XVIII. PRACTICE IN ASSOCIATING COLOR-NAMES WITH COLORS[1]

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It has long been known that the process of recognizing and naming a color takes more time than the process of recognizing and naming an isolated printed word, such as the word, for example, which designates the same color.[2] The following experiments represent an attempt to gain a clearer understanding of this phenomenon.

The first hypothesis which presented itself was that words can be recognized and named more rapidly because we have had more practice in doing this than in naming colors.[3] Accordingly a practice experiment was contrived on the basis of Cattell's familiar color-naming test.[4] Experi-

[1] From the Psychological Laboratory of the University of California.

[2] James, W., 'Principles of Psychology,' 1890, Vol. I., p. 559. Cattell, J. McK. 'Ueber die Zeit der Erkennung und Benennung von Schriftzeichen Bildern und Farben, *Philos. Stud.*, Vol. 2, 1885, pp. 635–650.

[3] This explanation of the phenomenon is clearly stated by Cattell in the account of its discovery which he gives under the title, 'The Time it Takes to See and Name Objects' (*Mind*, Vol. 11, 1886, p. 65). He says, "The time was found to be about the same (over ½ sec.) for colors as for pictures, and about twice as long as for words or letters. Other experiments I have made show that we can recognize a single color or picture in a slightly shorter time than a word or letter, but take longer to name it. This is because in the case of words and letters the association has taken place so often that the process has become automatic, whereas in the case of colors and pictures we must by a voluntary effort choose the name."

The same interpretation is given by J. O. Quantz in his monograph, 'Problems in the Psychology of Reading,' PSYCHOL. REV. MONOG., No. 5, 1897, p. 10. "The association is of the same sort in words as in forms or colors, for the connection between the written symbols and the spoken sound of any given word is just as arbitrary as is that between a particular geometrical form and its name as uttered. But the association between forms or colors and their names, being less necessary than between written and printed (spoken?) words has been less frequently formed and the former has remained a voluntary process while the latter has become automatic through repetition."

[4] Cattell and Farrand, 'Physical and Mental Measurements of Students of Columbia University,' PSYCHOL. REV., Vol. 3, 1896, p. 642. Wissler, C., 'The Correlation of Mental and Phsyical Tests,' PSYCHOL. REV. MONOG., No. 16, 1901, p. 8. Hollingworth, H. L., 'The Influence of Caffein on Efficiency,' *Arch. of Psychol.*, No. 22, 1912, p. 16.

ence had shown that the Columbia test was weak in the following points: Not all the color names were equally familiar; they were not all equally hard to say (for example *red, yellow; blue, violet*); there were strong brightness contrasts between some of the colors; the chance arrangement of the colors resulted in some bad sequences; the one-centimeter squares were too small, making it difficult to 'keep the place' with the eye. The test was accordingly modified in these respects: The color squares were increased in size to one inch; the sequence was so arranged that no color square was placed next to another of the same color and a color was not permitted to occur less than twice nor more than three times in any row; only four different colors were used in any one set and these were all either 'light' (white, pink, brown, gray) or 'dark' (black, red, blue, green);[1] the colors all had one-syllable names; all of these names were highly familiar.[2]

It was expected on the hypothesis of Cattell and Quantz that sufficient practice would make it possible to read off the color names as rapidly from the colors themselves as from a printed list. If the difference in speed depends upon previous practice it should, by further practice, be possible to reduce the time consumed in reading colors but not possible to reduce to any considerable extent the time required to read a list of words. In order to test the truth of this hypothesis it was necessary to show not only that the speed of color naming can be increased by practice but also that the speed of reading words can *not* be increased so much by an equal amount of practice. For the practice in reading words, lists were typewritten with the one hundred color-names arranged in the same order as the colors themselves. The words in

[1] The colors used were the papers supplied by the Milton Bradley Company, of Springfield, Mass., under the following designations: Black, White, Neutral Gray No. 2, Engine Colored Paper No. 2B (brown) and No. 1B (pink), Red, Green, and Blue.

[2] The modified form of the Columbia test recommended by Woodworth and Wells, 'Association Tests,' PSYCHOL. REV. MONOG., No. 57, 1911, p. 49, meets most of the difficulties mentioned above, but unfortunately it was not published until after the present experiments were partly completed. It may be noted that in the Woodworth and Wells test the colors appear on a white background whereas in the form here used the squares were larger and juxtaposed without background.

each line were separated by a comma and one space; the lines were separated by a triple space. For each set of colors there were, of course, four distinct lists of words, corresponding to the four arrangements of colors which were encountered on beginning in the four different corners of the color-set. For every practice trial in associating the colors with their names there was a practice in reading the words from the corresponding list.

A record-blank, including complete directions, was given to each worker at each practice sitting; it read as follows:

DIRECTIONS FOR THE EXPERIMENT ON NAMING COLORS

There are two boards of colors. Each board contains 25 squares of each of 4 colors, and there is a different color in each corner of the board. There are 4 typewritten lists of colors for each of the boards, and each list begins with the name of the color in one corner of the board, and gives the names of the colors in the order of their appearance on the board.

The purpose of the experiment is to measure the maximum rate of speaking when reading the lists of words or naming the colors, and to see how much this rate can be increased by practice.

First day's work. Take the time with a stop-watch for reading aloud, as fast as you possibly can, the words on the typewritten list beginning with Black. Enter the time, in seconds and fifths of a second, opposite "List black" in the table below. Then take the time for calling out the names of the colors, as fast as you possibly can, from the board, beginning with Black in the upper left-hand corner and reading by rows from left to right. Enter the time opposite 'Board black' in the table. Then enter the time for each of the remaining items in the table, being careful to take them in the order indicated by the numbers.

1. List black.....	3. List white.....
2. Board black.....	4. Board white.....
5. List blue	7. List brown.....
6. Board blue.....	8. Board brown..... ...
9. List green.....	11. List pink.....
10. Board green.....	12. Board pink.....
13. List red.....	15. List gray.....
14. Board red.....	16. Board gray..... ...

Second and succeeding days. Use only one board of colors and the lists which belong with it. Do not look at the other board or its lists, nor allow any one to read them in your hearing. Record the times for the right (left)[1] hand half of the table in the order given, and do nothing with the other half of the table.

Twelfth day. Exactly the same as the first day.

Forty-five students took part in the experiment. All

[1] If the subject was to practice the 'dark' colors the word *right* was expunged; if he was to practice the 'light' colors the word *left* was expunged.

practiced for twelve practice-periods. Most of them worked twice a week, but a few practiced daily. Twenty-five of the forty-five were women. Twenty, of whom ten were women, practiced on the 'dark' colors. Twenty-five, of whom fifteen were women, practiced on the 'light' colors. As no essential difference appears between the light and dark colors the data have been combined for the entire forty-five workers.[1]

The condensed data are presented in Table I. The table

TABLE I

GAIN BY PRACTICE IN NAMING COLORS AND READING WORDS

Average of 45 Subjects

The time is the average of the 4 trials made each day.

Day.	Colors: Av. Time Required to Name Them, Secs.	Colors: Av. Gain in Speed Over 1st Day, Secs.	Colors: Av. Gain in Speed Over 1st Day, Per Cent.	Words: Av. Time Required to Read Them, Secs.	Words: Av. Gain in Speed Over 1st Day, Secs.	Words: Av. Gain in Speed Over 1st Day, Per Cent.	Ratio: Time for Colors Divided by Time for Words
1	55.8			35.2			1.59
2	50.9	4.9	8.8	33.0	2.2	6.3	1.54
3	46.4	9.4	16.8	31.6	3.6	10.2	1.47
4	45.2	10.6	19.0	30.8	4.4	12.5	1.46
5	43.7	12.1	21.7	30.2	5.0	14.2	1.44
6	42.8	13.0	23.2	30.4	4.8	13.6	1.41
7	42.4	13.4	24.0	29.9	5.3	15.1	1.42
8	41.4	14.4	25.8	29 5	5.7	16.2	1.40
9	41.4	14.4	25.8	29.4	5.8	16.5	1.41
10	41.1	14.7	26.4	29.0	6.2	17.6	1.42
11	40.7	15.1	27.1	29.4	5.8	16.5	1.38
12	41.4	14.4	25.8	29.3	5.9	16.8	1.41

shows the average time required by the 45 subjects for naming the 100 colors and for reading aloud the 100 words. The time is the average for the four trials which were made each day.[2]

[1] On the first day of work, when records were made for all of the subjects with both light and dark sets (*i. e.*, the first practice record with one set and the first check record with the other set) the times were as follows:

Time required to name 100 dark colors 56.0 sec.; 100 'dark' words 36.0 sec.

Time required to name 100 light colors 55.8 sec.; 'light' words 35.2 sec.

This insignificant advantage of the light sets remains unehanged through the course of practice. Most persons prefer to work with the light colors on esthetic grounds. Some subjects complain of getting the tongue twisted around the words, *blue* and *black* in the dark sets because of the identity of their initial sounds.

[2] These four trials did not differ greatly from one another. As a rule the first trial was better than the others except that on the first day, and to some extent on the

The practice gains are shown both in seconds and in per cent. In both cases the amount of gain is computed on the basis of the speed on the first day of work. The table further shows the ratio between the time required for colors and the time required for words.

In Table I*a* the records are shown for the tests which

TABLE I*a*

TESTS ON UNPRACTICED SETS, FOR WHICH RECORDS WERE MADE ON THE 1ST AND 12TH DAYS OF PRACTICE

Column headings as above.

1	55.9			35.8			1.56
12	47.4	8.5	15.2	32.0	3,8	10.6	1.48

TABLE I*b*

SEPARATE STATEMENT FOR MEN AND FOR WOMEN FOR THE 1ST AND 12TH DAYS OF THE REGULAR PRACTICE WORK

Figures for Women in Italics

Headings as above.

1	58.9			35.6			1.66
1	*53.3*			*35.1*			*1.52*
12	42.0	16.9	28.7	29.9	5.7	16.0	1.40
12	*39.9*	*13.4*	*25.1*	*29.0*	*6.1*	*1.74*	*1.38*

were made on the first and last days with different sets of colors and words.

In Table I*b* the data of the first and last days are arranged to display the fact that women excel men in speed in naming colors, but that men improve more with practice.[1]

From the data of Table I. and from an inspection of the curves of Fig. 1 it can be seen that the hypothesis on which this experiment was based is probably not true. At the end

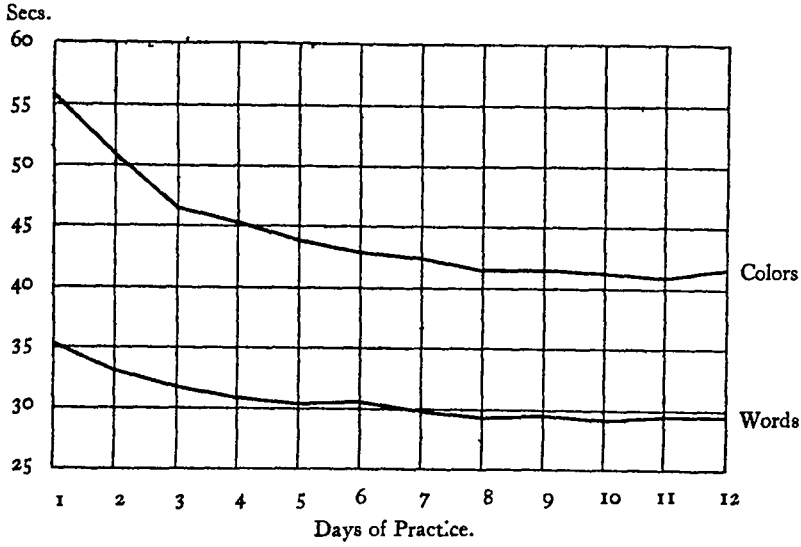
second day, there was improvement from trial to trial. The following figures were obtained by averaging the records for the last ten days of practice:

	1st trial	2d trial	3d trial	4th trial
Time for 100 colors.....	42.3	42.3	43.0	42.8
Time for 100 words.....	29.0	30.4	29.9	30.5

Evidently the practice gains during this period occur in the intervals between sittings, 'overnight,' and not during the course of a sitting.

[1] The superiority of women in naming colors has been observed by Woodworth and Wells, PSYCHOL. REV. MONOG., No. 57, 1911, p. 51, and by Wissler, PSYCHOL. REV. MONOG., No. 16, 1901, p. 17.

of twelve periods of practice it is evident that only a very slight further increase of speed in naming colors can be anticipated, no matter how much more practice is taken; yet the absolute rate in naming colors remains much slower than the rate of reading the same words from the list and is even slower than the word rate was before the beginning of practice. Furthermore the life-long practice which we have had in reading words has not brought that function to a maximum speed; on the contrary it shows an amount of practice-improvement almost proportional to the improvement shown in naming the colors. For every second gained in naming colors at any stage of practice approximately half a second has been gained in reading words. The ratio between speed



in color naming and speed in word reading (the last column of Table I.) shows no indication of approaching unity.[1]

From these data it seems safe to conclude that the dif-

[1] The statements of this paragraph are true not only for the average results given in the table, but for each individual subject who took part in the experiment. No statement of the variability or probable error of the measurements has been made because such a statement could have no direct bearing upon the interpretation of the figures in the present connection. The individual differences in absolute speed were very large, but they do not in any way affect the results.

ference in speed between color-naming and word-reading does not depend upon practice.

Further confirmation of this conclusion is found in the fact that the effects of training in reading words are specific for the particular words read and do not extend to other words. It will be recalled that each person was trained upon either the 'light' or the 'dark' set, but that a test was made, at the first and last sitting, of his speed with the other set (the one he did not practice). The results of these tests are indicated in Table I*a*. The speed on the unpracticed sets at the end of twelve days of practice is better than on the practiced sets on the second day of practice, but not so good as on the third day. In other words, three days of direct practice are better than two days of direct practice plus ten intervening days of indirect practice. This, too, in a case where the conditions regarding eye-movement and general adaptation to work might lead us to anticipate a considerable amount of transference of practice or 'formal' training. In the present connection the significant fact is that the amount of transfered practice is but little greater in the case of reading words than in the case of naming colors. Apparently we must have practice in reading specific words before we can attain great proficiency in reading them. It can not, therefore, be safely asserted that we read color names faster than we name colors simply because of the large amount of practice which we have had in reading words in general.

The Second Experiment

It now seemed clear that the effects of previous practice do not afford a sufficient explanation of the difference in speed between color-naming and word-reading. Accordingly the problem was attacked from another quarter. The introspections of practically all of the students who had taken part in the first experiment agreed upon one point: It is easier to speak a printed word than to name a color because when you want to name a color you have first to think of the name (the word) and then speak it, whereas the printed word can

be uttered without your having to think of anything. The observations of our foreign-born students were particularly clear on this point.[1]

On the basis of these introspections the hypothesis was formed that the process of color-naming would be facilitated by suggesting the word at the moment the color was presented. For actual experiment color-sets were prepared which had entire words or parts of words printed on the face of the colors themselves.

Nineteen students finally completed all the stages of this experiment. They were first given fifteen periods, twice a week, of practice in reading the lists and naming the colors from sets upon which nothing was printed, just as in the previous experiment. The color-set was named over three times at each sitting and the list of words was read once.

TABLE II

Day	Time Required to Name 100 Colors, Secs.	Time Required to Read 100 Words, Secs.	Ratio: Time for Colors Divided by Time for Words
1	53.8	35.5	1.52
2	48.2	32.7	1.47
3	46.2	31.7	1.45
4	45.3	31.1	1.46
5	42.9	29.8	1.44
6	42.2	30.2	1.39
7	41.3	29.4	1.41
8	40.7	28.8	1.41
9	39.3	28.5	1.38
10	39.5	29.0	1.36
11	40.4	28.8	1.40
12	38.8	27.6	1.41
13	38.2	27.7	1.38
14	37.9	27.6	1.37
15	37.1	27.4	1.35

Only the 'light' set was used. The words of the list, instead of being printed in a regular list with the ten words of a line separated by commas, were now typewritten on separate squares of paper, one inch square, which were mounted on a board just as the color-squares were mounted, so that the eye-movements involved were as nearly as possible the same as for the colors. The data for these fifteen preliminary

[1] Three Japanese and one Armenian took part in the experiment, but their records are not included in the tabulations.

practice sittings are given in Table II. The figures agree substantially with those presented in Table I.[1]

After the preliminary practice, which was only intended to bring the students to such a point that their speed for simple colors and lists of words would be nearly uniform from day to day, experiments were begun with sets of colors arranged just like the others except for words or letters typewritten upon them. The following transcript of the directions gives a sufficient outline of the course of this experiment.

DIRECTIONS

Sixteenth day. Read the list of words beginning with *brown:* then read the simple color-set beginning with *gray*. Then read color-set 2 with *b* on brown; then set 3 with *w* on white; then set 6, *b* on brown, *w* on white, *p* on pink, and *g* on gray.

Seventeenth day. Read the list of words beginning with *gray:* then the simple color-set beginning with *pink*. Then read color-set 7, *gr* on gray; then set 4, *p* on pink; then set 10, *br* on brown, *wh* on white, *gr* on gray, and *p* on pink.

Eighteenth day. Read the list of words beginning with *brown:* then the simple color-set beginning with *gray*. Then read color-set 11, *own* on brown; then set 12, *ink* on pink; then set 15, *own* on brown, *ink* on pink, *ite* on white, and *ay* on gray.

Nineteenth day. Read the list of words beginning with *gray:* then the simple color-set beginning with *pink*. Then read color-set 16, with full words on all colors. Then read the simple color-set again beginning with *brown*. Then read color-set 16, full words, again.

Twentieth day. Read the list of words beginning with *pink:* then the simple color-set beginning with *gray*. Then read color-set 16, with full words on all colors, two times. Then read the simple color-set beginning with *brown*.

Twenty-first day. Read the list of words beginning with *brown:* then the simple color-set beginning with *gray*. Then read color-set 13, with *ite* on white; then set 14, with *ay* on gray; then set 15, *own* on brown, *ite* on white, *ink* on pink, and *ay* on gray.

Twenty-second day. Read the list of words beginning with *gray:* then the simple color-set beginning with *pink*. Then read color-set 8, with *br* on brown; then set 9, with *wh* on white; then set 10, *br* on brown, *gr* on gray, *wh* on white, and *p* on pink.

Twenty-third day. Read the list of words beginning with *brown:* then the simple color-set beginning with *gray*. Then read color-set 4, with *p* on pink; then set 5 with *g* on gray; then set 6, with *b* on brown, *p* on pink, *w* on white, and *g* on gray.

The data for the last eight days of this experiment are presented in Table III. They are combined in the table so that wherever two records of the same kind were obtained on

[1] It may be noted that the rate of improvement is here almost the same as in the earlier experiment in spite of the fact that the colors were practiced only three times and the words only once instead of four times as in the earlier experiment. In view of the fact already mentioned that the first trial of a sitting is usually the best there is reason for believing that nearly the same results could be obtained in this work by one trial per day as by four trials per day.

TABLE III

TIME REQUIRED TO NAME 100 COLORS, TO READ 100 WORDS, AND TO NAME 100 COLORS WITH THE HELP OF PRINTED CUES

Day	Simple Colors	Words	Colors on Which the Following Letters Were Printed as Cues to Help in Naming the Colors	
16	38.1	28.1	40.8	An initial consonant on one color.
			39.4	An initial consonant on each color.
17	36.6	27.6	38.8	Initial pair of consonants on one color.
			36.4	Initial pair of consonants on each color.
18	36.6	27.6	38.0	Vowel and final consonant on one color.
			38.4	Vowel and final consonant on each color.
19	36.1	27.6	28.6	Entire word on each color.
20	35.7	27.2	28.3	Entire word on each color.
21	36.1	27.2	37.3	Vowel and final consonant on one color.
			36.4	Vowel and final consonant on each color.
22	35.0	27.9	36.9	Initial pair of consonants on one color.
			32.3	Initial pair of consonants on each color.
23	35.3	27.9	35.2	Initial consonant on one color.
			34.6	Initial consonant on each color.

the same day only their average appears. When the entire words are printed on the colors it is possible to read the words without attending to the colors, but even in that case the average speed is not so great as when the words are read alone without the colored background, as may be seen in the records of days nineteen and twenty. After having practiced with the full words on the colored backgrounds some of the students found it possible to read the color-names directly upon seeing the initial letters without considering the background. This accounts for the fact that the records for the twenty-second and twenty-third days, with initials, are considerably better than the records for the sixteenth and seventeenth days under the same conditions.

From the results of this part of the experiment it may be concluded that the association process in naming simple objects like colors is radically different from the association process in reading printed words. The presence of a visual symbol of the sound does not greatly, if at all, facilitate the process of association between color and color-name. Phonetic symbols which might suggest the name of the color do not help us in naming it unless they are so clear that they enable us to read the name itself directly without going through the process of naming the color. The one association

process does not reinforce the other. The introspections of all the subjects confirm the figures in declaring that the letters printed on the colors do not serve as helpful cues or prompts, but on the contrary actually interfere with the process of association.[1]

Conclusion

The conclusions of these experiments seem to be entirely negative. No facts have been adduced to explain why more time is required to associate speech movements with a color than with the corresponding printed word. But the evidence does throw some light on the problem in so far as it eliminates very definitely two lines of explanation which have been thought possible. First, the phenomenon does not spring from a difference in the amount of practice which the two functions have had in the past. Second the process of reading words is not involved in the process of naming colors as a subsidiary function. The two functions do not overlap, and in all probability they depend upon distinct physiological processes.

[1] A very similar problem has been attacked with the chronoscope by Bourdon. "Sur le temps nécessair pour nommer les nombres," *Rev. Philos.*, Vol. 65, 1908, p. 426. He finds that the time required to perceive and name a number of points of light (not exceeding four) is only slightly greater than the time required to read arabic numerals. Accordingly he infers that the process of perceiving a few points as a number is as simple as perceiving the symbol of the number. Apparent conflicts between this observation and the results in the case of naming colors are now under investigation in this laboratory.