A GENETIC STUDY OF COLOR NAMING AND WORD READING

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The normal adult requires a longer time to name colors than to read the names of the colors presented as words. This fact has been known for more than 50 years, during which time a number of studies have been made of the problem and a number of theories advanced in explanation, but the problem is still unsolved. It was, therefore, in the hope of gaining further knowledge of the phenomena which would lead to the ultimate explanation, that the present study was undertaken.[1]

Experimental Procedure

The observations for the present study were made in the public schools of New London, Connecticut. The experimenters were students of psychology in Connecticut College. Each experimenter was provided with the Woodworth-Wells color naming test.[2] A word reading test was prepared, which was a typewritten sheet containing 100 words, the names of the colors on the color naming test. The two tests were made as nearly identical as possible, except that one contained the colored squares and the other the names of the colors. The two tests were arranged in reverse order so that the sequence of responses in them would not be identical. Time was taken with a stop-watch.

The experimenters were divided into two groups. Group I presented to their *Ss* the color-naming test and then the word-reading test. Group II reversed this order. This was done to equalize in the averages any effects of practice and fatigue. A record was kept for every *S* of the name, sex, age, school grade, time for each test, errors, and any unusual observations. Later, class marks were obtained for two grades and intelligence test scores for seven.

The *Ss* used from the 1st to the 6th grade constituted the entire student body of one public school, thus including all grades of intelligence and an approximately equal number of boys and girls. The 7th, 8th, and 9th grades were in different schools. Caution was taken to assure the presence of a random sample of each grade. In all except the 9th grade, pupils had been divided into at least two and sometimes three sections, called A, B, and C. This division had been made in an effort to

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[1]I am indebted in this study to my students at Connecticut College who acted as experimenters; to the public school authorities of New London, Conn., whose permission to work in the schools made the study possible; and to the teachers and pupils in the schools whose hearty coöperation was necessary to the success of the work.

[2]R. S. Woodworth and F. L. Wells, Association tests, *Psychol. Monog.*, 13 1911, (No. 57), 1-85.

have the best students in section A, and the poorest in C. This sectioning was also recorded in the experiment, thus affording a rough intelligence classification, which for group comparisons might be reliable.

The experiment was conducted during school hours with the most hearty coöperation of both teachers and pupils.

Results

An analysis of the data obtained will now be presented. The problems on which data are available are as follows: (*1*) a comparison of the time required for the color naming and word reading functions, with *S*s classified both by school grade and chronological age; (*2*)

TABLE I

Average Time for Color Naming and Word Reading Tests by School Grade

(The numbers in parentheses are the medians)

Grade	No.	Colors	P.E.	Words	P.E.	Diff.	P.E.	Diff./P.E
I	76	130.2	3.1	100.6	2.9	29.6	3.4	8.7
		(123.0)		(93.0)		(30.0)		
II	83	107.4	1.7	79.6	1.7	27.8	2.0	13.9
		(107.0)		(75.0)		(32.0)		
III	69	90.7		63.2	1.5	27.5	2.1	13.1
		(89.0)	1.6	(59.0)		(30.0)		
IV	74	88.3		59.6	1.0	28.7	1.3	22.1
		(87.0)	1.2	(58.0)		(29.0)		
V	75	81.0		52.1	.6	28.9	1.0	28.9
		(80.0)	1.2	(50.0)		(30.0)		
VI	84	77.3		50.5	.7	26.8	1.3	20.6
		(75.0)	1.3	(49.5)		(25.5)		
VII	59	73.5	1.1	45.0	.5	28.5	1.1	25.9
		(72.0)		(43.5)		(28.5)		
VIII	64	68.7	1.6	45.3	.7	34.4	1.6	14.6
		(68.0)		(45.0)		(23.0)		
IX	54	69.1	1.1	45.8	.6	23.3	1.1	21.2
		(69.5)		(46.5)		(23.0)		
Total	638							

the correlation between these functions; (*3*) the relationship between each function and the difference between them; (*4*) the relationship between each function and intelligence; (*5*) the frequency of errors and the relationship between the two functions for erring; and (*6*) sex differences in the two functions.

(*1*) *Time required by the two functions.* In Tables I and II are the general results of the investigation. From them we may compare the temporal relations of the two functions.

Table I shows a comparison of all *Ss*, classified by school grades for the two functions. Attention is called to the very large number of cases, since this increases the reliability of the averages computed from them.

The average will be used as a measure of central tendency throughout the paper. The median is shown in this first table to show the very small difference between the average and the median. This justifies the exclusive use of the average as a measure of central tendency.

In Fig. 1 the data are presented graphically.

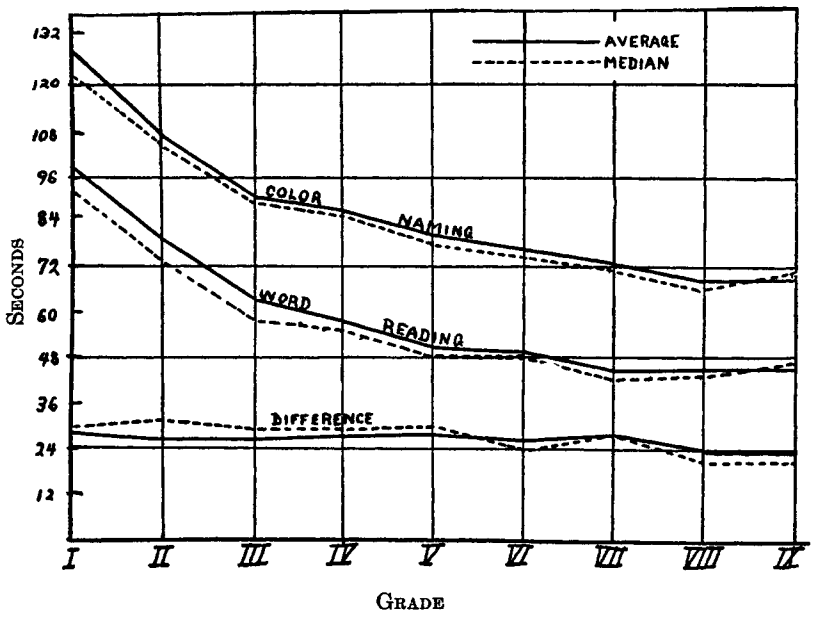

FIG. 1. COLOR NAMING COMPARED WITH WORD READING

It will be observed that in both functions there is a progressive increase in speed throughout the range tested. The improvement in the first few grades is much greater proportionately than in the last grades. This resembles most learning curves and immediately suggests that both functions contain some factor which is practiced in the normal education of the subjects.

The most striking feature of these data, however, is the approximate constancy of the difference between the two functions. The curves of the two functions are almost parallel. The curve of the difference is nearly a straight line, showing almost no decrease from the 1st to 9th grades. This difference between the two functions is the phenomenon which we are studying, and this feature of it will be of the utmost importance in its interpretation.

The probable error of the difference is so small as compared to the difference itself, that there can be no question of its reliability. It will be seen that it is always much more than four times its P.E.

TABLE II

AVERAGE TIME FOR COLOR NAMING AND WORD READING TESTS BY CHRONOLOGICAL AGES

(Ages 17 and 18 yr. not added because of the small number of cases)

Age	No.	Colors	P.E.	Words	P.E.	Diff.	P.E. Diff.	Diff./P.E.
6	16	128.8	6.0	103.5	4.7	25.3	6.9	3.7
7	54	128.9	3.8	92.6	3.0	36.3	4.8	7.5
8	78	107.2	1.8	80.6	1.6	26.6	2.4	11.0
9	52	97.0	2.3	73.4	2.7	23.6	3.5	6.7
10	74	89.6	1.5	55.0	1.1	34.6	1.9	18.2
11	78	83.5	1.1	55.4	.8	28.1	1.4	20.1
12	86	79.5	1.1	52.8	1.1	26.7	1.6	16.6
13	72	75.3	1.5	57.0	.9	18.3	1.7	10.8
14	80	74.7	1.2	48.9	1.0	25.8	1.6	16.1
15	37	70.6	1.0	46.5	.8	24.1	1.3	18.6
16	15	71.1	2.2	45.9	1.3	25.2	2.6	9.7

Table II shows the same data, with the *S*s classified by chronological age. The range of ages included is from 6 to 16 years. There were 3 *S*s 17 yr. of age and 1 who was 18. These were omitted in this table, both because of the unreliability of so small a group and because of the obvious selected nature of these samples, due to the fact that these *S*s are obviously much retarded in their school progress and are therefore not representative of their age. The opposite may be true of the 6-yr. old *S*s also, but since there is a larger group of them, they have been included.

There is very little difference between the data when classified in the two ways. In Table II the differences are slightly more variable. But it will be observed that there is no consistent tendency for the difference to become smaller as the subject grows older. Some

of the inconsistency can be explained by the presence of a larger number of boys or girls in the age group. There are sex differences, especially in the case of color naming.

The general results, then, show that older and more advanced *S*s perform both functions faster than the younger ones, but that the superiority of the speed of word reading over color naming is approximately constant despite age or school advancement.

(*2*) *Correlation between functions.* It has been suggested that the color naming function is the same process as the word reading, plus another process. *S*s, introspecting, often insist that this is true. If it is true, however, word reading would never be slower than color naming. There were a number of *S*s in this experiment who did read the colors faster than the words. Also, if the hypothesis be valid, there should be a very high correlation between relative ability on the two tests. Even if the additional process does not correlate highly with the common factor, the correlation should in groups be high and fairly constant.

TABLE III

RELATIONSHIP BETWEEN THE TWO FUNCTIONS

Grade	r	P.E.	Grade	r	P.E.
I	.709	.047	VI	.506	.060
II	.588	.052	VII	.275	.087
III	.162	.077	VIII	.394	.068
IV	.594	.502	IX	.423	.080
V	.405	.068	Av.	.450	.066

Table III shows the coefficients obtained between the two functions in the several grades. While, in most cases, the relationship indicated by these coefficients is high enough to be reliable, it seems neither high enough, nor constant enough, to substantiate the foregoing hypothesis.[3]

[3]During the experiment, 17 *S*s succeeded in naming the colors faster than they read the words. Of these, 5 were in grade I, 5 in grade II, 3 in III, and 1 each in grades IV, VI, VIII, and IX. Such scores might be due either to unusually fast color naming or unusually slow word reading. An analysis of the scores seems to indicate that both conditions were present. Of the 17 *S*s, 12 made color naming scores that excelled the average of their respective grades, and 5 made scores poorer than these averages. For the entire 17, the average deviation from the mean of their grades was −12.1 sec. On the other hand, all but one *S* read words slower than the average of their groups. The average deviation from the mean of their grades was +44.6. Of the 17 *S*s, 5 excelled their groups in color naming by larger amounts than they proved inferior in word reading; the other 12 reversed this condition. These results indicate that both factors then combined to produce these unusual scores, but that inferiority in word reading was the more important of the two.

The correlation between the functions is always positive and usually fairly high, showing that the two functions are certainly not entirely independent. Yet, the variability of the coefficient and the low level to which it drops, also, indicates that there are some factors at least in which the two functions vary independently.

(3) *Relationship of functions to differences.* Since the difference between the functions forms the central problem of this study, correlations were computed between it and each of the functions. The difference was computed by subtracting time for word reading from time for color naming. Those cases in which the word reading was the larger number were treated as negative differences. Table IV shows these results.

TABLE IV

CORRELATIONS BETWEEN FUNCTIONS AND DIFFERENCES

CN refers to color naming; WR to word reading; Diff. to the difference between the two.

Grade	r CN-Diff.	P.E.	r WR-Diff.	P.E.	σ CN/σ WR
I	.500	.055	−.220	.083	1.08
II	.460	.055	−.400	.063	1.00
III	.663	.047	−.599	.051	1.09
IV	.644	.047	−.284	.073	1.14
V	.944	.008	−.122	.079	1.90
VI	.763	.032	−.062	.079	1.73
VII	.855	.025	−.249	.083	1.94
VIII	.746	.038	−.323	.077	1.38
IX	.893	.018	−.222	.091	1.64
Av.	.717		−.274		

Rank Square Difference Correlations

First series	Second series	Rho
r CN-Diff.	r WR-Diff.	−.49
r CN-WR	r CN-Diff.	−.56
r CN-WR	r WR-Diff.	−.33
ratio of σ	r CN-Diff.	+.90
ratio of σ	r WR-Diff.	−.55
σ CN	r CN-WR	+.44
σ WR	r CN-WR	+.47

*Professor F. C. Chillrud checked these coefficients by computing them by formula instead of actual plotting as I have done.

Let us examine this table carefully, for in it there are many clues leading to the solution of our central problem; namely, the explanation of the difference between the two functions.

If the two functions were entirely independent, color naming being simply a longer process than word reading, certain results could be expected. In the first place, color naming would correlate positively with the difference, since (except for the chance variation in word reading time) the greater the time required for color naming, the greater would be the difference. In the same way, in the second place, word reading should correlate negatively with the difference, since (except for chance variation in color naming time) the longer the time required for word reading, the smaller would be the difference. In each case, the smaller the relative variability of the other, the higher the correlation. All of these conditions are fulfilled in the above data. Color naming correlates positively with the difference. The higher the ratio between the standard deviations of the two functions, the higher the correlation. The rank square difference coefficient between this ratio and the size of the correlation is 0.90. Word reading correlates negatively with the difference, and the corresponding rank square difference score is $=0.55$.[4]

There is, however, one further condition which should be fulfilled if the two functions are entirely independent; namely, there ought to be no relationship between them. There is, however, a fairly high relationship between them—it averages 0.450 (see Table III).

This would indicate a definite relationship between them. The two functions are not independent. If the assumption is made that they are very highly related, so that excellence in one signifies excellence in the other and vice versa, there ought to be much higher coefficients between the two functions than are found, and word reading ought to correlate positively with the difference; for in this case, the worse the score for word reading, the worse ought color naming time to be proportionately and the wider the difference between them. This condition is not found. This hypothesis cannot be maintained.

It is obvious then that the two functions cannot be regarded as simple entities, since they are both related and unrelated to each other. As will be pointed out in the conclusion, this practically eliminates the 'practice hypothesis.' Let us consider other possibilities.

[4]It will be observed that the ratio between the σ is computed by dividing the σ for color naming by that of word reading. Hence the greater the ratio, the relatively greater is the σ of color naming to that of word reading.

Suppose the color naming function is made up of two factors, in one of which it is entirely independent of the word reading function and in one of which it is identical. The latter may be referred to as the common factor and the former as the color naming special factor. The difference would then be a part of this color naming special factor. This would account for the high correlation between the color naming function and the difference and, since there is a common factor, between color naming and word reading.

But, why the negative relationship between word reading and the difference? If the common factor and color naming special factor were entirely independent, there ought to be a zero relationship between them. The only answer is that word reading is not entirely constituted of the common factor, but also has a special factor, which though very much smaller and less variable than the color naming special factor, influences the difference, and hence correlates negatively with it.

The common factor, then, causes the two functions to correlate with each other. The special factors cause this relationship to be low. It is easy to see that the common factor constitutes most of the word reading function, since the effect of the word reading special factor has so little influence upon the difference, as indicated by the correlation between word reading and the difference.

It is in the suggesting of this word reading special factor that I have entirely departed from previous hypotheses. It not only permits an explanation of the data just discussed, but it allows for those cases in which a longer time was required for word reading than for color naming.

That the two special factors are entirely independent is indicated, not only by the low correlation between the functions, but by the fact that the more each varies, the higher its correlation with the difference. Obviously, since the common factor would vary equally in the two functions, any difference in the variability of the two must be attributed to the special factors. The ratio between the σ of the two functions, then, is a statement of the variability of the color naming special factor as compared to the word reading special factor. If they are independent, the higher this ratio, the greater the relative variability of the color naming special factor and the higher will color naming correlate with the difference and the lower will word reading do so. The rank square difference coefficient between

this ratio and the r of color naming with difference is 0.90; between this ratio and the r of word reading with difference is −0.55.

The question also arises, as to whether the common factor is very variable or not. Any difference in variability between the two functions must be attributed to the color naming special factor. But of the variability of the entire word reading function, is it all in the common factor, in the special factor, or in both?

If all the variability were in the special factors, since they vary independently of each other, the larger this variability the smaller would be the correlation between the two functions. In this case the rank square difference coefficient between the size of the standard deviations and the r between the functions would be negative. In the case of color naming it is 0.439 and for word reading 0.470. This indicates that the greater the variability of the functions the greater the relationship between them. Hence a greater part of the variability must be in the common factor, a very little in the word reading special factor, and the same amount plus the difference in variability in the color naming special factor.

Since, according to this hypothesis, the common factor determines the relationship between the functions, it follows that the higher the correlation between them, the greater the influence of the common factor and the less the influence of the special factors. This would be indicated in their relationship to the difference. Hence the higher the correlation between the two functions, the lower ought to be the correlation between the functions and the difference. The rank square difference coefficients which express this are in the case of color naming −0.37 and for word reading −0.33.

It also follows, that since there is improvement in both functions with age, but with a constant difference, that it is the common factor which improves, whereas the special factors do so very little. This would indicate that the special are organic in their nature, whereas the common factor is a learned reaction.

(*4*) *Intelligence.* It will be valuable for the understanding of the problem, to find out whether either or both functions are related to intelligence. Three measures were secured in this experiment which might be expected to be measures of intelligence. In 2 grades, class marks for the year were obtained. In 7 of the 9 grades, intelligence test scores were available. In all the grades, except the 9th, there were two or three sections of each grade, made on the basis of school success. We have very little confidence in any of the three sources

as accurate indices of intelligence. Group scores should, however, be more reliable than individual and if the same results are obtained from all three sources, that in itself is evidence of reliability.

Class marks were available for the 7th and 8th grades. The correlations obtained with them are as follows: color naming with class marks; 8th grade −0.127, P.E. .086; seventh grade, −0.110, P.E. .094; for word reading with class marks, eighth grade −0.328, P.E. .076; seventh grade 0.099, P.E. .094. It will be remembered, of course, that a negative correlation indicates a positive relationship. We should expect that if the tests are indicators of school success or vice versa that high negative coefficients would be obtained. It is obvious that this is not true. Three of the 4 coefficients are approximately zero.

TABLE V

CORRELATION BETWEEN IQ AND THE TWO FUNCTIONS

Grade	r. IQ-CN	P.E.	r. IQ-WR	P.E.
I	−.148	.093	−.420	.080
II	−.049	.087	−.324	.079
III	.125	.094	−.006	.095
IV	−.026	.095	−.285	.086
V	.076	.122	.146	.120
VII	−.014	.095	−.004	.095
VIII	.192	.084	−.143	.085
Av.	.021		−.146	

An examination of this table only adds to the conclusions drawn from the class mark correlations. There are only three coefficients with any considerable size. It may be noted that both the significant coefficient in connection with school marks and the three significant scores in this table are in the word reading function and none of them in color naming.

There is one further line of evidence in connection with this problem. The average scores for the two functions may be obtained for the sections of each grade. Most of the grades were divided into three sections; three had only two sections; and the ninth grade was not divided at all. It has therefore been omitted from Table VI, which contains these results.

There is more indication of intelligence playing a part in this group comparison than in either of the other methods of comparison. The same tendency appears, however. While there is some tendency in color naming for section A to excel section B, and B to excel C,

it is by no means a marked tendency and has several exceptions. In word reading the tendency is much more pronounced. There is no definite trend in the comparison of differences at all.

TABLE VI

AVERAGES FOR SECTIONS OF SCHOOL GRADES

	Color Naming			Word Reading			Differences		
Grade	A	B	C	A	B	C	A	B	C
I	118.7	118.2	133.7	85.3	92.7	106.8	33.3	25.5	26.9
II	103.9	105.6	116.3	72.2	85.0	86.5	31.7	20.6	29.8
III	92.2	89.8	—	64.1	62.6	—	28.1	27.2	—
IV	85.4	88.7	94.9	55.0	61.4	67.0	30.4	27.3	27.9
V	79.3	82.8	—	51.3	52.9	—	28.0	29.0	—
VI	74.1	76.0	79.4	48.6	51.5	53.4	25.5	24.5	26.0
VII	73.8	73.4	—	45.7	42.7	—	28.1	30.7	—
VIII	67.2	73.2	69.6	41.9	47.7	45.9	25.3	25.5	23.7

From these data, the conclusions seem tenable that the common factor is related to intelligence, and that neither of the special factors are appreciably so related. This is indicated by the closer relationship between measures of intelligence with word reading, in which the common factor predominates, than with color naming, where the common factor is a much smaller portion. That the color naming special factor is very little related to intelligence is indicated by the complete absence of significant differences in the case of the different scores. The word reading special factor is likely to be the cause of the relatively low correlation between intelligence and word reading.

(*5*) *Errors.* A record was kept of the number of errors made by the *S*s taking the tests. An analysis of these records shows some interesting features, which will be valuable in the explanation of the phenomenon.

Table VII shows that the percentage of *S*s making errors is larger in color naming than in word reading. It shows that there is comparatively little improvement in the percentage making errors in either function through the nine grades studied. The average number of errors made by those who made errors is very strikingly constant for all grades in color naming. It is more variable for word reading, though showing little signs of improvement. In most cases, the average error for the erring is greater in color naming than in word reading.

For the group, the average error for color naming is always much greater than for word reading, due to the high percentage of *Ss* who make errors in color naming.

Since the common factor has been shown to improve throughout the 9 grades, and since there is almost no sign of improvement in eliminating errors, we are almost forced to assume that the errors are found largely in the special factors. The rank square difference correlation between the averages of the errors for those erring in the two functions is 0.30, which is surprisingly small, indicating a very low relationship between the two functions in the matter of erring.

TABLE VII

ERRORS IN THE TWO FUNCTIONS

Grade	Color Naming			Word Reading		
		Av. of			Av. of	
	% erring	erring group	entire group	% erring	erring group	entire group
I	71	2.40	1.71	50	2.65	1.36
II	63	2.76	1.73	31	1.69	.49
III	65	2.63	1.70	29	2.18	.61
IV	59	2.39	1.40	30	1.90	.59
V	55	2.89	1.59	25	2.47	.42
VI	68	2.65	1.81	29	1.68	.49
VII	58	2.40	1.41	15	2.33	.35
VIII	57	2.17	1.25	29	1.78	.52
IX	53	2.14	1.13	31	1.47	.46

It seems especially desirable to establish the last point. The rank square difference coefficient is hardly sufficient for this purpose. Recourse was taken to the individual cases. A table has been prepared, Table VIII, in which the average number of errors made in word reading is computed for those making a given number of errors in color naming. Thus in the first column are found individuals who made no errors in color naming; in the second column the average of those who made only one error in color naming, and so on. The number of cases has been placed at the bottom, so that an estimate of the reliability of the data obtained may be made.

An examination of this table shows that there is a very slight tendency for the errors made in one function to predict what will be made in the other. Even the averages, however, show great inconsistency. Certainly this table affords strong evidence of the high

degree of independence of the two functions. Since it may be assumed that most of the errors are due to the special factors, this still further establishes the comparative independence of these. That there is a very slight correlation indicates that there may be some tendency to error in the common factor.

TABLE VIII

RELATIONSHIP BETWEEN ERRORS IN THE TWO FUNCTIONS

	Errors in color naming										
Grade / Errors in word reading	0	1	2	3	4	5	6	7	8	9	10
I	.4	.8	2.0	2.2	.0	2.0	1.0				
II	.2	.3	.4	.7	1.1	2.0	2.0	2.0	.0	2.0	
III	.3	1.2	.6	.4	1.0	.0					
IV	.5	.5	.5	.5	.0	1.0	.0	7.0			
V	.1	.7	.6	.8	.0	.3	.0			.2	
VI	.2	.4	.4	1.1	.4	.8			2.0		2.0
VII	.1	.5	.4	.0	2.0	1.5	.0				.0
VIII	.4	.4	.7	.8	1.0		2.0				
IX	.3	.5	.6	1.0	2.0		.0		2.0		
Av.	.3	.6	.7	.8	.7	1.3	.8	5.5	1.0	1.0	1.0
No.	249	137	107	69	33	23	10	2	4	2	2

TABLE IX

SEX DIFFERENCES IN FUNCTIONS BY SCHOOL GRADE

Bold face type indicates those instances in which the difference is more than four times the P.E. and so statistically reliable

	Color naming				Word reading				Differences			
Grade	Boys	Girls	Diff.	P.E.	Boys	Girls	Diff.	P.E.	Boys	Girls	Diff.	P.E.
I	139.7	121.0	**18.7**	**3.1**	113.1	91.7	**21.4**	**2.9**	26.6	29.3	−2.7	4.2
II	108.5	107.4	1.1	1.7	83.1	76.7	6.4	1.7	25.4	30.7	−5.3	2.4
III	93.4	86.9	**7.5**	**1.6**	60.3	66.8	**−6.5**	**1.5**	33.1	20.1	**13.0**	**2.2**
IV	89.8	86.8	3.0	**1.2**	59.9	59.3	.6	1.0	29.9	27.5	2.4	1.6
V	85.5	76.9	**9.6**	**1.2**	52.0	52.3	−.3	.6	33.5	24.6	**8.9**	**1.3**
VI	84.3	72.4	**11.9**	**1.3**	51.7	49.8	1.9	.7	32.6	22.6	**10.0**	**1.5**
VII	78.4	68.9	**9.5**	**1.1**	43.8	44.8	−1.0	.5	30.5	24.1	**6.4**	**1.2**
VIII	72.5	64.3	**8.2**	**1.6**	45.8	44.9	.9	.7	26.7	19.4	**7.3**	**1.7**
IX	71.8	67.2	**4.6**	**1.1**	48.4	46.6	1.8	.6	23.4	20.6	2.8	1.3

(*6*) *Sex differences.* Previous investigators have found girls superior to boys in these functions. No extensive set of data has, however, been available for studying these differences.

Table IX indicates that there are very much greater sex differences in color naming than in word reading. The girls excelled the boys in color naming in every grade, with statistically reliable superiority in 7 of the 9 grades. In word

reading, on the other hand, there were 3 grades in which the boys excelled, and in only one did the girls have a reliable difference in their favor.

The logical deduction from this would be that girls are superior to the boys in respect to the color naming special factor, not in the common factor, with the word reading special factor in doubt. In a comparison of the differences, which constitute the major portion of the color naming special factor, we find the girls with a decided advantage except in the first two grades. There is evidence that the greater the influence of the color naming special factor, the greater the superiority of girls; and the greater the influence of the word reading special factor, the greater the superiority of boys.

TABLE X

SEXES COMPARED IN MAKING ERRORS

(Italics indicate sex making best score when difference is not reliable; bold face indicates sex making best score when difference is reliable)

	Color Naming						Word Reading					
	% erring		Av. erring		Av. group		% erring		Av. erring		Av. group	
Grade	B	G	B	G	B	G	B	G	B	G	B	G
I	*61*	63	*2.3*	2.6	*1.4*	1.6	47	*43*	3.3	*2.0*	1.6	*.9*
II	63	**40**	**2.7**	3.1	1.7	**1.2**	40	**26**	1.5	1.6	.6	*.4*
III	**49**	63	*2.1*	2.4	**1.0**	1.5	*23*	27	*2.0*	2.3	*.5*	.6
IV	63	**47**	*2.4*	2.5	1.5	*1.2*	38	15	**1.7**	2.6	.7	*.4*
V	62	**45**	**2.8**	3.4	1.8	*1.5*	24	*23*	1.7	1.7	.4	*.4*
VI	63	*61*	2.8	*2.4*	1.7	*1.5*	31	**24**	*1.6*	1.8	.5	.4
VII	64	**50**	2.8	**2.0**	1.8	**1.0**	*14*	16	**2.0**	2.6	*.3*	.4
VIII	59	**50**	2.5	**1.7**	1.5	.9	29	*27*	1.8	*1.8*	.5	*.5*
IX	57	**52**	2.3	*2.0*	1.3	*1.0*	*29*	32	*1.4*	1.5	*.4*	.5

Table X shows that the girls excel in both functions in the percentage of the availing errors. This is especially true in respect to color naming. In regard to the average errors made by those making errors, the boys excelled in the first 5 grades and the girls in the last 4, in color naming. The differences in word reading were variable and negligible. The average errors for the groups give the girls an advantage, especially in color naming. This shows that it is in the number of those making errors rather than in errors made in which the girls excel. We may conclude, then, that girls show a reliable superiority to boys in the color naming special factor. This advantage seems to lie, not in a general superiority of all girls over all boys, but in the greater percentage of girls who make a minimum of errors. The superiority of boys over girls in the first 5 grades in average error made by the erring and the reverse in the last 4, might seem to be an interesting phenomenon in need of interpretation. The differences, however, are not great at any time. Carelessness may be found more in girls and older boys. This may account for the fact.

It was observed that girls tended to be more advanced in school for their ages than did boys. This made it desirable to study these sex differences by ages as well as by grades. It might be possible that the superiority of girls over boys is entirely due to their age. Or on the other hand, if given equal age, the boys may not be inferior to the girls in color naming. Table XI shows the differences when computed on the basis of age, and its reliability.

TABLE XI

SEX DIFFERENCES BY CHRONOLOGICAL AGES

(Bold face type indicates a reliable difference)

Age	Av. grade			Color Naming			Word Reading			D-D
	B	G	Diff.	Diff.	P.E.	D/P.E.$_D$	Diff.	P.E.	D/P.E.$_D$	
6	1.00	1.08	.08	15.0	15.1	1.0	22.1	15.0	1.5	−7.1
7	1.32	1.44	.12	28.4	8.8	3.2	24.6	7.7	3.2	3.9
8	1.85	2.08	.23	12.6	3.5	3.6	13.6	3.4	**4.0**	−0.9
9	2.68	3.13	.45	7.6	4.7	1.6	0.1	5.3	0.0	7.6
10	3.74	3.96	.22	10.9	3.2	3.4	1.5	2.3	0.6	13.4
11	4.46	4.70	.24	11.1	2.1	**5.3**	−0.9	1.8	0.5	12.0
12	5.58	5.81	.23	11.2	2.0	**5.6**	3.9	2.3	1.7	17.3
13	6.50	6.78	.28	3.6	2.9	1.3	1.3	1.7	0.8	1.4
14	7.03	7.36	.33	10.3	2.4	**4.3**	0.3	1.9	0.2	9.9
15	8.59	8.40	−.19	13.6	2.0	**6.8**	3.8	1.8	2.1	9.9
16	8.73	8.75	.02	6.2	3.5	1.8	5.9	3.3	1.8	0.3

When this table is compared with Table IX, the general trends are found. The girls excel still more in color naming. The girls show a little more advantage in word reading than in the other classification. This would indicate that the color naming special factor is a product of age and organic, since when girls are given an equal advantage in age, their superiority is greater. On the other hand, the common factor seems to be in part at least subject to the influence of training, since girls show to better advantage when classified by age, where they have the advantage in school advancement.

A study of sex differences, then, shows the girls to be superior in the color naming special factor, regardless of classification. The common factor seems to be subject to school advancement, as is indicated when the subjects are classified both by grades and by ages.

Discussion. The first hypothesis intended to explain the phenomenon was suggested by Cattell.[5] He states the so-called 'practice hypothesis.' "The association between the color word and its name has been repeated so often that it has become automatic, whereas in the case of colors a voluntary effort is required."[6] When the data were secured from adult *Ss* only, this hypothesis was difficult to refute. The only effort was made by Brown who had his *Ss* practice for long periods of time.[7] On the basis of his results, he decided against the practice hypothesis, although as Lund points out, his data can be interpreted in either way.[8]

[5] J. McK. Cattell, The time it takes to see and name objects, *Mind*, 11, 1886, 63-65.

[6] *Ibid.*, 65.

[7] Warner Brown, Practice in associating color-names with colors, *Psychol. Rev.*, 22, 1915, 45-55.

[8] F. H. Lund, The rôle of practice in the speed of association, *J. Exper. Psychol.*, 10, 1927, 424-433.

The final test of the practice hypothesis could only be made by a genetic study. This Lund did. If the difference between color naming and word reading is entirely due to practice, children before the school age ought to read the colors faster than the words. But when reading habits are acquired, since words are used so much oftener than color names, we would expect the two curves to cross. This is exactly what Lund concludes upon the basis of his experiment.[9] Starting with 5-year-old children, he tested *Ss* up to 19 yr. of age. Unfortunately he does not show a table, but presents only a graph, showing the curves of the two functions. I have endeavored to construct a difference curve from his graph, represented by the solid line in Fig. 2.

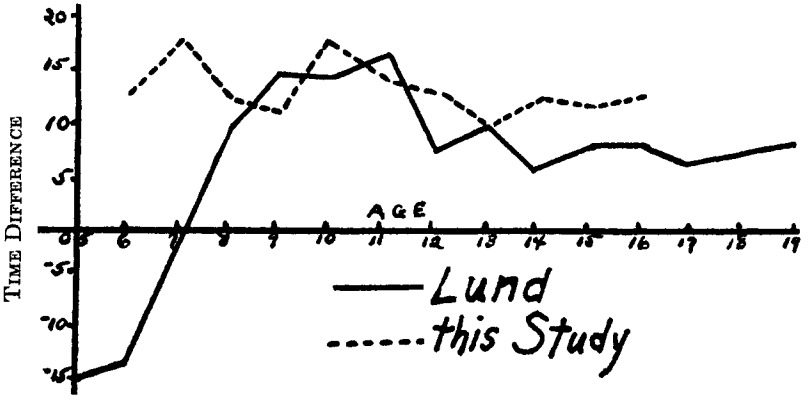

FIG. 2. COMPARISON OF THE 'DIFFERENCE CURVES' OBTAINED FROM LUND AND AND FROM THIS STUDY

(The 'Difference Curve' is obtained by subtracting the time required for word reading from that required for color naming)

He used 50 colors, whereas I used 100. I have, therefore, divided my differences in half. It is well known that the first half of the color naming test is faster than the second half, so that my corrected differences should be slightly greater than his. It is apparent that except for 6- and 7-yr. old *Ss*, we have obtained approximately the same results. At the 6-yr. old level, I used *Ss* already in the first grade. I do not know what type of *Ss* he used. But at the 7-yr. old level, where his would also be in the public school, I cannot account for our very wide disagreement. He used, however, only 6 or 7 *Ss* at each level. This would give much greater reliability to my results.

[9] *Ibid.*, 433.

It should be noted, however, that after the 8-yr. old level, his differences are almost constant, showing no gradual increase as would be expected on the basis of his hypothesis.

The 'practice hypothesis' assumes the independence of the two functions. The correlations found between them at the various grade levels averaged 0.450. These two facts seem to me to be quite complete proof that the 'practice hypothesis' is not tenable.

There is no doubt that both functions can be improved by practice. But it is the common factor which is practiced and not the special factors. The practice hypothesis cannot explain the difference between the functions.

Brown considered the possibility of the color naming function including the word reading function plus another factor. and found that this was untenable.[10] The data of my experiment also indicate that such an hypothesis cannot be supported. The fact that some *Ss* read colors faster than words is one such bit of evidence.

Hollingworth suggests that there is a time required for articulation, plus, in the case of color naming, an association time.[11] This is an hypothesis, which like the preceding one, is refuted with the same facts. In discussing articulation he speaks of the mispronunciation of the words in color naming, such as "bleen," "rellow," and the like. But he uses the word reading test as an articulation test, in which no such errors occur. He seems to neglect the necessity of an association time in the word reading test, and assumes that the association time for color naming is sufficient explanation of the difference. This is refuted by the constancy of the difference. If association were the only difference, time and practice should narrow this difference. Such is not the case.

In the study made by Gates, it is significant to note that the test showing the highest relationship with color naming was tapping, a much more structural function than the other tests used, adding, word building and multiplying tests.[12] This adds evidence to my contention that the color naming special factor is structural.

Garrett and Lemmon apparently abandon the 'practice hypothesis' entirely.[13] They assert that the difference is due to an inter-

[10] *Op. cit.*, 45 ff.

[11] H. L. Hollingworth, Articulation and association, *J. Educ. Psychol.*, 6, 1915, 99-105.

[12] G. S. Gates, Individual differences as affected by practice, *Arch. Psychol.*, 8, 1922, (no. 58), 1-74.

[13] H. E. Garrett and V. W. Lemmon, An analysis of several well-known tests, *J. Appl. Psychol.*, 8, 1924, 424-438.

ference factor. This factor is based on the introspective evidence of their *S*s. They measure it by obtaining a ratio between the color naming test and a color finding test. The latter consists of asking the *S* to pick out all the squares of the same color at once. They assert that the *S*s can recognize the colors fast enough, as is shown by their speed in color finding, but are prevented by the interference factor, from naming them. The question that arises is, why does this interference factor not operate in the word reading test? This they do not consider. If *S* can recognize the color as fast as the word, why can he not pronounce it as fast? To be sure, there is an interference factor, but it is in the color naming test and has nothing to do with the articulation process in pronunciation.

Since none of these hypotheses are supported by the data of this investigation, it seems desirable that a new hypothesis be formulated, which will explain these data. Such an hypothesis can only be tentative, awaiting further experimentation for its testing. Three experiments are now under way in the Union Laboratory, which will have very direct bearing upon this problem when they are completed.

As I have already indicated, the three-factor hypothesis seems tenable in view of these data. The question that now arises is what are these factors? What is the common factor? What are each of the two special factors? Before answering, even tentatively, it must be stated that the common factor may be and probably is a group of factors, which are common to both functions. The same may be said of the special factors.

Perhaps an analysis of each function may help. In color naming, the *S* must recognize the color, must recall its name, and must articulate its name. In word reading, the *S* must recognize the word, must recall its pronunciation, and must articulate it. I recognize that this analysis is entirely logical and may not be an actual description of the psychological process at all.

In looking for the common factor, there seems little doubt that the articulation time for both is common. Whether this is sufficiently influenced by practice to explain the preceding data is doubtful. The recognition process may be so similar that it will be common except for the difference in reaction time to the colors as contrasted with the words. A reaction time experiment, which is now being done, may give evidence that will help answer this question.

The recognition process and the articulation process are both evidently necessary to either function. But what happens between the two seems likely to form the basis for the special factors. It seems logical to assume that it requires more time to translate a recognized color into the spoken color name, than to translate a recognized word into a spoken word. That this should make color naming slower than word reading is a very reasonable assumption. But why the difference between the translation time for the two functions should have an almost constant value irrespective of age and educational advancement is difficult to see.

This seems as far as it is possible to go toward an hypothesis to explain the phenomenon, until further data are secured from the experiments now in progress.

Summary and Conclusion

The Woodworth-Wells color naming and a word reading test, consisting of a sheet on which the color names as found in the color naming test were listed in the same order, was given to 638 *S*s ranging from the 1st to 9th grades in school and from 6 to 18 years of age.

(1) There was a progressive improvement in the performance of both functions throughout the range of those tested.

(2) The differences between the two functions remained remarkably constant throughout the 9 grades. Color naming was consistently poorer than word reading. Only 17 *S*s gave opposite results.

(3) There was a fairly high correlation between the two functions. The relationship between color naming and the difference between the functions was positive and high, and that between the difference and word reading was negative and relatively low.

(4) The assumption that there was a common factor for the two functions and special factors peculiar to each was defended statistically. If this assumption is true, there was a very low correlation between the two special factors and between each special factor and the common factor.

(5) An analysis of the errors indicated that they were in the special factors more than in the common factor.

(6) Measures of intelligence correlated low with the two functions. There was evidence of a higher correlation with the common factor than with the special factors.

(7) The low relationship between tendency to err in the two functions added evidence of the independence of the special factors.

(8) Girls excelled the boys consistently in color naming. No great differences were found in word reading.

While previously suggested hypotheses for the ability to read the words faster than the colors have been shown untenable in the light of the data of this study, no new hypothesis beyond the three-factor theory could be offered. Unquestionably recognition, mental translation of the stimulus into the response, and articulation are factors likely to be found among the three factors.