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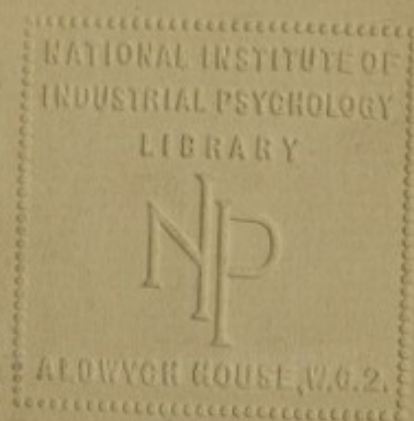
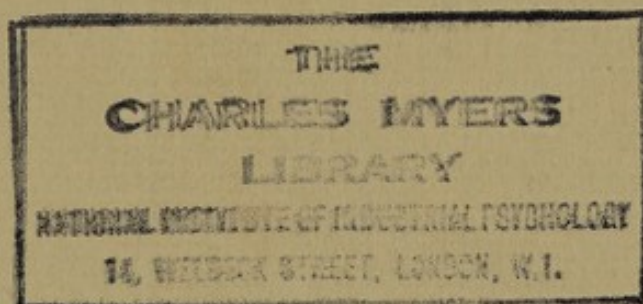


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THE DISTRIBUTION AND FUNCTIONS OF MENTAL IMAGERY

BY

George Herbert Betts, Ph.D.

TEACHERS COLLEGE, COLUMBIA UNIVERSITY
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INTRODUCTORY STATEMENT

The pioneer work in experimentation in mental imagery was begun by Fechner in 1860 in his "Psychophysik." Galton followed with his epoch-making studies twenty years later. The field has proved a fascinating one, and many investigations have followed the work of Galton. Few of these studies have approached Galton's in either scope or thoroughness, and probably none has excelled it. A majority of students of the field have followed Galton's lead and investigated chiefly *voluntary imagery*, or the ability to call up certain specified images at will. Comparatively little attention has been given to *spontaneous imagery*, or the normal functioning of imagery in the mental processes. The failure to recognize this second distinct, even if related, problem has resulted in a certain haziness in many of the discussions, and is chiefly responsible for the large amount of error relating to the functions of imagery which has crept into pedagogical writings and practise.

This study will attempt to examine both of the above fields, and its problems will therefore divide themselves into two distinct groups: (1) those which grow out of the power to evoke images voluntarily; and (2) those which grow out of the spontaneous use of imagery in thought.

THE QUESTION OF METHOD

The essence of scientific accuracy lies in the possibility of repetition and verification. So far as the determination of facts is concerned, scientific method concerns itself largely with these two factors. Since mental processes, and particularly mental imagery, can never be precisely repeated, the question of method becomes a crucial one in an investigation of this subject.

The investigator may take his choice of two plans. He may experiment with a small group of trained observers, usually the advanced students in the department of psychology; or he may make use of a larger group possessing less skill in observation, for instance the undergraduate classes in psychology. Each method has its advantages, and both should be used. The first method possesses great individual accuracy, but the results for

the group may have a high degree of unreliability because of a small number available for the tests. The latter method has less individual accuracy, but avoids the unreliability which comes from small numbers. No results can be more accurate than the data which go into them; on the other hand, results may be less accurate than full data will give, if the results are generalized from a small number of cases.

If a group of subjects has had a reasonable amount of training in introspection; if they thoroughly understand the problem on which they are working; if they are interested and serious; if the experiment is free from suggestions tending to bias judgment;—then results of considerable scientific value may be expected. That material from such a source is not to be despised is shown by the high degree of similarity between the results obtained from the three groups of students in the following tests, and the group of psychologists. Binet has shown in a recent admirable study¹ that valuable results can be obtained from even children, if they are carefully instructed and if their attitude toward the work is what it ought to be.

After the fitness of the subjects employed in the tests, the next consideration is that of the questions used. Galton's questionnaire set a high standard, and possessed many admirable features, especially as related to visual imagery. But it left something to be desired in definiteness and accuracy even in this field, and slighted all the other types of images. The Titchener questionnaire² permits loose and general answers, and is far below this author's usual high demands for scientific accuracy. Questions as to whether one possesses accurate mental pictures of places he has visited; whether, when he thinks of a piano, he calls up a visual image of it, or an auditory image of its tone; whether one recalls music readily; whether one enjoys reading descriptive novels; whether one has more of visual or of auditory imagery; whether one can tell how many windows there are in the front of a familiar building; whether one can think "bubble" without closing the lips,—these and many other questions like them which have been used by various investigators are not calculated to give results which would be considered safe as a basis for generalization in other domains of science.

¹*L'Etude Experimentale de L'Intelligence.*

²*Experimental Psychology, Students' Manual*, p. 198.

Two alternatives present themselves in arranging a set of questions on imagery. One may (1) set a mental problem for his subjects, and require that they describe in their own words the imagery present, both as to its nature and as to its degree of clearness and vividness. Or, (2) he may set the mental problem, and then ask a series of questions concerning the imagery present, himself suggesting the alternatives as to its nature, clearness and vividness, etc.

The former method has the advantage of allowing the subject greater freedom to suggest his own interpretation of his imagery. Often also an incidental statement by the relatively naïve subject may reveal to the investigator even more than does the formal description. But herein lurks a danger. One can never be sure that in informal description the subject is not following the line of the most obvious or striking details of his imagery, and omitting other lines which may be even more important, but which were overlooked in the stress of finding suitable description for the others. Again, the standpoint or bias of mind of the investigator is almost certain to color the interpretation of the answers, so that they may be made to tell a somewhat different story from that which the subject intended. Finally, the method of informal description does not lend itself well to the quantitative measurement of imagery in groups. The use of questions requiring categorical answers and the selection of definite alternatives, avoids these dangers. It also allows the investigator to control the direction of the subject's introspection so as to distribute it over all the more important phases of imagery. The chief defect in this method is the loss of the information which comes through the spontaneous replies of the subject. This is probably more than compensated for, however, by the gain in accuracy. If the latter method is supplemented by personal interviews, or by a written description by the subject following his categorical replies and adding points not brought out in the questions, it is probably the best that can be employed with the relatively untrained subject.

In any case, the only safe evidence of the presence of imagery in any mental process is direct introspective evidence. The image is easily enough discerned when present. If no image is discernible in a given mental content, the only safe conclusion is that no image exists in the consciousness of that moment.

In other words, an image which is "implicitly present," but not discoverable through introspection, is not present at all. To say that the image is present but below the threshold of consciousness is but to beg the question. Any other conclusion must rest on *a priori* grounds. Nor is the use of words which might be construed as indicative of the presence of imagery to be accepted as proof that imagery really forms a part of the mental content. Various writers, notably Lay,¹ have used this method. Lay read aloud to 100 subjects a paragraph calculated to suggest visual and auditory images. He then asked his subjects to write down in their own words all they could remember of it. From the words they used Lay computed the percentage of visual and auditory images employed by the subjects in their interpretation and recall. But language stands as a symbol not for objects and images alone, but for meanings as well; and meaning as well as image may form mental content. Two psychologists, friends of the writer, assert that they have practically no visual imagery, yet they use much the same language as the best visualizers of us. Lay also made a study of the consonants used by Browning, Shelley, Tennyson and others, and inferred therefrom their types of mental imagery. But there are many other reasons for choosing certain words than the types of imagery they evoke. Many persons sadly deficient in sensory images are using the very words whose presence in Tennyson leads Lay to conclude that Tennyson "seems to have paid particular attention to the mental imagery of the five senses that his poems would excite." The writer interviewed a literary friend one of whose descriptions contains as large a percentage of words suggesting visual and auditory imagery as any of Tennyson's. Yet this friend avers that he is deficient in both types of images, and a somewhat through test given him confirms this judgment.

The following general principles underlying methods of investigating mental imagery seem clear. Spontaneous description of imagery should be used chiefly to supplement answers to definite questions requiring categorical replies. The questions should be so constructed as to allow the subject to discriminate among a reasonable number of alternatives as to the nature and clearness and vividness of the images. Subjects reasonably familiar with the elements of psychology and having fair training in introspec-

¹Mental Imagery, p. 6.

tion can supply valuable material if the tests are well arranged and carefully carried out. The only safe evidence of the presence of imagery as a part of mental content is its discovery through immediate introspection.

One further fact requires mention. This study concerns primarily *non-verbal* imagery. Inner speech, which may be imagery, or actual movements and their consequences for sensation, or a mixture of the two, is not counted as imagery in the study of spontaneous imagery and is not made a topic of investigation in the study of voluntarily evoked images. This may seem an unwise restriction, but it has great practical advantages. Also, inasmuch as many expert psychologists are unable to decide whether their inner speech consists of images or actual movements and sensations thereof, it seems inadvisable to treat inner speech by the methods which are satisfactory in the case of the more obvious images of things and of words as heard or seen.

SECTION I. IMAGES VOLUNTARILY EVOKED

Three general questions are discussed in this section: (1) the ability to summon before the mind images of the various types, and the degree of clearness and vividness of the images; (2) the correlation of the various types of images with each other; and (3) the correlation of ability in voluntary imagery with scholarly ability in general. The method employed in all the experiments was that of the questionnaire, supplemented in most cases by personal interviews.

The study included four different groups aggregating 143 persons. Two of these groups were junior and senior students in psychology classes at Cornell College. Another group consisted of extension students in the writer's classes in educational psychology at Teachers College, Columbia University. The remaining group was made up of professors and other trained students in psychology at Columbia University and elsewhere. All four of the groups contributed data for the study of the first two questions. The data for the study of the correlation between ability in imagery and ability in school studies came from the two classes at Cornell College. The discussion will describe the experiments with each group separately, and then deduce certain general conclusions from the whole.

EXPERIMENT I

This experiment was a study of the mental imagery of 46 Cornell College students, 31 women and 25 men, 41 of whom were seniors, and all of whom had had nearly one year of work four hours a week in psychology. About one-fourth of this work had been in the laboratory, and the class had answered and discussed Titchener's questions on imagery besides having read the chapters on imagination in the standard works on psychology. The questions employed in the experiment were those proposed by Galton supplemented by others suggested by Thorndike. The entire test covered about two laboratory periods. In addition to the written tests the writer interviewed the students individually, securing fuller and more explicit answers in many cases.

The test consisted of 65 questions, of which 24 related to visual images, 8 to auditory, 8 to cutaneous, 3 to kinaesthetic, 6 to gustatory, 8 to olfactory, and 8 to miscellaneous and organic images. Five degrees of clearness and vividness were used: *very clear and vivid*, *good*, *fair*, *faint* and *none*. In making the computations arbitrarily numerical values were given as follows to the different degrees: Very clear and vivid=1, good=2, fair=3, faint=4, none=5. To find the imagery standing or score, each of these values was multiplied by the number of cases which came under it in the record of any individual. Thus, if Mary Jones distributed her 24 answers on visual imagery so as to credit herself with 3 *very vivid and clear*, 5 *good*, 9 *fair*, 6 *faint*, and 1 *none*, then her standing in visual imagery would be found by taking $(3 \times 1) + (5 \times 2) + (9 \times 3) + (6 \times 4) + (1 \times 5) = 71$; while, if John Smith's record was 5 *very vivid and clear*, 6 *good*, 10 *fair*, 2 *faint*, and 1 *none*, his standing would, by the same process, be 60, the lower number of course being the higher standing.

Of course this is an entirely arbitrary method of computation. Allowance must be made for individual differences in interpreting the precise values of the different degrees of clearness and vividness, both as concerns the highest degree, and the intervals or steps downward. The multiplication of each number standing for a degree of clearness and vividness by the number of images reported as belonging to this degree is wholly arbitrary. The effect is, to "weight" the tendency of relatively untrained observers to overrate themselves in any such test as this as to the clearness and vividness of their imagery. This tendency probably comes partly from failure to interpret fairly what the different degrees stand for, and partly from the half unconscious desire to make as good a record as possible. However this may be, certain it is that the overrating exists. In proof of this, it is almost always true that in a series of imagery tests the degree of clearness and vividness reported decreases as the series proceeds. Again, a discussion with students over their imagery as reported in the experiment commonly results in a desire to lower the degrees of clearness and vividness reported, no matter how careful the instructor may be not to influence the students by suggestion.

In comparing ability in imagery with ability in college studies in general, the latter ability was computed by counting the entire number of credits in percents earned during the college course. That is, a student who had earned 40 term credits averaging 85% each would have 3400 percents credit assigned him. When the test was given most of the students had about 40 term credits. Those who had under or over 40 have their credits reduced to a basis of 40, so that comparison may be possible.

While it is fully recognized that some discount must be made on the accuracy of material which depends for its validity upon the introspective report of relatively unskilled observers, yet every effort has been made in this experiment to secure careful and unbiased reports, and also an impartial interpretation of the replies. The material is therefore probably as trustworthy as the scope and time of such tests will permit.

Table I shows the entire distribution of ability in imagery and also the variability of the group as measured by the test described.

TABLE I. SCORES IN IMAGERY AND DEVIATIONS FROM THE CENTRAL TENDENCIES OF THE GROUP IN THE CASE OF 46 CORNELL COLLEGE STUDENTS.

Subjects	Scores in Imagery						Deviations from Averages							
	Vis.	Aud.	Cut.	Kin.	Gust.	Off.	Org.	Vis.	Aud.	Cut.	Kin.	Gust.	Off.	Org.
1.....	59	17	17	12	15	23	19	-1	0	0	3	1	1	0
2.....	55	17	9	7	10	11	8	-5	0	-8	-2	-4	-11	-11
3.....	57	19	20	12	18	20	16	-3	2	3	3	4	-2	-3
4.....	59	16	14	5	12	19	28	-1	-1	-3	-4	-2	-3	9
5.....	71	11	24	7	18	32	32	11	-6	7	-2	4	10	13
6.....	40	26	20	7	15	19	21	-20	9	3	-2	1	-2	2
7.....	71	26	16	12	8	16	20	11	9	-1	3	-5	-6	1
8.....	63	18	18	4	11	14	21	3	1	1	-5	-3	-8	2
9.....	54	15	10	6	7	21	13	-6	-2	-7	-3	-7	-1	-6
10.....	56	15	19	15	10	17	16	-4	-2	2	6	-4	-5	-3
11.....	62	20	17	9	9	26	14	2	3	0	0	-5	4	-5
12.....	37	8	8	6	6	14	16	-23	-9	-9	-3	-8	-8	-3
13.....	74	10	16	12	6	24	12	14	-7	-1	3	-8	2	-7
14.....	59	9	16	9	12	16	16	-1	-8	-1	0	-2	-6	-3
15.....	41	16	20	7	10	15	16	-19	-1	3	-2	-4	-7	-3
16.....	66	36	8	13	12	23	32	6	19	-9	4	-2	1	13
17.....	41	18	8	12	9	27	11	-19	1	-9	3	-5	5	-8
18.....	54	22	18	12	17	32	19	-6	5	1	3	3	10	0
19.....	59	12	14	3	20	21	17	-1	-5	-3	-6	6	-1	-2
20.....	63	15	25	12	26	18	15	3	-2	8	3	12	-4	-4
21.....	77	11	8	7	12	16	32	17	-6	-9	-2	-2	-6	13
22.....	50	16	21	12	15	21	16	-10	-1	4	3	1	-1	-3
23.....	55	16	20	12	12	25	26	-5	-1	3	3	-2	3	7
24.....	53	12	24	5	18	20	19	-7	-5	7	-4	4	-2	0
25.....	59	15	32	12	24	32	24	-1	-2	15	3	10	10	5

TABLE I. Continued.

Subjects	Scores in Imagery						Deviations from Averages							
	Vis.	Aud.	Cut.	Kin.	Gust.	Off.	Org.	Vis.	Aud.	Cut.	Kin.	Gust.	Off.	Org.
26.....	60	13	14	8	13	17	24	0	-4	-3	-1	-1	-5	5
27.....	65	18	22	7	27	32	24	5	1	5	-2	13	10	5
28.....	69	8	12	4	11	21	12	9	-9	-5	-5	-3	-1	-7
29.....	80	26	24	5	20	27	22	20	9	7	-4	6	5	3
30.....	89	28	27	10	22	29	27	29	11	10	1	8	7	8
31.....	71	17	21	10	6	15	24	11	0	4	1	-8	-7	5
32.....	60	21	18	5	15	20	16	0	4	1	-4	1	-2	-3
33.....	73	17	8	12	12	21	8	13	0	-9	3	-2	-1	-11
34.....	66	10	10	7	6	20	15	6	-7	-7	-2	-8	-2	-4
35.....	51	25	24	12	24	32	26	-9	8	7	3	10	10	7
36.....	61	23	16	9	18	32	20	1	6	-1	0	4	10	1
37.....	57	18	10	9	15	19	16	-3	1	-7	0	1	-3	-3
38.....	65	16	17	9	13	19	16	5	-1	0	0	-1	-3	-3
39.....	57	12	12	10	13	17	20	-3	-2	-5	1	-1	-5	1
40.....	49	15	22	9	18	32	27	-11	-2	5	0	4	10	8
41.....	61	12	21	12	16	20	16	1	-5	4	3	-8	-2	-3
42.....	45	9	22	5	10	19	22	-15	-8	5	-4	-4	-3	3
43.....	56	15	19	7	15	16	16	-4	-2	2	-2	1	-6	-3
44.....	61	12	12	3	19	31	24	1	-5	-5	-6	5	9	5
45.....	76	22	16	3	20	22	18	16	5	-1	-6	6	0	-1
46.....	38	24	16	12	12	24	16	-22	7	-1	3	-2	2	-3
Averages.....	60	17	17	9	14	22	19	8.3	4.4	4.6	2.7	4.5	4.8	4.7

The average deviations from the average were as follows:

Visual.....	8.32, or 13.87%
Auditory.....	4.43, or 26.06%
Cutaneous.....	4.59, or 27.00%
Kinaesthetic.....	2.74, or 30.44%
Gustatory.....	4.50, or 32.14%
Olfactory.....	4.82, or 22.00%
Organic.....	4.74, or 24.95%

The average percent of deviation from the average was 22.5. The 2793 individual answers received in the test were distributed as follows among the different degrees of vividness and clearness of the imagery:

1. Very clear and vivid.....	744, or 26%
3. Good.....	880, or 32%
3. Fair.....	667, or 24%
4. Faint.....	363, or 13%
5. None.....	139, or 5%

This means that more than one-fourth of all the images were reported as very clear and vivid, that almost three-fifths were reported as better than fair, that more than four-fifths were reported as fair or above, that less than one-fifth were reported as faint or worse, and that one-twentieth of the questions were reported as calling up no images. A more detailed statement of these facts is seen in Table II.

TABLE II. RELATIVE FREQUENCIES OF DIFFERENT DEGREES OF IMAGERY IN 46 CORNELL COLLEGE STUDENTS.

Scale	Vis.	Aud.	Cut.	Kin.	Gust.	Olf.	Org.
1. Very clear, etc...	19%	40%	32%	22%	29%	23%	37%
2. Good.....	42%	21%	31%	21%	31%	36%	1%
3. Fair.....	21%	26%	24%	11%	20%	36%	32%
4. Faint.....	8%	12%	13%	42%	17%	3%	29%
5. None.....	10%	1%	1%	4%	3%	2%	1%

Contrary to a rather common supposition, visual imagery does not appear to be superior in vividness and clearness to the other types. On the contrary, while the highest degree (No. 1) contains 26% of all the different classes of imagery taken together, only 19% of visual images are found in this class. This proportion is exceeded by all other classes. Taking the highest two degrees together, however, visual imagery slightly more than

holds its own, having 61% of its images in these two groups, while the proportion for the aggregate of all the types is 58%. Visual imagery is also at a disadvantage in the number of instances in which no image appeared, there being 10% of such cases as against 5% in the aggregate of all the types taken together. Auditory imagery leads in the proportion reported as of the highest degree of vividness and clearness, but if we group the highest two classes, it just equals the visual, and is slightly excelled by the cutaneous. Perhaps the most striking thing about the distribution is, after all, its similarity in the different types of imagery, indicating a rather high degree of resemblance.

The correlation of each type of imagery with every other type in the case of the 46 individuals is computed from Table I, using the average as the measure of central tendency, and the average deviation from the average as the measure of variability. Both the Pearson method and the percentage of unlike signed pairs were used to obtain the coefficient of correlation. Table III shows the correlations by each method and by the average of the two:

TABLE III. THE RELATIONS OF THE DEGREE OF IMAGERY OF ONE SORT TO THAT OF OTHER SORTS IN 46 CORNELL COLLEGE STUDENTS.

			r. Pearson	r. Per cent U. S.	r. Average
Visual	with auditory.....		.14	.47	.30
Visual	" cutaneous.....		.07	.00	.04
Visual	" kinaesthetic.....		.06	.20	.13
Visual	" gustatory.....		.18	— .07	.06
Visual	" olfactory.....		.11	.34	.23
Visual	" organic.....		.23	.40	.31
Auditory	" cutaneous.....		.11	.27	.19
Auditory	" kinaesthetic.....		.21	.58	.40
Auditory	" gustatory.....		.27	.52	.40
Auditory	" olfactory.....		.27	.67	.47
Auditory	" organic.....		.35	.46	.40
Cutaneous	" kinaesthetic.....		.14	.40	.27
Cutaneous	" gustatory.....		.54	.67	.61
Cutaneous	" olfactory.....		.37	.20	.28
Cutaneous	" organic.....		.29	.46	.37
Kinaesthetic	" gustatory.....		— .07	.13	.03
Kinaesthetic	" olfactory.....		.15	.63	.39
Kinaesthetic	" organic.....		— .06	.27	.10

TABLE III—Continued

		r. Pearson	r. Per cent U. S.	r. Average
Gustatory	" olfactory.....	.57	.52	.55
Gustatory	" organic.....	.35	.34	.35
Olfactory	" organic.....	.35	.63	.49
Averages.....		.23	.39	.30

In column 2 of Table IV is shown the aggregate score for each subject in the 7 types of imagery, and in column 3 the aggregate score for each subject in college studies. Columns 4 and 5 show the deviations from the average in each of the abilities, and columns 6 and 7 the ranks in ability in imagery and college studies respectively. Computing the correlation between ability in imagery and in college studies by the method of percentage of unlike signed pairs, the correlation is $+.27$; by the Pearson method it is $-.08$. The average of these two is $+.095$, which is probably closer to the truth than either figure alone. The average deviation from the average is in imagery, 18.6, and in college studies, 121.

TABLE IV. THE DEGREE OF IMAGERY IN GENERAL AND THE DEGREE OF SCHOLARSHIP FOR EACH OF THE 46 CORNELL COLLEGE STUDENTS.

Individual	Total score in imagery	Total score in College studies	Deviations from the averages of the 46 in imagery	Deviations from the averages of the 46 in scholarship	Rank in imagery	Rank in scholarship
1.....	162	3365	3	-84	29	33
2.....	177	3350	18	-99	2	35
3.....	162	3563	3	114	28	10
4.....	153	3382	-6	-66	23	32
5.....	195	3526	36	77	42	15
6.....	148	3514	-11	65	16	17
7.....	169	3536	10	86	35	14
8.....	149	3390	-10	-58	18	31
9.....	126	3292	-33	-156	4	40
10.....	148	3558	-11	108	15	11

TABLE IV—Continued

Individual	Total score in imagery	Total score in College studies	Deviations from the average of the 46 in imagery	Deviations from the averages of the 46 in scholarship	Rank in imagery	Rank in scholarship
11.....	177	3512	—2	63	27	22
12.....	95	3342	—64	—106	1	36
13.....	154	3538	—5	89	24	13
14.....	137	3661	—22	212	8	4
15.....	129	3513	—30	64	6	20
16.....	190	3510	30	60	40	23
17.....	126	3700	—33	248	3	1
18.....	174	3696	15	246	37	2
19.....	146	3361	—13	—87	14	34
20.....	174	3464	15	14	38	25
21.....	163	3565	4	116	31	9
22.....	151	3314	—8	—135	21	37
23.....	166	3408	7	—40	33	28
24.....	151	3200	—8	—249	20	43
25.....	198	3513	39	64	44	18
26.....	149	3462	—10	13	19	26
27.....	195	3497	36	48	43	24
28.....	137	3292	—22	—156	9	39
29.....	204	3210	45	—239	45	42
30.....	232	3140	73	—309	46	45
31.....	164	3632	5	143	32	5
32.....	155	3195	—4	—254	26	44
33.....	151	3514	—8	60	22	19
34.....	134	3400	—25	—49	7	29
35.....	194	3508	35	30	41	21
36.....	179	3575	20	126	39	8
37.....	144	3300	—15	—149	12	38
38.....	155	3246	—4	—202	25	41
39.....	141	3520	—18	70	10	16
40.....	172	3611	13	162	36	6
41.....	148	3462	—11	13	17	27
42.....	127	3587	—32	138	5	7
43.....	144	3400	—15	—49	13	30
44.....	162	3120	3	—329	30	46
45.....	167	3675	8	226	34	3
46.....	142	3540	—17	91	11	12
Averages..	159	3449	18.6	121		

It is interesting also to make a comparison based on the relative positions of individuals in the group as measured by rank.

Sum of college ranks for highest 10 in imagery.....	227
Sum of college ranks for second highest 10 in imagery.....	226
Sum of college ranks for lowest 10 in imagery.....	223
Sum of college ranks for second lowest 10 in imagery.....	176
Sum of college ranks for the highest 20 in imagery.....	453
Sum of college ranks for lowest 20 in imagery.....	399

So far as this test is concerned, therefore, there appears to be a very slight positive correlation between ability in imagery of the voluntary kind and ability in college studies. The evidence is not at all strong, however; for the Pearson method, which is the more accurate, gave a small negative correlation.

After giving the foregoing test and analyzing carefully the data received, the writer felt that scientific accuracy, particularly of the quantitative sort, required a new type of questionnaire, which should contain certain desiderata demanded above in the discussion upon methods of investigating imagery, but largely lacking in the one employed. With the principles already stated in mind, the following requisites were sought: (1) The questions should first of all leave as little room as possible for the answers to take the form of general description, but should rather present definite alternatives which can be definitely decided upon and answered. (2) In order that personal bias may be kept out, the answers should require a minimum of interpretation through the judgment of the investigator, being, on the other hand, so definite that only one interpretation is possible. (3) The questions should cover a reasonably wide range of experience in the fields investigated. (4) The only testimony received should be that of immediate introspection. (5) If any attempt is to be made to study the correlation of the various types of imagery, the questions should cover the fields with a somewhat similar scope, and should be as nearly as possible of the same degree of difficulty in the different fields. (6) The same standard or criterion of measurement for the degrees of clearness and vividness of the images should be employed for the entire test so far as is possible. (7) In order that the scope of the questions may be broad without requiring too much of the subject's time, the questions should admit of brief answers. (8) In order that the investigator's time may be saved, it is desirable that the answers should admit of quick summarization.

The questionnaire which follows was devised with the aim of meeting these demands. It covers visual, auditory, cutaneous,

kinaesthetic, gustatory, olfactory, and organic imagery. An aggregate of 150 questions are employed. Owing to the wide range of our visual experience, 40 questions were devoted to this field, while 20 questions were devoted to each of the other fields, except the organic, which has but 10 relating to it. The questions in each field were planned to cover as wide a scope as the number would permit; e. g., the questions on the visual field cover form, distance, direction, size, definition, brightness, and color. Those on the auditory field cover pitch, timbre, intensity, tones, noises, etc.

The standard, or *Key*, presents seven alternatives for discriminating the degrees of clearness and vividness of the images, 1 standing for the highest degree and 7 for the lowest. Each student was supplied with a copy of the questionnaire, and wrote his answers immediately after the questions. The *Key* was on a separate slip, and was kept constantly before the subject as he was working out the test. The answers consisted simply of the appropriate number decided upon from the *Key* and written after the question. The time required for writing the test was not above one laboratory period. The questionnaire as printed here is in condensed form, each question in the set used with the subjects in the test having had its own separate line or paragraph.

QUESTIONNAIRE UPON MENTAL IMAGERY

Directions

The 7 grades or degrees of clearness and vividness printed in the *Key* below will give you a standard by which to determine your answers to the questions of the tests. Read and re-read this slip until you fully understand what each grade or degree means. Keep this slip before you as you answer the questions, and refer to it constantly in deciding what your answer shall be. Please answer *all* the questions. Simply write the *number* (3, 5, 2, etc), which corresponds to the degree of clearness and vividness upon which you decide for your image. Do not hurry in answering the questions, and answer each strictly upon its own merits, that is, regardless of how you have answered any other one.

Key for Answering Questions

With respect to the mental picture suggested in each of the questions of the test, is the image which comes before your mind,

1. Perfectly clear and as vivid as the actual experience, *or*
2. Very clear and comparable in vividness to the actual experience, *or*

3. Moderately clear and vivid, *or*
4. Not clear or vivid but recognizable, *or*
5. Vague and dim, *or*
6. So vague and dim as to be hardly discernible, *or*
7. No image present at all, you only *knowing* that you are thinking of the object?

Visual Imagery

I. Think of your breakfast table as you sat down to it this morning, considering carefully the picture that rises before your mind's eye, and classify the images suggested by each of the following questions as indicated by the degrees of clearness and vividness specified in the Key:

A. As to *outline*, or *shape* and *size*.

1. The table as a whole seen at one glance. 2. The different dishes, e. g., cups, plates, etc. 3. The spoons, knives and forks. 4. Different articles of food, e. g., bread, muffins, cakes.

B. As to *colors*

5. Color of the table cloth and napkins. 6. Colors on the dishes. 7. Color and shine of the silver. 8. Colors of food, e. g., butter, toast, meat, fruit, etc.

II. Think of some relative or friend whom you frequently see, considering carefully the picture that rises before your mind's eye, and classify the images suggested by each of the following questions as indicated by the degrees of clearness and vividness specified in the Key:

A. As to *form*, *feature* etc.

9. The exact contour of face, head, shoulders, and body. 10. Characteristic poses of head, attitudes of body, etc. 11. The precise carriage, length of step, etc., in walking. 12. Cut of clothes, style of collar, tie, hat, shoes, etc.

B. As to *colors*

13. The exact complexion, both as to color and clearness of skin. 14. The different colors worn in some familiar costume. 15. The precise shade of color of the hair. 16. The precise shade of color of the eyes.

III. Recall some familiar landscape which you have recently seen, considering carefully the pictures which rise before your mind's eye; and classify the images suggested by each of the following questions as indicated by the degrees of clearness and vividness specified in the Key:

A. As to *distance*, *size*, etc.

17. The scene as a whole, actual size, distance, etc. 18. The location of particular objects, e. g., trees, hills, etc. 19. The size and shape of par-

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ticular trees, houses, etc. 20. The difference in sharpness of details between nearby or distant objects.

B. As to *light* and *color*

21. The brightness of the atmosphere. 22. The different shades and tints in the sky or clouds. 23. The exact colors of particular objects. 24. The different shades of green in grass, of grey in clouds.

IV. Read carefully the following: "Stealthily the assassin advanced to the bedside of his sleeping victim. He paused a moment irresolute, awed by the nobility of the white face showing so calm and peaceful in the soft light of the moon. But no! His uplifted dagger gleams, hesitates, descends! Just one convulsive start! Just a blotch of red working slowly out over the white of the bed and down to the floor! Just a murderer fleeing in the night! Just a cold form growing rigid in death!"

Now classify the images which rose before your mind's eye, as directed by the degrees of clearness and vividness specified in the Key:

A. As to *form* and *movement*

25. The form and movement of the assassin approaching the bed. 26. The position and attitude of the assassin before the blow. 27. The blow as it descends. 28. The movement of the victim when struck.

B. As to *colors* and *light*

29. The degree of brightness or light in the room. 30. The gleam of the dagger. 31. The color of the sleeper's face. 32. The red of the blood.

V. Think of seeing each of the following, considering carefully the picture which comes before your mind's eye; and classify the images suggested by each of the following questions as indicated by the degrees of clearness and vividness specified in the Key:

33. Sheet lightning low on the horizon. 34. The landscape revealed by a sharp flash of lightning on a dark night. 35. The sun as it is sinking below the horizon. 36. The forked tongues of a bright flash of lightning. 37. A fish darting through clear water. 38. The stars on a clear winter night. 39. The lights of a city through the darkness. 40. Your own name written or printed on a calling card.

Auditory Imagery

I. Think of Professor.....saying at the close of the lecture hour, "*The next lesson will be chapter V.*" Consider carefully the image of his voice which comes to your mind's ear, and classify the images suggested by each of the following questions as indicated by degrees of clearness and vividness specified in the Key:

1. The exact quality as different from all other voices. 2. The very articulation and pronunciation used. 3. The amount of force or loudness. 4. The precise pitch.

II. Recall some perfectly familiar tune, considering carefully the image of the sound which comes to your mind's ear, and classify the images suggested by each of the following questions as indicated by degrees of clearness and vividness specified in the Key:

5. As played on a piano. 6. As sung by a friend's voice. 7. As sung by your own voice. 8. As played on a violin.

III. Think of each of the following sounds, considering carefully the image which in each case comes to your mind's ear, and classify the images suggested by each of the following questions as indicated by degrees of clearness and vividness specified in the Key:

9. The beat of rain against the window. 10. The whistle of a locomotive. 11. The clink of glasses. 12. The slam of a door. 13. The honk of an automobile. 14. The mewing of a cat. 15. The sound of escaping steam. 16. The clapping of hands in applause. 17. The rattling of a newspaper. 18. The swish of a silk dress. 19. The sound of a clock striking. 20. The humming of a mosquito.

Cutaneous Imagery

Think of "feeling," or touching each of the following, considering carefully the image which comes to your mind's touch, and classify the images suggested by each of the following questions as indicated by the degrees of clearness and vividness specified in the Key:

1. Velvet. 2. Silk. 3. Wet soap. 4. Sand. 5. A crisp dead leaf. 6. A smooth door knob. 7. Woolen mittens. 8. Linen. 9. A fur muff. 10. The clasp of a hand. 11. Your hand on another person's hair. 12. A soft, comfortable bed. 13. The prick of a pin. 14. The warmth of a tepid bath. 15. The sting of cold against the face. 16. The tickling of a fly at the nose. 17. The smart of a pin scratch. 18. The pain of a burn. 19. The heat of a burning sun. 20. The beating of the wind against the face on a gusty day.

Kinaesthetic Imagery

Think of performing each of the following acts, considering carefully the image (do not confound this with an incipient movement of the muscles concerned) which comes to your mind's arms, legs, lips, etc., and classify the images suggested as indicated by the degrees of clearness and vividness specified in the Key:

1. Running upstairs. 2. Springing across a gutter. 3. Drawing a circle on paper. 4. Writing your name. 5. Lifting a heavy weight. 6. Running fast to catch a car. 7. Reaching up to a high shelf. 8. Striking at a troublesome fly. 9. Nodding your head in assent. 10. Rising out of a low chair. 11. Carrying a heavy hand bag. 12. Waving your hand to a friend. 13. Counting to 10 orally as fast as you can. 14. Throwing a ball. 15. Kicking something out of your way. 16. Stooping down to tie your shoe. 17. Suspending your weight by the hands. 18. Striking a ball

with a bat. 19. Passing a heavy dish at the table. 20. Tilting the head back to look at some object high above you.

Gustatory Imagery

Think of tasting each of the following considering carefully the image which comes to your mind's mouth, and classify the images suggested by each of the following questions as indicated by the degrees of clearness and vividness specified in the Key:

1. Salt. 2. Bitter. 3. Granulated (white) sugar. 4. Lemons.
5. Oranges. 6. Chocolate. 7. Jelly. 8. Radishes. 9. Vinegar.
10. Pepper. 11. Cheese. 12. Your favorite soup. 13. Coffee. 14. Oatmeal.
15. Beefsteak. 16. Fried eggs. 17. Peanuts. 18. Your favorite candy.
19. Watermelon. 20. Pineapple.

Olfactory Imagery

Think of smelling each of the following, considering carefully the image which comes to your mind's nose and classify the images suggested by each of the following questions as indicated by degrees of clearness and vividness as specified in the Key:

1. Roses. 2. Onions. 3. An ill-ventilated room. 4. Cigar smoke.
5. Coffee. 6. Cooking cabbage. 7. Your favorite perfume. 8. An oil lamp blown out.
9. Smoke from a train. 10. Roast beef. 11. A fur coat.
12. Camphor. 13. Fresh paint. 14. Some odor which you particularly dislike.
15. Tea. 16. Apple blossoms. 17. Newmown grass. 18. Burnt meat.
19. New leather. 20. Cheese

Organic Imagery

Think of each of the following sensations, considering carefully the image which comes before your mind, and classify the images suggested as indicated by degrees of clearness and vividness specified in the Key:

1. A headache. 2. Fatigue. 3. Hunger. 4. A sore throat. 5. Well-being, or vigor and vitality.
6. Drowsiness. 7. A cold in the head.
8. Thirst. 9. Nausea. 10. Repletion (as from a very full meal).

EXPERIMENT 2

The following experiment was made with 34 Cornell College seniors, 21 women and 13 men. The class had studied psychology to the extent of a two-hour course for one year, and had had laboratory and experimental work which required introspection. The subject of imagery had been studied, and introspective reports in imagery made and discussed in class. The questionnaire just preceding was employed in this, as in the two following tests. The time occupied in the test was one laboratory hour.

The class seemed much interested in the questions, and answered them with evident thoughtfulness and seriousness. The method of computing the results was the same as in the first experiment except that seven instead of five degrees of clearness and vividness were here used. Table V shows the distribution of ability in imagery for the group.

TABLE V. SCORES IN IMAGERY AND DEVIATIONS FROM THE CENTRAL TENDENCIES OF THE GROUP IN THE CASE OF 34 CORNELL COLLEGE STUDENTS.

Subjects	Scores in Imagery						Deviations from Averages							
	Vis.	Aud.	Cut.	Kin.	Gust.	Olf.	Org.	Vis.	Aud.	Cut.	Kin.	Gust.	Olf.	Org.
1.....	111	40	37	40	56	49	20	8	-12	-13	-13	1	-16	-7
2.....	100	62	66	62	72	80	28	-3	10	16	9	17	15	1
3.....	96	53	45	61	56	81	31	-7	1	-5	8	1	16	4
4.....	85	30	36	36	39	44	16	-18	-22	-14	-17	-16	-21	-11
5.....	124	63	61	52	47	48	24	21	11	11	-1	-8	-17	-3
6.....	100	61	20	89	74	90	24	-3	9	-30	36	19	25	-3
7.....	125	54	69	70	66	68	37	22	2	19	17	11	3	10
8.....	104	42	37	43	38	54	23	1	-10	-13	-10	-17	-11	-4
9.....	96	45	49	24	35	40	27	-7	-7	-1	-20	-20	-25	0
10.....	132	73	63	71	85	77	33	29	21	13	18	30	12	6
11.....	73	50	39	33	50	83	20	-30	-2	-11	-20	-5	18	-7
12.....	65	28	28	35	20	24	17	-38	-24	-22	-18	-35	-41	-10
13.....	96	49	50	47	65	67	30	-7	-3	0	-6	10	2	3
14.....	78	42	45	53	42	51	21	-25	-10	-5	0	-13	-14	-6
15.....	96	49	48	35	63	86	21	-7	-3	-2	-18	8	21	-6
16.....	110	46	38	46	35	54	23	7	-6	-12	-7	-20	-11	-4
17.....	96	30	20	20	32	29	16	-7	-22	-30	-33	-23	-36	-11
18.....	74	44	35	41	26	51	21	-29	-8	-15	-12	-29	-14	-6
19.....	135	74	79	68	77	70	31	32	22	29	15	22	5	4
20.....	133	74	57	60	69	91	42	30	22	7	7	14	26	15

21.....	133	54	58	55	71	59	24	30	2	8	2	16	-6	-3
22.....	57	28	36	34	22	29	22	-46	-24	-14	-19	-33	-36	-5
23.....	132	88	98	97	88	83	33	29	36	48	44	33	18	6
24.....	87	40	36	39	37	48	22	-16	-12	-14	-14	-18	-17	-5
25.....	120	69	55	78	65	72	39	17	17	5	45	10	7	12
26.....	110	49	52	61	59	52	16	7	-3	2	8	4	-13	-11
27.....	138	61	56	42	58	72	35	35	9	6	-11	3	7	8
28.....	152	78	67	78	76	82	36	49	26	17	25	21	17	9
29.....	58	27	22	26	21	25	13	-45	-25	-28	-27	-34	-40	-14
30.....	98	46	50	53	49	64	40	-5	-6	0	0	-6	-1	13
31.....	89	58	62	54	109	126	39	-14	6	12	1	54	61	12
32.....	112	52	63	64	64	65	26	9	0	13	11	9	0	-1
33.....	96	54	47	71	57	113	44	-7	2	-3	18	2	48	17
34.....	80	57	61	54	59	73	31	-23	5	11	1	4	8	4
Averages.....	103	52	50	53	55	65	27	19	12	13	15	17	18	7

The following were the average deviations from the average:

Visual.....	19.50, or 18.93%
Auditory.....	11.66, or 22.42%
Cutaneous.....	13.21, or 26.42%
Kinaesthetic.....	15.29, or 28.09%
Gustatory.....	16.65, or 30.27%
Olfactory.....	18.47, or 28.41%
Organic.....	7.09, or 26.26%

The average per cent of deviation from the average is seen to be 25.8.

The seven degrees of vividness and clearness provided for in the key had the following proportions of images credited to them respectively:

1. Perfectly clear, etc.....	1037, or 20%
2. Very clear, etc.....	1670, or 32%
3. Moderately clear, etc.....	1195, or 23%
4. Not clear, etc.....	656, or 13%
5. Vague and dim.....	336, or 7%
6. So vague and dim, etc.....	144, or 3%
7. No image, etc.....	104, or 2%

Thus, one-fifth of the total number of images were reported as possessing the highest degree of clearness and vividness, and almost another third the next highest degree, or, one-half reported their images as being equal or comparable with the actual experience in clearness and vividness. Almost one-fourth were reported as moderately clear and vivid, and exactly one-fourth as not being clear, or of still lower quality, the image failing to appear in 2% of the cases. Stated differently, three-fourths of the images were reported as moderately clear or above, and one-fourth as below moderately clear. The details are shown in the table which follows:

TABLE. VI. RELATIVE FREQUENCIES OF DIFFERENT DEGREES OF IMAGERY IN 34 CORNELL COLLEGE STUDENTS.

Scale	Vis.	Aud.	Cut.	Kin.	Gust.	Olf.	Org.
1. Perfectly clear, etc.....	18%	21%	22%	23%	20%	17%	19%
2. Very clear, etc.....	38%	35%	35%	29%	28%	23%	35%
3. Moderately clear, etc.....	23%	21%	24%	23%	21%	21%	24%
4. Not clear, etc.....	10%	14%	12%	14%	15%	16%	10%
5. Vague, etc.....	6%	4%	5%	7%	6%	12%	6%
6. So vague, etc.....	3%	2%	1%	2%	3%	6%	4%
7. No image, etc.....	2%	3%	1%	2%	2%	4%	2%

Here, as in the preceding experiment, visual imagery does not equal the other types in the proportion of images reported of the highest degree of clearness and vividness, being excelled by all except olfactory and organic, which are each 1% below visual. In images of medium grade or above, the visual images just about hold their own, and are exceeded in the proportion of cases in which no images appear by auditory and olfactory. As might be expected from the fairer distribution of questions among the various fields in this experiment than in the last, the proportions of the different types reported as of the same degree of clearness and vividness are much more constant than in the preceding test.

The correlations of the various classes of imagery with each other in the case of these 34 individuals are shown in the following table.

TABLE VII. THE RELATIONS OF THE DEGREE OF IMAGERY OF ONE SORT TO THAT OF OTHER SORTS IN 34 CORNELL COLLEGE STUDENTS.

			r. Pearson	r. Per cent U. S.	r. Average
Visual	with	auditory.....	.77	.60	.68
Visual	"	cutaneous.....	.59	.85	.72
Visual	"	kinaesthetic.....	.63	.53	.58
Visual	"	gustatory.....	.63	.53	.58
Visual	"	olfactory.....	.36	.18	.27
Visual	"	organic.....	.68	.27	.47
Auditory	"	cutaneous.....	.80	.93	.86
Auditory	"	kinaesthetic.....	.88	.96	.92
Auditory....	"	gustatory.....	.80	.89	.84
Auditory	"	olfactory.....	.69	.89	.79
Auditory.	"	organic.....	.68	.89	.78
Cutaneous	"	kinaesthetic.....	.62	.89	.75
Cutaneous	"	gustatory.....	.71	.85	.78
Cutaneous	"	olfactory.....	.49	.74	.61
Cutaneous	"	organic.....	.58	.85	.71
Kinaesthetic	"	gustatory.....	.75	.93	.84
Kinaesthetic	"	olfactory.....	.80	.85	.82
Kinaesthetic	"	organic.....	.66	.85	.75
Gustatory	"	olfactory.....	.85	.93	.89
Gustatory	"	organic.....	.62	.80	.71
Olfactory	"	organic.....	.72	.93	.82
Averages.....			.68	.73	.71

Column 2 of Table VIII shows the aggregate score for each subject in the 7 types of imagery, and column 3, the aggregate score in college studies. Columns 4 and 5 show the deviations from the average in each of the abilities, and columns 6 and 7, the ranks in ability in imagery and college studies, respectively.

TABLE VIII. THE DEGREE OF IMAGERY IN GENERAL AND THE DEGREE OF SCHOLARSHIP FOR EACH OF THE 34 CORNELL COLLEGE STUDENTS.

Individual	Total score in imagery	Total score in College studies	Deviations from the averages of the 34 in imagery	Deviations from the averages of the 34 in scholarship	Rank in imagery	Rank in scholarship
1.....	333	3480	62	112	10	11
2.....	470	3410	-75	42	27	18
3.....	423	3570	-28	202	22	2
4.....	286	3215	109	-153	5	28
5.....	419	3270	-24	-98	21	25
6.....	458	3550	-63	182	25	3
7.....	489	3470	-94	102	28	13
8.....	341	3478	-54	109	12	12
9.....	316	3034	79	-338	8	33
10.....	534	3261	-139	-107	31	26
11.....	348	3441	47	73	13	15
12.....	217	3289	178	-79	2	23
13.....	404	3413	-9	45	19	17
14.....	332	2881	63	-481	9	34
15.....	398	3539	-3	171	16	6
16.....	352	3280	43	-88	14	24
17.....	243	3495	152	127	4	9
18.....	292	3150	103	-218	6	31
19.....	534	3198	-139	-170	32	29
20.....	526	3626	-131	258	30	1
21.....	454	3104	-59	-264	24	32
22.....	228	3251	167	-117	3	27
23.....	619	3465	-224	97	34	14
24.....	309	3485	86	117	7	10
25.....	498	3501	-103	133	29	8
26.....	399	3347	-4	-21	17	21
27.....	462	3335	-67	-13	26	22
28.....	569	3367	-174	-1	33	19
29.....	192	3180	203	-188	1	30
30.....	400	3364	-5	-4	18	20
31.....	337	3426	58	58	11	16
32.....	446	3534	-51	166	23	7
33.....	382	3545	13	177	15	5
34.....	415	3549	-20	181	20	4
Averages..	395	3368	83	138		

The Pearson method of computation shows a negative correlation of $-.149$; the method of unlike signed pairs gives $-.240$. If we take the average of the two the figure becomes $-.194$. The average deviation from the average is 83 in imagery and 138 in college studies. A comparison of the ranks in the two abilities also bears out the negative correlation.

Sum of college ranks for the highest 10 in imagery.....	236
Sum of college ranks for the next highest 7 in imagery.....	99
Sum of college ranks for the lowest 10 in imagery.....	153
Sum of college ranks for the next lowest 7 in imagery.....	107
Sum of college ranks for the highest half in imagery.....	335
Sum of college ranks for the lowest half in imagery.....	260

Thus it is seen that the lowest 10 in imagery far outranked the highest 10 in college rank, and that the lowest half in imagery outranked the highest half in almost the same proportion.

Perhaps final conclusions as to the correlation between ability in imagery and general scholastic ability should not be drawn from experiments of the scope of those preceding. Yet one cannot but be impressed with the smallness of positive correlation shown in the first experiment, and even more impressed by the negative correlation shown by the second experiment, where the scope of the test was much larger and the methods employed much more exact. The results of these tests agree with the conclusion of Armstrong,¹ that whatever correlation there is between ability in imagery and ability in college studies in general is of a negative sort.

EXPERIMENT 3

The third experiment of the series is a duplication of the preceding one, employing a different group of subjects. The questionnaire used in the experiment just described was also employed in this one. The group studied consisted of 45 students, 40 women and 5 men, in the writer's classes in psychology in the Extension Department of Teachers College, Columbia University. Most of the students were college or normal school graduates, and all had had at least one semester's work in psychology, and a number of them considerably more than this. All but one or two were teachers. The class had discussed the subject of imagery, read the standard chapters upon

¹The imagery of American Students, *Psych. Rev.* Vol. 1.

it, and had had some practice in introspection, including Galton's questions as quoted by Thorndike in his "Elements of Psychology." The test was taken with interest by each of the three sections into which the class was divided, and the questions were answered with care and thoughtfulness. Table IX shows the distribution of ability in imagery as reported by this group. The correlation between ability in imagery and ability in college studies was not studied in this group.

TABLE IX. SCORES IN IMAGERY AND DEVIATIONS FROM THE CENTRAL TENDENCIES OF THE GROUP IN THE CASE OF 45 TEACHERS COLLEGE STUDENTS.

Subjects	Scores in Imagery					Deviations from Averages								
	Vis.	Aud.	Cut.	Kin.	Gust.	Off.	Org.	Vis.	Aud.	Cut.	Kin.	Gust.	Off.	Org.
1.....	119	79	74	69	98	110	35	18	22	16	10	36	41	7
2.....	97	52	54	49	72	63	34	-4	-5	-4	-10	10	-6	7
3.....	94	54	50	56	62	54	22	-7	-3	-8	-3	0	-15	-6
4.....	84	50	49	37	76	77	22	-17	-7	-9	-22	14	8	-6
5.....	91	59	92	43	96	69	33	-10	2	34	-16	34	0	5
6.....	97	47	71	60	60	59	29	-4	-10	13	1	-2	-10	1
7.....	96	68	77	74	79	77	47	-5	11	19	15	17	8	19
8.....	114	67	63	71	60	58	23	13	10	5	12	-2	-11	-5
9.....	97	63	64	60	65	63	26	-4	6	6	1	3	-6	-2
10.....	89	71	48	59	57	59	13	-12	14	-10	0	-5	-10	-15
11.....	86	20	42	40	42	44	24	-15	-37	-16	-19	-20	-25	-4
12.....	78	46	53	53	63	80	26	-23	-11	-5	-6	1	11	-2
13.....	92	58	60	63	40	77	30	-9	1	2	4	-22	8	2
14.....	114	51	56	63	71	76	22	13	-6	-2	4	19	7	-6
15.....	106	61	60	65	57	71	31	5	4	2	6	-5	2	3
16.....	74	72	66	67	49	101	22	-27	15	8	8	-13	32	-6
17.....	145	67	52	44	37	44	19	44	10	-6	-15	-25	-25	-9
18.....	76	74	51	52	69	108	26	-25	17	-7	-7	7	39	-2
19.....	91	50	45	40	72	66	10	-10	-7	-13	-19	10	-3	-18
20.....	81	46	41	52	61	51	24	-20	-11	-17	-7	-1	-18	-4
21.....	106	37	24	52	53	68	21	5	-20	-34	-7	-9	-1	-7
22.....	98	57	64	53	57	70	15	-3	0	6	-6	5	1	-13
23.....	116	69	44	64	69	85	37	15	12	-14	5	7	16	9
24.....	118	63	79	62	71	82	25	17	6	21	3	9	13	-3
25.....	119	66	66	69	79	89	33	18	9	8	10	17	20	5

TABLE IX. Continued.

Subjects	Scores in Imagery						Deviations from Averages							
	Vis.	Aud.	Cut.	Kin.	Gust.	Off.	Org.	Vis.	Aud.	Cut.	Kin.	Gust.	Off.	Org.
26.	123	56	59	59	41	53	26	22	-1	1	0	-21	-16	-2
27.	80	47	40	35	46	44	26	-21	-10	-18	-24	-16	-25	-2
28.	117	48	38	29	39	70	28	16	-9	-20	-30	-23	1	0
29.	72	33	42	52	34	41	30	-29	-24	-16	-7	-28	-28	2
30.	84	51	114	117	139	130	39	-17	-6	56	58	77	61	11
31.	99	74	64	65	49	66	36	-2	17	6	6	-13	-3	8
32.	44	21	20	22	20	21	15	-57	-36	-38	-37	-42	-48	-13
33.	98	93	68	70	77	65	30	-3	36	10	11	15	-4	2
34.	133	58	50	72	56	68	39	32	1	-8	13	-6	-1	11
35.	95	48	70	66	64	75	38	-6	-9	12	7	2	6	10
36.	78	50	34	34	23	26	10	-23	-7	-24	-25	-30	-43	-18
37.	140	71	102	118	110	102	60	39	14	44	59	48	33	32
38.	96	62	40	35	30	48	20	-5	5	-18	-24	-32	-21	-8
39.	131	80	79	75	80	106	30	30	23	21	16	18	37	2
40.	113	51	53	34	73	78	39	12	-6	-5	-25	11	9	11
41.	102	65	63	59	68	68	29	1	8	5	0	6	-1	1
42.	116	56	68	77	64	71	34	15	-1	10	18	2	2	6
43.	100	58	39	44	44	76	21	-1	1	-19	-15	-18	7	7
44.	159	52	50	108	49	45	24	58	-5	-8	49	-13	-24	-4
45.	89	63	65	47	62	53	21	-12	6	7	-12	0	-16	-7
Averages....	101	57	58	59	62	69	28	16	11	14	14	16	16	7

The average deviation from the average was as follows:

Visual.....	16.44, or 16.37%
Auditory.....	10.68, or 18.74%
Cutaneous.....	14.00, or 24.14%
Kinaesthetic.....	14.49, or 24.56%
Gustatory.....	16.01, or 24.82%
Olfactory.....	16.00, or 23.18%
Organic.....	7.15, or 25.54%

The average per cent of deviations from the average is 22%.

In this group the distribution among the different degrees of clearness and vividness as provided in the key was as follows:

1. Perfectly clear, etc.....	855, or 13%
2. Very clear, etc.....	2177, or 32%
3. Moderately clear, etc.....	1849, or 28%
4. Not clear, etc.....	973, or 14%
5. Vague and dim.....	477, or 7%
6. So vague and dim, etc.....	201, or 3%
7. No image, etc.....	212, or 3%

This test shows a smaller proportion of images classed in the highest degree of vividness and clearness than in the preceding one, there being but 14% here as against 20% there. The second degree of clearness and vividness has the same proportion in both tests, 32%. Or, to compare the highest three grades, this test shows 73% reported as moderately clear or above, while the preceding test shows 75% in the same classes. This test shows images as lacking in 3% of the cases as against 2% of the cases in the preceding and 5% in the first test. The details of the distribution among the different degrees was as follows:

TABLE X. RELATIVE FREQUENCIES OF DIFFERENT DEGREES OF IMAGERY IN 45 TEACHERS COLLEGE STUDENTS.

Scale	Vis.	Aud.	Cut.	Kin.	Gust.	Olf.	Org.
1. Perfectly clear, etc.....	17%	12%	12%	12%	10%	9%	15%
2. Very clear, etc.....	42%	29%	32%	32%	27%	23%	31%
3. Moderately clear, etc....	25%	33%	29%	28%	28%	25%	28%
4. Not clear, etc.....	10%	15%	14%	14%	19%	19%	13%
5. Vague and dim.....	3%	7%	7%	7%	9%	11%	7%
6. So vague and dim, etc....	1%	2%	2%	4%	4%	6%	4%
7. No image, etc.....	2%	2%	4%	3%	3%	7%	2%

Contrary to the results in the former two tests visual imagery here excels the other types in the proportion of its images reported

as belonging in the highest degree, having 17% of this rank as against an average of 13% for all types together. If all grades moderately clear or above are taken together, visual imagery still maintains its superiority, having 84% in these three grades, while all types of imagery together average but 73% in the same grades. It may be noted that the proportion of the different types of images reported as of the same degree of clearness and vividness is not quite so constant as in the preceding test.

This group showed the following correlations of the various types of imagery with each other.

TABLE XI. THE RELATIONS OF THE DEGREE OF IMAGERY OF ONE SORT TO THAT OF OTHER SORTS IN 45 TEACHERS COLLEGE STUDENTS.

		r. Pearson	r. Per cent U. S.	r. Average
Visual	with auditory.....	.39	.24	.31
Visual	" cutaneous.....	.21	.17	.19
Visual	" kinaesthetic.....	.47	.61	.54
Visual	" gustatory.....	.19	.17	.18
Visual	" olfactory.....	.19	.38	.28
Visual	" organic.....	.34	.31	.32
Auditory	" cutaneous.....	.49	.67	.58
Auditory	" kinaesthetic.....	.39	.67	.53
Auditory	" gustatory.....	.16	.24	.20
Auditory	" olfactory.....	.45	.31	.38
Auditory	" organic.....	.27	.44	.35
Cutaneous	" kinaesthetic.....	.70	.88	.79
Cutaneous	" gustatory.....	.78	.50	.64
Cutaneous	" olfactory.....	.65	.44	.54
Kinaesthetic	" gustatory.....	.60	.44	.52
Kinaesthetic	" olfactory.....	.24	.72	.48
Kinaesthetic	" organic.....	.25	.60	.42
Gustatory	" olfactory.....	.76	.77	.76
Gustatory	" organic.....	.47	.50	.48
Olfactory	" organic.....	.52	.60	.56
Averages.....		.43	.49	.46

EXPERIMENT 4

In order to compare the results of the tests already given with results from a group thoroughly practiced in introspection, the

questionnaire was given a group of 18 trained psychologists, 4 women and 14 men, about two-thirds of whom were connected with Columbia University as professors or assistants in education and psychology. Table XII shows the distribution of ability in imagery of this group.

TABLE XII. SCORES IN IMAGERY AND DEVIATIONS FROM THE CENTRAL TENDENCIES OF THE GROUP IN THE CASE OF 18 PSYCHOLOGISTS.

Subjects	Scores in Imagery							Deviations from Averages						
	Vi.	Au.	Cu.	Ki.	Gu.	Ol.	Or.	Vi.	Au.	Cu.	Ki.	Gu.	Ol.	Or.
1.....	107	63	87	125	75	54	46	-55	-14	-5	-32	-18	-40	0
2.....	108	114	119	130	119	124	65	36	37	27	37	26	21	19
3.....	56	28	36	32	45	44	10	-106	-40	-52	-61	-48	-50	-36
4.....	90	57	44	48	21	78	35	-72	-20	-48	-45	-72	-25	-11
5.....	95	33	54	58	60	68	34	-67	-44	-38	-35	-33	-35	-12
6.....	146	42	43	41	52	55	21	-16	-35	-49	-52	-41	-48	-25
7.....	125	68	69	65	102	140	53	-37	-9	-23	-28	9	37	7
8.....	252	84	136	123	130	140	70	90	47	44	30	37	37	24
9.....	205	119	120	140	140	140	61	43	42	28	47	47	37	15
10.....	228	60	128	95	126	137	57	66	-17	36	2	33	34	11
11.....	275	136	140	133	140	140	70	113	59	48	40	47	37	24
12.....	203	88	119	112	100	105	35	41	11	27	19	7	2	-11
13.....	183	107	106	103	126	130	63	21	30	14	10	33	27	17
14.....	272	105	130	140	135	132	59	111	28	38	47	42	29	13
15.....	131	64	116	124	94	104	57	-31	-13	24	31	1	1	11
16.....	136	110	67	84	91	112	25	-26	33	-25	-9	-2	9	-21
17.....	126	66	71	71	76	76	46	-36	-11	-21	-22	-17	-27	0
18.....	90	39	57	52	51	50	23	-72	-38	-35	-41	-42	-53	-23
Averages.	162 24	77 8	92	93	93	103	46	58	28	33	33	31	33	16

The following were the average deviations from the average:

Visual.....	57.72, or 35.61%
Auditory.....	27.62, or 35.87%
Cutaneous.....	33.44, or 36.35%
Kinaesthetic.....	32.66, or 35.12%
Gustatory.....	31.33, or 33.69%
Olfactory.....	33.00, or 32.04%
Organic.....	15.55, or 33.80%

The average per cent of deviations from the average is 34.6.

One is immediately struck by two facts which appear from Table XII: one is that the group as a whole have rated themselves very much lower in imagery than any of the other groups, and the other is that the variability is greater than in any of the other groups. According to the method of scoring used, the lowest

score that could be obtained in visual imagery, with 40 questions, would be 280, and in each of the other types with 20 questions, 140, and in organic, with 10 questions, 70. The table shows eleven instances in which images were reported to be entirely lacking in one of the various fields, and a much larger number of instances in which the images were very few and of an exceedingly low grade as regards clearness and vividness. On the other hand, the highest scoring (40 for visual, and 20 for each of the others except organic, which is 10) is approached in a goodly number of instances. Olfactory images were most deficient, with gustatory, kinaesthetic and cutaneous following closely after.

The following statement shows the general distribution among the different degrees of clearness and vividness:

1. Perfectly clear, etc.....	169, or 6%
2. Very clear, etc.....	429, or 16%
3. Moderately clear, etc.....	445, or 17%
4. Not clear, etc.....	364, or 13%
5. Vague and dim.....	262, or 10%
6. So vague and dim, etc.....	367, or 14%
7. No image, etc.....	660, or 24%

The results thus show about two-fifths of all the images as moderately clear and vivid or better, and three-fifths not clear and vivid or worse. The most striking fact of all, however, is that the image was reported as entirely lacking in one-fourth of all the cases, while no other group reported the image as failing to appear in more than five percent of the cases. A more detailed statement of the distribution in this group follows:

TABLE XIII. RELATIVE FREQUENCIES OF DIFFERENT DEGREES OF IMAGERY IN 18 PSYCHOLOGISTS.

Scale	Vis.	Aud.	Cut.	Kin.	Gust.	Olf.	Org.
1. Perfectly clear, etc.....	9%	9%	4%	3%	6%	3%	8%
2. Very clear, etc.....	18%	19%	18%	17%	11%	12%	14%
3. Moderately clear, etc....	20%	21%	15%	16%	16%	12%	8%
4. Not clear, etc.....	13%	19%	10%	13%	13%	13%	15%
5. Vague and dim.....	10%	10%	11%	6%	10%	9%	11%
6. So vague and dim, etc...	11%	10%	17%	13%	19%	14%	16%
7. No image, etc.....	19%	12%	24%	32%	25%	37%	28%

There is also more variability in this group than in the others in the proportion of the various types of imagery which are reported as falling in the different degrees of clearness and vividness. For example, while images fail to appear in 12% of the cases in the auditory field, they fail in 19% of the cases in the visual, and in 37% in the olfactory. The variability obtains in lesser amount in the other degrees of clearness and vividness also.

The correlations of the various types of imagery with each other are shown in the following table.

TABLE XIV. THE RELATIONS OF THE DEGREE OF IMAGERY OF ONE SORT TO THAT OF OTHER SORTS IN 18 PSYCHOLOGISTS.

			r. Pearson	r. Per cent U. S.	r. Average
Visual	with	auditory.....	.72	.94	.83
Visual	"	cutaneous.....	.89	.98	.93
Visual	"	kinaesthetic.....	.73	.94	.83
Visual	"	gustatory.....	.87	.94	.90
Visual	"	olfactory.....	.78	.87	.82
Visual	"	organic.....	.80	.87	.83
Auditory	"	cutaneous.....	.81	.64	.72
Auditory	"	kinaesthetic.....	.87	.77	.77
Auditory	"	gustatory.....	.78	.77	.77
Auditory	"	olfactory.....	.70	.87	.78
Auditory	"	organic.....	.67	.94	.80
Cutaneous	"	kinaesthetic.....	.90	.98	.94
Cutaneous	"	gustatory.....	.90	.98	.94
Cutaneous	"	olfactory.....	.76	.94	.85
Cutaneous	"	organic.....	.84	.94	.89
Kinaesthetic	"	gustatory.....	.83	.94	.88
Kinaesthetic	"	olfactory.....	.70	.86	.78
Kinaesthetic	"	organic.....	.70	.94	.82
Gustatory	"	olfactory.....	.86	.98	.92
Gustatory	"	organic.....	.82	.98	.90
Olfactory	"	organic.....	.80	.94	.87
Averages.....			.79	.91	.85

The first thing which strikes one from this table of correlations is the high average of all the correlations. The other three groups averaged .49 for correlations among all types of images; the group of experts averaged .85, or 73 per cent more than the

average for the other groups combined. It is hard to find the explanation of this high degree of correlation in the relatively low rating in clearness and vividness of this group as compared with the others. It is fair to suppose that in the expert group both constant and variable errors are reduced to a minimum, hence if there are any constant errors on the part of the other groups which might lead to too high a correlation, these are evidently overbalanced by variable errors, and one must conclude that the correlations shown for the other groups are probably too small rather than too large.

Several summaries and tables will now be given bringing the four groups together to make comparisons and show averages. It has already been stated that the students in the first college group were given a test in which they were required to classify their images under five degrees of clearness and vividness, while the succeeding three tests employed seven degrees. In making the comparisons of all the groups, the five degrees used in the first experiment are distributed so as to facilitate the comparison with the groups. This was done by arranging the five degrees in the scale of the seven degrees, leaving 3 and 5 blank.

Table XV shows the percentage for the four groups of all the images reported as belonging to the different degrees of clearness and vividness, 1 being the highest degree and 7 the lowest as already explained in the questionnaire. Column I gives the percent accorded to the different degrees by the Cornell College group No. 1; column II, by the Cornell College group No. 2; column III, by the Teachers College group; and column IV, by the group of psychologists.

TABLE XV. THE DISTRIBUTION OF IMAGES IN GENERAL AS TO DEGREE OF CLEARNESS AND VIVIDNESS FOR ALL FOUR GROUPS MEASURED.

Degree	I	II	III	IV	Average
1.....	26%	20%	13%	6%	16%
2.....	32%	32%	32%	16%	28%
3.....	....	23%	28%	17%	17%
4.....	24%	13%	14%	13%	16%
5.....	....	7%	7%	10%	6%
6.....	13%	3%	3%	14%	8%
7.....	5%	2%	3%	24%	9%

From this table it is seen that 16% report images perfectly clear and in general as vivid as the actual experience, while 9% report no image present at all. It is also to be noted that the per cent reported lacking in images by the psychologists is more than 7 times greater than the average for the other three groups. While this is no doubt in part to be accounted for by the tendency of the relatively untrained observer to overrate his imagery, it is certainly not true that so wide a divergence is caused by this factor alone. It is more probable, as Galton concluded, that persons who deal chiefly with abstract forms of thinking finally come to find the power of imaging greatly diminished. The average for all the groups showed 61% of images which were reported as moderately clear and vivid or better, and 23% which were vague and dim or worse.

Table XVI shows for the four groups the percentages of each different type of images which were classed under each of the seven degrees of clearness and vividness. The first column under each type of images represents the Cornell College group No. 1; the second column, the Cornell College group No. 2; the third column, the Teachers College group; and the fourth column, the psychologists. The average for the four groups is shown for each type of images.

TABLE XVI. THE DISTRIBUTION FOR ALL FOUR GROUPS OF THE DIFFERENT TYPES OF IMAGES AS TO THE DEGREES OF CLEARNESS AND VIVIDNESS.

Degree	Visual				Av.	Auditory				Av.	Cutaneous				Av.
1.....	19	18	17	9	16	40	21	12	9	20	22	23	12	3	15
2.....	42	38	42	18	35	21	35	29	19	26	31	35	32	18	29
3.....		23	25	20	17		21	33	21	19		24	29	15	17
4.....	21	10	10	13	13	26	14	15	19	18	24	12	14	10	15
5.....		6	3	10	5		4	7	10	5		5	7	11	6
6.....	8	3	1	11	6	12	2	2	10	8	13	1	2	17	8
7.....	10	2	2	19	9	1	3	2	12	4	1	1	4	24	8

Degree	Kinaesthetic				Av.	Gustatory				Av.	Olfactory				Av.
1.....	22	23	12	3	15	29	20	10	6	17	23	17	9	3	13
2.....	21	29	32	17	25	31	28	27	11	25	36	23	23	12	23
3.....		23	28	16	17		21	28	16	16		21	25	12	14
4.....	11	14	14	13	13	20	15	19	13	17	36	16	19	13	21
5.....		7	7	6	5		6	9	10	6		12	11	9	8
6.....	42	2	4	13	15	17	3	4	19	11	3	6	6	14	7
7.....	4	2	3	32	10	3	2	3	25	8	2	4	7	37	15

Degree	Organic				Av.
1.....	37	19	15	8	20
2.....	1	35	31	14	20
3.....		24	28	8	15
4.....	32	10	13	15	18
5.....		6	7	11	6
6.....	29	4	4	16	13
7.....	1	2	3	28	8

It is seen from this comparison and summary that above 16% of all the different types of images were reported by the average of the four groups as being of degree 1, or perfectly clear and as vivid as the actual experience, while 9% were reported as lacking: also that almost 59% of all the images were reported as belonging to degree 3 or better, while a little less than 26% were reported as belonging to degree 5 or worse. Visual imagery is excelled by auditory, organic and gustatory in the percentage of images reported in the highest degree of clearness and vividness, and is excelled only by the olfactory and kinaesthetic in the percentage of cases in which images were reported as entirely lacking. The visual excels all the others, however, in the propor-

tion reported in the aggregate of the highest three degrees, having 68% as against 65% for auditory, 61% for cutaneous, 58% for gustatory, 57% for kinaesthetic, 55% for organic, and 50% for olfactory. This showing would seem to contradict the oft repeated statement that visual imagery is far superior to the other classes in clearness and vividness, at least so far as voluntary imagery is concerned.

Table XVII shows the summary of the averages of the correlations. It is seen from this table that the highest relative correlation is of gustatory with olfactory, the percentage of correlation between these two being almost 26% higher than between gustatory and the other types (on the average). The second highest is between cutaneous and gustatory, the percentage being almost 19% higher than between cutaneous and all other types than gustatory. The next in succession are organic with olfactory, visual with auditory, and auditory with kinaesthetic. The lowest degree of relative correlation is that of visual with olfactory, this correlation being one-fifth less than that for visual with all other types than olfactory. Next in succession of low correlations are kinaesthetic with organic, and visual with gustatory. Table XVIII gives a complete statement of the comparative correlations, showing in each instance the percentage to which the correlation between the pair shown is greater than the average correlation between the first of the pair and all the other types of images except the one listed as the second member of the pair.

TABLE XVII. SUMMARY OF AVERAGE OF CORRELATIONS.

	Vis.	Aud.	Cut.	Kin.	Gust.	Olf.	Org.	Avg.
Visual.....		.53	.47	.52	.43	.40	.48	.47
Auditory.....	.53		.59	.65	.55	.60	.58	.58
Cutaneous.....	.47	.59		.69	.74	.57	.69	.625
Kinaesthetic.....	.52	.65	.69		.57	.62	.52	.595
Gustatory.....	.43	.55	.74	.57		.78	.61	.61
Olfactory.....	.40	.60	.57	.62	.78		.68	.61
Organic.....	.48	.58	.69	.52	.61	.68		.59
Averages.....	.47	.58	.625	.595	.61	.61	.59	

TABLE XVIII. THE RELATIVE AMOUNT OF CORRELATION OF TWO SORTS OF IMAGERY AS COMPARED WITH THE CORRELATION OF THE FIRST MEMBER OF EACH PAIR WITH ALL OTHER SORTS THAN THE SECOND MEMBER OF THE PAIR. THUS THE CORRELATION OF VISUAL WITH AUDITORY IS 13.2% HIGHER THAN THE AVERAGE CORRELATION OF VISUAL WITH ALL OTHER TYPES THAN AUDITORY; VISUAL WITH CUTANEOUS, 4.3% LOWER, ETC.

Vis.	with aud.	+13.2%	Cut.	with kin.	+11.6%
Vis.	" cut.	-4.3%	Cut.	" gust.	+18.9%
Vis.	" kin.	+11.5%	Cut.	" olf.	-10.5%
Vis.	" gust.	-11.6%	Cut.	" org.	+11.6%
Vis.	" olf.	-22.5%	Kin.	" gust.	-5.2%
Vis.	" org.	+2.1%	Kin.	" olf.	+4.8%
Aud.	" cut.	+1.7%	Kin.	" org.	-17.2%
Aud.	" kin.	+12.3%	Gust.	" olf.	+25.7%
Aud.	" gust.	-7.3%	Gust.	" org.	00.0%
Aud.	" olf.	+3.3%	Olf.	" org.	+16.2%
Aud.	" org.	+1.7%			

Of course the value of generalizations from the results of the preceding experiments will depend first of all on the reliability of the data received from the tests. The writer believes that these data are as reliable as can be hoped for from any tests of this scope and character. Nor is he ready to agree with Armstrong that "we have learned all that we may by the usual 'breakfast table' questionnaire, or like methods relying upon uncritical introspection,"¹ particularly if one classes as uncritical all introspection which is not that of expert psychologists. The rather marked agreement (in respect to relationships) of the results obtained from the group of experts with those obtained from the other three groups in this study tends to give confidence in the introspective results from student classes in psychology, providing the questionnaire is adequate and carefully constructed. The question of the *presence* of imagery of a certain type, and its degree of clearness and vividness is not a particularly difficult introspective problem for anyone who understands fully what introspection is, and what it is that he is looking for. The *function* which the images play in thinking is a far more difficult problem, and one which requires a much higher degree of introspective ability. This phase of the question must probably be left chiefly to thoroughly critical introspection.

It was stated at the beginning of Section I that the following three questions would be studied in this section; (1) ability in imagery of the various types, including the degree of clearness

¹Some Observations on Visual Imagery, *Psych Rev.*, Vol. 11, p. 319.

and vividness; (2) the correlation of the various types of images with each other; and (3) the correlation of ability in voluntary imagery and ability in general scholarship. Certain conclusions, at least of a tentative nature, may now be stated relative to these questions. For convenience of discussion the first two of the questions will be considered together.

1. There exists a marked difference in ability in voluntary imagery between college students and specialists more advanced in years who are dealing chiefly with abstract lines of thought. The median imagery of the college students as reported is between "Very clear and comparable in vividness to the actual experience" and "Moderately clear and vivid," whereas the median imagery of the psychologists is between "Not clear or vivid, but recognizable" and "Vague and dim." These results accord well with Galton's conclusions as to the decrease of imagery with the progress of age and abstract thinking.¹

2. Few if any are absolutely lacking in the power of voluntary imagery. A large majority of people have this power in a rather high degree. Individual differences are found chiefly in the degree of clearness and vividness of the images. Just how great these differences are cannot, of course, be objectively determined, since the only standard obtainable is a wholly subjective one, and probably no two persons estimate the different degrees on just the same scale.

3. Ability in voluntary imagery is distributed much more evenly among the different types of images than has been commonly thought. Measured by the proportion of images classified under the highest three degrees of clearness and vividness, all the seven types of images studied are included between 68% and 50%, the average variation being only 5%. Better evidence still is the fact of the high correlations found in all the tests, and the further fact that the highest correlations of all were found as a result of the test given the experts. Further, so far as voluntary imagery is concerned, visual images cannot claim the supremacy often ascribed to them.

Armstrong,¹ using the Galton questions in studying the imagery of 188 Princeton and Wesleyan students, concludes that visual imagery is greatly in excess of other types. We have, however,

¹*Inquiries into Human Faculty*, pp. 83-114.

²*Psych. Rev.*, Vol. I, p. 500.

already seen reasons to doubt the validity of conclusions as to the distribution of imagery based on Galton's questions; for this test expends its emphasis on visual imagery, and adds questions as to the other types rather as an appendix. It may also be noted that the first test of the present study, using the Galton questions, but supplementing them to remedy their one-sidedness, fails to bear out Armstrong's conclusions, finding visual imagery lower than several other types.

Tichener says,¹ without stating the basis for his conclusions, "There seems to be no doubt that the great majority of students are predominantly visual." French, however, using the Tichener questionnaire with 118 Vassar juniors, finds no such predominance of the power of visual imagery. He concludes that "the differences in mental imagery of the several members of the class are almost entirely a matter of degree. All are able to call up visual, auditory and tactile images. Only one or two in each case are lacking in either taste, smell, temperature, or motor images."²

Stetson, in his rather loose study of the imagery of 100 Oberlin students,³ finds that none lacked visual or auditory imagery; that 1% lacked motor; and 3%, tactile imagery. His conclusion that "tactile images are agreed by all to play the slightest rôle in imagination," and that "they are oftenest entirely lacking," seems rather too broad a generalization for the nature of his evidence, and is not borne out by other studies of imagery,—certainly not by the present one.

It is probably safe to say that, if a test is employed which appeals as nearly equally as possible to experience in the different sensory fields, at least 95% of college students are able to summon at will mental images of a fair degree of clearness and vividness corresponding to these fields. The percentage decreases with age, the degree of decrease depending in part at least on the type of thinking done by the individual in his habitual occupation. Whether the several types of imagery are used in ordinary thinking in the same proportions which they assume in voluntary recall is an entirely different question, which will come up for later discussion.

4. The wide and rather even distribution of the power of

¹Experimental Psychology, *Instructor's Qual. Man.*, p. 393.

²*Psych. Rev.*, Vol. 9, p. 55.

³*Psych. Rev.*, Vol. 3, p. 398.

imagery among the different types seems to leave no foundation for such classifications as "eye-minded," "ear-minded," "muscle-minded," etc., if by these terms we mean mental traits which come to us through original nature, or the mind's fundamental constitution, by which we are compelled to think in these mental terms exclusively or even chiefly because of a lack of other material. There is no doubt that most minds do select certain forms of imagery, and use these much more than other types; on the other hand there is little doubt that by practice the various types could be kept approximately on a level in our thinking, as they are in voluntary imagery. Whether this would be desirable depends on another question; namely, the real function of imagery in our thinking.

To be sure, being "eye-minded" or "ear-minded" does not necessarily mean that one has visual or auditory imagery respectively predominating as mental content. For instance, I have two learned friends who learn much more easily and quickly through reading than through listening, but both are sadly lacking in visual images, employing auditory and motor images so far as imagery functions in their thinking. Common pedagogical usage would class both of these men as "eye-minded," yet visual images are almost unknown to them. Jastrow, using these terms in this loose way, and assuming certain brain "centers" to be the physiological correlates of types of images¹ makes much of the educational aspect of "eye-mindedness" and "ear-mindedness." He says, "Certain acquisitions depend almost exclusively upon the development of one intellectual center (music upon the auditory, painting upon the visual); and one in whom this center is poorly developed is deprived of all but mediocre achievement in that direction." Also, "The 'eye-minded' person should reduce everything to visual terms." And the "ear-minded" person "must have everything read to him." Built on this doubtful foundation we have also had whole systems of "methods" devised for teaching language or numbers by an appeal to a particular kind of imagery. But, even taking "eye-mindedness" and "ear-mindedness" in their broader meaning, Bryan's² 41 tests upon 600 school children resulted in the conclusion that "the majority of pupils are not eye-minded or ear-minded." Taking

¹*Pop. Sc. Mo.*, Vol. 33, p. 597.

²*Proc. N. E. A.*, 1893, p. 780.

the number of errors made by the pupils when using the eye and when using the ear respectively in various phases of discrimination and memory, he found that for the 41 tests "many more than half of all the pupils have an excess either way of less than five errors; that about ninety-four per cent. have an excess either way of less than ten errors when fifty-two figures were written." He judges that out of the 600 pupils tested, from five to ten would include all that showed extreme "eye-mindedness" or "ear-mindedness." Neumann also concludes that "pure types" are exceedingly infrequent amongst children. This is precisely what one would expect from the wide distribution of imagery found in the present study.

5. There seems to be almost an entire absence of correlation between ability in imagery of the voluntary sort and ability in college studies as measured by the teachers' markings. Whatever little correlation there is is almost certainly negative. This study did not go into the question far enough to state quantitatively just what this relation is to the various lines of study, such as language and literature, science, mathematics, etc. From a partial examination, however, there seems to be no better correlation between ability in imagery and ability in any certain lines of study, than between ability in imagery and ability in the college course as a whole. Nor could it be discovered that the persons who possessed the highest ability in imagery had a predilection for or ability in any particular studies, while those who possessed but low ability in imagery leaned in the direction of other studies. In other words, ability in imagery does not seem to be a determining or even an influential factor in selecting lines of study or measuring the amount of ability available for their pursuit.

SECTION II. THE SPONTANEOUS USE OF IMAGERY IN THINKING

The second section of this study deals with the spontaneous use of imagery in thinking. This problem is closely related to the problem of the voluntary recall of imagery, but it is not the same. For, while it is very improbable that a person who is unable to call up certain images voluntarily will ever find them appearing spontaneously in his thought, yet it is entirely conceivable that one who can summon any type of imagery clearly before his mind at will, may after all, employ very little imagery in his thinking. In spite of Royce's sweeping statement that "Whatever the mental significance of a thought, however far-reaching its scope, however vast its meaning, it must, as a present thought, be embodied in a consciousness either of objects present to the senses or of objects present as images,"¹ we shall have to insist that imagery, apart from inner speech, not only does not constitute the major part of the thought stream, but also that the thought stream may and does go on efficiently at times without any imagery whatever in it. And this absence of imagery in much of our thinking does not mean mental poverty, but only mental selection. At this point, as at all others, the mind is but following the fundamental law of economy, and using the elements which will most efficiently do its work with the least effort. Hence it is that the measure of an individual's voluntary imagery is no sure measure of the amount of imagery which spontaneously appears in his thinking. We may go still farther and say that the amount of imagery which *appears* in his thinking is not necessarily a measure of the extent to which imagery *functions* in his thinking. For it might very well happen, indeed it is altogether certain, that our associative machinery may bring before the mind many elements which have no function in the thought of the moment, but are only incidents, by-products of the thought process.

An investigation of the spontaneous use of imagery presents greater experimental difficulties than an investigation of voluntary imagery. In the first place, it is difficult to control the

¹Outlines of Psychology, p. 157.

direction of a person's thinking, or even to subject him to observation, without destroying spontaneity and naturalness. And to the degree in which this is done the data returned are rendered unserviceable. Again, the introspective report is considerably harder when the attention has been focussed, not on the imagery, but on the thought itself. These are by no means insuperable difficulties, however, and to eliminate them, or at least greatly to reduce them, only requires greater care and patience on the part of the investigator, and greater skill in introspection on the part of the persons reporting.

The methods used in the second part of this study were chiefly two: (1) The first is the method of interrupted thinking. In tests under this method the subject is pursuing some line of thought without expecting interruption. At a certain point his thought is broken in upon by the investigator, and the subject at once introspects to determine the mental content of the moment preceding the interruption, and makes a report of his findings. (2) The second is the method of setting a definite problem for the subject to solve without interruption, he to describe the course of his mental processes immediately at the completion of the solution. Two variations of this method were employed; in the first, the subject was told, when given the problem, that an introspective report would be called for at the completion of the work, but was strongly urged to give his attention as completely as possible to the working out of the problem. Frequently a speed test or some other form of competition was introduced as a help to concentrated effort. The second variation employed was that of causing the subject to work through the completion of the problem without knowing that he was to be called on for an introspective report, the instructor calling for this report immediately at the close of the solution.

The method of interrupted thinking has been used most extensively, and also probably most successfully by Binet in a long series of studies upon the spontaneous use of imagery.¹ After testing it thoroughly he is satisfied of its value, even when used with children of a dozen years, providing the subjects are properly trained in its use. The essential conditions for successfully employing this mode of test are (1) not to render the subject suspicious by too frequent interruptions, thereby destroying the

¹L'Etude Experimentale de L'Intelligence.

naturalness and spontaneity of his thought; (2) to have him so trained in introspection and so instructed in the requirements of the experiment that immediately upon interruption he will proceed with his introspection without waiting to receive any directions; (3) so to control the thinking that the experiment may be tried under approximately identical conditions with other subjects for verification; and (4) so to control the thinking that the mental processes involved may be typical.

The method of setting a definite mental problem has the advantage of enabling the experimenter better to control the thinking of his subjects, but this very fact causes a loss in spontaneity. If the subject comes to suspect that he is to be questioned at the end of his solution, even if he has not been forewarned, his train of thought is almost sure to be more or less influenced by this suspicion. Two types of this method were used in the experiments which follow: First, that in which the subject was given directions to solve the problem in the quickest, most accurate, and most natural way possible, no other directions or suggestions being made. Then, immediately on the completion of the solution, he was given a list of questions to answer concerning the character of his mental content during the solution. Under the second plan, the subject was told before he was given the problem what the character of the introspection required of him would be, and instructed at the same time to give his mind as completely as possible the solution of the problem until that is fully completed, not pausing to introspect until the answer is reached.

The greatest difficulty in using the set problem method is in avoiding the influence of suggestion. It may be accepted as a rule that inquiry concerning any particular mental element will serve to bring it into unnatural prominence, and hence over-emphasize it. This fact depends on the simplest laws of attention. Careful tests and many personal conferences with the students involved in the following experiments proved beyond any doubt that direct questioning as to the imagery employed in the mental operations introduced the factor of suggestion to such an extent that the imagery phase of the mental content was almost sure to be over-emphasized. The "psychologist's fallacy" finds its counterpart in the constant tendency to refer back to the mental state being examined the images *which are suggested by the questions asked concerning it*. For example, students have frequently testi-

fied that in a series of alternative questions, as, "Did you have before your mind's eye an image of the house (1) perfectly clear and vivid, approximating the reality, or (2) only moderately clear and vivid, as if seen through a mist, or (3) very vague and dim, as seen through the dusk?" they have experienced in succession each of the images suggested in the questions. Similarly, if a person is set to multiply a three-place multiplicand by a three-place multiplier, and is asked after the work is completed, whether he had a visual image of the problem set down ready to multiply, the partial products, etc., he is very likely to get an image of these things *now* at least, and to read it back into the mental state which he is examining unless he is a trained observer, and realizes the force of this tendency.

To save some of these errors, and help train in introspection the following "Guide to Introspection" was given to the students, and they were trained in introspection problems illustrating its use.

A GUIDE FOR INTROSPECTION

In seeking to read what is going on in your mind at any given moment, it will be of assistance to know some of the things which one may expect to find as parts of his mental content. To this end the following groups of mental elements will be suggestive:

1. *Sensory elements*: From sight, hearing, muscles, skin, internal organs, etc.
2. *Feelings of relation*: Feeling of meaning, recognition, thought, etc.
3. *Images*: Visual, auditory, cutaneous, kinaesthetic, etc.
4. *Feelings of effort*: Feeling of compulsion, strain, intention, expectation, attention, etc.
5. *Personal feelings*: Pleasure or displeasure, interest, emotion, cheerfulness, sadness, etc.

It is entirely probable that one will always find his mental state a complex in which more than one of the above groups are represented. In describing his mental state one should mention *all* the elements discernible, explain their nature as far as possible, and tell the order in which they appeared. Be careful not to refer back to a mental state which you are examining any element which may arise in your mind *NOW*, but was not in your mind *THEN*.

It is to be noted that none of these experiments require the observers to testify as to the actual *function* of the imagery in their thinking, but only as to its *presence*. It would be highly desirable to have testimony on the former point, but it is very doubtful whether the testimony of any except the most thoroughly

trained observers would be of any considerable value, and it would probably lead only to speculation on the part of the relatively untrained student. To tell *whether* imagery is present in any given thought content, and if so, what its type, is relatively easy, but to tell just *what* function it is playing is very difficult.

Much light is thrown on the function of imagery, however, by its *character*, the *time* of its appearance, and the fact of its *absence* in the thought content of a certain proportion of persons. For example, if imagery is wholly irrelevant to the object of thought, as when the image of a cross teacher of former days appears before one when he is working out a mental multiplication, it is safe to say that this particular image is not functioning, but is rather a mere concomitant of the thought process, brought into consciousness through association. Likewise, if the imagery appears after the solution is reached, as when, in thinking of the opposite of *cowardly*, the visual image of a soldier appears after the word *brave* has flashed into the mind, it seems fair to conclude that the image played no real part in the mental operation of thinking of the right word, but rather came in as an accident. Also, if it is found that 60% of a group of people carry on a certain thought process without the use of imagery, and do thinking which is equally effective with that of the 40% who report imagery, it leads to the conclusion that not all of the imagery which appeared in the case of the 40% was of real value in their thinking.

If it should further develop that imagery appears in greatest abundance at the points where our thought is baffled, and refuses to flow on in its usual channels, it would seem to mean that abundance of imagery does not go along with the most efficient thinking. Whether the images which appear at the baffled points really function in clearing up the thought, or are only an incident, is a question which would still need to be settled. It would please the imagination to conceive of the images as an army of helpers rushing to the mind's assistance at its points of greatest need. If it should turn out, however, that a large proportion of the images which present themselves at the baffled points are irrelevant to the question which is causing the trouble, then we might be obliged to conclude that they were mere idle on-lookers rendering no assistance, possibly being only in the way. But more of this later in the discussion.

The persons serving as subjects in the experiments which follow were principally two groups of students: One group being members of the writer's classes in educational psychology in the Extension Department of Teachers College; the other group consisted of various classes in psychology in Cornell College. The Teachers College classes were the same as those constituting group III of the first section of this study. These classes had all taken the test of the general questionnaire upon imagery before the tests of this section were given. All but a few were college or normal school graduates, and had had elementary courses in psychology. The tests were all given by the writer personally, and were taken in good spirit and with careful attention by the classes. The Cornell College students were in either the writer's classes or those of a colleague who was thoroughly trained in experimental methods. These students had also all taken the test on imagery provided in the general questionnaire, had read the standard chapters on the subject of imagination, and were fairly well acquainted with introspective method. These classes were not the same as the ones constituting groups I and II of the first section. A few tests were given to classes not included in the above groups. A further description of such classes will be given in connection with the experiments.

Wherever in the following tests the degrees of clearness and vividness are referred to, the scale used, unless otherwise stated, is that of the general questionnaire employed in the last three experiments of Section I. In this scale 1 equals a degree of clearness and vividness matching that of the original experience, 7 means an absence of all imagery, and the intervening members represent so many steps between 1 and 7.

EXPERIMENT I. IMAGERY IN SIMPLE ASSOCIATION

The experiment was made with 52 students in educational psychology in the Extension classes of Teachers College during the winter of 1907-8. All but two or three were teachers in the schools of New York City or vicinity. The test was preceded by a study of imagery and the imagination, by answering the questions of the general imagery tests, and by a short period of practice in thinking of opposites and in the introspection of the mental content concerned therein. The experiment was

given as a class exercise. The instructor pronounced a word, the class being asked to think of the opposite as quickly as possible and to write it down immediately upon its appearance in thought. As soon as the opposite was written down, the student was also to state the nature of the image which appeared, if any, whether it came before or after the opposite, and, finally, the degree of clearness and vividness, 1 standing for very clear and vivid, 2 for moderately clear and vivid, and 3 for very dim and vague. Another word was then pronounced, and so on through the list. The class was urged to think of the opposite as quickly as possible, not troubling in the least about introspection until the opposite was decided upon. Table XIX shows the list of words used, and the results of the experiment.

TABLE XIX. IMAGERY ACCOMPANYING THE THINKING OF OPPOSITES.

Words Used	No answer	No image	Visual image of object	Visual image of word	Image after the opposite	Image before the opposite	Image clear	Image medium	Image dim
Integrity.....	4	33	12	3	12	3	1	7	5
Indolence.....	0	27	33	2	15	10	7	12	6
Veracity.....	0	38	11	3	12	2	4	4	6
Generosity.....	0	20	32	0	20	12	11	11	10
Unless.....	7	25	4	14	12	8	7	8	7
Courageous.....	0	24	25	1	23	5	9	7	12
Sympathetic.....	0	27	19	4	19	6	7	10	8
Haughty.....	0	21	30	1	18	13	11	11	9
Eloquent.....	2	23	23	3	17	10	6	15	6
And.....	2	37	1	12	7	6	8	0	5
Totals.....	15	275	180	43	153	75	71	87	74

Out of a possible 520 opposites 505 were given. Of these 275, or 54% are reported as accompanied by no imagery except that of internal speech, which is not here reported. An aggregate of 230 opposites, or 46%, are reported as accompanied by images. Of these images, all but 7 were visual; 6 being auditory, and 1 kinaesthetic. Of the visual images, 80% were of the objects and 20% of the desired word written or printed before the eyes. Of all the images reported, 67% were reported as coming *after* the

opposite was thought of, and 33% *before* it. Since the images which came after the opposite presumably appeared as appendages instead of having any part in producing it, it follows that, in only one-third of the 46% of the cases in which images accompanied the opposite could the image have been instrumental in suggesting the correct word. That is, in not more than about 15% of the cases could the association have depended in any degree upon imagery. It is seen that the images reported were distributed almost equally among the three degrees of clearness and vividness.

The testimony was quite general that, where one was baffled in thinking of an opposite, a flood of imagery would appear, usually all of it being irrelevant, and that when the word finally appeared it generally came in a flash and could not be accounted for. It seems safe to say that in this test nearly all of the words which came easily came without any imagery preceding them, and that, in the cases in which the imagery preceded the words, much of it was largely irrelevant to the words selected.

This experiment was repeated under as nearly identical conditions as possible with a class of 30 juniors and seniors in Cornell College. The class consisted of 12 men and 18 women. They had had almost precisely the same introductory preparation as the first group. Following is a summary of the results of the experiment.

Out of a possible 300 opposites, 264 were given. Of this number, 135, or 51%, are reported as without imagery except that of internal speech, as in the former group; 129, or 49% were reported as accompanied by images. Of these, slightly more than 90% were visual, the remainder being auditory and kinaesthetic. Of the visual images, 68% were of objects, and 32% of words written or printed. Slightly more than 50% of all the images are reported as appearing *after* the opposite was thought of. Admitting that an image which appears after the word sought could not function in its choice, it is seen that in less than 25% of the cases could imagery have brought about the association of the opposite. That imagery did cause the association in all these cases is not certain, nor even probable. The testimony of this group was strikingly like that of the former group, that the greater part of the images appeared in connection with the words which they found difficult, and frequently had little or no

relevancy. A striking feature in both of these tests is the large proportion of visual imagery reported as compared with the other types.

EXPERIMENT 2. IMAGERY AND THE THINKING OF FAMILIAR OBJECTS

The following experiment, which consisted of three separate tests, was made with 79 sophomores in psychology in Cornell College. The class had studied descriptive psychology for one semester, had had considerable practice in introspection, had filled out the general imagery questionnaire, and had worked numerous problems in imagery. In conducting the first test, one upon visual imagery, the class was given the following instructions:

You will be given ten seconds in which to write down the names of as many things as you can think of in that length of time.

You are to begin when you hear the signal "GO."

The names are to be the names of things you would see lying on the bed of the ocean if all the water in the Atlantic should suddenly dry up,—ready, GO!

As soon as the ten seconds were up, the following questions previously prepared on a screened blackboard were displayed, and the class asked to answer them as carefully and completely as possible.

Answer the following questions for EACH of the names you wrote down:

1. Did there appear before your mind's eye an image of the object which you named? (If so, answer by writing the degree, 1, 2, etc.)

2. If an image of the object appeared, did it come simultaneously with the name, or after the name?

3. Or did you have no image of the object at all, but only *think*, or *remember*, or *know* the name?

Be careful not to confuse an image which may arise in your mind now with what was in your mind when you were thinking of the names.

The following were the results for the visual imagery:

A total of 313 objects were named by the 79 persons, an average of about 4. The average deviation from this average was .76. For those who reported visual images accompanying the names, the average degree of clearness and vividness reported was 3.3, with an average deviation of .86. Out of the 313 objects named, 230, or 73%, were reported as accompanied by visual images, and 83, or 27%, as without images. Of those which were

accompanied by images, 84, or 27%, were reported as having the images come after the names were thought of. Thus, in but 47% of the cases was visual imagery reported as appearing simultaneously with the names of the objects.

There were 11 persons, 14% of the group, who reported no visual images at all. The average number of objects named by this group was 3.6, an average .4 less than that for the whole class.

For the 36 persons who ranked their imagery 3 or better in clearness and vividness, the average number of objects named was 4, or just that of the entire class.

The number of objects written down in the ten seconds is a very doubtful test of the relation of visual imagery to quickness of association, however, for the time taken to write the object down is much longer than the time required to think of it, and the fact that those who reported no imagery did not make quite so good a score as those who reported imagery might equally well mean that visual imagery correlates with speed in writing, which is a very doubtful conclusion.

The more significant facts are that imagery was reported as entirely absent in more than a quarter of the cases, and was reported as coming in after the name in more than another quarter.

In a test upon auditory imagery the following directions were given:

You will be given ten seconds to write down the names of as many things as you can think of in that length of time.

You are to begin when you hear the signal "GO!"

The names you write down are to be the names of the sounds you would hear if you were suddenly transported to the midst of a great city,—ready, GO!

The following questions were then displayed as in the former test:

Now answer the following questions for EACH of the names you wrote down, being careful not to confuse an image which may arise in your mind NOW with what was in your mind when you were writing the words.

1. Did there appear to your mind's ear an image of the sound? (If so, answer by writing the degree, as 1, 2, etc.)

2. If an image appeared, did it come simultaneously with, or after the name?

3. Or did you only *think*, or *remember*, or *know* the name, but have no auditory image?

The summary for the auditory test gives the following results: A total of 273 sounds were named by the 77 persons who took the test. This is an average of about 3.5. The average deviation was .78. Out of the 273 sounds named, 181, or 66%, were reported as accompanied by auditory images, and 92, or 34%, were reported as unaccompanied by auditory images. Of the 181 images reported, 65, or 24% of the whole, were reported as coming after the sound was thought of. In 42% of the aggregate number of sounds named, therefore, were auditory images reported as coming simultaneously with the name of the sound. The auditory images reported averaged 3.3 in vividness and clearness, being just the same as in the visual of the preceding test. The average deviation from this average was .85.

There were 14 persons, or 18% of the class who reported no auditory images at all. The average number of sounds named by this group was less by .1 than the average for the class. There were 38, or 50%, of the class who reported auditory imagery as 3 or better in clearness and vividness. The average number of sounds named by this group was .2 above the average for the class, and .3 better than the average for those who reported no auditory imagery.

The striking thing in this test as in the preceding one is the fact that in fully one-third of the cases no imagery was reported as present, and that in almost two-fifths of the cases in which auditory images accompanied the names of the sounds it came after the name was thought of, evidently coming in only by the accident of association with the name, and having no part in the production of the name in the thought at all.

In a test upon gustatory imagery the same directions were given as before:

You will be given ten seconds to write down the names of as many things as you can think of in that length of time.

You are to begin when you hear the signal "GO!"

The names you write down are to be the names of things you like best to eat,—GO!

The questions to be answered were as follows:

Answer the following questions for EACH of the names you wrote down, being careful not to confuse an image which may arise in your mind now with what was in your mind when you were writing the words.

1. Did there appear in your mind's mouth a taste of the food you named?

2. If an image appeared, did it come simultaneously with the name or after it?

3. Or did you only *think*, or *remember*, or *know* the name, but have no image of the taste?

The summary for the test upon gustatory images shows the following results: A total of 351 objects of taste were named. This is an average of 4.5 for the 78 persons who took the test. The average deviation from this average was 1.2. Gustatory imagery was reported as present in 142 out of the 351 objects thought of, or in 40% of the cases, while in 209 of the objects thought of, or 60% of the cases, gustatory imagery was absent. In 46 instances, or 13% of the whole number of objects thought of, the images were reported as appearing after the name was thought of. In only 27% of the entire number of objects thought of, therefore, did gustatory imagery appear simultaneously with the name.

There were 37 persons, or 47%, who reported no gustatory imagery in connection with any of the instances. The average number of names written down was .1 below the average for the entire class. There were 22 who reported their gustatory imagery as 3 or better in clearness and vividness. The average number of names written down by this group was just the average for the class. The average deviation from this average was .6.

The following table gives a condensed summary of the above results.

	Visual	Auditory	Gustatory
Number of persons taking test.....	79	77	78
Total number of objects named.....	313	273	351
Average number named per person.....	4	3.5	4.5
A. D. from the average.....	.86	.78	1.2
Percentage of persons reporting no images.	14	18	47
Average number objects named by these...	3.6	3.4	4.4
Percentage persons with images reported 3 or better in vividness.....	46	50	27
Average number named by these.....	4	3.7	4.5
Percentage of names accompanied by images.	73	66	40
Percentage of images <i>after</i> names.....	26	24	13
Percentage of images same time with name.	47	42	27

The largest number of names written was of foods, this evidently being the easiest and most familiar association. The smallest number was of the sounds of a city street, with which most of the class were relatively unfamiliar. The smallest percentage of names accompanied by images was in the case of the gustatory, where the number of names written was largest. This would seem to indicate that in the more familiar associations imagery tends to fall out, although the general deficiency of gustatory imagery as compared with visual and auditory probably also has its influence. It is true that the visual terms have a larger percentage of images accompanying than the auditory, but this is probably to be accounted for by the general preponderance of visual imagery in our thinking. It is also seen that in the case of gustatory imagery, the image appeared following the name in a larger percentage of cases than in either auditory or visual. This would reduce the relative rank of gustatory imagery still more. Taking the average of the three tests, imagery was reported as appearing simultaneously with the names thought of in 39% of the cases. This seems to mean that in at least three-fifths of all the cases the name was thought of without any reference to imagery. It should be noted that the classes were instructed not to report any imagery other than the type called for in each case; that is, in reporting the gustatory images, no account was to be taken of visual images of the foods, etc.

EXPERIMENT 3. IMAGERY AND SELECTIVE THINKING

This experiment was made with 19 students in educational psychology in the Extension classes at Teachers College. The class consisted almost wholly of normal school and college graduates, and all had had some training in introspection. All were teachers in New York or vicinity.

The class had been reading and discussing the section on "Capacities" in Thorndike's "Elements of Psychology." At the close of the discussion, the instructor said, "Now will each of you think of five capacities in which you excel." The class understood that this was preparatory to writing out the list and handing it in to the instructor. But, after allowing 75 seconds, he gave the second direction, "Instead of writing the list of your capacities, write down an account of your mental processes while deciding

upon the five capacities." The class had had exercises previously in introspection of interrupted thinking, and knew what was expected of them. They were familiar with the "Guide for Introspection," and gave their replies largely under the heads suggested there.

The replies were fairly complete and explicit. Of the five groups of mental content used, viz., sensory; feelings of relation, meaning, etc.; imagery; feelings of effort, attention, etc.; and personal feelings, such as interest, etc., none was omitted entirely. Mental elements from all five groups were described by 8 persons; from four groups by 6 persons; from three groups by 4 persons; from two groups by 1 person.

The number of persons describing sensory elements was 16; elements of relation and meaning, 17; imagery, 15; feelings of effort, strain, and attention, 17; various personal feelings, 16. It is seen, therefore, that out of 19 persons, 15 reported imagery as a part of the mental content. Imagery constitutes less than one-fifth of the mental elements described by all the class. In the fifteen cases of imagery described, 9 or 60%, were of such nature to be of possible relevancy; 6, or 40%, seemed to be wholly irrelevant. The nature of the problem set the class in this experiment is such as to cause some indecision and hesitancy in the thinking. The relatively large number who experienced imagery as a part of the mental content may have been due in part to this fact. There follow two abbreviated samples of the replies selected at random:

1. The murmur and rustle of the class; someone passing in the hall; surprise and bewilderment at the question; a comprehension of its meaning, and my relation to it; visual image of school I attended as a boy; dim image of self riding a horse; the thought of certain of my capacities, from among which I selected the best; a feeling of concentration and attention; feelings of interest in the matter, and finally, of pleasure as I selected the capacities asked for.

2. A feeling of bewilderment and blankness for a moment; then comprehension of the meaning of the question; indecision; accompanied by a sense of necessity, or compulsion to select the five capacities asked for; visual and auditory percepts from the class; cold toes, and a cramped hand; visual image of myself as a little girl in a spelling class; interest in the question, yet disappointment both with the question and my list of capacities.

Summary of all the images mentioned:

Visual image of self working mathematics, writing, and sewing. Visual and motor image of myself doing certain things. Visual and auditory image of school principal where I used to attend school. Visual image of school house where I attended as a boy. Visual and muscular image of self sewing. Visual image of myself teaching history, and riding on horseback. The visual image of a teacher where I once attended school. Image, visual and muscular, of myself sewing. Image of columns of words I used to spell, also of books I used to read. Visual image of myself as a little girl in a spelling class. Visual and auditory image of a friend speaking of one of my capacities. Visual and muscular image of myself performing certain tasks. Visual and auditory image of my primary class learning the figure 4 on the blackboard. Visual image of piano, and some drawings. Visual and auditory images of the names of the capacities I had decided upon.

After reading the descriptions of the images one is still more impressed with the purely incidental nature of very many of them.

EXPERIMENT 4. IMAGERY IN CONTROLLED THINKING

The following experiment was made with 25 members of an Extension class in educational psychology at Teachers College. The class had been studying the subject of "Instinct," and discussing it during the class hour. Near the close of the hour, the instructor, as if entering upon a summary of the discussion, said: "To sum up. We may look upon instinct, then, as the habits of the race, which enable the individual to begin his life progress where the race left off." Immediately at the close of this sentence the class were asked to write a description of their mental content. The class had had previous experience in the introspection of interrupted thinking, and knew what was expected of them. Their replies were grouped under the five heads of the "Guide for Introspection," with which they were familiar. In most instances the replies showed fair ability in introspection, and care in description.

All of the five groups of mental content referred to in the blank were included in the replies. Mental elements from all the groups were described by 4 persons; from four groups by 19 persons; from three groups by 2 persons. No one referred to fewer than three groups.

The number of persons describing sensory elements as a part of the mental content was 25; feeling of relation, meaning, etc., 25; imagery, 8; feelings of strain, attention, etc., 23; personal feelings, as of interest, mood, etc., 20. In this summary imagery constitutes only 8% of the elements of mental content described. Of the eight images mentioned, six were of illustrations just used in the lesson of the hour. There seemed to be but little relevancy in most of them. The images described were as follows:

Visual image of a boy previously used as an illustration. Visual image of a test question on the blackboard, which had contained a similar thought. Vague visual images of a column of men marching. A visual image of a wagon previously used as an illustration. Visual image of a drawing just used as an illustration. Visual image of a wagon formerly used in an illustration. Visual image of a sentence written on the blackboard a few minutes before. Visual and muscular image of myself writing note.

The following condensed summaries represent fairly the type of introspective accounts received.

1. I was conscious of the form and voice of the speaker; of a gust of wind from an open window; consciously related thought expressed to one previously stated; feeling of expectation of a longer summary; feeling of compulsion to understand the summary; a feeling of general cheerfulness and satisfaction interrupted by a flash of worry over an examination of the preceding hour; a feeling of assent to the truth stated.

2. I was conscious of a certain quality in the instructor's voice; also heard sounds from the street; the chief thing, however, was a feeling of meaning, or comprehension of the truth stated in the summary; a feeling of pleasure and mastery that I had grasped the thought and understood it perfectly.

3. I noticed the voice of the speaker and a piece of paper in his hand; felt a grasp of the meaning, and the relation to a discussion recently had at home; an image of a wagon used in an illustration;—a feeling of effort and concentration; interest in what it was all to lead to.

Here again the imagery seems almost purely incidental. Almost no imagery appeared, and what little there was strikes one as being of small relevancy. Feelings of comprehension, of meaning, of relation, of the strain of attention, together with the affective tone, seem to have constituted practically all of the mental content of the moment.

EXPERIMENT 5. IMAGERY AND CONCEPTS

This experiment was made with 23 students in elementary psychology in the Extension classes in Teachers College. The class had answered the questions in the general imagery blank, and had had other training in introspection. The words *religion*, *youth*, *happiness*, *animal*, and *mankind* were given, one at a time, with the direction to write immediately the best definition which could be put in a sentence or two. Immediately upon completing a definition, as full a description as possible of the mental content during the formation of the definition was to be written before the next was to be taken up. Emphasis was put on the necessity of giving full and undivided attention to the definition without troubling about the mental content until the definition was completed.

The definitions given were reasonably full and explicit, and ranked high in thought and insight. The descriptions of the mental content also showed care, and a good degree of ability in introspection. The list of mental elements mentioned included various sensory processes, feelings of strain, compulsion, doubt, certainty, meaning, interest, indifference, pleasure, repugnance, headache, fatigue, etc., in addition to imagery.

Only three persons out of the twenty-three reported images in connection with all five of the definitions. For the aggregate of the 115 definitions, 40, or 35%, were reported as having been formulated without images. No account was taken of how many of the cases reporting images experienced the image after the thought instead of before it or in connection with it. It is entirely certain, however, from the other experiments, that this number would be large. About 20% of the images reported appear to be clearly irrelevant, as when the visual or auditory image of the word to be defined presents itself, or when the image of the dinner table ready for the meal appears, or the visual image of the teacher of zoology arises, in connection with the definition of "animal." In not more than 50% of the cases does it seem that imagery could possibly have played any part in the mental process of arriving at the definition, in so far as the introspective accounts are to be trusted. Whether imagery actually played a vital part in the other 50% of the cases, or only accompanied the mental processes as a by-product, the experiment does not, of course, reveal.

The following is a summary of the images as reported for each word. (Where the same image is mentioned by several persons, it is not repeated in the list.)

Religion.—Visual image of men bowing before idols. Auditory image of the word "religion." Visual image of priest and idols. Dim image of persons kneeling. Visual image of the word "religion." Image of the word "creed," and also of a church. Visual image of a Christian and a pagan at worship. Visual image of an African. Visual and auditory images of certain speakers. Visual image of people on way to church.

Youth.—Visual image of children frolicking. Images of people. Visual image of group of girls seen just a moment before. Vague image of a certain person. Visual image of the word "youth." Visual image of a child and a plant. Image of young men and women. Image of a school at recess. Visual image of bright sunshine and flowers. Visual image of group of young people, and also of old people. Image of a boy of sixteen. Image of a spring day.

Animal.—Visual image of a terrier. Visual image of birds and also of men. Visual image of small sea animals seen in an aquarium. Visual image of a cat, a dog, a monkey, and a horse. Visual image of the word "animal." Vague image of a multitude of people. Visual image of a picture of a diver going after sponges. Visual image of an amoeba as seen under a microscope, and of my zoology teacher.

Happiness.—Visual image of people showing various moods. Visual image of the word "happiness." Visual image of a light-haired girl. Vague images of happy people. Vague image of Rasselas. Visual image of a happy face. Image of children at play. Visual image of a certain acquaintance. Visual image of a certain classroom where I was a student.

Mankind.—Image of old geography pictures. Auditory image of yells at Harvard. Vague image of women and children. Visual image of watching process of making a composite photograph. Image of a mass of moving men. Visual image of the psychology class.

It would seem to be clear that in so far as the image functions at all in concepts, it occupies a minor roll, for there is a very wide range of imagery reported for these concepts, while the meanings were much the same for the different persons defining the terms. The truth probably is, that with reasonably familiar concepts, at least, the image tends to drop out, leaving the meaning only. Indeed, the clearness and usability of a concept seems to depend on the extent to which imagery is eliminated or kept in the back-

ground, instead of depending on the presence of much imagery. For whatever may be the outcome of the *a priori* reasoning about "generic" images, the introspective testimony is to the effect that all images, even those accompanying concepts of the most abstract nature, are of specific objects, while the meaning of the concept must be general.

The fallacy of measuring concepts by the imagery which accompanies them is illustrated in Miss Wiltse's study of the conceptual imagery of Boston high school boys.¹ Her test took in 113 boys from 13 to 18 years of age. The test consisted in writing on the blackboard, one word at a time, eleven different words, and asking the boys to write down immediately the first thought or image which these words suggested. The words were, Being, The infinite, Abstraction, Literature, Number, Coldness, Horror, Play, Heat, Faith, Fun. She says that the answers were colored very much by local occurrences. There had just been a railway accident which gave many of the images on the word *horror*. A recent study in Scott had left its mark on the images from *literature*. She found on the whole that the images evoked were largely of the sense kind, with very few attempts at abstraction or logical definition. Her conclusion was as follows: "Children up to these ages (13-18 years) show few traces of any other kind of knowledge (than "mere sense knowledge"), but think mainly in visual pictures, their mental life being chiefly made up of imagination and memory of their personal experiences. Logical definitions are never attempted."

Doubting whether so sweeping a generalization should be made on a test of this character, the writer took the same list of words and made the test on 22 University of Chicago students, most of whom were in the graduate school working in the department of philosophy. As might be expected, the test resulted in as large a proportion of images showing "mere sense knowledge" on the part of the university students as Miss Wiltse received from her high school boys. My record contained in all 228 answers, of which 213 referred to sense images of one class or another. Only 15 of the answers referred to something abstract or indefinite as being the *first* thing which appeared in consciousness. Either the students in the department of philosophy in the University of Chicago "show few traces of any other kind of knowledge than

¹*Am. Jour. of Psych.*, Vol. III., p. 147.

mere sense knowledge and think mainly in visual pictures, their mental life being made up chiefly of imagination, and memory of their own personal experiences, with no attempt at logical definition," or else there is something wrong with this kind of a test as a means of discovering the nature and scope of one's conceptual furnishings. In both of these tests the imagery reported was for the most part irrelevant, and seemed but to illustrate the activity of the associative machinery in attaching imagery to any recent or vivid experience, or throwing it into a breach in our thought made by the mental stream being temporarily balked or baffled.

EXPERIMENT 6. IMAGERY IN LOGICAL THINKING

The experiment was made with 27 teachers in the Extension class in educational psychology at Teachers College.

The following question was propounded to the class: Should the death sentence ever be inflicted? The class had already had some exercises of this kind, and had been instructed first of all to answer the question, Yes or No, stating briefly the reasons for their conclusion, and then immediately write an introspective account of their mental processes during the time they were reasoning upon the question. Care was exercised that the thinking of the class should be as natural as possible; that is, that the attention should be centered completely on the solution of the problem until an answer was reached, and not be distracted by the thought of the required introspection which was to follow.

Of the 27 in the group, 16 answered the question as to the death sentence in the affirmative and 11 in the negative. All but two gave fairly clear and detailed descriptions of their logical processes, images, and feelings involved in reaching their conclusions. Those reporting images were divided about equally between affirmative and negative replies. The two examples given below are fair samples of the replies:

Yes. The safety of society demands it; there is no valid reason why it should not be done; it is not forbidden either by reason or revelation.

Introspection: The answer Yes was decided upon almost immediately, for this presented itself as soon as I had comprehended the question, and immediately felt "fit." When I came to think of the reasons, the thought of society immediately presented itself,

and with this a very vague and dim visual image of people, chiefly women, dressed in dark clothing. A feeling of sympathy came when I thought of mercy, and a feeling of God, when I thought of revelation. Vague images of the words used came from time to time, especially when I paused on a word, or when I hesitated what word to use. A general feeling of somberness pervaded the whole thought. After the reasoning really got under way no images came except images of words, both visual and auditory, and perhaps motor, as from speaking them.

Yes, Because there are some who have so outraged society as to have forfeited their right to live. Also because capital punishment is the only sure prevention of repeated crime by the same person, and because it deters others from like offenses.

Introspection: I first had a rather vague visual image of a person hanging, and also a rather clear image of a miniature gallows which I once saw. My mind then seemed almost a complete blank, except for a feeling of compulsion to write my reasons. The memory of the Thaw and Bradley case arose for an instant, with a slight visual image of Thaw. This faded at once, and I had a feeling of trying to inhibit irrelevant thoughts, and to pin my mind down to reasons. The first reason presented itself without images, but with a feeling of comprehension, or meaning of "society." As the second reason came to mind, I had a fleeting idea of ways in which prisoners for life might be freed in spite of all precautions. The third reason was the most important of all. That is as far as I can recall it.

Out of the 27 persons, 12 reported visual images, 19 images being described in all. No images but visual were mentioned. Out of all the images described, it is hard to see how more than about half of them are in any way relevant to the question under consideration. Following is a list of all the images mentioned:

Visual image of words Yes and No. Image of a page in a book which discusses this question. Auditory image of brother's voice discussing this question. Visual image of a book describing life of prisoners. Very vague image of a death chair and a guillotine. Faint image of Hudson river at Sing Sing. Faint image of an electric chair. Visual image of group discussing this question recently. Vague visual image of different modes of death punishment. Visual images of characters in present Thaw case. Image of group of teachers at a table discussing school punishments. Visual image of words "a life for a life," and "Thou shalt not kill." Image of words, "An eye for an eye and a tooth for a tooth." Image of a man about to strike a blow. Visual image of Yes. Visual image of a room filled with convicts. Very vague image of people in reckless attitude toward law. Clear

image of a stake I once saw where a negro had recently been burned.

EXPERIMENT 7. IMAGERY IN THE SIMPLER FORMS OF THINKING

The three experiments which follow were made with 28 senior students in psychology in Cornell College. They had pursued an elementary course in psychology, had answered the questions of the general questionnaire on imagery, and had had some additional training and practice in introspection. The problems of the experiment were given as a part of the regular class exercises, and the questions were seemingly all answered seriously and with care. Each student was given a sheet of paper with the problem and the questions typewritten upon it. The sheet was so folded that the questions concerning the imagery were not seen until the problem was solved. As soon as this was done the sheet was turned, and the questions upon the imagery answered. Following are the problems and questions, and a summary of the replies.

1. A squirrel is clinging to one side of a tree, and a man is standing opposite on the other side of the tree. The man walks around the tree, but the squirrel also moves around the tree, so as to keep just out of the man's sight. They continue this movement until each has gone entirely around the tree. Has the man gone around the squirrel,

a. In the sense of having been in front, behind, and on both sides of him?

b. In the sense of having been east, west, north and south of him?

Now recall carefully the images, if any, which came before your mind as you were thinking out your answer, and indicate the degree of clearness and vividness by using the numbers employed in the general questionnaire:

a. Of the squirrel. b. Of the tree. c. Of the man.

All of the class reported images of the squirrel and the tree, and all but 6 images of the man also. Several of these six spoke of themselves taking the place of the man, and moving around the tree watching the squirrel. The degree of clearness and vividness runs from 1 to 5, and averages 3. Several spoke of localizing the problem on the college campus. The striking thing in the result of this problem is the large number of images reported as compared with certain of the other problems. The question arises in this connection whether imagery does not have a tendency to appear chiefly at the places where percepts would be of service in the solution of the problem.

2. A three-inch cube, painted red, is sawed into inch cubes.

a. How many of the inch cubes have paint on three faces? b. How many on two faces? c. How many on one face? d. How many have no paint on them?

Now describe the images, if any, which came before your mind in thinking out the answers, indicating the following particulars, with the degree of clearness and vividness, using the numbers employed in the general questionnaire:

a. The exact shade and brightness of the red. b. The form and outline of the cube as a whole. c. The faces of the cube invisible from a single view. d. The scratches made in the paint by the sawing. e. The actual size of the cube, and its distance and direction from you as you look at it.

The replies indicate that visual images accompanied the solution to a large extent. All but four out of the twenty-eight reported visual images for three or more of the five points of the questions. Three of those who reported visual images used a wood-colored cube instead of a red one. The average degree of clearness and vividness averaged slightly under 3, and ran from 1 to 6. All but two gave in correct answers for the respective numbers of cubes with paint on the various faces. These two reported images of medium degree of clearness and vividness. However, 16 out of the 28 had made one or more corrections on their papers after the first answers were put down, probably indicating correction by computation. The following are fair samples of the explanations which accompanied the papers.

I saw the cube before me, but computed in part. Used visual and kinaesthetic images, taking the cube apart. Saw the cube clearly, but turned it about to see other sides. Saw all parts clearly, the cube seemed to fall apart. Image of blocks formerly used, no paint, no scratches. Saw the side and top clearly, had to compute the other parts. Saw the cube as if it stood before me.

3. Multiply mentally $X + Y$ by $2X + Y$, and write down the product after you have it all complete.

Now recall carefully the character of the images, if any, which came before your mind in the solution, and describe them as to their degrees of clearness and vividness according to the numbers used in the general questionnaire:

a. Visual image of the problem set down ready to multiply. b. Visual image of the product of the first multiplication. c. Visual image of the product of the second multiplication. d. Visual image of the product complete. e. Any other kinds of images which may have appeared.

All but two of the class got the correct answer. The time employed ranged from 10 seconds to 100 seconds, and averaged

about 63 seconds. Out of the 28, 10 had visual images of the problem set down only, or else had no visual imagery at all. One reported a visual image of the formula to be used, but no imagery used in the solution. The other 17 reported visual imagery used in a part or all of the multiplications, though several remarked that it did not seem to help much. Nearly half reported kinaesthetic imagery in the organs of speech, or in the hand as from writing the problem down. Three reported auditory imagery of a voice speaking the processes. There was no correlation between imagery and speed of solution. The degrees of clearness ranged from 1 to 6, and averaged a little less than 3. Samples of the explanatory notes which accompanied the replies follow.

I saw the problem as it would look on a printed page; the image seemed clear, yet did not seem to figure much in the solution. The kinaesthetic images in the organs of speech were very vivid. I just seemed to repeat the computations in my mind. Both visual and auditory imagery seemed to accompany the solution. Imaged the problem set down, then saw no more imagery until I had reached the product, when that appeared before me. Used no imagery. Saw problem set down only, used no other imagery. Saw each part clearly. Heard my own voice saying the words. Saw parts in visual images, but too vague to be of service. Just thought it out and remembered the products, no imagery.

It is seen that 35% of the class reported no imagery, except that of internal speech, accompanying the solution. The fact that 35% of the cases made the solution without the use of imagery, and made as good a record in accuracy and speed as was made by those who reported the presence of imagery, makes one seriously question whether the accompanying imagery may not have been an incident rather than a necessary factor in the solution in many of the other cases as well.

EXPERIMENT 8. IMAGERY IN MENTAL MULTIPLICATIONS

This experiment was conducted in conjunction with an experiment made by Professor E. L. Thorndike with his graduate class in educational psychology in testing the effect of practice in arithmetical multiplications.¹ After a short preliminary training, 33 individuals multiplied mentally from 50 to 96 three-place multi-

¹The Effect of Practice in the Case of a Purely Intellectual Function. *Am. Jour. of Psych.*, Vol. 19, p. 374.

plicands by three-place multipliers. Of the 33 individuals, 1 did only 50, 1 only 60, 1 only 66, 1 only 75, 1 only 85 examples. The remaining 28 did 96 each. As a rule, 5 or 6 examples were done per day.

The following method was followed in working the examples. At the time set and recorded for beginning the example, it was taken up and looked at long enough to fix the two numbers in memory so well that they could be easily repeated without further reference to the paper. The paper was then laid aside, and no sensory aids were used. When the full answer was reached it was written down and the time recorded when the last figure was completed. No directions or suggestions were given as to how the mental operations should be carried out, each individual being left to use whatever method suited him. The subject of imagery was not mentioned until the series had been completed. Then each individual was asked to answer the following questions given the class in the form of a questionnaire.

Please answer the following questions with regard to the mental operations involved in the solution of the problems upon which you have been engaged in the experiment. Read the questions all through before you begin to answer, and do not confuse what you have in your mind NOW as you think about it with what was in your mind as you worked the problem.

Did you have before your mind's eye a visual image of the problem?

1. Which you used in performing each individual multiplication?
2. By which you saw each partial product written down?
3. By which you saw all the partial products ready to add?
4. By which you added to secure the complete product?
5. By which you saw the answer so complete that you could read it off?

Or did you not use visual images at all in your solutions, but *only say to yourself, or hear, or feel, or know, or remember* the various figures, products, etc.?

If you used visual imagery in your solutions, were the images perfectly clear and vivid, or only moderately clear and vivid, or vague and dim?

Can you tell whether, in general, the visual images were most likely to appear in the problems or parts of problems which were the hardest, or the easiest for you?

Can you tell whether, as the series went on, visual images became more frequent or less frequent?

A summary of the replies to these questions shows the following results. There were 13 of the 33, or 39% who reported visual images in some degree. The remaining 20 reported no visual imagery employed, except a few who spoke of a slight tendency

to visualize the original example. One said he tried images at first but gave it up. Another said he had a tendency at first to visualize the hardest points, but did not find it serviceable, and gave it up. Of the 13 who reported visual images, none reported them as perfectly clear and vivid; 8 reported them as moderately clear and vivid; and 5 reported them as vague and dim. Of the 13 reporting visual images, 3 could see no difference in the tendency of the image to appear at the hardest or the easiest points. Of the remaining 10, half thought the images appeared most frequently at the hardest points, and half thought they appeared most frequently at the easiest points. Nine reported that the use of images decreased as the series went on; 3 reported an increase; and 1 could see no change.

Quoting Thorndike's conclusion,—“There is apparently a slight negative relationship (of improvement through practice) with the vividness and fidelity of visual images of the numbers, partial products, etc. The proportions of those of strong and weak visual images were closely the same in those improving much and those improving little. Of the few cases who reported increase or decrease in the strength of the visual images during the course of practice, those who reported a decrease improved somewhat more.”

The thing which impresses one most in this report is that more than three-fifths of the persons in the test reported an entire absence of visual imagery in connection with the whole series. It would seem that the associative processes required in mathematical computations of this sort need not, with most minds, depend in any considerable degree on visual images. This may mean that the emphasis upon visualization urged by many teachers of arithmetic is altogether misplaced.

EXPERIMENT 9. IMAGERY AND THE DISCRIMINATION OF LENGTH OF LINES, THE PITCH OF TONES, AND SHADES OF GRAYS

The class with whom this experiment was made consisted of 83 sophomores in psychology at Cornell College. The class understood thoroughly the nature of imagery, and had had considerable training in introspection before these tests were taken. The tests were taken on three different days, and great care was exercised to secure unbiased and accurate results. The object was to discover what relation imagery bears to discrimination of length of lines,

pitch of tones, and shades of gray, and also the correlation between the types of imagery used in these lines of discrimination.

1. *Discrimination of the Length of Lines*

Each student was given a sheet of paper on which were printed 15 lines varying from 100 to 110 millimeters in length, and was also given a slip of paper on which was printed a line of 100 millimeters, called the "standard" line, the length of which was told to the class.

The method of conducting the experiment was as follows: The student was given five seconds to look at the standard line, he then laid it face down on the table, and waited while the time-marker counted off 10 seconds. He then looked at line number 1 of the series, decided upon and wrote down its length, and immediately stated also the extent to which visual images of the standard line were present in deciding the length of the line under consideration. The degree of vividness and clearness of the imagery was indicated by the numbers 1-7 as indicated for the general questionnaire, 1 meaning the highest degree, and 7 meaning that no image appeared. This process was repeated for each of the 15 lines. At another class meeting the experiment was repeated, making 30 judgments in all for each student.

In computing the results the average amount of error in millimeters for the 30 judgments was found for each student, and also the average of his marks in imagery. The average error in millimeters for the class was 3.8 with an average deviation of 1.1. The average mark for visual imagery was 4.7 (a little better than "vague and dim"). There were 21 cases who reported no imagery used, the average error in millimeters for this group being 3.6, or .2 better than that for the entire class. There were 23 who reported visual imagery of the degree of 4 or better. The average error in millimeters for this group was 3.2, or .6 better than the average for the class, and .4 better than that for those who reported no imagery. Thus it would seem that those who report the better visual imagery and those who report an absence of imagery are both better in discrimination of the lengths than those whose imagery is of a poor grade in vividness and clearness. The method of the percentage of unlike signs shows an absence of correlation between ability in visual imagery and the discrimination of line lengths.

The differences are too small, and the number tested too few to draw any final conclusions in favor of visual imagery in this type of discrimination. Indeed the precise quantitative differences in the amount of error shown by those good in imagery, and those using no imagery are not the most important thing. The striking thing is that no correlation appears between ability in visual imagery and ability to discriminate lengths from a remembered standard as shown by the class as a whole, and also that 27% of the group reported no visual imagery employed, and yet made approximately as good a record as those who reported the best imagery, and a better record than those who reported imagery of an inferior class in vividness and clearness. Thorndike and Woodworth decided that a mental standard once established for lines or surfaces serves better than an objective standard.¹ The results of this experiment would seem to indicate that this mental standard may equally be an unconscious one, a certain "set" or habit of the brain, instead of a conscious one such as imagery. This conclusion is also in accord with the law of the mind's economy in transferring adaptive reactions as rapidly as possible from the field of consciousness to that of habit.

2. *Discrimination of the Pitch of Tones*

The persons taking this experiment were the same as those in the preceding experiment. The tones used were those from a set of 13 miniature organ pipes blown by the breath, and representing, by half steps, the octave ascending from middle C as follows: C, C*, D, D*, E, F, F*, G, G*, A, A*, B, C. These letters of the scale were also numbered from 1 to 13, and the letters and their corresponding numbers placed on a chart before the class. The class was then given a short practice in discrimination of the tones of the scale. After this preliminary exercise, the experiment proceeded as follows: A note was blown on a pipe and the class told what it was. After an interval of 15 seconds, a second tone was blown, upon which each was to write down immediately what he judged the tone to be, and also state the character of his auditory imagery, and of the kinaesthetic imagery connected with the vocal organs. The following were the 30 pairs of tones used, the first of each pair being the standard or test tone given, and

¹*Psych. Rev.*, Vol. VIII.

the second the tone to be estimated: 6-8; 5-7; 8-12; 7-9; 10-8; 3-3; 1-2; 3-6; 9-11; 5-8; 8-6; 7-5; 12-12; 9-7; 8-10; 1-3; 2-1; 6-3; 11-9; 8-5; 13-11; 12-10; 9-7; 6-6; 5-6; 4-2; 1-5; 5-8; 8-4; 10-13.

The errors were computed in half-steps. The degree of clearness and vividness of imagery was expressed by the use of the numbers 1-7, as in the general questionnaire, with which the class were familiar.

The average error in half-steps for the class was .75, the average deviation from this average being .36. All but 12 of the class had studied music. About half had had the public school course only, and the remainder had studied in advance of this from one term to two or three years. The average error for those who had not studied music was .83 of a half-step, or .08 of a half-step higher than for the group as a whole. There were only 6 who reported absolutely no auditory or kinaesthetic imagery. The average error for this small group was .74 of a half-step, of .01 better than the record for the whole class. All but 6 report some use of auditory imagery. Almost half of the class, 39, reported no kinaesthetic imagery. The average error for this group exceeds that for the class, being .87 of a half-step.

The average degree of vividness and clearness reported was 4.1 for the auditory images, and 5.7 for the kinaesthetic.

There were 18 persons who reported themselves as 3 or better in auditory imagery of the tones. The average error for this group was but .56 of a half-step, or only 76% as great as for the entire class. There were 9 persons who reported themselves as 3 or better in kinaesthetic imagery. Their average error was but .50 of a half-step, or 67% as great as for the class. The correlation between accuracy of tone discrimination in this test and clearness and vividness of auditory imagery was +.19; between accuracy of tone discrimination and kinaesthetic imagery, +.38.

So far as the auditory imagery is concerned the results agree with those of the preceding test in showing the best record for those who reported no imagery.¹ and for those who reported a high degree of vividness and clearness in their imagery. This statement does not seem to hold for the absence of kinaesthetic imagery, whose presence seems more closely related to accuracy

¹Cf. Whipple, Discrimination of Clangs and Tones, *Am. Jour. of Psych.*, Vol. 13, p. 261 ff.

of tone discrimination than auditory imagery. It is to be noted that while visual imagery was absent in 27% of the cases in the discrimination of length of lines, auditory imagery was lacking in less than 8% of the tone discrimination.

3. *Discrimination of Shades of Gray*

Those taking this test were the same as in the two preceding tests. The shades of gray used were made by mixing standard black and white discs on an electric color-mixer. The class were given a series of practice exercises in determining the percents of black in mixtures ranging from 5% black to 95% black, no difference used being less than 5% from the preceding one. The experiment was conducted as follows: A gray of a certain per cent black was shown the class, they being told what per cent of black it contained. After an interval of 15 seconds another gray was shown them in which they were to judge the percent of black, writing it down on paper. Immediately upon writing down their judgment they proceeded to describe their visual imagery of the first of the pair of grays, if any appeared, expressing the degree of clearness and vividness in the numbers of the key, 1-7, as already described. The experiment then proceeded to another pair of grays in the same way, continuing until 30 judgments had been recorded during two different class meetings. The class was told that the per cents of black used would always be a multiple of 5. As a matter of fact, the largest difference employed in any pair was 20%, and the smallest 5%, the differences most often being 10% or 15% either above or below the first one of the pair. The errors were computed in per cents.

The results show that the average error for the entire class was 4.6%. The average deviation from this average was 1.0. The average degree of clearness and vividness of visual imagery was 5.6 for the class, the lowest of this series of tests except the kinaesthetic imagery in the preceding test. There were 30 who reported an entire absence of visual imagery. The average error for this group was 4.4, or .2 better than the average for the class as a whole. There were 14 persons who reported their visual imagery as 4 or better in the degree of vividness and clearness. The average error for this group was 4.3, or .3 better than the average for the class, and .1 better than the average for those

who reported no imagery. Here again, then, we see the score of those who report no imagery at all better than that of those who report mediocre or poor imagery. It is seen that while visual imagery was reported as absent in 27% of the cases in the discrimination of line lengths, it was reported as absent in about 40% of the cases in the discrimination of grays.

The following are the correlations shown in these experiments, as computed on the basis of the percentage of unlike signed pairs.

Errors in line discrimination with errors in tone discrimination . . . . .	.21
Errors in line discrimination with errors in discrimination of grays . .	.18
Errors in tone discrimination with errors in discrimination of grays .	.02
Visual imagery with accuracy in line discrimination . . . . .	.00
Visual imagery with accuracy in discrimination of grays . . . . .	.15
Auditory imagery with accuracy in tone discrimination . . . . .	.19
Kinaesthetic imagery with accuracy in tone discrimination . . . . .	.38
Visual imagery for lines; with visual imagery for grays . . . . .	.31
Visual imagery for lines with auditory imagery for tones . . . . .	.28
Visual imagery for lines with kinaesthetic imagery for tones . . . . .	.13
Visual imagery for grays with kinaesthetic imagery for tones . . . . .	.40
Visual imagery for grays with auditory imagery for tones . . . . .	.46
Auditory imagery for tones with kinaesthetic imagery for tones . . . .	.19

Table XX gives in detail the average of errors and of imagery for each individual in the class. Column I represents the different individuals; II, the average error for each in millimeters in the discrimination of line lengths; III, the average of each in visual imagery involved in the discrimination of line lengths; IV, the average error of each in half-steps in the discrimination of tones; V, the average of each in auditory imagery in tone discrimination; VI, the average of each in kinaesthetic imagery in tone discrimination; VII, the average error for each in percents in the discrimination of the amount of black in a series of grays; VIII, the average of each in the visual imagery employed in the discrimination of the series of grays.

TABLE XX. COMPARISON OF ABILITY IN IMAGERY AND ABILITY IN DISCRIMINATION OF LENGTHS OF LINES, SHADES OF GRAY, AND PITCHES OF TONES IN THE CASE OF 83 CORNELL COLLEGE STUDENTS.

Individual	Average error (in mm)	Average degree of visual imagery	Average error (in half-tones)	Average degree of auditory imagery	Average degree of kinaesthetic imagery	Average error (in percentage of blacks)	Average degree of visual imagery
1.....	3.1	6.7	.87	5.2	7.0	4.3	5.6
2.....	3.9	7.0	1.50	4.7	6.1	4.3	7.0
3.....	5.3	7.0	.43	5.1	5.1	5.6	4.5
4.....			.60	3.7	7.0	6.5	4.5
5.....			1.90	6.4	3.3	4.0	5.0
6.....	2.4	3.5	.73	3.9	4.3	3.1	3.0
7.....	1.8	4.3	.23	3.2	3.6	3.6	3.3
8.....	7.4	6.0	.50	2.0	2.2	3.3	2.6
9.....	3.1	5.0	1.66	2.0	2.0	5.5	4.3
10.....	3.1	7.0				4.3	7.0
11.....	2.2	2.0	.90	7.0	7.0	3.5	7.0
12.....	4.2	4.0	.83	3.1	7.0	2.5	7.0
13.....	4.1	4.1	1.16	3.5	7.0	5.8	4.0
14.....	1.8	3.5	1.00	3.2	7.0	4.8	6.4
15.....	2.8	2.0	.97	3.7	3.5	2.6	4.4
16.....	1.8	2.4	.67	3.0	3.3	3.5	5.6
17.....	2.6	4.3	.57	3.3	5.4	4.5	5.5
18.....	3.3	6.0					
19.....	3.6	2.8	.67	4.2	4.7	4.5	2.5
20.....	2.6	2.8	1.33	4.5	6.0	5.2	3.2
21.....	3.4	3.0	.54	3.2	7.0	4.3	3.6
22.....	1.7	4.1	.70	5.3	6.6	3.3	7.0
23.....	2.1	3.4	.67	7.0	7.0	3.0	4.6
24.....	1.9	2.5	.20	7.0	7.0	3.3	3.0
25.....	2.4	4.0	.90	3.1	7.0	4.0	5.6
26.....	2.1	7.0	.53	4.4	7.0	3.5	4.3
27.....	3.5	7.0	.83	5.9	7.0		
28.....	3.2	7.0	.73	1.9	7.0	4.6	4.6
29.....	3.0	7.0	.40	7.0	7.0	5.1	6.1
30.....	1.9	6.6	.60	4.6	7.0	6.0	6.4
31.....	2.5	7.0	.77	5.1	7.0	4.3	7.0
32.....	2.6	5.5	1.17	7.0	7.0	2.8	5.7
33.....	4.3	3.8	1.20	4.0	6.6	4.8	7.0
34.....	2.9	3.1	.60	2.8	7.0	4.8	7.0
35.....	6.5	4.4	.50	5.4	7.0	3.2	7.0
36.....	3.5	2.0	.87	3.3	7.0	5.5	4.0
37.....	4.3	7.0	.83	4.8	7.0	3.1	7.0
38.....	4.6	7.0	.63	6.2	7.0	9.0	7.0
39.....	2.8	5.5	.67	3.9	7.0	5.6	7.0
40.....	3.2	5.1	.17	2.5	3.4	3.6	5.6

TABLE XX. Continued.

Individual	Average error (in mm)	Average degree of visual imagery	Average error (in half-tones)	Average degree of auditory imagery	Average degree of kinaesthetic imagery	Average error (in percentage of blacks)	Average degree of visual imagery
41.....	3.2	6.1	.20	4.7	5.1	5.7	7.0
42.....	3.3	4.2	.57	5.1	5.7	5.7	7.0
43.....	6.2	2.8	1.40	3.6	7.0	4.0	6.6
44.....	3.8	7.0	.50	2.4	2.9	3.1	4.0
45.....	2.5	7.0	.17	2.5	2.2	5.8	7.0
46.....	2.8	5.5	1.23	4.1	7.0	5.0	6.0
47.....	7.9	7.0	1.17	3.5	7.0	6.1	4.9
48.....	2.4	5.6	4.7	4.9	2.6	3.5	7.0
49.....	2.4	6.5	2.0	1.3	1.8	2.3	2.2
50.....	5.1	7.0	.47	6.6	7.0	7.0	6.0
51.....	2.4	5.5	.30	3.5	3.9	3.5	5.5
52.....	2.0	4.5	.40	2.9	7.0	6.5	3.0
53.....	4.2	4.0	.50	3.1	5.7	8.0	3.5
54.....	3.4	5.1	.23	2.5	7.0	5.1	4.3
55.....	2.6	6.3	.87	2.8	6.9	4.3	3.6
56.....	3.0	4.9	.77	4.1	7.0	6.5	7.0
57.....			.77	3.1	3.3	4.0	6.0
58.....	2.7	4.1	1.17	3.4	6.0	5.8	4.1
59.....	4.4	5.0	1.77	6.0	7.0	3.5	7.0
60.....	4.0	3.0	1.17	6.0	6.1	5.0	5.1
61.....	5.1	4.3	.57	3.2	4.0	5.5	4.8
62.....	2.0	7.0	.50	4.1	7.0	4.0	7.0
63.....	2.4	7.0	.47	4.3	2.3	3.6	7.0
64.....	2.9	4.8	.50	4.0	7.0	3.3	7.0
65.....	3.4	3.8	.70	3.0	6.5	2.8	7.0
66.....	3.9	3.6	.43	2.8	2.3	3.1	3.0
67.....	3.0	4.0	1.00	4.0	5.0	7.6	6.0
68.....	6.3	6.0	.13	1.9	1.9	5.0	6.5
69.....			.87	3.1	7.0	4.3	6.2
70.....	4.2	7.0	1.10	7.0	7.0	4.5	7.0
71.....	5.0	4.9	1.00	1.9	7.0	9.1	5.0
72.....	6.3	6.7	.37	3.4	7.0	3.0	7.0
73.....			.03	3.6	6.1	4.0	7.0
74.....	2.0	3.9	.53	3.0	7.0	5.0	6.2
75.....	4.1	7.0	.57	2.8	5.5	4.3	4.0
76.....	5.3	3.6	.83	5.0	3.8	6.5	6.2
77.....	2.9	2.2	.67	5.5	4.1	4.3	7.0
78.....	3.7	7.0	1.63	4.8	7.0	5.5	7.0
79.....			1.00	3.7	6.4	3.8	4.3
80.....	3.4	6.1	.90	3.9	4.6	4.6	6.5
81.....	2.0	4.0				5.0	7.0
82.....	2.9	7.0	.97	5.0	6.7	4.3	7.0
83.....	2.8	7.0	1.77	6.1	6.3	4.8	7.0
Averages	3.8	4.7	.75	4.1	5.7	4.6	5.6

The average deviation from the average of the errors in millimeters for discrimination of the lengths of lines was 1.13; from the average of the errors in half-tones for discrimination of pitch was .36; from the average of the errors in per cents of black in discrimination of grays, 1.0.

EXPERIMENT 10. IMAGERY AND THE MEMORY OF UNRELATED CHARACTERS

This experiment was made with 76 sophomores in elementary psychology in Cornell College. The class had answered the questions of the general questionnaire upon imagery, and had had some additional practice in introspection. Several practice experiments were made with other sets of characters before this test was made.

The method of the experiment was as follows: Each student was given a sheet of paper with the following set of twelve letters arranged in three lines of four letters each.

Q H B K
Y N P G
F T C V

The papers were so folded that the letters were hidden until a signal was given. Then 15 seconds were given for committing the set. The papers were at once reversed so as to hide the set, and the class, led by the instructor counted aloud for 15 seconds. Each one then wrote down as many of the letters as he could remember, and in their proper order if possible. As soon as this was done the sheets were unfolded once more, and replies to the following questionnaire made:

Read all the questions before answering any. Be careful not to confuse an image which may appear NOW with what was in your mind DURING the recall.

1. In recalling the letters did you have a visual image of the set as a whole? 2. Of each separate letter as you wrote it? 3. Did you have an auditory image of yourself or anyone else speaking the letters? 4. Describe any other kinds of images which you may have had? 5. Or did you only *remember* or *know* the letters, and have no images?

In computing the replies, a value of 1 was given for each letter of the set which was placed in the correct position, and a value of $\frac{1}{2}$ for each correct letter which was found out of position. On this basis it is seen that 12 would make a perfect score.

Immediately upon the completion of the preceding test, the following set of letters was given with the explicit direction that they should be committed by horizontal lines, as in reading.

R P B Y
V M H C
D T X L

Fifteen seconds was allowed for the committing, as before, and fifteen seconds given to counting aloud. Then the direction was given, *Write the set by vertical columns*. The immediate object of this test was to use it as a check on the accuracy of introspective account in the preceding experiment. It is evident that in learning the set in one direction, and writing it down in another direction, the good visualizer should have a decided advantage over one who used auditory imagery or who employed no imagery, if visual imagery is a significant factor in recall of this kind. The method of computation was the same in this test as in the preceding one. It is to be noted that no report of the imagery employed in the second test was asked. It is probably safe to assume that the process would be practically identical in the two cases.

Summary of Results

Average of correct score for Test I, 7.55, or 63%, A. D. 2.20.

Average of correct score for Test II, 7.01, or 58%, A. D. 2.84.

Reporting visual image of whole square, Test I, 22, or 29%.

Reporting visual images of lines or letters, 50, or 66%.

Reporting auditory images, 35, or 46%.

Reporting other types of imagery, 15, or 20%.

Reporting no imagery of any kind, 27, or 36%.

Average on Test I of those reporting visual image of whole square, 7.40, or 62%, A. D. 2.50.

Average on Test II of those reporting visual images of whole square, 7.39, or 62%, A. D. 2.90.

Average on Test I of those reporting no images, 6.74, or 56%, A. D. 2.00.

Average on Test II of those reporting no imagery, 6.70, or 56%, A. D. 2.20.

The coefficient of correlation between the abilities in the two tests computed by the method of the percentage of unlike signs is 80% for the whole group, and is likewise the same for those who reported visual imagery for the whole letter square and for those who reported an entire absence of imagery.

It is seen that those who reported a visual image of the entire letter square averaged a score of 62% of correct memory on Test

I, and of 62% on Test II. Those who reported no imagery averaged a score of 56% of correct memory on Test I, and 56% on Test II. Thus, while the former group made a higher score on both tests than the latter group, each of these groups did just as well on the second test as on the first. It is hard to understand how this could be if visual imagery was really a significant factor in the score of the first group for Test II. The conclusion seems to force itself upon one that the difference in the scores of the two groups may not be accounted for by the difference in imagery at all, but rather by a difference in general retentiveness, ability to learn, etc. To use such a test as the above for a test of imagery, as has been done by several investigators, is surely unjustifiable.

EXPERIMENT II. IMAGERY AND THE INTERPRETATION OF MUSIC

The three experiments which follow were made with the class in Ear-Training and Public School Music in Teachers College, Columbia University. Most of the class had had no previous training in psychology, but a few practice experiments of the same nature as the test were given to make sure that they knew what was required of them.

The first experiment was conducted as follows: A note was struck on the piano, and the class told what the note was. After an interval of 30 seconds, a second note was struck, and the class were at once to write down the name of the second note. This was repeated ten times. After each separate trial, the student indicated whether he had in his mind an auditory image of the first tone with which he compared the second tone, or whether he only *felt* or *knew* what the second tone was. Also, if an image appeared, whether it was perfectly clear and vivid, only moderately clear and vivid, or vague and dim.

The replies show that 14 out of the 18 students report auditory images for every judgment. Of the remaining 4, 3 report no imagery, and 1 reports dim auditory images in four cases out of the ten. In the aggregate, 81% of the judgments are reported as accompanied by auditory images.

Based on the entire number of separate judgments, no imagery was reported in 19% of the cases; vague and dim imagery (3), in 11% of the cases; moderately clear and vivid imagery (2), in 12% of the cases; and perfectly clear and vivid imagery (1), in 58% of the cases.

The accuracy of the judgments was computed in the number of tones the estimated tone was from the true one. On this basis the average error for the class was .68 of a tone. The average error for those who reported no imagery was 1.06 tones. The average error for those who reported imagery accompanying the judgments was .64 of a tone.

It is therefore seen that the percentage of accuracy is greatly in favor of those who reported auditory imagery accompanying their judgments. The percentage of error being almost twice as high for those who reported no imagery.

In conducting the second experiment each student was given a sheet containing the following directions and questions, but, so folded that the questions relating to the imagery were not seen until the reading of the music was completed.

Read the following music, aiming to interpret or understand the music as completely as possible, that is, getting from it what you think the author intended you should when you read it:

(Here followed the air through several bars.)

Now recall what was taking place in your mind while you were reading the score, and answer the following questions as accurately as you can:

1. Did you hear in your mind's ear the tones corresponding to the notes? If so, were the tones from a voice (whose?), or from an instrument (what)? If you heard the tones in your mind's ear were the force, *pitch* and *quality* (1) perfectly clear and vivid, or (2) only moderately clear and vivid, or (3) vague and dim?

2. Did you have in your mind's vocal organs a feeling of yourself producing the tones? Or in your mind's fingers and arms a feeling of yourself playing them? If you had those feelings were they (1) perfectly clear and vivid, or (2) only moderately clear and vivid, or (3) vague and dim?

3. Did you see in your mind's eye yourself or anyone else, or any instrument or anything else connected with producing the music? If so, tell what? Were these images (1) perfectly clear and vivid, or (2) only moderately clear and vivid, or (3) vague and dim?

In reply to the first question, 15 reported auditory images of some kind, and 4 reported no auditory images. Of these four, 3 reported kinaesthetic images as from singing the notes, and 1 reported no images of any kind, but an interpreting of the notes "as notes." Of the 15 auditory images reported 5 were reported as from the person's own voice, 4 as from other voices, 6 as from a piano.

In answer to the second question, 16 reported kinaesthetic images in the vocal organs or fingers, or both. Three reported no kinaesthetic images.

In reply to the third question, 10 reported visual images; 8 of themselves at a piano, 1 of herself singing, and 1 of birds singing. Nine reported no visual images.

The fourth question suggested the following explanatory statements:

This score appealed to me as a recitative sung by a female voice, but not my own. I can hear the music as if sung, but not by myself. I marked the time in my mind, and it seemed as if a horse was galloping, and the wind blowing. I tried to get an idea of how the piece would sound on the piano. I seemed to go through the singing and playing of the music myself, and also saw a kind of dignified dance going on at the same time. I imagined I heard it on the piano.

The average degree of clearness and vividness was reported as 1.7, or a little better than moderately clear and vivid.

In making the third experiment, the class were asked to listen to the playing on a piano of several bars of a piece of music, with the aim of interpreting it as fully as possible. (The selection was from Mendelssohn's "Spring Song.") They were then asked to describe as fully as possible the images, if any, which appeared in the mind as they listened to the music.

Out of the 19, all but one reported either visual or kinaesthetic images, 15 reporting visual images, and 17 kinaesthetic images in the organs of speech or other parts of the body.

The following are different visual images reported: Children dancing. Regiment of children marching. Festival crowd of people. Procession of girls marching. A brass band marching. A church with a spire. The picture of a church in Lohengrin. People dancing in Swiss costume. A running brook. Children dancing in a drawing room. Lots of notes on a paper. An image of very bright and joyous people dancing.

One is impressed with the large amount of imagery reported in all of these tests, and, even after allowance is made for the tendency of the untrained observer to over-state his imagery, the conviction still obtains that a great deal of imagery of visual, auditory, and kinaesthetic kinds accompanied the interpretation of the tones and the music. Of course, this does not in the least indicate that all of this imagery really functioned in the inter-

pretation of the music, for much of it, here as in the experiments on thinking, etc., is probably purely associational and incidental.

EXPERIMENT 12. IMAGERY AND THE ENJOYMENT OF LITERATURE

The following experiment undertakes to study the relation of imagery to the enjoyment of favorite pieces of literature. The test was made with 42 senior students in psychology in Cornell College, 30 women and 14 men. The questionnaire given below was in the hands of each student. It was also suggested to the class that they were at liberty to select from a long selection any well-known section upon which to base their answers.

You will confer a great favor by answering the following questions as fully and as carefully as you can, first reading the entire list through.

What is your favorite poem, or the piece of literature which you most enjoy?

Now will you answer the following questions about it:

1. As you ordinarily think it through or read it (not in connection with this test, but naturally), do there come before your mind's eye *visual images* of the various persons, places, and objects suggested or described? If so, are these images very vivid and clear, only moderately so, or vague and dim? (Underline to show.)
2. Do there come to your mind's ear *auditory images* of the sounds which are suggested or described? Vivid, moderate, vague?
3. Do there come to your mind's muscles *images of the movements* suggested or described? Vivid, moderate, vague?
4. Do there come to your mind's skin *images of touch* as suggested or described? Vivid, moderate, or vague?
5. Do there come to your mind's mouth and nose *images of tastes* or smells suggested or described? Vivid, moderate, or vague?
6. Or, do you not experience these images at all, but only *feel*, or *know*, or *understand* the meaning of the piece?
7. If the images suggested above do appear when you think of the piece, is it the images you love to think about and dwell upon, or is it the *thoughts*, the *meaning*, the *feeling*, the *sentiments*, the *language*, or the *rhythm*, or some other qualities?
8. Add any further explanations of your own to show *how you think about the piece*, or why you like it.

Of the 42 taking the test, 7% reported an entire absence of visual imagery; 12% an absence of auditory imagery; 17% an absence of kinaesthetic imagery; 48% an absence of cutaneous imagery; and 60% an absence of gustatory and olfactory imagery. Of course the percentages do not measure the relative ability of

the group in the different types of imagery, for no measure was taken of the amount of each type suggested in the various productions.

For those reporting the presence of imagery the average degree of clearness and vividness was as follows:

Visual, auditory and kinaesthetic, each 1.8; cutaneous, olfactory and gustatory, each 2.2.

The favorite literary productions were widely scattered as the following list will show: "Evangeline" leads, being selected by eight persons; "Paradise Lost" and "The Ring and the Book" were each selected by five persons; "The Vision of Sir Launfal" and "Pippa Passes," each by two persons; and the remaining titles each by one person. Below are given the titles together with comments made by different subjects under questions 7 and 8 of the questionnaire, explaining the features of the production which they most cared to think about and dwell upon.

"Evangeline." I enjoy the images greatly, but it is after all the fine spirit and the beautiful language even more than the imagery which I like to think about.

I love the images, but the sentiment, the spirit and the rythm even more; the entire poem soothes me and makes me feel more self-sacrificing, and devoted to others.

I enjoy the imagery, but also the feeling and the sentiment; perhaps I like the latter even more.

I enjoy particularly the visual imagery, but also the thought and language and movement.

I think the images are the chief feature.

Images add much, but I believe it is the beauty of the spirit and the sentiment which I really care most about and love to think of.

The language, rhythm and feeling are the chief features. The images are beautiful but they are not the most important by any means.

Partly the images, but principally the language, the rhythm and the beautiful meaning.

"Paradise Lost." The thought and meaning seem to be the chief interest? Images are not dwelt upon unless I chance to think of them.

It is the grandeur of the thought and feeling and the majestic swing of the rhythm which attract me. The images seem wholly incidental.

Both the images and the tone and majesty of the thought appeal to me.

The images are important in my pleasure in the piece, yet I am sure that they are not what I most care for and think about.

It is the beautiful thought and the beautiful language rather than the mental images which appeal to me in the piece.

"The Ring and the Book." The imagery is all so vivid that it seems the basis of meaning in the piece. Yet so far as what I like is concerned, I believe it is not after all the images but the thought and meaning and the feeling.

I like to dwell upon the images but even more upon what it all means.

It is really the thought and the meaning which appeal to me. I have vivid images but do not care so much for them.

All the passions and heart beats and the optimistic view of life get hold of me. I have vivid images, but care little after all to think of them.

The thought and feeling come first, the images are secondary.

"The Vision of Sir Launfal." I enjoy the feeling, sentiment and language, it seems to me, more than the imagery.

I think the images add to the pleasure, but it is the greatness of the meaning, after all, that I love to think about.

"Pippa Passes." I think my enjoyment is about equally divided between the images and the meaning.

Thought predominates, but the images are connected with much of the thought.

"Saul." I think the images are wholly secondary. It is response to the greatness of the meaning which appeals to me.

"Thanatopsis." While I enjoy the images, it is the feeling and the meaning that I care for chiefly.

"The Psalm of Life." I feel only the strong appeal and the deep meaning of the poem. The images mean little to me.

"The Egoist." I do not have very many images and what I do have do not seem to figure in my liking the piece. It is the "feel" of it.

"Crossing the Bar." The sentiments of this beautiful poem are what I think of and care for. The imagery does not particularly appeal to me.

"The Twenty-third Psalm." I enjoy both the images and the feeling. When I am tired I nearly always think this through, putting myself in the place of one of the sheep, and the whole thing seems very real.

"Ulysses." I do not think of the images, but of the strong, restless spirit of manhood presented.

"My Star." I have vivid images, but it is the thought after all which I care about, the meaning of it all.

"I am the Captain of My Soul." The images themselves are not pleasant, but the thoughts and feelings hold me.

"Cotter's Saturday Night." I believe it is the thought, meaning and appeal to sentiment, not the images which I care for.

"The Other Wise Man." I feel that the lesson makes me want to be stronger; the language also is beautiful. I have vivid images but I do not think much about them.

"The Lost Word." The images are a part, but I believe that the feeling and emotional appeal together with the lesson constitute the attraction.

"Idyls of the King." Both the images and the meaning and sentiments are greatly enjoyed.

Channing's "Symphony." The images are only incidental. The thought and meaning with the bearing on life are the principal thing.

Milton's Sonnet on his Blindness. The chief attraction, I believe is the lesson and high spirit of life purpose presented. I can get vivid enough images but I really care little for them.

"Drifting." The sentiment is surely made more beautiful by the figures of speech and images.

"Guinevere." The sentiment, feeling and language chiefly attract me.

Wordsworth's "Recollections of Childhood." The images seem to me to be the chief source of pleasure.

"The Deserted Village." The thoughts and sentiments are what I like most to think about, although images are vivid enough.

"Prothalamion." I am held by the majesty and dignity of the piece, yet it would lose much without the imagery.

Two things are very evident from the replies given to the questionnaire. First, a great deal of imagery accompanies the interpretation of literature of the character mentioned. Only one person reported no imagery in connection with the interpretation of the selection. This was the one whose preference was "The Cotter's Saturday Night." All but 4 reported more than two kinds of imagery present. Moreover, the images reported were of rather a high degree of clearness and vividness. The second thing which impresses one is the small part which imagery is reported as playing in the appreciation of literature. An abundance of imagery was present, but almost the universal testimony was that the influence of imagery was much less than meaning, feeling, and sentiment in producing enjoyment in the selection. It raises the question in this connection as in so many others, whether much of the imagery which floods the mind in reading is not largely incidental, not alone from the intellectual standpoint, but from the standpoint of aesthetic appreciation as well.

All development in thinking, including both memory and imagination, is a process of divesting oneself of the necessity of the present concrete situation as the adequate stimulus and content of thought, and a growth in the ability to use symbols for con-

crete thought terms. The percept stands for the interpretation of the immediate and concrete. The image is a step toward symbolism and away from the concrete. It allows the element of "present" to drop out, and enables us to recall approximately a former "present," or to combine the elements of former "presents" without reference to time. Language, at once the product and the means of generalizing concrete situations, had as its first written forms pictures of the concrete, particular objects. Little by little its forms became more indirect until its symbolism is almost entirely abstract, standing, however, for all meanings from the most concrete and particular to the most abstract and general. Through this means, relations and meanings have become generalized and we have concepts, whose function is a certain generalized meaning. These concepts may or may not have an imagery core, are almost always thought in terms of language, yet are possible without either.¹ The meaning, that is, the comprehension of the relations of an object is the goal of thinking. This lies at the bottom of all intelligent adaptation. The percept, the image, and language in its symbolizing capacity, are all secondary and ancillary to meaning, and are ruthlessly abbreviated and eliminated in the mind's economy in the interests of the ultimate meaning. For example, with familiar objects we need but the fraction of the complete percept,—we see a mere corner of a well-known garment, and it means for us the entire coat. We need only the fleeting and vague image of a certain face or voice, and it means to us our friend. Moreover, the images may drop out, and the mere name, or even the "thought" of the friend may serve for the basis of the meaning. At first, words and sentences, say of a foreign language, yield us their meaning but

¹There is no call here to enter into the controversy of Berkeley, Hume, and the others who claim that the concept cannot exist except upon a basis of images. Their discussions are chiefly *a priori*, and the court of final resort in this matter is introspection, not the introspection of one man, but the introspective testimony of many. And the evidence here is perfectly clear that meanings can be had without images, or even without language. I am at a loss also to understand the contention of MacLennan, *The Image and the Idea*, *Psych. Rev.*, Vol 9, p. 72, when he says that introspection makes it clear that images furnish "the base of the idea," and then explains in the next sentence that "In all processes of ideation imagery is constantly overlooked, and whenever meaning absorbs our attention, the concrete characteristics retreat so far into the background as to fade altogether from view." This is pure jugglery of words. A mental element which has retreated so far into the background as to fade entirely from view simply does not exist for consciousness.

slowly, and we have to look or listen well in order to get it. Later, we come to ignore the words and sentences, the meaning only occupying the mind. It is true that we still think in words and sentences, yet so supreme is the meaning of the words we use that it requires the most expert kind of introspection to tell whether the internal speech is in auditory or motor terms. That thought can go on without this internal speech is evidenced by the many introspective accounts of thoughts which flash into the mind without warning, and consist of nothing but a certain meaning or relation which was being sought.

This mode of abbreviating the mental procedure applies in all cases where the chief meaning of the thought object is found in its relations to other thought objects. The child in learning that two and two are four may learn, (1) that two apples (percepts) and two apples are four apples; or (2) that two apples (visual image) and two apples are four apples; or (3) that 2 (symbol) $+ 2 = 4$; or (4) he may finally come to generalize the meanings and think the values without reference to figures, images, or apples. The last form is of course the aim in developing the number concept. This being the case, it would seem that number teaching should be calculated to eliminate the intermediate steps as rapidly as possible. We should use "apples" in number teaching only long enough to give full content to the language symbols. We should use images only where the percept has failed to give the required content, and where the percept cannot be easily repeated. To keep a child adding images is as little to be desired from the standpoint of the developing number concept as to keep him adding apples.

What is true of the development of the number concept will hold for other lines of thought as well in their development toward meanings. Where the percept is not possible frequently enough or constantly enough to put adequate meaning into the language symbols, the image may undoubtedly lend its assistance. That this is no mean function is implied in the abundance of imagery in the mental content of the young. But once meanings are well in hand, the image like the percept plays a smaller rôle and may finally drop almost entirely out in thinking which deals chiefly with meanings growing out of relations of the objects of thought. That imagery persists in the degree which it does is undoubtedly in large part due to the permanence of association,

which also accounts for the presence of so much imagery which is irrelevant.

But the greatest function of imagery is probably found in cases where the meaning sought would be best found in the percept itself rather than in its relations. In presenting scenes which are lost to us as percepts, but which we would fain look upon again; in bringing to the mind's eye the faces of our friends whom we long to see; in enabling us to feel again the clasp of a hand; to smell again the perfume of an old cabinet in childhood's home; to build Castles in Spain and fill them with people we have not yet seen,—in these and all other places where we would welcome the percept but cannot have it, the image may serve as a very acceptable substitute, though it is still lifeless and colorless as compared with the perceptual reality. In proof of which witness the impatience of the lover who has to be content with the images of the maid, or the hungry boy who must satisfy himself with gustatory and olfactory images of a savory meal.

That children should employ much more imagery than adults in their thinking is wholly in accord with the mode of the mind's development. The child is much nearer the world of the concrete. The meanings of things are chiefly in the objects themselves, and but little in their relations to other objects. The child's mental world is relatively a world of percepts, covering the range of all the senses. Each percept is the basis for an image, which comes to supplement the percept, and make possible a greater complexity of experience. The images take on the same meanings as the percepts in a degree, and sometimes become almost as real. But gradually the meanings come to inhere more in the relations of the objects than in the objects themselves, and imagery gradually loses its function except where the meaning continues to reside chiefly in the object itself as such. Language also plays an important part in the mutation, serving more and more as a core or foundation for meaning, until the function of the image is reduced to a relatively minor rôle in all logical thinking.

SUMMARY AND CONCLUSIONS

1. Comparing the results of the experiments on voluntary imagery with those of spontaneous imagery, it is evident that most persons can command a far wider range and greater profusion of imagery than they normally employ in thinking. Using an analogy from physiology, this surplus imagery may be looked upon as the "vestigial" element in the mental process. In no cases except possibly the problems in which the percepts would have been of the greatest assistance (for example, in the "Squirrel" problem, Experiment 7, Section 2) did the amount of imagery reported as spontaneously appearing, compare at all with the amount subject to voluntary command.

2. There are two points in our thinking at which imagery has the greatest tendency to emerge. (1) At points where our thinking is baffled; (2) at points where percepts would be of great assistance. If the baffled points are not dependent on percepts, the images which offer are usually for the most part irrelevant, and hence of no possible service in reaching the solution. The most efficient and successful thinking, at least of logical and abstract nature, is with most persons accompanied by the least imagery.

3. Thinking can and does go on without the intervention of imagery, the mental content being made up of feelings of meaning, relation, intention,¹ effort, identity, interest, pleasure, displeasure, etc. Imagery may and often does serve as a familiar background for the meaning with which we are dealing, but it cannot be said to be essential to meaning,² except to the extent that meaning may inhere in a given percept *as such*, e. g. the meaning of a beautiful sunset is chiefly this same *beautiful sunset*. The meaning of yesterday's sunset, which I can no longer see, may depend largely on my visual image of it. But all meanings of a logical sort, that is, those which grow out of relations, not only *are not* an image, but are independent of it except for the accident of association, by which a meaning may call up an image equally well with an image calling up a meaning.³ Whatever

¹Cf. Boodin, Truth and Meaning, *Psych. Rev.*, Vol. XV, p. 172.

²Cf. Pillsbury, Meaning and Image, *Psych. Rev.*, Vol. XV, p. 150.

³Cf. Woodworth, Imageless Thought, *Jour. of Phil., Psych. and Sc. Method*, Vol. III, p. 701.

the logical theories against it, imageless thought "is an apparent fact of introspection," as shown over and over in the foregoing experiments.

Binet, summing up his painstaking and convincing study, comes to the following conclusions:¹

"Nous avons distingué plus fortement qu'on ne l'avait fait jusqu'ici ces trois phénomènes: La pensée, l'image et le langage intérieur. Nous nous sommes surtout intéressés au travail de la pensée, cette force invisible qui agit derrière l'abri des mots et des images. Nous avons constaté que le travail de la pensée n'est point suffisamment représenté par le mécanisme des associations d'idées; c'est un mécanisme plus complexe, qui suppose constamment des opérations de choix, de direction. Nous avons vu aussi que l'imagerie est bien moins riche que la pensée; la pensée d'une part interprète l'image, qui est souvent informe, *indéfinie*; d'autre part, la pensée est souvent en contradiction avec l'image, et toujours plus complète que l'image, et parfois aussi elle se forme et se développe sans le secours d'aucune image appréciable; il y a telles de ses démarches où l'image ne peut la suivre. Dans la généralisation, c'est *l'intention*, c'est-à-dire en somme la direction de pensée, qui constitue le général, et non l'image; l'image peut se prêter à la généralisation si elle est indéterminée; parfois même, par ses caractères fortement particuliers, elle ne s'y prête pas, mais elle n'empêche pas pour cela l'essor de la pensée vers le général.

"Enfin, et c'est là le fait capital, fécond en conséquences pour les philosophes: toute la logique de la pensée échappe à l'imagerie."

These conclusions, reached after a long experimental investigation, are in striking contrast with the same author's earlier statement in his "Psychology of Reasoning" that, "Images, along with sensations constitute the material of all intellectual operations: memory, reasoning, imagination, are acts which consist, in an ultimate analysis, of grouping and co-ordinating images, in apprehending the relations already formed between them, and in reuniting them into new relations." These two standpoints illustrate well the difference in an *a priori* view and an experimental view of the place of mental imagery in the mental processes.

¹ L'Etude Expérimentale de L'Intelligence, p. 308.

4. Imagery as a mental standard in discrimination, as of magnitudes, pitches of tones, and shades of gray is of doubtful service. And, unless the images are very clear and vivid, they are probably in the way of accurate discrimination. In the tests bearing on discriminations in these lines those who reported no images were uniformly better than those who reported images of medium or low degree of clearness and vividness. It seems rather that accuracy depends on a feeling of identity or a feeling of so much divergence one way or the other. Both the feeling of identity and of divergence have a tendency to become associated with language; for example, in the experiment on pitches of tones, many of the subjects very soon came to think of the tones as 7, 5, 13, etc., of the series, and similarly in the related experiments on line lengths and shades of gray. In all cases a diminution in the amount of imagery was reported as the series proceeded; at the same time accuracy in discrimination increased with the progress of the series.

5. Very much of memory is accomplished without the use of imagery, and much of the imagery which accompanies memory is of no advantage to it. The "memory image," used as a general term to cover all memory stuff is a fiction. In one of the hardest possible tests on memory, and one most calculated to evoke images, namely that on the memory of unrelated characters, imagery failed to make any convincing showing of its utility. The universal experience in this experiment was that the mind sought to establish some form of association upon which to depend in recall, even in cases where the imagery also appeared. This is but another evidence of the mind's tendency to deal in relations instead of detached pictures. Even if the relations must be arbitrarily set up, as when the letters of the test were made to stand for certain names, the majority of minds will prefer this method to that of dependence on imagery.

Fracker found in his study of transference of training of memory¹ that his subjects imaged various arrangements of dots, stairs, etc., in remembering tones, shades, and numbers, and that those who developed the most definite imagery forms improved most. He concludes therefore that the central or most important element in improvement and transference is imagery. But it is to be remarked that the introspective accounts of his subjects show

¹ *Psych. Rev.*, Mon. Sup., Vol. IX, No. 2.

that their imagery was always an imagery of related positions of the dots, etc., and that the terms to be remembered were associated with these positions. Thus the highest number or tone was associated with the highest dot of the visual image, and the lowest number or tone with the lowest dot, etc. One is at once led to inquire whether it is not after all the ability to establish some system of association rather than the ability to develop any system of imagery that is the central element in improvement and transference of memory.¹ That these two alternatives are not synonymous has already been abundantly demonstrated.

6. Imagery is much less closely connected with the appreciation and enjoyment of literature than is commonly supposed. While a great deal of imagery undoubtedly accompanies the reading of descriptive literature, yet much of it is merely associative and incidental, and in the degree in which the meaning of the production becomes familiar, the imagery has a tendency to drop out. It is finally the sentiments, feeling, meaning, and other of the deeper qualities which come to stand for the selection in the mind's grasp and appreciation of it. These mental elements may be associated with images, or may arise directly from the language symbols of the production. Absence of imagery does not therefore mean failure adequately to interpret and appreciate literature. On the contrary, it is entirely certain that if a flood of profuse imagery should accompany the words as we read, interpretation and appreciation would be seriously interfered with, if not rendered impossible. As well try to think or feel with a bewildering panorama of percepts crowding in upon eye and ear with their consequent distraction of attention from all except the immediate objects themselves. Only when the meaning inheres in the objects themselves *as such* do the percepts aid in thinking; otherwise we close our eyes to them, or shut ourselves away from them. Likewise, only when the meaning inheres in the images themselves *as such*, are they essential in thinking; otherwise they tend to drop out of attention, and hence out of consciousness.

It would seem therefore, that to place great stress upon image-getting in teaching literature may be in large part a mistaken emphasis. There is no doubt that imagery will lend much to the understanding and appreciation of a great deal of descriptive

¹Cf. Coover and Angell, General Practice Effects of Special Exercise, *Am. Jour. of Psych.*, Vol. XVIII, p. 328.

literature. There is no doubt, on the other hand, that much literature of the highest meaning and greatest depth and beauty can be fully understood and appreciated without the use of imagery.

7. Finally, it seems that imagery has been greatly over-emphasized as to its relative importance as mental content. Images, along with sensations, have been said by many writers to represent the entire mental content on the cognitive side. They have been assumed by others to be the only stuff of memory, the basis of all thought and meaning, and the condition of all aesthetic enjoyment from literature. So all-inclusive has the word "imagery" become that it has been claimed that all past experience on the mental side is conserved in the form of images, and hence any vestiges of experience, no matter what their nature, have been denominated mental images. In so far as the results from the foregoing experiments are trustworthy, it has been shown that all these claims are greatly over-stated, and that in many instances they are wholly at variance with the facts. Imagery probably has some function, just how important no one can yet say, in the development of content in speech and language; it gives to the child's world of imagination a touch of reality that means much to his play life; it gives the adult material for his dreams; it serves us all in some degree where we would be glad to use percepts but find them lacking; it gives a dash of life and color to much of our thinking which else would be cold and lifeless. But imagery is after all only one mental element among many, and in adult thinking at least, may often drop out altogether without in any way hampering the efficiency of the other mental elements, but, on the contrary, often even increasing their efficiency by getting out of the way.¹

These facts mean that the section of descriptive and dynamic psychology which deals with mental imagery needs rewriting with the aim of better definitions of terms and functions and a better weighing of values. The field of the genetic function of mental imagery is as yet almost untouched, and is greatly in need

¹ Cf. Woodworth, *The Cause of a Voluntary Movement*, p. 388 ff., in which he concludes that, "We have rejected first the kinaesthetic image, and second any image at all, as the adequate determinant of voluntary movement."

Cf. also the following: Gamble and Calkins, *Zeitschrift für Psychologie*, 1903, Vol. XXXII, pp. 177 ff., and Schumann, *ibid.*, 1898, Vol. XVII, p. 119; 1902, Vol. XXX, pp. 241, 321.

of investigation in the interests of genetic and educational psychology.

No attempt will be made in this study to present a critical or historical review of the work previously done on the subject of mental imagery. This has been done for one phase of the subject by Bentley in his excellent study on "The Memory Image."¹ In his monograph on "Mental Imagery"² Lay gives a list of the more important studies prior to 1898, together with a brief critical estimate of each. The most important studies since Lay's have been noted in the course of the discussion in the present study, and many of them quoted from. The various studies upon memory and association all contain much material which is related more or less directly to the question of mental imagery. The more important of these studies contain extensive bibliographies on their respective fields.

¹*Am. Jour. of Psych.*, Vol. XI.

²Pages 47-53.



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