At the first of the experiment, then, two such L series were presented to the subject. As each figure was shown its name was called out by the experimenter. The subject repeated the name of the figure while still looking at it. This provided a combination of visual, auditory, and kinesthetic (from the speech movements) stimulation. Koch has shown this method to be one of the most effective in learning responses of this sort. As the third series was about to be shown, the subject was instructed to call off the names without prompting. This routine, 2 L series and 1 R series, was followed until the subject named all the figures in one series correctly. However, never more than nine series were shown in one day, regardless of the subject's performance.

After the subject had given one perfect R series, the order was changed from 2 L and 1 R to 1 L and 1 R, except that after each perfect R series another R series was given. At all times throughout the learning period the subject continued to call off the names without prompting until he made a mistake. After each R series in which an error was made, an L series was introduced. This procedure was followed until such a time as the subject had on each of three successive days given six successive perfect R series, a total of 18 successive R series without error.

Having reached that point, the speed of presentation of the figures was increased from one exposure every 4.6 sec. (exposure time 2.3 sec.), the speed at which the experiment had started, to one exposure every 3.6 sec. (exposure time 1.8 sec.). As before, an L series was introduced following every R series in which an error was made. A maximum of six consecutive R series was given in one day. The subject continued to work at this speed until he had again on each of three successive days given six consecutive R series without error. Following the satisfactory attainment of this criterion on the second speed, the speed of the bradyscope was again increased, to one exposure in 3.2 sec. (exposure time 1.6 sec.). Again the same criterion of learning was imposed. The subject had to give six consecutive R series on each of three successive days. When he had once done this, the learning period was considered finished.

In the post-learning period there was no change in technique other

than that no L series were ever introduced, regardless of the number of mistakes made, and that six, and only six, R series were given each day. At the completion of the learning period the subjects were told to come only three days a week, the three alternate school-days, instead of five.

As the subjects appeared individually, each was allowed to proceed at his own rate, to pass on to the next higher speed, and eventually to the post-learning period as soon as he was able to do so, without regard to the speed of learning of the other subjects.

Records were kept in a phonetic alphabet of all responses made to the figures, with the exception that if the name given was strictly correct, the symbol 'K' was used. The values of the phonetic symbols used are given in the Appendix.

For the association tests the following directions were read to the subject :

I am going to call off the names of the figures one at a time. As I call each name I want you to answer with the first other name that you think of. Do not have a name picked and ready, but as soon as you hear the name that I say, answer with the first other name that comes to you.

The times at which these association tests were given differed for the two experiments, so they will be taken up later in discussing the particular conditions of each experiment. The association tests consisted of the names of the figures presented orally and in random order.

IV. RESULTS

SPECIAL CONDITIONS OF EXPERIMENT I :

The linguistic system used in Experiment I was one involving a perfect correlation between the linguistic elements involved and the two stimulus variables, form and size. The four forms used are shown in Figure 2. Table 1 gives the relationship between the four sizes of each form, the 16 individual figures, and their names.

Six association tests were given during the course of the experiment. The first of these was given 20 days after the experiment began, regardless of the proficiency of the subject. The second was given 13 days after the first. Thereafter the tests were given at weekly intervals. Each association test consisted of four series of names arranged in random order. The subject thus reacted to each name four times in each association test.

In discussing the results of both experiments, the term 'period' will refer to that portion of the experiment bounded by association tests. Thus the first period included the time up to the first association test; the second period included the time from the first to the second association test, and so on.

AN ANALYSIS OF LEARNING IN EXPERIMENT I :

That the figures were not of uniform learning difficulty is shown by the distribution of errors given in the right-hand column of Table 2, which presents the total number of errors made during the learning period by all subjects in responding to each of the figures. While the total number of errors for individual figures varied from 65 to 152, the total number made on any particular size or any particular form does not show a very wide variation. Perhaps the size *poj* and the form *zlg* were the easiest categories to learn.

In general the learning curves for the subjects show a complete S-shaped learning-function. The rate of improvement varied tremendously, but the general form of the curve was constant, an S-shaped curve with an inflection point at or slightly below the point of 50 percent learning. An average curve for all subjects is shown in Figure 4, Curve I. Learning was slow at first, increased rapidly as

TABLE I
THE LINGUISTIC SYSTEM USED IN EXPERIMENT I

Size	Form Categories			
Categories	A. NAS	B. ZIG	C. TAV	D. VUS
1 <i>lud</i>	<i>ludnas</i>	<i>ludzIG</i>	<i>ludtav</i>	<i>ludvus</i>
2 <i>grč</i>	<i>grčnas</i>	<i>grčzIG</i>	<i>grčtav</i>	<i>grčvus</i>
3 <i>sεb</i>	<i>sεbnas</i>	<i>sεbzIG</i>	<i>sεbtav</i>	<i>sεbvus</i>
4 <i>poj</i>	<i>pojnas</i>	<i>pojzIG</i>	<i>pojtav</i>	<i>pojvus</i>

The form names are given horizontally at the top of the table, with the size names vertically at the left. The names of the individual figures are obtained from the size name plus the form name, and are given in the body of the table. For example, the names given in the first row of the table are of the largest size, *lud*, of each of the four forms, *nas*, *zig*, *tav*, and *vus*; giving as figure names *ludnas*, *ludzIG*, *ludtav* and *ludvus*.

the subject began to distinguish the separate syllables characteristic of the four forms and the four sizes, and then slowed down again before perfect learning was accomplished. The other curve in the Figure is that of the second experiment. A comparison of the two will be made later.

ANALYSIS OF WRONG RESPONSES MADE DURING EXPERIMENT I:

Table 2 presents the relationship between the several stimulus figures and the wrong names given in response to them. The errors included in this analysis were of two sorts, first, those cases in which a name, correct in itself, was applied to another figure, and second, those cases in which the correct name was interfered with by another to such an extent as to produce a new formation. Errors made to the figure *ludnas* illustrate both types. In the first place the subject might respond to this figure with the name *ludtav*. That would be an error of the first type mentioned. In the second place the response to the figure *ludnas* might be *ludtas*. This mixture of *ludnas* and *ludtav* would be an error of the second type. Both errors, however, were due to the interference of the same figure, *ludtav*, and so are classed together in Table 2.

The most frequent type of error was that of giving the name of a figure of the same form and of adjacent size to that of the stimulus figure. The next most common error was that of giving the name of a figure of identical size but different form. Generally from one third to one half of the errors made to any specific figure were the names

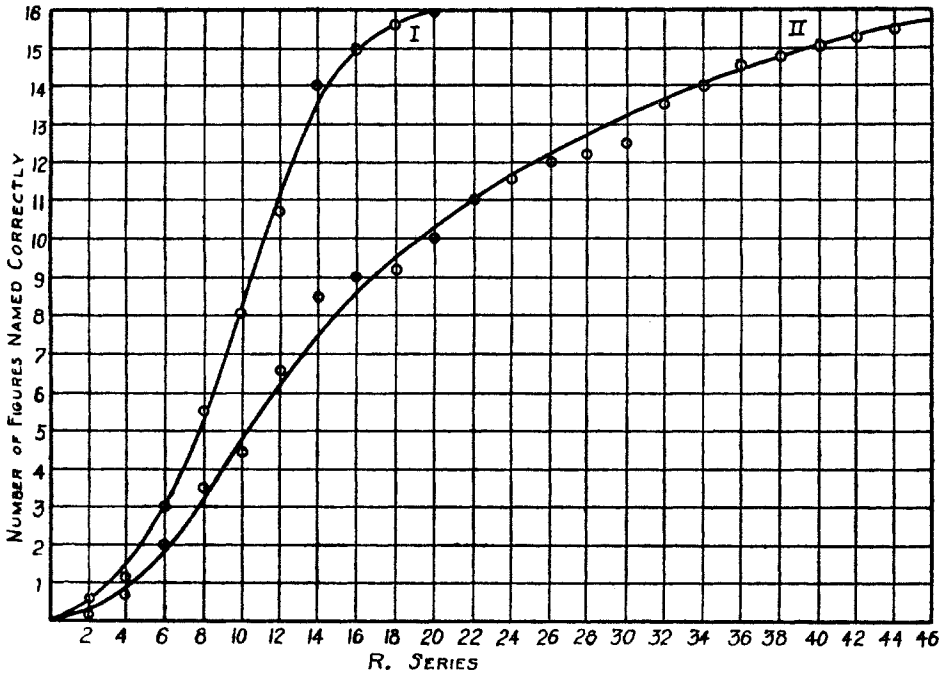


FIGURE 4. AVERAGE LEARNING CURVES FOR HOMOGENEOUS (I) AND HETEROGENEOUS (II) LINGUISTIC SYSTEMS.

TABLE 2

THE WRONG RESPONSES TO EACH FIGURE DUE TO THE INTERFERENCE OR SUBSTITUTION OF EACH OF THE OTHER FIGURES

Stimulus Figure	Interfering Figure																Total	
	<i>ludnas</i>	<i>grėnas</i>	<i>seėnas</i>	<i>poėnas</i>	<i>ludzig</i>	<i>grėzig</i>	<i>seėzig</i>	<i>poėzig</i>	<i>ludtav</i>	<i>grėtav</i>	<i>seėtav</i>	<i>poėtav</i>	<i>ludvus</i>	<i>grėvus</i>	<i>seėvus</i>	<i>poėvus</i>		Odd
<i>ludnas</i>	—	64	5	5	5	6	1	3	13	5	2	0	10	5	1	3	3	131
<i>grėnas</i>	18	—	40	1	1	8	3	1	5	10	7	5	3	7	2	1	4	125
<i>seėnas</i>	10	25	—	16	3	2	8	6	1	8	13	3	4	2	4	2	5	112
<i>poėnas</i>	3	4	14	—	0	2	6	9	0	2	2	25	1	1	2	5	4	80
<i>ludzig</i>	6	2	3	0	—	33	3	4	6	4	5	2	9	5	2	1	6	91
<i>grėzig</i>	5	7	1	1	16	—	34	3	4	10	4	1	2	5	3	1	3	100
<i>seėzig</i>	0	4	5	1	5	32	—	20	0	2	8	4	3	0	3	1	6	94
<i>poėzig</i>	1	2	2	7	6	5	22	—	0	1	3	8	0	0	0	5	3	65
<i>ludtav</i>	24	8	3	2	6	3	2	0	—	54	18	5	6	5	1	1	6	144
<i>grėtav</i>	4	20	5	4	3	12	2	2	14	—	38	5	2	5	1	2	3	122
<i>seėtav</i>	0	7	18	4	2	5	10	4	4	25	—	29	1	1	4	2	2	118
<i>poėtav</i>	1	0	2	40	2	1	6	13	4	4	18	—	1	1	1	15	5	114
<i>ludvus</i>	17	6	1	1	21	4	3	2	6	3	1	2	—	19	4	2	6	98
<i>grėvus</i>	5	8	1	1	3	9	4	3	1	23	5	2	11	—	17	3	6	102
<i>seėvus</i>	1	6	3	6	6	3	13	0	2	16	22	3	5	49	—	11	6	152
<i>poėvus</i>	4	4	15	10	1	1	3	6	0	0	11	29	5	6	10	—	2	107
Totals	99	167	118	66	80	126	120	76	60	176	157	123	63	111	55	55	70	1755

The names at the left of the table are of the figures on which errors were made. Given horizontally at the top of the tables are the names of the figures whose interference produced the error. Thus in responding to the figure *ludnas* no errors were due to the interference of *ludnas*, 64 were produced by the interference of *grėnas*, 5 by *seėnas*, 5 by *poėnas*; and so on. The errors listed under the column 'Odd' were such unusual mixtures as not to be attributable to any specific one of the 16 figures. In the last column are given the total number of errors made to each figure (e. g., 131 errors made in naming *ludnas*). The row of figures at the bottom of the table gives the total number of times each figure interfered with any of the other figures to produce an error; thus *ludnas* interfered with the other 15 figures to the extent of producing 99 wrong responses.

of the same form but one size smaller or larger. Tables 3 and 4 group the data of Table 2 into statements of the errors made to each form and size category in terms of the other form and size categories rather than in terms of the specific figures.

TABLE 3

DISTRIBUTION OF ERRORS ACCORDING TO FORM CATEGORY

Stimulus Form	Form Category of Error					Total
	<i>nas</i>	<i>ʒig</i>	<i>tav</i>	<i>vus</i>		
	no. %	no. %	no. %	no. %		
<i>nas</i>	205 47	64 15	110 25	53 12		432
<i>ʒig</i>	47 15	183 55	62 19	40 12		352
<i>tav</i>	142 29	73 15	218 45	49 10		482
<i>vus</i>	89 20	82 19	126 29	142 32		439
Total	483	402	516	284		1685

This table is to be read as follows: 205, or 47 % of the errors made in naming figures of the *nas* category were either substitutions of some other member of the same category or effects of the interference of some other member of that category. Sixty four, or 15 %, of the errors made in naming members of the *nas* category were due to the substitution or interference of some member of the *ʒig* category. Similarly the members of the *tav* category contributed 110, or 25 %, and of the *vus* category 53, or 12 %, of the errors made in naming the four figures of the *nas* category. The total number of errors made to the four members of each category are given in the final column of the table. The totals at the bottom of the table are the total number of times the members of each form category interfered with any other figure to produce an error.

Inspection of Table 3 shows a tendency for errors to consist of the names of other figures within the same form category as the stimulus figure. For example, 47 % of all errors made in naming the four members of the *nas* category (form) were attributable to some other member of the same category. While 47 % was not a majority of all errors, it was a higher percentage than that attributable to the interference of any of the three remaining form-categories. The predominant type of error made to the figures within any of the other three form-categories was also that of giving the name of some other member of the same form category. In addition to this general tendency, the two categories of *nas* and *tav* seemed peculiarly susceptible to confusion. Perhaps the presence of the same vowel sound in each was responsible. Generally this error took the form of 'tas' or 'nav'. The fewest errors seemed to be due to the interference of the members of the *vus* category, and the most to the interference of the *tav* category.

In Table 4 the errors are classified according to the size of the figures on which they were made and the size of figure whose

TABLE 4
DISTRIBUTION OF ERRORS ACCORDING TO SIZE CATEGORY

Stimulus Size	Size Category of Error								Total
	<i>lud</i>		<i>grč</i>		<i>seb</i>		<i>prof</i>		
	no.	%	no.	%	no.	%	no.	%	
<i>lud</i>	129	29	226	51	55	12	33	07	443
<i>grč</i>	97	22	133	31	167	39	36	08	433
<i>seb</i>	47	10	187	41	111	24	112	24	457
<i>prof</i>	29	08	34	10	117	33	172	49	352
Total	302		580		450		353		1685

With the substitution of the word Size for the word Form, Table 4 is to be read as was Table 3.

name interfered to produce the error. Most errors on all sizes consisted of the name of other figures either one size smaller or one size larger than the stimulus figure. The only exception to this was on the size *prof*. More errors made to that size consisted of the names of other figures of the same size than of any other size. In the remainder of the system this was the second most common type of error. For example, the greatest percentage of errors made to figures of the *lud* category (the largest size), 51%, was due to the interference of the names of figures one size smaller, the members of the *grč* category. The second most frequent cause of error (29%), to the *lud* figures was the interference of the other members of the *lud* category. Definitely fewer errors were made to the smallest size than to any other, while the differences in frequency of errors among the larger sizes was statistically insignificant. What errors were made seemed to be due to the interference of one of the intermediate sizes. The largest and smallest sizes accounted for relatively fewer errors.

To sum up the data of Tables 3 and 4 in terms of probability, the chances were 44 out of 100 that a given error was attributable to the interference of some other member of the same form category; and 18 out of 100 that the error was attributable to some specific other form category. The only exception to this was that the *vus* category was responsible for fewer errors than the others.

When an error was made, the chances were 32 out of 100 that it was due to some other figure of the same size category; 54 out of 100 that it was produced by a figure of a size category but one size removed from that of the figure on which the error was made; 10 out of 100 that the category of the interfering figure was two sizes removed

from that of the figure on which the error was made ; and 4 out of 100 that the cause was three sizes removed from that of the stimulus figure.

RELATIONSHIP BETWEEN STIMULUS NAME AND ASSOCIATES :

There was no general tendency for the number of different associates, given in response to any specific stimulus name, to decrease in the successive association tests. While isolated instances of this tendency did occur, they were counterbalanced by other cases in which the opposite tendency was shown. To take a hypothetical case, if a given subject responded to the stimulus word *ludnas* in the first association test with *ludzig* once, *sebnas* once, and *ludtav* twice, each of these responses, with the stimulus word, would constitute a distinct stimulus-associate pair. There were thus three different associates given in response to the same stimulus. No general tendency was evident for this number to decrease ; hence there was no indication that the associations to a given name were becoming more fixed, or stronger. Considering all subjects it must be concluded that the associations were as well formed, or as fixed, by the time the first association test was given as they were at the end of the experiment. In fact the average number of distinct stimulus-associate combinations on the successive association tests showed remarkably little change. A graphical presentation of this is given in Figure 5.

Figure 5 also includes an analysis of the relationships of the stimulus-names to the associated name with respect to the form and size of each. The average number of associates corresponding neither in form nor in size with the stimulus is indicated for the successive association tests by the line labelled N. Such an associate would be *pofvus* to the stimulus *ludnas*. The lines labelled S and F give the average frequencies of associates corresponding in size and form respectively to the stimulus-name. To the stimulus *ludnas*, an associated response of *ludvus* would be an associate corresponding in size to the stimulus ; a response of *sebnas* would correspond in form. There were no statistically significant changes in the average frequencies of any of these three classes of associations.

RELATIONSHIP BETWEEN ERRORS AND ASSOCIATES :

A comparison of the errors made to each figure with the associates given to the same figure is given in Figure 6. The percentage of errors which corresponded exactly to an associate given in the same period as the error was made (as for example *sebtav*, which was both

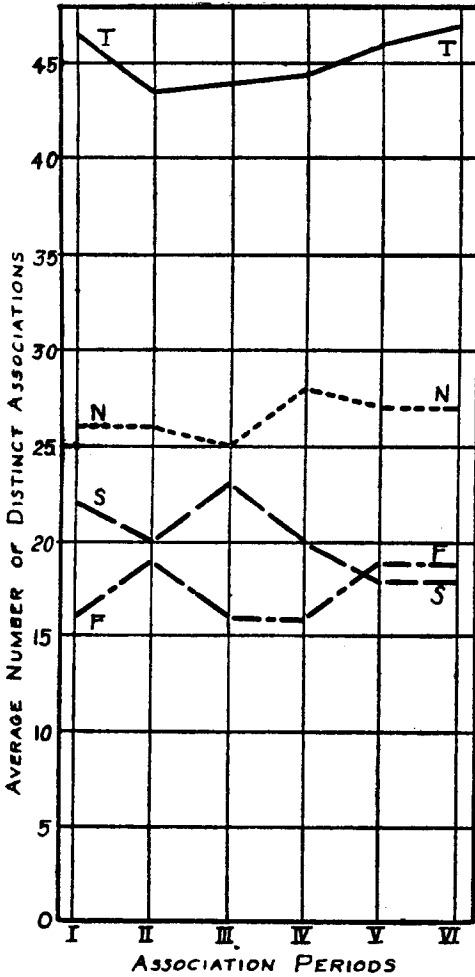


FIGURE 5. AVERAGE NUMBER OF DISTINCT STIMULUS ASSOCIATE PAIRS (I—I) IN EACH PERIOD, AND AVERAGE NUMBER OF ASSOCIATES CORRESPONDING TO THE STIMULUS NAME IN SIZE (S—S) IN FORM (F—F) AND NOT IN EITHER (N—N).

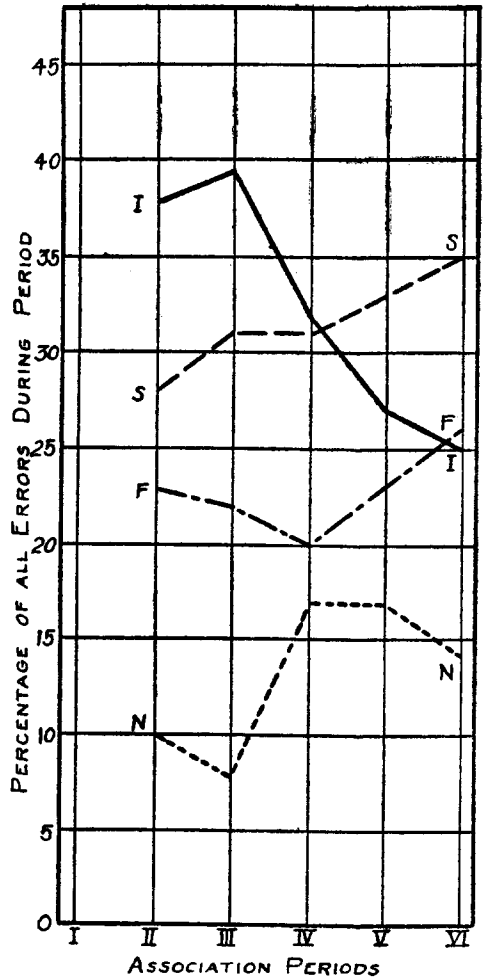


FIGURE 6. PERCENTAGE OF ERRORS ON ALL FIGURES CORRESPONDING IDENTICALLY (I—I), IN FORM ONLY (F—F), IN SIZE ONLY (S—S), AND IN NEITHER (N—N), WITH ONE OR MORE OF THE ASSOCIATES GIVEN DURING THE SAME PERIOD AND TO THE FIGURE ON WHICH THE ERROR WAS MADE.

an associate and a wrong response to *sebmas*), decreased from the first to the last period of the experiment. The decrease, as shown in the line marked I, with one inversion, was a fairly regular one. Likewise the errors made to a given figure which during the same period had an associate that corresponded to the error in size but not in form became more frequent with practice. For example *sebmas* might be a cause of error in naming *sebtav*, but not itself be an associate of *sebtav*, although other members of the same size category were. The percentage of all errors which resembled the associates in size only, increased during the successive periods of the experiment. While the increase was not particularly large it was quite regular and of fair statistical significance. Less consistent were the other types of errors. Those errors made to a figure having associates identical in form, but not in size (as *ludnas* and *sebmas* were identical in form but not in size) to that of the error, first decreased slightly and then increased as the experiment progressed. The percentage of errors made to figures which had no associates either of the same size or the same form as the error showed no consistent trend, but increased slightly during the course of the experiment. Further relationships between errors and associates will be evident in discussing the variant responses.

VARIANT RESPONSES GIVEN IN EXPERIMENT I :

Table 2 summarized all of the errors made by all of the subjects. A large part of these errors consisted of misapplying the correct name of some other figure. Although such errors may be of importance in indicating where confusion lies, and where associative interference is apt to lead to the formation of new words, they are not in themselves examples of analogic change. Part of the errors included in Table 2 were, however, new forms or variants which, while never heard by the subjects, were given as names to the figures. In this experiment such new forms occurred predominantly in the early part of the experiment. Out of approximately 350 such variants, 300 were given in the first part of the learning period. Some of these clearly indicated the mixture of two or more of the names of the language. As mentioned before, *tav* and *nas* very frequently became *tas* and *nav*. Both of these new forms appeared unquestionably to be due to the mixture of *nas* and *tav*. Similarly other mixtures or new forms occurred. Many of these variants were simply mispronunciations of the name, as when *grè* became *grf* or *gras*. Other variants were of much more doubtful origin. While they may have been due to the mixture of

TABLE 5

VARIANT RESPONSES GIVEN IN THE FIRST PERIOD OF EXPERIMENT I

Correct Response	Variant Response	No. of Subjects	Freq.	Most Probable Interfering Cause	
<i>ludnas</i>	<i>ludnav</i>	4	4	<i>ludtav</i>	
	<i>ludtas</i>	1	2	<i>ludtav</i>	
	<i>lufnās</i>	1	2	<i>poſnas</i>	
	<i>ludvas</i>	2	2	<i>ludvus</i>	
	<i>lustnas</i>	1	1		
	<i>luwstas</i>	1	1	<i>ludtav</i>	
	<i>θudnas</i>	1	1		
	<i>ludnaz</i>	1	1		
	<i>grēnas</i>	<i>grēnav</i>	3	5	<i>grētav</i>
		<i>grēnaz</i>	2	3	- <i>zig</i>
<i>grēwas</i>		2	3	<i>grēvus</i>	
<i>grasnas</i>		1	1		
<i>grasnus</i>		1	1	<i>grēvus</i>	
<i>grfnus</i>		1	1	<i>grēvus</i>	
<i>grēnis</i>		1	1	<i>grčzig</i>	
<i>vrēnas</i>		1	1	- <i>vus</i>	
<i>drēnas</i>		1	1		
<i>grēnaz</i>		1	1		
<i>grfnuf</i>		1	1	- <i>vus</i> , <i>poſ-</i>	
<i>grfnup</i>		1	1	- <i>vus</i>	
<i>grsnuf</i>		1	1	- <i>vus</i> , <i>poſ-</i>	
<i>grasnuf</i>		1	1	- <i>vus</i> , <i>poſ-</i>	
<i>grčnuf</i>		1	1	- <i>vus</i> , - <i>poſ-</i>	
<i>sebnas</i>		<i>zebnas</i>	2	6	<u><i>zebzig</i></u>
		<i>sebtas</i>	3	4	<i>sebtav</i>
	<i>sebnaz</i>	2	3	- <i>zig</i>	
	<i>sebnuf</i>	1	3	<i>sebvus</i>	
	<i>sebnav</i>	2	2	<i>sebtav</i>	
	<i>sebnuus</i>	1	1	<i>sebvus</i>	
	<i>sednas</i>	1	1		
	<i>stēpnas</i>	1	1		
	<i>sepnuus</i>	1	1	<i>sebvus</i>	
	<i>lebtas</i>	1	1	<i>ludnas</i> , - <i>tav</i>	
	<i>sebvvas</i>	1	1	<i>sebvus</i>	
	<i>sepnaf</i>	1	1	<i>poſ-</i>	

Correct Response	Variant Response	No. of Subjects	Freq.	Most Probable Interfering Cause	
<i>pořnas</i>	<i>pořhaus</i>	1	6		
	<i>pořtas</i>	2	5	<i>pořtav</i>	
	<i>pořfnas</i>	3	4	<i>ludnas</i>	
	<i>pořnas</i>	1	3		
	<i>pořnav</i>	1	2	<i>grčtav</i>	
	<i>pořvuas</i>	1	2	<i>pořvuus</i>	
	<i>pořnaz</i>	2	2	<i>-řig</i>	
	<i>pořtaus</i>	1	2		
	<i>pořhas</i>	1	2		
	<i>pořvuas</i>	1	1	<i>pořvuus</i>	
	<i>pořnaz</i>	1	1		
	<i>pořtus</i>	1	1	<i>pořtav, pořvuus</i>	
	<i>pořsa</i>	1	1		
	<i>pořfnas</i>	1	1	<i>grčnas</i>	
	<i>pořcnas</i>	1	1	<i>grčnas</i>	
	<i>pořčtas</i>	1	1	<i>grčtav</i>	
	<i>pořtas</i>	1	1	<i>pořtav</i>	
	<i>pořnav</i>	1	1	<i>pořtav</i>	
	<i>pořnřs</i>	1	1	<i>pořřřig</i>	
	<i>pořtnas</i>	1	1	<i>pořřřig</i>	
	<i>pořnaz</i>	1	1		
	<i>ludřig</i>	<i>ludřvřg</i>	2	3	<i>ludřvuus</i>
		<i>ludřřg</i>	1	2	
		<i>ludřdrřg</i>	1	2	
		<i>ludřdzřg</i>	1	2	
		<i>ludřdnřg</i>	1	1	
<i>nudřřg</i>		1	1		
<i>ludřřřg</i>		1	1		
<i>ludřřřg</i>		1	1	<i>sebřřřg</i>	
<i>grčřřg</i>		<i>grasřřg</i>	1	2	<i>-nas</i>
		<i>grasřřg</i>	1	2	<i>-nas</i>
	<i>grčřvřg</i>	1	2	<i>grčřvuus</i>	
	<i>grřřřřg</i>	1	1		
	<i>grasřřg</i>	1	1	<i>-nas</i>	
	<i>krčřřřg</i>	1	1		
<i>sebřřřg</i>	<i>řsebřřřg</i>	3	9		
	<i>ředřřřg</i>	1	3		
	<i>řřbřřřg</i>	1	1		

Correct Response	Variant Response	No. of Subjects	Freq.	Most Probable Interfering Cause
	<i>nɛdrɪg</i>	1	1	
	<i>sɛfzɪg</i>	1	1	<i>poʃzɪg</i>
	<i>lɛbzɪg</i>	1	1	<i>ludzɪg</i>
	<i>sɪbvɪg</i>	1	1	<i>sɛbvus</i>
	<i>sɛpʒɪg</i>	1	1	<u><i>sɛptav</i></u>
<i>poʃzɪg</i>	<i>puʃzɪg</i>	4	8	<u><i>ludzɪg</i></u>
	<i>počzɪg</i>	2	4	<i>grčzɪg</i>
	<i>postzɪg</i>	1	2	
	<i>poʃrɪg</i>	1	2	
	<i>puzɪg</i>	1	2	<i>ludzɪg</i>
	<i>puszɪg</i>	1	1	<i>ludzɪg, -nas</i>
	<i>poszɪg</i>	1	1	<i>-nas</i>
	<i>pozɪg</i>	1	1	
<i>ludɪav</i>	<i>ludɪas</i>	2	3	<i>ludnas</i>
	<i>nudɪav</i>	1	2	
	<i>ludnav</i>	1	1	<i>ludnas</i>
	<i>lustav</i>	1	1	<i>grčtav</i>
<i>grčtav</i>	<i>grastav</i>	1	6	<i>-nas</i>
	<i>grčtas</i>	2	3	<i>grčnas</i>
	<i>grčtat</i>	1	1	
	<i>grastuf</i>	1	1	<i>-vus</i>
	<i>grstav</i>	1	1	
	<i>grtas</i>	1	1	<i>grčnas</i>
	<i>grčtaʒ</i>	1	1	<i>grčnas</i>
<i>sɛbtav</i>	<i>sɛbtas</i>	2	6	<i>sɛbnas</i>
	<i>ʒɛbtav</i>	4	6	<u><i>ʒɛbzɪg</i></u>
	<i>ʒɛbnav</i>	1	1	<u><i>ʒɛbzɪg, -nas</i></u>
	<i>sɛbtavv</i>	1	1	
	<i>nɛbtav</i>	1	1	
<i>poʃtav</i>	<i>poʃtas</i>	4	17	<i>poʃnas</i>
	<i>počtav</i>	3	8	<i>grčtav</i>
	<i>puʃtav</i>	3	5	<i>ludtav</i>
	<i>postav</i>	2	3	<i>grčtav</i>
	<i>postnav</i>	1	2	<i>poʃnas</i>
	<i>puʃta</i>	1	1	<i>ludtav</i>
	<i>poʃtavv</i>	1	1	
	<i>poʃnav</i>	1	1	<i>poʃnas</i>
	<i>potas</i>	1	1	<i>poʃnas</i>

Correct Response	Variant Response	No. of Subjects	Freq.	Most Probable Interfering Cause
<i>ludvus</i>	<i>pofta</i>	1	1	
	<i>ludvos</i>	2	3	<i>poj-</i>
	<i>ludvu</i>	1	3	
	<i>ludvis</i>	1	1	<i>ludzɪg</i>
	<i>pudpu</i>	1	1	<i>poj-</i>
	<i>lufvus</i>	1	1	<i>pojvus</i>
	<i>ludvuus</i>	1	1	
<i>grčvus</i>	<i>ludvaz</i>	1	1	<i>ludnas</i>
	<i>grčvos</i>	1	6	<i>poj-</i>
	<i>grčvuus</i>	1	2	
	<i>grčvus</i>	1	2	
	<i>grasvu</i>	1	2	<i>-nas</i>
	<i>grčvu</i>	1	1	
	<i>grčpu</i>	1	1	<i>poj-</i>
<i>sebvus</i>	<i>grčvas</i>	1	1	<i>grčnas</i>
	<i>zɛbvus</i>	1	2	<u><i>zɛbzɪg</i></u>
	<i>sebvuuus</i>	1	2	
	<i>sebvu</i>	1	1	
	<i>sebpu</i>	1	1	<i>poj-</i>
	<i>sɪbvɛb</i>	1	1	<i>-zɪg</i>
	<i>sebvos</i>	1	1	<i>poj-</i>
<i>pojvus</i>	<i>sedvus</i>	1	1	
	<i>sebnuf</i>	1	1	<i>sebnas</i>
	<i>sebluč</i>	1	1	<i>grč-</i>
	<i>pufov</i>	1	5	<i>ludvus</i>
	<i>lufvus</i>	3	4	<i>ludvus</i>
	<i>počvus</i>	1	3	<i>grčvus</i>
	<i>pufnu</i>	1	2	<i>ludvus, pojnas</i>
	<i>pojfnus</i>	1	2	<i>pojfnas</i>
	<i>pufovuz</i>	1	2	<i>ludvus</i>
	<i>pojvos</i>	1	2	<i>poj-</i>
	<i>parvus</i>	1	2	<i>-nas, -tav</i>
	<i>pufnud</i>	1	1	<i>ludvus, -nas</i>
	<i>pojvas</i>	1	1	<i>pojfnas</i>
	<i>posvus</i>	1	1	<i>grčvus</i>
<i>pojvus</i>	1	1	<i>grčvus</i>	
<i>pojvuus</i>	1	1		
<i>pojvus</i>	1	1		

Changes due to Assimilation

Correct Response	Variant Response	No. of Subjects	Freq.	Most Probable Interfering Cause
<i>pofnas</i>	<i>povnas</i>	1	1	
<i>grčz1g</i>	<i>grčs1g</i>	4	11	
<i>sebz1g</i>	<i>zɛbz1g</i>	2	4	
<i>pořz1g</i>	<i>pořs1g</i>	1	1	
	<i>povz1g</i>	2	2	

other members of the system, in many cases sounds from three or four distinct sources were present, together, perhaps, with sounds which did not occur in the system at all. For the first period, a list of all the variant pronunciations and new forms is given in Table 5. The variants occurring after the first period are given in a later table. The stimulus figure, the variant response, the number of subjects giving each variant, and the total frequency of occurrence of each are given in the table. Whenever possible the name of the figure which most probably interfered to produce the new form is also indicated. The blank parts of this last column are due to the fact that in many cases it was impossible to give with any certainty the name of the figure which caused the interference. In some cases, as for instance where *pořz1g* became *povz1g*, the variant appeared to be simply a case of assimilation. Where this seemed to be the case, the word Assimilation is given under the heading of cause.

In some cases a form altered by assimilation seemed to manifest all the characteristics of the primary names with respect to taking part in the process of analogic change. Because of its occurrence before a voiced consonant the final sound of the first syllable might also become voiced. When such a change developed, for instance *pov* from *poř*, the new form would sometimes be carried over into situations in which it would never by itself have become voiced. When *pov* replaced *poř* in the name *pořz1g*, the change was simply a case of regressive assimilation, but assimilation could not explain the development of the form *povtav*. Apparently forms altered by assimilation are also subject to analogic transfer. Thus by analogy, on the basis of *povz1g*, *pořtav* became *povtav*. Similarly the *ř* of *z1g* might become unvoiced, changing *pořz1g* into *pořs1g*, and then this new form transfer to other words producing *luds1g* or *seb1g*. There were several such cases in which assimilation changed a voiced sound into an unvoiced one, or vice versa, and then the new form transferred into combinations in which it would never have developed by itself.

TABLE 6

VARIANT RESPONSES AFTER PERIOD I IN EXPERIMENT I

Correct Response	Variant Response	No. of Subjects	Freq.	Most Probable Interfering Cause
<i>sebnas</i>	<i>sobnas</i>	1	1	
<i>pofnas</i>	<i>sed</i>	1	1	
	<i>pofnus</i>	1	1	<i>pofovs</i>
<i>sebzig</i>	<i>segzig</i>	1	1	
	<i>gr̄s̄eb</i>	1	1	
<i>pozzig</i>	<i>pufzig</i>	1	1	<i>ludzig</i>
<i>ludtav</i>	<i>luk</i>	1	1	
<i>sebtav</i>	<i>sebtas</i>	1	1	<i>sebnas</i>
<i>poftav</i>	<i>so</i>	1	1	
<i>sebvus</i>	<i>sepvus</i>	1	1	
	<i>sebtvus</i>	1	1	
<i>pofovs</i>	<i>pufvus</i>	1	1	<i>ludvus</i>

Changes due to Assimilation

<i>pofovs</i>	<i>porvus</i>	2	21
	<i>poovus</i>	1	1
	<i>porvus̄s</i>	1	1
	<i>poovus</i>	1	1
<i>pozzig</i>	<i>pozzig</i>	2	16

While progressive assimilation is commonly said to be the characteristic type of assimilation in English, in these records regressive assimilation was about four times as frequent as the progressive type. This may, however, have been due to the particular speech sounds included in the language. If the linguistic system had contained other sound combinations the results might have been more in accordance with the normal trend of English, the native language of the subjects.

Table 6 presents similar data to those of Table 5, but for the latter part of the experiment. The period included in Table 6 was for the entire time after the first association test, that is, all but the first three weeks of the experiment. Table 5 included all variants up to that time. As before, the stimulus-figure, the variant, and the frequency of each are given. Again an interfering cause is assigned whenever possible. This should have been more generally possible with the

variants of the later period, as errors due to simple misunderstanding or careless pronunciation were less frequent. However, the analogic variants of this period were very scarce.

The most remarkable thing about these variants of later appearance was their scarcity. After the language had once been learned there seemed to be very little tendency to alter it. When mistakes were made, they generally consisted of the correct name of some other figure. Aside from errors classifiable as examples of assimilation, which are included in the table, there were only 12 variants given during this entire period, which included some 35000 separate presentations on each of which an error might possibly have been made. Even the variants which did occur were scattered. The same one was never given by two subjects, nor by the same subject twice. Extreme stability seemed to be characteristic of a language as systematic as this. Since the course of analogic change is commonly in the direction of greater systematization, and since this language was, from the start, as systematic as it could be made, perhaps the results obtained were to have been expected.

SUMMARY OF EXPERIMENT I :

By the use of a highly systematic language, one in which there was a perfect correlation between the two variables, form and size, and the two-syllable names applied to the figures, learning was very rapid and very regular. The learning curves were S-shaped and symmetrical about the inflection points.

There was no general tendency for the associations to become more fixed, or for a given stimulus-associate combination to be given more and more frequently as more association tests were given. While isolated examples of this tendency did occur, the total number of distinct stimulus-associate pairs remained about the same on all association tests.

The percentage of errors which corresponded identically to the associates of the figure on which the error was made decreased with practice. Errors corresponding only to the size or the form of the associates to the figure on which the error was made increased slightly with practice. Non-identical errors also increased slightly. In general more errors were made which corresponded to associates in size only than in form only. Confusion of figures of the same size but different form seemed to follow more closely the association tendencies of a given figure than did confusion of figures within the same form category.

TABLE 7
 NAMES OF THE FIGURES USED IN EXPERIMENT II

Size Category	A. <i>poř</i>	Form Category B. <i>seb</i>	C. <i>grč</i>	D. <i>lud</i>
1 <i>vus</i>	<u><i>vuskof</i></u>	<u><i>sebvus</i></u>	<i>vusgrč</i>	<i>vuslud</i>
2 <i>nas</i>	<u><i>naspoř</i></u>	<u><i>sebnas</i></u>	<i>nasgrč</i>	<i>neslud</i>
3 <i>řig</i>	<u><i>řinpoř</i></u>	<u><i>řigseb</i></u>	<i>řiggrč</i>	<u><i>řiglud</i></u>
4 <i>tav</i>	<u><i>tavpoř</i></u>	<i>tavseb</i>	<i>tavgrč</i>	<i>tavlud</i>

Table 7 is to be read as was Table 1

Most of the errors consisting of a correct but misapplied name were names of other figures within the same form category and next in size to the figure on which the error was made. The second most frequent type of error was in giving the names of figures of the same size, but from other form categories.

In the use of such a systematic language, very few new linguistic formations developed. While many new names were applied to the figures during the early part of the learning period, new formations were very rare after the subjects had become familiar with the material. Such variant names as were given during the latter part of the experiment were scattered and never occurred more than once.

SPECIAL CONDITIONS OF EXPERIMENT II :

The linguistic system used in Experiment II was not as exactly correlated with the stimulus variables, form and size, as that of Experiment I. This system might be described as a perfectly correlated one into which several changes were arbitrarily introduced. The relationships between the two categories, form and size, and the names applied to them, are given in Table 7. The same syllables that made up the language of Experiment I were used in Experiment II, changed, however, so that those syllables which in the first language were names of the forms now became the size names and vice versa. The names underlined in Table 7 are those which were altered from their systematic form. These alterations were of three types. *Vuspoř* and *řigpoř* were changed to *vuskof* and *řinpoř* by changing a consonant, once in the first and once in the second syllable. *Vusseb* and *nasseb* had their syllable order reversed to produce *sebvus* and *sebnas*. *Naslud* and *řiglud* were changed to *neslud* and *řiglud* by altering a vowel. Here also one change was made in the first and one in the second

syllable. One complete form-category, *grê*, and one complete size-category, *tav*, were left unaltered. Two of the six alterations were made in each of the three remaining form-categories and two in each of the three remaining size-categories. In some ways this type of linguistic system was a closer approximation to a real language than was the systematic language of the first experiment, as the conditions of regularity between variables and name, combined with a certain amount of irregularity, found in ordinary languages, was duplicated in this artificial one.

The same stimulus-figures were used here as in Experiment I. The only changes were in the names applied to them.

Experiment II was unfortunately interrupted after seven experimental days because of the necessity of replacing some faulty apparatus. How much this interruption influenced the results cannot be determined. In some respects the period before the interruption served simply to acquaint the subjects with the nature of their task. However, some of the quicker learners had, even in the first seven days, more or less completely learned the language, at least to the point of being able to give one perfect R series. After this enforced rest there was some, but not a great deal, of forgetting. Most of the subjects went on from approximately the point that they had reached at the end of the first period. After returning from this vacation the subjects continued to come five days a week for the next five weeks. This meant that the total experimental time was less than that of Experiment I by from three to four weeks.

Three association tests were given during this experiment. The first was given at the end of the first seven experimental days. The second was given 17 days after work was resumed, and the last at the end of the experiment. These tests divided the whole experiment into three parts. The first of these constituted the first seven experimental days. The last two were of about equal length, of twelve and ten experimental days respectively. The word 'period' in the following discussion and tables will refer to these three divisions of the experiment.

The first association test was given as were those of Experiment I, consisting of four series of the names given in random order. The last two association tests consisted of one long series in which each name appeared three times. The only criterion in determining the order of names in these series was that no name should occur twice consecutively. Otherwise there was no attempt to give all of the

names before starting to repeat them. Later, in comparing numbers of associations and fixity of associations, the first test was reduced to a basis of three presentations of each name, in order to make it comparable with the two later tests.

Data were available on the hearing ability of five of the eight subjects used in this experiment. With the exception of one subject who had a 30 % loss for the frequencies of about 2048 cycles, all subjects tested had 90 % hearing or better in one or both ears for all frequencies up to 8000 cycles. As the experimenter always attempted to say the names rather loudly, it is improbable that the difficulties of hearing were responsible for many of the changes introduced into the language.

The experimenter's hearing is in both ears 90 % or better for all frequencies up to 8000 cycles. At that point, which includes the high pitches characteristic of *s* and *z*, it falls off to 60 %. It is thus possible that some of the changes recorded in these sibilants, particularly in Experiment I, were the fault of the experimenter and not of the subjects.

AN ANALYSIS OF LEARNING IN EXPERIMENT II :

The heterogeneous language of Experiment II presented considerably greater learning-difficulty than did the more homogeneous one of Experiment I. The average learning-curves of the two groups, given in Figure 4, show a much more rapid rate of learning in the first experiment than in the second. In Experiment I, in which a perfectly logical language was used, the point of almost perfect learning was reached after only 18 R series. At that time the group as a whole was averaging well over 15 (out of 16 possible) correct responses in each R series. After the same amount of practice the group learning the heterogeneous language was averaging only 10 correct responses per R series. A record equal to that of the group learning the homogeneous language was not reached until after more than 50 R series.

A comparison of the first errorless R series of the two groups showed a similar difference. The first group, with a homogeneous language, averaged 14.8 R series, while the group learning the heterogeneous language averaged 27.6 R series before an errorless one was given. Using the first errorless R series as a criterion of learning, the homogeneous language was learned in approximately half the time necessary for the heterogeneous one. The actual difference was over three times its Standard Deviation, so there is little possibility that the

apparent superiority of the homogeneous language was due to chance factors.

A further difference between the two groups was shown in the location of the inflection-points of their respective curves. While the curve representing the learning process of the first group was symmetrical about its inflection point, the learning-curve of the second group showed no such symmetry. In the second curve the inflection-point was in the lower half of the curve, at the point where the material was about one-fourth learned.

Both the general shapes of these curves and the location of the inflection-point in each was in exact accord with Thurstone's assumptions regarding the learning-process. The shape of the individual curves was substantially the same as that obtained by Hull for the learning of generalized abstractions.

The comparative time necessary to learn these two languages suggests that in the construction of practical universal languages the most perfect correlation possible between the linguistic elements and the things which they represent would be highly desirable from the standpoint of economical learning.

The several names composing the linguistic system used in Experiment II did not all present the same amount of difficulty to the learner. The correlation of .61 between the number of errors made on each figure in the first experiment with the number of errors made in the second suggests that the figures themselves, regardless of the names given to them, were not of uniform difficulty. In part this was due to the fact that the names of the smallest figure of each form were left unaltered in the second language. In the first experiment the smallest sizes were the most easily learned. This might have been true also in the second experiment even had their names not been made more systematic than those of any other size category. When the easiest figures of the systematic language were made the easiest ones of the other language as well (by leaving them systematic in an unsystematic language), some correlation between the difficulty of the two languages was bound to result. While there was this evidence for the belief that the difficulty of learning was a function of the figure and not of its name, somewhat contradictory evidence is to be seen in the data presented in Table 8. Inspection of the number of errors attributable to the interference of each figure shows a considerably greater frequency of error in dealing with those names which did not fit exactly into the logical scheme of the language. This will be shown more conclusively in the analysis of the variant responses.

TABLE 8

WRONG RESPONSES TO EACH FIGURE DUE TO THE INTERFERENCE
OR SUBSTITUTION OF EACH OTHER FIGURE

Stimulus Figure	Interfering Figure																Total	
	<i>vuskof</i>	<i>naspoj</i>	<i>ziflavz</i>	<i>tavpoj</i>	<i>sebvus</i>	<i>sebnas</i>	<i>zigseb</i>	<i>tavseb</i>	<i>vusgrč</i>	<i>nasgrč</i>	<i>ziggrč</i>	<i>tavgrč</i>	<i>vuslud</i>	<i>neslud</i>	<i>ziglod</i>	<i>tavlud</i>		Odd
<i>vuskof</i>	—	40	28	2	1	4	5	1	7	9	5	2	1	14	0	2	2	123
<i>naspoj</i>	26	—	78	3	0	1	5	1	0	18	3	2	1	22	1	1	3	165
<i>ziflavz</i>	19	28	—	9	0	2	4	0	0	3	9	0	1	5	2	3	3	88
<i>tavpoj</i>	4	3	15	—	0	2	1	1	0	1	1	14	0	0	2	8	12	64
<i>sebvus</i>	0	2	3	0	—	48	7	1	0	2	2	2	5	13	2	1	3	91
<i>sebnas</i>	1	0	4	2	15	—	35	10	0	6	0	3	2	5	3	3	2	91
<i>zigseb</i>	0	0	19	1	12	61	—	14	0	3	9	1	2	0	2	5	8	137
<i>tavseb</i>	0	1	4	5	2	15	10	—	0	0	0	6	0	0	5	10	3	61
<i>vusgrč</i>	3	5	12	0	3	3	6	2	—	62	17	2	2	14	7	1	1	140
<i>nasgrč</i>	1	4	9	2	0	6	2	1	11	—	50	7	1	56	6	1	2	159
<i>ziggrč</i>	2	2	37	0	0	6	7	0	7	34	—	10	3	9	8	4	3	132
<i>tavgrč</i>	1	1	2	12	2	2	1	9	3	3	8	—	2	4	0	9	4	63
<i>vuslud</i>	3	2	4	3	3	9	1	2	3	9	7	2	—	25	13	5	0	91
<i>neslud</i>	0	1	4	4	0	5	3	2	0	11	8	2	18	—	24	4	3	89
<i>ziglod</i>	0	3	35	3	0	3	3	2	0	6	5	3	1	50	—	17	5	136
<i>tavlud</i>	1	1	3	7	0	4	0	12	0	2	0	16	4	1	18	—	3	72
Total	61	93	257	53	38	171	90	58	31	169	124	72	43	218	93	74	57	1702

Table 8 is to be read as was Table 2.

ANALYSIS OF ERRORS IN EXPERIMENT II :

Table 8 presented the frequency of the substitution or interference of each name as a cause of error in naming each other figure. These data become clearer if analyzed into the categories of form and size. Table 9 presents the frequency of error segregated according to the four form categories.

TABLE 9
DISTRIBUTION OF ERRORS ACCORDING TO FORM CATEGORY

Stimulus Form	Form Category of Error				Total
	<i>pof</i> no. %	<i>seb</i> no. %	<i>grċ</i> no. %	<i>lud</i> no. %	
<i>pof</i>	255 61	28 07	74 18	63 15	420
<i>seb</i>	42 12	230 63	34 09	58 16	364
<i>grċ</i>	93 19	50 10	214 44	127 26	484
<i>lud</i>	74 20	49 13	74 20	180 48	377
Total	464	357	396	428	1645

Table 9 is to be read as was Table 3.

In general, 55 % of all errors made were attributable to the interference of some other name within the same form-category as the figure on which the error was made. Stated in terms of probability, the chances were 55 out of 100 that the error was the result of interference of some other member of the same form-category. Roughly, the chances were 15 out of 100 that the error was a result of the interference of a member of any other specific form-category. These proportions did not apply to any of the specific form-categories. For example, 61 % of the errors in naming figures of the *pof*-category were produced by other members of the same category; 7 % by members of the *seb*-category; 18 % by the *grċ*-category and 15 % by the *lud*-category. However, the figures given above are averages for the errors on all four form-categories.

A similar analysis of the errors on the basis of the size categories is given in Table 10.

From the standpoint of the size category of the error, it may be seen that 56 % of all errors consisted of the substitution or interference of the name of a figure one size removed from that of the figure on which the error was made. In the case of the two larger sizes, the most frequent error was that of giving the name of a figure next smaller in size. For the two smaller sizes, interference of the next larger figure became the most common source of error. This was not strictly true, however, of the figures of the smallest size, *tav*, to which the most common error was the name of another figure of the same size. Taken as a whole, the chances were that an error made to any

TABLE 10
DISTRIBUTION OF ERRORS ACCORDING TO SIZE-CATEGORY

Stimulus Size	Size Category of Error				
	<i>vus</i> no. %	<i>nas</i> no. %	<i>zlg</i> no. %	<i>tav</i> no. %	
<i>vus</i>	31 07	261 59	119 27	28 06	439
<i>nas</i>	76 15	135 27	235 48	48 10	494
<i>zlg</i>	47 10	215 45	140 30	72 15	474
<i>tav</i>	19 08	40 17	70 29	109 46	238
Total	173	651	564	257	1645

Table 10 is to be read as was Table 9.

figure would in 26 out of 100 cases consist of the name of another figure of the same size as the one on which the error was made; 56 in 100 that the error would consist of the name of a figure next in size to that on which the error was made; about 16 in 100 that the error would be two size-categories removed from the figure on which it was made; and 3 chances in 100 that the error would be three size-categories away from the figure on which it was made.

As with the classification on the basis of form, the errors on no one size agreed exactly with these averages. For instance, only 7%, instead of 26% of the errors on the largest size, *vus*, were attributable to the interference of other figures of the same size; 59%, instead of 56%, were produced by the next smaller size, *nas*. The figures two sizes away from the *vus* category, *zlg*, produced 27% instead of 16%; and the smallest figures, *tav*, produced 6% instead of 3% of the errors. Again the percentages quoted were simply averages for all sizes.

The close agreement of these probabilities with those found in Experiment I suggests again that the errors were largely a function of the figures themselves and only secondarily of the names given to them. The type of language had but little effect on where the errors were made. It did affect the type of errors found. In the systematic language of the first experiment the errors consisted mainly of substitutions of the associated name. In the language of Experiment II, given the same associations, the errors were much more apt to consist of mixtures and new forms.

To sum up the results of Tables 9 and 10, the most common type of error was the substitution or interference of a figure of the same form and of adjacent size to that of the figure on which the error was made. For example, the most common error made in naming the figure *vuskof* was the substitution of the name *naspoj*; the most common error in naming the figure *zigsab* was the substitution of the name *sebnas*; and similarly for the remaining figures. It would not necessarily be true that the variant responses would show the same tendencies as the substitutions. However, frequent examples of this tendency will be found in the analysis of the variant responses. The variants though, much more than the substitutions, were attributable to the interference of one of the unsystematic names of the language.

RELATIONSHIP BETWEEN STIMULUS-NAME AND ASSOCIATE :

The line labelled T in Figure 7 gives the total number of distinct stimulus-associate pairs in the successive association tests. The fact that this line has a negative slope indicates that as the experiment progressed there was a tendency for a specific name to be given more and more frequently as the response to a specific other name, used as a stimulus word in the association test. In other words, the associations became more fixed. This was not found to be true in Experiment I, but in Experiment II the trend seemed to be moderately reliable. Statistically there were 96 chances in 100 that the difference between the end points of the curve was not due to chance.

The remainder of Figure 7 analyses the associates according to their relationship with the stimulus-word. The associates might either be within the same form-category as the stimulus word, within the same size-category, or in neither. The associate could not be a member of both the form-category and the size-category characteristic of the stimulus, or it would be merely a repetition of the stimulus-word. While such repetitions were given in a few isolated cases, they were so few that they have been neglected in this analysis. From the slopes of the lines it may be seen that with practice there was a marked tendency to increase the associations within the same size-category and to decrease the associations within the same form-category as the stimulus. The tendency to give associates which differed in both categories from the stimulus name also decreased somewhat with practice, but the decrease was not statistically reliable. The strength of the two categories, form and size, in producing associations, was about equal in the first association test. But in later tests the gap between

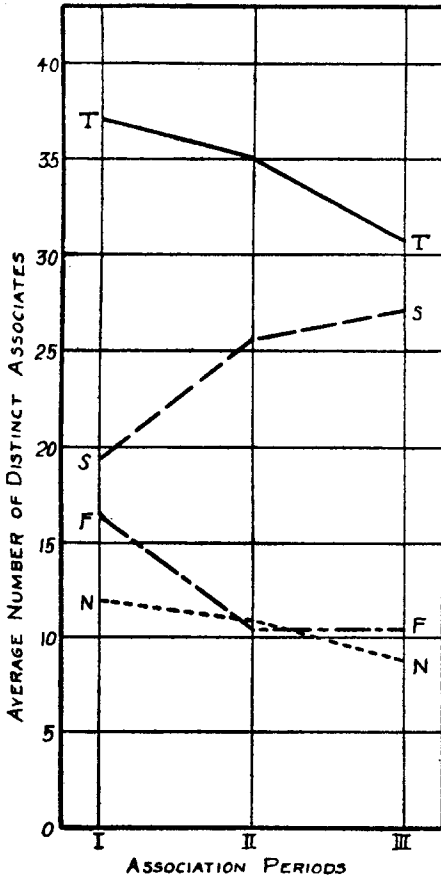


FIGURE 7. AVERAGE NUMBER OF DISTINCT STIMULUS-ASSOCIATE PAIRS (T—I) IN EACH PERIOD, AND AVERAGE NUMBER OF ASSOCIATES CORRESPONDING TO THE STIMULUS NAME IN SIZE (S—S) IN FORM (F—F) AND NOT IN EITHER (N—N).

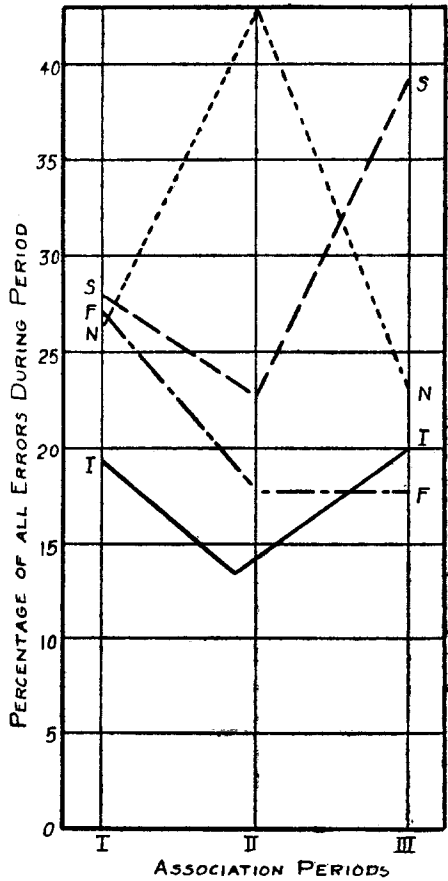


FIGURE 8. PERCENTAGE OF ERRORS ON ALL FIGURES CORRESPONDING IDENTICALLY (I—I), IN FORM ONLY (F—F) IN SIZE ONLY (S—S), AND IN NEITHER (N—N), WITH ONE OR MORE OF THE ASSOCIATES GIVEN DURING THE SAME PERIOD AND TO THE FIGURE ON WHICH THE ERROR WAS MADE.

them became increasingly wider. This group tendency was more or less characteristic of seven of the eight subjects. However, the remaining subject showed exactly the opposite tendency. With practically 100% frequency, her associated responses were within the same form-category as the stimulus-word. The other subjects, however, all agreed with the averages.

RELATION BETWEEN ERRORS AND ASSOCIATES :

Since analogic change has been attributed to the interference of associated words, an examination should be made of the relationship between the associates to a given name and the errors made in naming that figure. Such an analysis is made in Figure 8. As any error in naming a figure which can be traced to the influence of some other specific figure may be as indicative of associative interference as are actual cases of analogic change, all errors have been included in this analysis.

Various relationships were possible between the associates and the errors to a given figure. In the first place the associates and the errors might be identical. For example, when the figure *neslud* was presented it was sometimes called *nasgrč*. That, of course, was an error. If now *nasgrč* was a response to the stimulus-word *neslud* in an association-test, then the error and the associate corresponded identically. In the second place, the associate and the error might correspond only in form or only in size, but not in both as the previous example did. If *neslud* were again sometimes called *nasgrč* and if *sebnas* or *naspoj* or both were given as associates to *neslud*, then the error corresponded to the associates in size only. If *vusgrč*, *zīggrč*, or *taugrč* was an associate of *neslud*, and if *nasgrč* was a wrong response or error in naming *neslud*, then the error corresponded to the associate in form but not in size. The third possibility was to have no relationship between errors and associates. If again *nasgrč* was a wrong response to *neslud*, but if *neslud* had no associates within either the *nas* (size) or the *grč* (form) categories, then there was no correspondence between the error and the associates.

An examination of Figure 8 shows no consistent trends in the frequencies of any of these relationships between errors and associates. Those errors which corresponded identically with associates increased a very little from the first to the last of the experiment. The errors which corresponded to associates in form only decreased, while the errors which corresponded in size only to the associates showed a statistically significant increase as the experiment progressed. The

errors which had no relationship with the associates ranged from 26 % in the first period, to 43 % in the second, and back to 23 % in the third. No explanation can be offered for these radical shifts.

Supposedly association is the necessary antecedent of the development of errors. However, in neither this nor in the first experiment was there any very close agreement between the errors and the associations to a given figure. This fact might lead either to the conclusion that formal association is not necessary for the development of errors, or that the association-test technique is not adequate as a measure of association. At best these data alone would not permit a highly accurate prediction of the specific effects nor of the extent of associative interference within this linguistic system.

ANALYSIS OF VARIANT RESPONSES :

In Tables 11 and 12 are presented the variant responses given in naming each of the figures. Table 11 gives the variants occurring during the first period ; Table 12, the variants occurring after the first period was completed. The stimulus-figure, the variant response, the number of subjects giving each variant, and the total frequency of occurrence of each are given in the tables ; as in the similar ones of the first experiment. Whenever possible the name of the figure which most probably interfered with the correct name to produce the new form is also given. In some cases the suggested cause is not a specific name, but a whole category, as for example, *pof* is listed as the most probable cause of the alteration of *vuskof* to *vuspoj*. In this case *pof* was the regular name of that form and *kof* a deviate from it. The change to *vuspoj* was probably influenced not by any specific name ending in *pof*, but by all of the rest of the *pof* category. In explaining the variants *vusseb* and *nasseb* the whole system is invoked. In making up the language these two names had arbitrarily had their syllable order reversed. As the remaining 14 names were of the syllable order *size-form*, it is probable that all were instrumental in producing this change in *sebvus* and *sebnas* to the syllable order characteristic of the remainder of the system. In a few cases words are underlined in the final column of the table. These names were not properly a part of the system, but were variants made by the subjects which then seemed to influence other members of the system. For example *vusseb* was produced by changing the syllable order of *sebvus*. This new form in turn influenced *nasseb*, which was also formed by changing the syllable order, to produce the new variant *nusseb*.

TABLE II

VARIANT RESPONSES GIVEN IN THE FIRST PERIOD OF EXPERIMENT II

Correct Response	Variant Response	No. of Subjects	Freq.	Most Probable Interfering Cause
<i>vuskof</i>	<i>vusɔof</i>	5	11	-ɔof
	<i>vusɔof</i>	1	1	<i>vusgrč</i>
	<i>vaskof</i>	1	1	<i>nasɔof</i>
	<i>vuvɔɔof</i>	1	1	
<i>nasɔof</i>	<i>nesɔof</i>	4	7	<i>neslud</i>
	<i>neskof</i>	1	2	<i>neslud, vuskof</i>
	<i>naskof</i>	1	2	<i>vuskof</i>
	<i>naθɔof</i>	1	1	
	<i>napɔof</i>	1	1	
<i>zɪŋɔof</i>	<i>vasɔof</i>	1	1	<i>vuskof</i>
	<i>zɪgɔof</i>	7	42	<i>zɪg-</i>
	<i>zɪŋkof</i>	2	6	<i>vuskof</i>
	<i>zɪgkof</i>	2	3	<i>zɪg-, vuskof</i>
	<i>zɪŋɔuf</i>	2	2	-lud
	<i>sɪgɔof</i>	1	1	<i>zɪg-</i>
	<i>zɪglɔf</i>	1	1	<i>zɪglɔd</i>
	<i>zɪgtɔf</i>	1	1	<i>zɪglɔd</i>
	<i>zɪŋtɔf</i>	1	1	<i>zɪgrč</i>
<i>tavɔof</i>	<i>tavɔof</i>	2	8	<i>tavlud</i>
	<i>pavɔof</i>	2	4	<i>tavlud</i>
	<i>tavɔf</i>	2	2	<i>zɪglɔd</i>
	<i>taɔɔof</i>	1	2	
	<i>pavlav</i>	1	1	
	<i>taɔof</i>	1	1	
	<i>paɔɔof</i>	1	1	
	<i>tavɔč</i>	1	1	<i>tavgrč</i>
	<i>sɛbvus</i>	<i>vussɛb</i>	5	13
<i>sɛdvus</i>		1	2	
<i>fɛbvus</i>		1	1	
<i>zɛbvuvus</i>		1	1	
<i>sɛzvus</i>		1	1	
<i>buvusɛb</i>		1	1	
<i>sɛbnas</i>	<i>nassɛb</i>	7	26	The entire system
	<i>nassɛb</i>	1	1	» » »
	<i>nasɛb</i>	1	1	» » »
	<i>nussɛb</i>	1	1	» » »

and *vussɛb*

Correct Response	Variant Response	No. of Subjects	Freq.	Most Probable Interfering Cause
	<i>zɛbnas</i>	1	1	
<i>zɪgseɓ</i>	<i>zɪnseɓ</i>	6	17	<i>zɪnpoɓ</i>
	<i>zɪgseɗ</i>	1	1	
	<i>zɪgseɓ</i>	1	1	
<i>tauseɓ</i>	<i>tauzɛɓ</i>	3	8	
	<i>tafsɛɓ</i>	1	1	<i>-poɓ</i>
	<i>taused</i>	1	1	
<i>vusgrɛ</i>	<i>vuwusgrɛ</i>	1	5	
	<i>vɔsgrɛ</i>	1	3	<i>zɪglɔɗ</i>
	<i>vosgrɛ</i>	1	1	<i>-poɓ</i>
	<i>vasgrɛ</i>	1	1	<i>nasgrɛ</i>
	<i>nusgrɛ</i>	1	1	<i>nasgrɛ</i>
	<i>huusgrɛ</i>	1	1	
<i>nasgrɛ</i>	<i>nesgrɛ</i>	4	26	<i>neslud</i>
	<i>nusgrɛ</i>	2	3	<i>vusgrɛ</i>
	<i>fasgrɛ</i>	1	1	<i>vusgrɛ</i>
	<i>nogrts</i>	1	1	<i>-poɓ</i>
	<i>nosgrɛ</i>	1	1	<i>-poɓ</i>
	<i>nadsgrɛ</i>	1	1	
<i>zɪggrɛ</i>	<i>zɪngrɛ</i>	7	14	<i>zɪnpoɓ</i>
	<i>sɪgrɛ</i>	1	2	
	<i>sɪggrɛ</i>	1	1	
	<i>zɪɗgrɛ</i>	1	1	<i>-lud</i>
	<i>zɪgtɔɓ</i>	1	1	<i>zɪglɔɗ</i>
	<i>zɪntɔɓ</i>	1	1	<i>zɪnpoɓ, zɪglɔɗ</i>
	<i>zɪgkrɛ</i>	1	1	<i>vuskof</i>
	<i>sɪngrɛ</i>	1	1	<i>zɪnpoɓ</i>
	<i>zɪngr</i>	1	1	<i>zɪnpoɓ</i>
<i>taugrɛ</i>	<i>pavgrɛ</i>	1	2	<i>-poɓ</i>
	<i>tafgrɛ</i>	1	1	<i>-poɓ</i>
	<i>pavgrts</i>	1	1	<i>-poɓ</i>
	<i>tasgrɛ</i>	1	1	<i>nasgrɛ</i>
	<i>tavgɔ</i>	1	1	<i>zɪglɔɗ</i>
<i>vuslud</i>	<i>lusguw</i>	1	1	<i>vusgrɛ</i>
	<i>vaslud</i>	1	1	<i>naslud</i>
	<i>nuslud</i>	1	1	<i>neslud</i>
<i>neslud</i>	<i>naslud</i>	6	30	<i>nas-</i>
	<i>nasluw</i>	1	1	<i>nas-</i>

Correct Response	Variant Response	No. of Subjects	Freq.	Most Probable Interfering Cause
	<i>naslus</i>	1	1	<i>nas-</i>
	<i>nasgud</i>	1	1	<i>nasgrč</i>
	<i>nuslud</i>	1	1	<i>vuslud</i>
	<i>nislīg</i>	1	1	<i>zīg-</i>
	<i>nusgud</i>	1	1	<i>vusgrč</i>
	<i>nrsgud</i>	1	1	<i>vusgrč</i>
<i>zīgłd</i>	<i>zīgłud</i>	4	17	<i>-lud</i>
	<i>zīηłd</i>	4	11	<i>zīηpof</i>
	<i>zīηłud</i>	3	4	<i>zīηpof, -lud</i>
	<i>zīgłf</i>	1	2	<i>-pof</i>
	<i>zεblud</i>	2	2	<i>-sεb</i>
	<i>zīηłid</i>	1	1	<i>zīηpof</i>
	<i>zīηpud</i>	1	1	<i>zīηpof, -lud</i>
	<i>zīgñub</i>	1	1	<i>-lud</i>
	<i>zεblđ</i>	1	1	<i>-sεb</i>
	<i>zīηhuf</i>	1	1	<i>zīηpof</i>
	<i>zīgłblud</i>	1	1	<i>-lud</i>
<i>tavłud</i>	<i>tavłđ</i>	2	5	<i>zīgłđ</i>
	<i>tævłđ</i>	1	3	<i>zīgłđ</i>
	<i>tavłuv</i>	1	3	
	<i>pavłuv</i>	1	2	<i>-pof</i>
	<i>tavłuf</i>	1	1	<i>tavpof</i>
	<i>savłud</i>	1	1	<i><u>naslud</u></i>
	<i>tavlav</i>	1	1	<i>tav</i>

In general, even in the variants occurring during the first period, in which responses were very unstable and apt to deviate rather widely from the correct form, there were marked tendencies for the variants to be of the type which, if they became permanent, would introduce greater regularity into the system. The variants to the figure *zīgłđ* may be used as an illustration. The most common variant was *zīgłud*. Since *lud* was the general form-name of the category of which *zīgłđ* was a member, a change to *zīgłud* would have made that form-category a perfectly regular one. The second most common variant was *zīηłđ*. This change again was in the direction of increased regularity. True, *zīg* was the general name of the size category of which the figure was a member, but the name *zīη* showed marked

tendencies to replace it. And if it had done so, that size-category would have become perfectly systematic. The question of the correct name of the category was only a relative one. Three of the figures were given names beginning with ζIg ; the fourth one, $\zeta I\eta$. Either of these might replace the other and become the perfectly regular name of that size. The fact that in naming the figures originally the syllable ζIg was used three times and the syllable $\zeta I\eta$ only once was an arbitrary matter. Either might, for any subject, become the correct and characteristic name of that size-category. And there was evidence of tendencies to make both of them the regular name. $\zeta Ig\phi\phi$ was substituted for $\zeta I\eta\phi\phi$ over 40 times. This was a change in the direction of increased regularity. But an approximately equal number of times the other names which began with ζIg were changed to $\zeta I\eta$. And this too was a change in the direction of increased regularity. If the experiment had gone on long enough it is entirely possible that one of them would have become the only name applied to that size. The other would, for those subjects who made the change, have been completely lost. It is certain that the variants given during the succeeding portion of the experiment showed an increasing tendency for both of these changes to occur.

In describing the changes introduced into this language by the subjects as reversions to its previously systematic form, nothing of explanation is to be implied. The term is used in a purely descriptive sense. The fact that the language was simplified and regularized by the subjects is important. The fact that this new and simplified language sometimes approximated the language as it existed prior to the arbitrary introduction of alterations in it seems to be purely adventitious. Probably the extent to which the language 'reverted' to its unaltered form was a function of the amount of alteration. What the alterations were, or what the language was before it was altered, the subjects never knew. The fact that the subjects did make changes which systematized the language was independent of the fact that these changes, unknown to the subjects, made the language revert to an earlier form. In order to avoid any possible misunderstanding, the term reversion, even in its descriptive sense, has been avoided whenever possible.

Taking only those names which had arbitrarily been altered from their systematic form, considerably greater tendencies toward analogic change were found in the first syllable of a word than in the second. Of the four names which had one speech sound altered, two had the

change made in the first, and two in the second syllable. During the first period the two which were altered in the first syllable had a total of 94 variants of which 81 were in the direction of increased regularity. The two names which had alterations in the second syllable had a total of 57 variants of which 36 increased the systematic nature of the language. In general the tendency toward analogic change was about twice as strong for sounds occurring in the first syllable as for sounds in the second.

A total of 71 variants were made to the two names in which a consonant had been altered. Of these, 60 consisted of substitutions of the consonant found in the remainder of the category. Seventy-nine variants were given to the two figures in which a vowel had been altered, in 56 of which the change made the syllable conform to that of the remainder of the category. There is here no evidence as to the relative strength of vowels and consonants in either resisting or following the course of analogic change.

Two of the six alterations in the form of the names consisted in reversing the syllable-order from that of the remainder of the system. A total of 49 variants were made to these two figures, of which 43 consisted of a change to the normal syllable-order. The syllable-order size-form so far outweighed that of form-size (14 to 2) that perhaps very little tendency for the order form-size to become characteristic was to have been expected. Certainly very little was found. There were only two variants which could possibly have been interpreted as showing a change to the syllable order form-size. And these may or may not have been that. Both were combinations which were given once each, but which did in the first syllable contain some, but not all, of the sounds which should have been in the last.

In Table 12, data similar to those of Table 11 are given except that the variants were given after the completion of the first period. In general the type of variants of such later occurrence tended merely to confirm the tendencies manifested in the earlier part of the experiment. In every case where that was possible the most common variant to a given figure was of such a nature as to increase the regularity of the system. There was, thus, a tendency for all six altered names to be changed so as to increase the systematic nature of the language. There were also tendencies for some of these altered names to draw the remainder of the system to them. As pointed out before, this too would have served to increase the regularity of the linguistic system.

The errors occurring during the early stages of the experiment gave

TABLE 12

VARIANT RESPONSES AFTER PERIOD I IN EXPERIMENT II

Correct Response	Variant Response	No. of Subjects	Freq.	Most Probable Interfering Cause
<i>vuskof</i>	<i>vuspoj</i>	4	19	-poj
	<i>vaskof</i>	1	3	<i>naspoj</i>
	<i>vaspoj</i>	1	2	<i>naspoj</i>
	<i>vusnes</i>	1	1	<i>neslud</i>
	<i>vuuslof</i>	1	1	<i>vuslud</i>
	<i>vuuspoj</i>	1	1	-poj
	<i>vusgof</i>	1	1	<i>vusgrč</i>
<i>naspoj</i>	<i>nespoj</i>	6	20	<i>neslud</i>
	<i>naskof</i>	2	6	<i>vuskof</i>
	<i>vaspoj</i>	1	1	<i>vuskof</i>
	<i>baskof</i>	1	1	<i>vuskof</i>
	<i>nesgof</i>	1	1	<i>neslud, nasgrč</i>
	<i>nasgof</i>	1	1	<i>vuskof</i>
<i>zɪŋpoj</i>	<i>zɪgpoj</i>	7	66	<i>zɪg-</i>
	<i>zɪŋkof</i>	2	9	<i>vuskof</i>
	<i>zɪgkof</i>	2	6	<i>zɪg-, vuskof</i>
	<i>zɪŋkof</i>	2	2	<i>vuskof</i>
	<i>sɪŋpoj</i>	1	1	
	<i>sɪgkof</i>	1	1	<i>zɪg-, vuskof</i>
	<i>zɪggof</i>	1	1	<i>zɪggřč</i>
<i>taupof</i>	<i>taugof</i>	1	9	<i>taugřč</i>
	<i>taukof</i>	4	4	<i>vuskof</i>
	<i>tauhof</i>	1	2	
	<i>taugoč</i>	1	2	<i>taugřč</i>
	<i>taulof</i>	1	1	<i>taulud</i>
	<i>taupoč</i>	1	1	<i>taugřč</i>
	<i>sebvus</i>	<i>vusseb</i>	7	30
	<i>sedvus</i>	1	2	
	<i>sezvuus</i>	1	1	
<i>sebnas</i>	<i>nasseb</i>	7	47	The entire system
	<i>nesseb</i>	4	6	The entire system, <i>neslud</i>
	<i>sebnes</i>	1	1	<i>neslud</i>
	<i>sebnus</i>	1	1	<i>sebvus</i>
	<i>sebnud</i>	1	1	<i>sebvus</i>

Correct Response	Variant Response	No. of Subjects	Freq.	Most Probable Interfering Cause	
	<i>sednas</i>	1	1		
<i>zɪgseb</i>	<i>zɪŋseb</i>	4	10	<i>zɪŋpof</i>	
	<i>zɪgseb</i>	3	4		
	<i>ðɪŋseb</i>	1	1	<i>zɪŋpof</i>	
<i>tavseb</i>	<i>tavzeb</i>	1	1		
<i>vusgrċ</i>	<i>vasgrċ</i>	1	6	<i>nasgrċ</i>	
	<i>vɔsgrċ</i>	1	4	<i>zɪglɔd</i>	
	<i>vusgrɔf</i>	1	1	<i>zɪglɔd</i> , <i>vuskɔj</i>	
<i>nasgrċ</i>	<i>nesgrċ</i>	7	48	<i>neslud</i>	
	<i>vasgrċ</i>	1	2	<i>vusgrċ</i>	
	<i>nasgrċ</i>	1	1	<u><i>nesgrċ</i></u> , <i>-seb</i>	
	<i>næsgrċ</i>	1	1		
	<i>nasgrɔf</i>	1	1		
	<i>zɪggrċ</i>	<i>zɪŋgrċ</i>	6	22	<i>zɪŋpof</i>
		<i>sɪggrċ</i>	1	4	
<i>sɪŋgrċ</i>		1	1	<i>zɪŋpof</i>	
<i>tavgrċ</i>	<i>tævgrċ</i>	1	1		
<i>vuslud</i>	<i>vuslɔd</i>	2	2	<i>zɪglɔd</i>	
	<i>vuvslud</i>	1	1		
<i>neslud</i>	<i>naslud</i>	6	49	<i>nas-</i>	
	<i>naslɔd</i>	1	1	<i>nas-</i> , <i>zɪglɔd</i>	
	<i>neslud</i>	1	1	<i>sɛbnas</i>	
	<i>naislud</i>	1	1		
	<i>neslɔd</i>	1	1	<i>zɪglɔd</i>	
<i>zɪglɔd</i>	<i>zɪglud</i>	4	26	<i>-lud</i>	
	<i>zɪŋlɔd</i>	5	15	<i>zɪŋpof</i>	
	<i>zɪŋlud</i>	2	5	<i>zɪŋpof</i> , <i>-lud</i>	
	<i>sɪglɔd</i>	2	3		
	<i>zɪŋlɔf</i>	1	1	<i>zɪŋpof</i>	
	<i>zɪŋlɔd</i>	1	1	<i>zɪŋpof</i>	
<i>tavlud</i>	<i>tavlɔd</i>	2	3	<i>zɪglɔd</i>	
	<i>tævɔd</i>	1	2	<i>zɪglɔd</i>	
	<i>taflud</i>	1	1	<i>-pof</i>	

a good prediction of the type of changes made later. Again many more changes were found in the first syllable than in the second. The two names which had alterations made in the first syllable showed a total of 139 variants, 124 of which increased the regularity of the

language. The two names altered in the second syllable showed a total of 79 variants, of which 53 were in the direction of increased regularity. There was then a very clear tendency for changes to occur more frequently in the first syllable than in the last.

Again the difference between vowels and consonants was not large. One hundred and four variants were given to the two words in which a vowel had been altered. Of these, 81 consisted of the substitution of the vowel characteristic of that category. One hundred and fourteen variants were given to the two names in which a consonant had been altered, of which 96 were substitutions of the characteristic consonant. The difference between the two is not statistically significant. Again nothing can be said relative to the susceptibility of vowels and consonants to analogic change, except that this experiment agrees with the historical information that both vowels and consonants take part in analogic change to about the same extent.

On the two names in which the syllable order had been reversed there was a total of 91 variants of which 83 consisted of changes to the normal syllable-order. There were no examples of any of the other names being altered to conform to this unusual syllable-order.

Not the most common cause of all errors, but the most frequent cause of analogic changes, was the interference of another figure of the same size but of other form than the stimulus-figure. Only in this respect was there a lack of close agreement between the relative frequencies of the two kinds of error, substitutions and actual changes. In other respects the amount and location of substitution predicted fairly well the subsequent development of analogic change. When the fact that figures of the same size as the stimulus-figure were the most frequent cause of analogic change is compared with the fact that the associations to a given name were predominantly drawn from the other figures of the same size, some evidence is seen for the statement that analogic change is a product of the interference of associated words. Even though the most frequent associations did not consistently lead to the most errors, they did lead to the most frequent actual changes.

RETENTION OF THE LANGUAGE :

Thirty-eight days after the completion of the experiment all subjects were recalled for one day and given six R series to test their retention of the language, and to determine what effect such a period of no practice would have on the type of errors that they would make.

In general the retention was very good. Out of 778 presentations of figures the group as a whole made 123 errors and failed to give any name 26 times. Thus in more than 80% of the cases the figures were named correctly. Of the 123 errors, 62 were made on the six irregular or unsystematically named figures and 61 on the ten perfectly regular ones. Of the omissions, 12 were made on the six irregular, and 14 on the ten regular figures. Seventy-five of the errors consisted of giving the name of some other figure. Thirty-two errors consisted of altering the six irregular names to make them conform to the systematic arrangement, and seven altered some one of the ten systematic names to make them conform to the pattern set by one of the irregular ones. The remaining nine errors consisted of part names, or mixtures unclassifiable under any of the above headings.

In summary then, five and one half weeks after it was last used, the language was employed properly 80% of the time. The 20% of errors consisted primarily of substitutions of names of other figures. The other errors were of the same types that had been consistently made during the experiment, that is, they were changes in the direction of increased systematization.

SUMMARY OF EXPERIMENT II:

The language used in this experiment was basically a systematic one with specific names for each of the form and size categories. The names of six of the figures were, however, altered from their systematic form. Two of these changes consisted of a vowel change and two of a consonant change. Two of the changes were a reversal of syllable-order. One complete form-category and one complete size-category were left unaltered. The six changes were distributed evenly among the three remaining size-categories and the three remaining form-categories.

With such a linguistic system, learning was much slower than that found in the first experiment. The point at which all figures were named correctly was reached only after more than twice as much practice as was necessary for the systematic language of Experiment I. The learning curve was still, however, an S-shaped one, but with a low inflection point.

A much greater tendency toward analogic change was demonstrated in this language than in the systematic one of the first experiment. This was evident not only during the learning period, but became increasingly so as practice continued. A comparison of the types of

errors made on the two languages showed that in the highly systematic one any tendencies toward associative interference were manifested by the misuse of names, giving the name of an associated figure. In the less systematic language the same trends were expressed in the form of variants or mixtures resulting from a combination of the correct and the associated names.

The changes made were predominantly of two types. The most common type of change was that which would serve to make the six altered names conform to the systematic arrangement of the remainder of the language. The next most common type of change was that which would serve to make the remaining members of the language conform to the pattern set by the altered names. Either of these types of change, if allowed to progress far enough, would have made the language into a perfectly systematic one.

There were approximately twice as many examples of analogic change occurring in the first syllable as in the second. This was true whether the altered sound was a vowel or a consonant.

At least with this language there were only insignificant differences in the tendency toward analogic change as shown in vowels and consonants.

While the two names in which the syllable order had been reversed were continually re-reversed, thus again making them comply with the normal syllable-order, there was no apparent tendency to make the syllable order of the 14 remaining names conform to that of the two which had been altered.

The types of change which occurred early in the learning process were highly predictive of the types which occurred after considerable practice.

There is further substantiation of the explanation of analogy as being due to associative interference in that the trends of association and of analogic change were quite parallel throughout the experiment, both as to frequency and as to fixity, and in relation to the category from which the associates and the errors to a given word were drawn.

V. CONCLUSIONS

Two types of artificial linguistic structures were taught to two separate groups. Records of the rate of learning and of the errors made in using the languages both during and after the learning period suggest the following points :

1. The systematic language was learned in approximately half the time necessary for learning the unsystematic language.

2. In both languages the associations followed the categories of size more closely than those of form.

3. The most common type of error, including both substitutions and actual changes, in both languages consisted of the interference of the name of the figures of the same form and of adjacent sizes. The second most frequent type of error consisted of the interference of names from the same size category.

4. While the associations and the general distribution of errors were very similar in the two languages, the type of error differed. In the systematic language any tendencies toward associative interference were manifested by the substitution of the associated name. In the unsystematic language such associative interference was much more apt to be expressed in actual changes or mixtures of the names. This leads to the conclusion that while association may be a necessary antecedent of analogic change, it is not a sufficient cause. Whether or not a given association will result in actual change seems to be a function also of the nature of the names involved and of their systematic relation to the structure of the language.

5. The analogic changes which developed in the unsystematic language were predominantly of the type which reduced the language to a more systematic basis.

6. In both languages the errors made during the learning period were highly predictive of later errors. In other words those figures which at first were most subject to confusion and were most difficult to learn, later were most apt to have their names altered by the process of associative interference.

APPENDIX

The values of the phonetic symbols used in this treatise are expressed by the pronunciation of the italicized letters in the following words :

<i>p</i>	<i>pet</i>	<i>m</i>	<i>man</i>
<i>b</i>	<i>bet</i>	<i>n</i>	<i>not</i>
<i>t</i>	<i>tip</i>	<i>ŋ</i>	<i>sing</i>
<i>d</i>	<i>dip</i>	<i>r</i>	<i>urn</i>
<i>k</i>	<i>kid</i>	<i>i</i>	<i>sleep</i>
<i>g</i>	<i>get</i>	<i>ɪ</i>	<i>slip</i>
<i>ç</i>	<i>choke</i>	<i>e</i>	<i>fate</i>
<i>f</i>	<i>fat</i>	<i>ɛ</i>	<i>pet</i>
<i>v</i>	<i>vat</i>	<i>æ</i>	<i>hat</i>
<i>θ</i>	<i>think</i>	<i>a</i>	<i>father</i>
<i>ð</i>	<i>this</i>	<i>ɔ</i>	<i>all</i>
<i>s</i>	<i>son</i>	<i>o</i>	<i>coat</i>
<i>ʃ</i>	<i>shun</i>	<i>u</i>	<i>good</i>
<i>ʒ</i>	<i>zeal</i>	<i>uw</i>	<i>moon</i>
<i>ʒ̄</i>	<i>azure</i>	<i>ə</i>	<i>the</i>
<i>h</i>	<i>hat</i>	<i>ɪ</i>	<i>but</i>
<i>l</i>	<i>lap</i>		