PSEUDO-CHROMESTHESIA, OR THE ASSOCIATION OF COLORS WITH WORDS, LETTERS AND SOUNDS.

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The first problem of psychology is the study of sensation. A wealth of material comes to the investigator as the deliverance of the various special senses when the several end-organs are appropriately stimulated. But the *pseudo* sensations constitute the subject matter of psychology just as much as those arising from "bona fide" stimuli. Indeed, much light is thrown upon the problems of psychology by following out this line of study and investigation. Some of the most useful as well as the most interesting psychological material comes to us in the form of *pseudo* sensations. Of all the interesting phenomena which fall under this head, the pseudo sensations of sight are the most numerous. The present paper deals with one form of pseudo photesthesia, to wit—that large class of phenomena in which colors are called up in the mind of the subject when certain letters or words are spoken, or seen in print or writing. The term "color audition," so commonly used, does not cover all the cases, for there are instances, as the context will show, in which individuals have these pseudo sensations of color when they *see* words, but *not* when they hear them enunciated. The term we choose as a sort of label for this interesting class of phenomena is that of "pseudo-chromesthesia." Pseudo-chromesthesia is that peculiar faculty of association of the sensorial perceptions, by means of which any primary sensation, or even a purely psychical process can evoke, in the case of certain persons, a false visual sensation of color, constant in the case of the same stimulus with the same person. The phenomena may be of optical origin, i. e., the efficient cause may come through the eye (or the memory image of a visual sensation) of the graphical forms of a letter, a number, a geometrical figure, such as a circle, triangle or square. They are of acoustic origin when the efficient cause passes through the ear or is a memory image associated

with that organ. Thus every noise, every sound perceived objectively, or evoked mentally can arouse these pseudo sensations of color. This is especially noticeable in the case of the human voice, as in public speaking or reading aloud.

A.—HISTORICAL AND DESCRIPTIVE.

The great poetic genius, Goethe, was one of the very first to make reference to this subject, which he does in his Theory of Colors (1810). In this connection he refers to the little writing by Hoffman, which was published in 1786, in which a case is cited of a Swiss magistrate and painter who seemed endowed with the power of giving color to sounds. The sounds of the various musical instruments evoked strong color impressions, which were especially vivid in the case of the high notes. Thus the notes of the violoncello seemed to him, indigo blue; clarionet, yellow; trumpet, bright red; flute, dark red; violin, very bright blue; hautboy, rose color; and the flageolet, violet.

The first case of pseudo-chromesthesia to find a place in the medical journals, and the first, as well, to receive a minute description, is that detailed by Dr. George Sachs—a case which occupied a considerable portion of his inaugural dissertation at Erlangen in 1812, written in Latin, and afterwards translated (1824) into German by Schlegel. The person to whose peculiarity he gives so much space was an Albino, and colored the following:

1. Vowels.
2. Consonants.
3. Musical notes.
4. Sounds of instruments.
5. Figures.
6. Names of cities.
7. Days of the week.
8. Dates.
9. Epochs of history.
10. Phases of human life.

His pseudo-color sensations were of three kinds with reference to their origin — optical, acoustic, and purely psychical.

The vowels appeared as follows:

a = vermilion red.
e = rose.
i = white.
o = orange.
u (oo) = black.
ü = white.

Of the consonants:

c = ash.
d = yellow.
f = opaque white.
h = blue grey.
k = dark green.
m = white.
n = white.
s = navy blue.
w — brown.

Musical notes generally had the same color as the letters which would indicate these notes.

In the case of the numbers:

1 = indistinct white.
2 = uncertain.
3 = ash color.
4 = red.
5 = yellow.
6 = indigo.
7 = bluish white.
8 = brown.
9 = dark green.
0 = pale uncertain yellow.

It is an interesting observation that in groups of numbers of several figures, each group takes the color of the *last* figure, but the tints remained rather distinct without entirely merging into a single color, the figure of a superior order dominating in general. Zero does not change the color of the figures to which it is joined, but does change the general appearance, e. g., 10, 11, 100, 110 and 111 all are white, but they differ in brightness and clearness. This subject had local colors for each of the cities which did not always correspond with the colors he gave to the isolated letters, which, when grouped together, constituted the name of the city. Likewise as to the days of the week. Sunday was white, sometimes slight yellow; Monday, a cloudy white; Tuesday, indistinct tint; Wednesday, yellow; Thursday, green; Friday, obscure white; Saturday, a bluish ash color. It is to be noticed that the colors of this man were not equally distinct or intense, and that he did not perceive in his pseudo photesthesia all the colors of the spectrum.

Some of the early observations along this line were those of Gautier in 1843. He contributed nothing new, except in recording the fact that he could produce these pseudo sensations of color artificially, in particular by the use of hasheesh.

In 1848 Dr. Cornaz sought to stir up investigations and researches into the matter by publishing a little brochure on the hyperesthesia of colors. His efforts were not entirely fruitless, for very soon after, Dr. Wartmann gave out an abridged description of two cases. In 1855, Joachim Raff, the composer, declared that the sounds of instruments produced color impressions of various kinds. Thus the sound of a flute produced the sensation of intense azure blue; of the hautboy, yellow; cornet, green; trumpet, scarlet; the French horn, purple; and the flageolet, gray. The clearest and most distinct shades were those evoked by the high notes. Also Ehlert in one of his musical letters from Berlin describing one of the symphonies of Schubert, says: "The air in the scherzo is a sunny warmth, and a green so tender, that it seems to me that I breathe the odor of young fir trees."

Chabalier published some interesting cases in 1860, but

nothing at all new was contained in his little book, and in the same year Vauthier published a little account of his own experiences, in which a certain sound awakened not only a color impression but also an excruciating toothache.

But Perroud, in 1863, was the first man to recognize the physiological character of these phenomena, and also the first to attempt an explanation. The case he records is that of himself, and is of especial interest because it was a case in which the impressions were aroused by *optical* and not by auditory stimulus. His experience with these phenomena did not begin until he was about fifteen years of age, when he began to see certain letters, especially vowels, intimately bound with colors.

With Perroud:

a = orange yellow.
e = bluish or pearl gray.
i = carmine.
o = canary yellow.
u (oo) = sombre brown.

Diphthongs give the sensation of *two* distinct colors, but this is not the case with compound vowels. These form a single tint, a trifle more intense than that produced by a single vowel. V appears greenish, while all of the other consonants partake of the color of the neighboring vowel (irradiation). Figures are also united by him to ideas of color, but less distinct—1, carmine (same as i); 2 and 3, gray; 4, sombre brown; 5, indistinct; 6, green; 7, carmine; 8, canary yellow [might not 8 be two o's? (oo)]. It is a point of great interest that with this person the colors become more intense the further one reads, and the more tired he becomes, as well as the more his attention is concentrated.

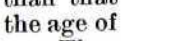
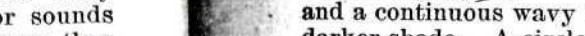
Chabalier again took up the matter, and in a more thoroughgoing way, in 1864. His explanation was also physiological like that of Perroud. With him a is a deep black; e, gray; i, red; o, white; and u (oo), sea-green. He observes that, as *printed*, these vowels appear uncolored, and perfectly black, but he could have no mental concept of them without arousing the colors as given above. He describes the consonants as "dead, inanimate and entirely secondary." With him proper names had very vivid colors according to the grouping of the vowels. The color much more vivid than the name. Would often forget names, but never the color of the name. With numbers he noticed that 2 and all numbers terminating in 2 seemed white merging into gray; 5 and all terminating in 5, a vermilion red. The days of the week also had colors as well as the months of the year. Thus, Juin, very red; Juillet, light red; Août, sea-green; and all the "ber" months were an earthy gray

(colored by e). In 1865 Verga observed some new cases and revised Chabalier, and in 1871 Kaiser also observed some new cases, which he treated in his compendium on optical psychology.

Perhaps there is no contribution of more interest than that of Nussbaumer, who, when a student at Vienna, at the age of 23, published his observations and those of his brother. They both possessed the finest discriminative ability for sounds from a very early age. From the age of 4 or 5 years they both experienced the phenomena of color audition. In one of their games they used three spoons with strings attached to make bells, and each tried to excel the other in making sounds, claiming different ones produced this or that color, the discussion always ending in a fight. With these two brothers the perception of color seemed purely subjective. Of the letters they colored the vowels only and not the consonants. With F. Nussbaumer, of the piano sounds, *re* is chestnut brown; *fa* is brown with gray lines; mi_2 is sombre brass color at the beginning of the sound and blue at the expiration; *la* is chamois skin yellow; la_3 is a clear orange yellow; fa_4 is a transparent lemon; *sol* is yellow changing into blue; do_6, white at beginning and then changes into transparent light blue. The sound of a rolling carriage is a gray mixed with yellow; that made by a saw is green. The voices of men, if effeminate and sharp, are like the color of a faded leaf in autumn; harsh voices are a brownish gray. The highest tones of a trumpet are a golden yellow and diaphanous; a little table bell, yellow at first and bluish toward the end.

These sensations of color with John Nussbaumer were also of acoustic origin. The high sound of a trumpet gave him the impression of lightning. Other sounds called forth simple tints of color. In 1876 Prof. J. Nuel made a résumé of the facts related by Nussbaumer and set himself to explain them. Of this attempt we shall speak later.

Of all the works on this class of sensations, none is more familiar or more frequently quoted than that of Bleuler and Lehmann. We will cite but one of his cases in detail, and select the one we do because it is a clear case of color *hearing*. The subject (the 77th) maintains that the form of a letter has but little to do in evoking color impressions, but the least change in the sound or quality of the tone greatly changes the shade of color.

Words learned before he knew his letters, e. g., "millionen," have a single color, while others take their color from the component letters. Of the languages, French is sombre brown; German is green; English, light brown; Italian, bluish; ancient Greek, yellow; and Hebrew a sombre tint. Up to this point it is, as stated above, a case of color audition; but when we come to the figures, we find that the various digits evoke color sensations entirely independent of sound, and it thus becomes a case of pseudo-photesthesia. In the case of geometrical figures, a succession of acute angles,  , gives a light tint; a series of obtuse angles,  , gives a little darker; and a continuous wavy line,  , gives a still darker shade. A circle gives a bright yellow tint, while a triangle gives a clear, bright, silvery image, and the rectangle also a very light color.

The low sounds with this subject were all black, passing as they rise in the scale into a reddish brown and brownish yellow in turn. The middle sounds are yellow and the most elevated are pure white. Surely the "chromatic scale" should possess no terrors for such a man. The noise of respiration is gray. A crackling sound is made up of white points; a tremulous sound is a light bluish gray.

With this subject the color associations transcend the ordinary limits, for he has them awakened by senses other than those of vision and audition. Thus, with the sense of smell there is no odor without a color sensation. A cold in the head changes the color of these odors. The odor of vanilla is a light lilac; of the rose is rose color; odor of ammonia is whitish; of vinegar, red; of cologne at a distance, reddish, but under the nose it becomes a transparent gray. In the realm of taste — a sweet taste is red, a bitter taste is a dark brown; with vanilla the taste evokes the same color as the odor, showing that the so-called sensations of taste are largely those of smell. The painful sensations color themselves according to their intensity: thus, violent pain is white; heavy headache is black; an intermittent sharp pain is made up of white points, the same as a crackling noise; a pinch gives a yellow color. The days and months are also colored, but independent of sounds.

In 1882, Pedrono, the well-known rhetorician of Nantes, published a case of no little interest. He seems to have colored sounds rather than words or letters. These color impressions he describes as sudden and spontaneous. *The sounds are translated into color before he can stop to think whether the voice is high or low.* He externalizes an image hovering round about and above the person singing or producing the noise. Vowels when standing alone give *no* chromatic sensations, only when uttered, and then they take their color from the tone of voice. In general, low sounds are sombre and high sounds are bright. Every noise, whether a harmony, discord, crash or clang, produces a

chromatic sensation. Of voices, yellow voices are the most agreeable, and fortunately the most frequently met by him. The same melody when played on different instruments gives different color impressions. Upon a harmonium or tenor saxophone it is yellow; clarionet, red; and piano, blue. Whether the person is seen or not the color is there; whether the eye is opened or closed makes no difference.

In his little work published also in 1882, G. Mayerhausen tells of a lady of 25, a wife of a physician, who had some very vivid color impressions, which seemed to be associated with sounds rather than forms. One of the interesting things he relates is that polysyllabic words, if quickly pronounced, give the color of the principal syllable accented; if slowly spoken, each syllable has its own color. The cases related by Francis Galton, in his well-known work, are sufficiently familiar and need only a passing allusion.

The case related by Rochas is that of a lawyer of 57, who, while he likes music, is not a musician. He is a traveller and an accomplished linguist, but has never heard of color audition as a phenomena, but always thought his experience an entirely normal one. He possesses this faculty to a remarkable degree and his impressions are entirely acoustic as to their origin and psychical. He does not exteriorize sensations, but sees, as he expresses it, the color in his brain. Of the vowels a is carmine; e, white; i, black; o, yellow; u, (oo) azure blue. The consonants are as a rule pale grey. Words take their color from the component letters. The various languages also have their color labels. Thus German, in which consonants predominate, is mouse colored; French, green merging into yellowish white; English is dark gray; Spanish has three colors, in the main, either yellow or carmine, but sometimes a dazzling metallic tint; Italian is yellow, carmine and black. It is with reference to musical sounds that this is a case of especial interest. The low notes are a very dark or deep rose tint; the more intense and higher pass from red to yellow, then blue, and finally black or a deep violet, precisely the order in the spectrum. The order is also according to the number of luminous light vibrations, thus the low notes of few vibrations produce red, while the highest, of many vibrations, cause the perception of violet. In singing the notes by names the vowels give the color. Low voices are of a deep carmine, while high sharp voices are a crude dark blue. Among musical instruments the sound of a bass drum is chocolate; of a trumpet, a brilliant yellow; hautboy, flute or piano, blue; violin and fife, deep violet or glossy black; guitar, gray.

Lauret acquaints us with the case of a man aged 50,

an intelligent scientist of normal vision, no musician, but likes music. His chromatic sensations are of acoustic origin and are always externalized. He fixes the colored image at a distance of one or two meters from his eyes. With him, as is usual in the case of letters, the dominating impression is produced by the vowels. Each image arouses not only a special color but a special form as well. Thus a is oval in form on a perpendicular axis of black; é and ê are squares of a dirty straw yellow color; i is a large point of silver white; o and ô are chestnut red on disks of madder red; u is a greenish blue. Diphthongs are colored like vowels: oë gives a circle, each half of a different color. Consonants have no influence upon the color of a vowel except in the case of m and n at the end of a word. Noises are also colored by this individual; thus the noise of the waves (French, vague) gives the color sensation of ou and i together. Deep voices are a dark chestnut if low and pass to light chestnut in louder tones. In singing the color impression produced by the baritone is chestnut passing into yellow; tenor is a deep yellow; contralto, light chestnut; mezzo-soprano, light yellow; soprano, passes into light and lighter yellow ending in a cream. Of the different instruments the clarionet produces in low notes a deep dirty yellow, while in the high notes it arouses a light yellow. The low tones of a flute are yellow, changing suddenly into light blue and then into white; hautboy, chrome yellow; the piano, if played moderately quick from low to high, gives first chestnut, then clear red, wavy yellow, blue, bluish white and white in turn; the violin gives garnet, orange, yellow and white in turn when passing from low to high notes, while in the same way the 'cello gives chestnut passing into carmine.

Prof. Steinbrügge of Giessen informs us of a case that was brought to his attention by an exile German Jesuit in Madeira. It was of a boy of sixteen, who had always lived in one of the country districts of the island, was strong and healthy, unimaginative, lazy and unmusical. His color impressions came spontaneously and suddenly; no time elapsed in which mere association could take place. It was rather a case of perceiving the objects, sounds and noises as actually colored. Fechner also collected a large number of cases, of which 347 were decidedly clear and authentic. Under these we find two of persons totally blind, who never noticed this peculiar faculty until after they became blind, when they possessed it to a remarkable degree. Also the case of a color blind person is cited, but he associated only the colors, known to him, while red was lacking. One lady, who always had color impressions in connection with numbers, proper names and days

of the week from her earliest childhood, wrote in connection with the answer to the list of questions sent out to such persons: "My mother associated other colors and was always very indignant when I maintained that the colors were other than those she gave."

The subject of whom Paul Raymond writes is a man of 30, strong, never been sick, but impressionable and has alternative moods of excitement and depression. From the earliest times he has had these color impressions called up chiefly with the vowels. No musical sounds give him perception of color. Each syllable takes its color from the vowels. The languages are also colored. Thus English is gray; Italian, yellow; German, black; Spanish, blue. But each word takes its color from its component vowels no matter in what language the words are found.

The case related by Grüber possesses nothing especially new. It is a case in which these pseudo sensations can be traced both to acoustic and optic origin. Figures also have colors with this person, and merely by the aid of combinations of colors alone is he able to carry on arithmetical processes.

Of the printed cases in English that which Prof. Holden records of his daughter Mildred is one of the most interesting and thoroughgoing. (Cf. Nature Vol. 44 p. 223σ.) By mere accident he learned of the color associations possessed by his daughter and became intensely interested. He made a record of the colors as associated with letters at six different periods, when she was 7, 8, 10½, 13, 14½ and 17½ years of age, respectively. The agreement of these different lists is most remarkable, showing very plainly that it is not a case of mere memory, but one of vivid and permanent associations. In numbers, 1 is black; 2, cream color; 3, light blue; 4, brown; 5, white; 6, crimson; 7, greenish; 8, white; 9, greenish; 10, brown; 11, black; 12, cream color; 13, blue; 14, brown, and so on. Thus 11 has the same color as 1; 12 as 2; 13 as 3; 14 as 4; 15 as 5, etc. In going over the table we find that G, P, T, Z, 7 and 9 are green; A, H, 5, 8, V and Friday are white; C, O, S, U and Saturday are yellow.

We will not give place here to the contribution of President Jordan, because it has been so recently published and is very familiar to all. In this same article are also detailed some of the interesting experiences of Prof. Spencer, of Moore's Hill College, Indiana. The writer is under great obligations to President Jordan for the hitherto unpublished account of the following three cases. The first two were furnished him by Mr. Launcelot and Mr. Harris, of Lexington, Va., while the latter was received from Miss Woodward, a student in Stanford University. They will be given with the exception of a few minor changes in the correspondents' own words. The young lady in the first case is about 18 years of age.

My sister, who had been amused at my color associations, jokingly asked Miss Julia B—— the color of A. She replied, "Brown, of course," and was surprised to hear that it did not so appear to everyone. "How could anyone tell whether a name was pretty or not except by its color?" On further examination she gave without hesitation the colors of most of the letters, there being a few the color of which she found difficulty in expressing in words.

A=brown.	J=black.	S=lead-color.
B=gray.	K=green.	T=*pale* yellow.
C=yellow.	L=brown.	U=blue.
D=gray.	M=green.	V=gray.
E=yellow.	N=green.	W=brown.
F=black.	O=red.	X=lead-color.
G=light pearl.	P=gray.	Y=purple[1].
H=black.	Q=green.	Z="gray & brown mixed."
I=lead-color.	R=red.	

She also gave the colors of a number of names of persons, indicating whether they were pretty or otherwise.

About two weeks after this I questioned her myself and found the colors of the letters, which she gave instantly, to be, with one exception,[2] precisely the same as those on the foregoing page which my sister had taken down. I also asked the color of a number of names of persons and other words. I at once discovered that the word took the color or colors of the vowel or vowels which it contained.[3] The color in the accented syllable predominated, and when a syllable was but slightly pronounced, its color was ignored altogether. Thus Ashley is brown only.

The name or word is colored according to its printed or written form, not its sound. Thus *Lila* is yellow and lead-color, while the *ine* in *Josephine* is lead-color and yellow—the former color, however, predominating in each case. When I asked the color of *Goethe* she answered blue, spelling to herself *Gurty*, but on writing the name and showing it to her, she said it was *red* and *yellow*. Yet the sound evidently plays a part, as the following list shows:

Lancy,[4] bright brown.	Myrtle, color of y, a beautiful name.
Lila, bright yellow.	
Lina, nearly black.	Larkin, "wine-color brown."

[1] Color of crape-myrtle.
[2] Y given as black in my sister's list.
[3] Cf. Galton fig. 68, which I have since seen.
[4] Sounded as in Alice—seems inconsistent. The *n* seems to figure.

Lilly, lighter shade-lead-color.
ine in Josephine, Lilly.
Rosa, bright red.
Lula, deep blue.
Ulla, lighter blue.
Alice, dull brown (a hideous name).
Amy, less dark.
Lettie, light yellow.

There are some exceptions to her law for coloring words, the following being those I could discover :

Buck, red.	Will, red.	Mary, green.
*Wirt, wine-color.	Willie, white.	*Cassie, green.
Bird, red.	Ruth, lilac.	Lizzie, green.

All of these except those marked with an * are names, chiefly in her family, with which she was familiar before she knew her letters. The other two, however, she had not heard until recently. Moreover, a number of her family names are colored according to her general law.

It is with names of persons that she chiefly associates color, but she gives the color or colors of any word according to its vowels.

She has three colors for sounds—yellow, red and dark. A high note on the piano, a cricket's chirp are yellow; a low note, a man's deep voice, dark (precisely as with myself). She gives as red a cat's mew, a cock's crow, a man's whistling. A rattle is yellow.

She has no associations for tastes, smells or pains.

The second is the case of Miss Rosa B——. These two young ladies are cousins.

a=brown.	j=lead color.	s=yellow.
b=blue.	k=light brown.	t=yellow.
c=gray.	l=black.	u=blue.
d=lead color.	m=green.	v=gray.
e=yellow.	n=gray.	w=brown.
f=brown.	o=red.	x=black.
g=yellow.	p=yellow.	y=lead color.
h=green.	q=green.	z=gray.
i=lead color.	r=dark red.	

"U" when connected with "H" is always green; if not is blue. The color of a word is generally determined by the vowels it contains.

Names that she was familiar with before she learned her letters are exceptions to this rule.

The third case is in the form of a confession by Miss M——.

I think I must have been about four years old when I began to associate color with words, and it was evidently their sound and not their meaning that aroused the sensation.

Yet I do not remember that letters or numbers conveyed any such impression. Only new words such as I heard for the first time, gave me a distinct idea of color. Family names as well as given names nearly always had some color, and those which had none were soon forgotten by me. I can recall the name of some people in stories told me when I was a child and even now their color accompanies them. Again, I may think of a story and a person in it in whom I was as much or more interested than in those first mentioned, yet I can not think of the name. When the name is told me the color is lacking or indistinct. The same word or name always bore the same color, no matter where it was used.

Words which I had been accustomed to hearing daily had no color. At one time my brother, who could speak French, pronounced the word "encore," but without giving any meaning; it sounded yellow to me and I did not forget it.

I don't think that music was ever accompanied by color, at least not a melody, but I think that certain chords had color. I recall those words as having a distinct color, England, blue; Bertha, blue; Robert, brown; alligator, green; hyena, yellow; Alma, orange; Emma, blue; Charlie, red.

In the April number of the current volume of the *Revue Philosophique*, Beaunis and Binet publish results of their endeavor to measure the reaction time in two cases of color audition. The time indicated is that which elapses between the lettering of a certain letter and the touching of the electric key as soon as the associated color is announced. Even with their imperfect apparatus the time is found to be remarkably short. Thus in one case the average for a is .47″; e, .62″; i, .43″; o, .49″ and u, .56″, making an average of .51 sec. On the other hand the mean time for the recognition of the letter alone regardless of color was .45 sec. Thus the mean time occupied for the association of color was .06 sec. Phillippe made a series of experiments in which the mean reaction-time for figures alone was greater than for the associated color; for the person to name the figure it took 0.76 sec., to name the color 0.70 sec. The color was always seen before the meaning of the word was observed. In moments of fatigue the color impressions are more intense.

A considerable number of cases have been investigated by the writer, but only one is selected for a detailed statement on account of limited space. It is that of Miss S——, a young lady much above the average in intelligence and very accomplished. The æsthetic element is a prominent factor in her psychic life. She is a skillful musician, having taught in a conservatory of music for some years; very well informed as to literature and is herself a pleasing writer. With her

the color impressions are produced in three ways. First, and chiefly through the graphic forms; second, through auditory stimulation; and third, by means of ideation. It is a complete and fully rounded out case. *All* the letters are colored thus.

A=opaque white.
B=dark cactus green.
C=pale yellow.
D=tan color.
E=warm grey but pale.
F=very dark brown.
G=yellowish bright tan.
H=red, crimson.
I=black.
J=black sometimes shades into green.
K=red—very like H.
L=black.
M=blue.
N=gray.
O=black on white ground.
P=bright yellow.
Q=Naples yellow (buff).
R=dark green.
S=light green.
T=red; less intense than H or K.
U=gray.
V=pearl—slightly lavender.
W=black.
X=red; still less intense.
Y=yellow into green.
Z=brown sometimes shading into an iridescent purple.

The numerical digits are also colored. Thus 1 is black like i; 2 is opaque white, like a; 3 is bright green, slightly yellow; 4 is seal brown; 5, black; 6, grey; 7, yellow; 8, pink; 9, brown, lighter than 4. The colors of numbers are often and even generally more intense than those of letters.

In music written in different keys C. D. etc., the music has a general background of color which is the same as that of the index letter indicating the key. Thus music written in the key of D is tan color. All "sharp" keys are brighter and "flats" are less brilliant.

Words pronounced alike but spelled differently have *different* colors. Words generally take their tone of color from the *initial* letter. Thus with the same letters in different combinations we have different color-impressions, e. g., deer=tan; reed=greenish yellow. With this person we find there is an intimate relation between form and color. In grouping several letters of one color we find that H, K, T and X are red; B, R, S and 6 are green; C, G, P, Q, D, tan color; Y and 7 are yellow; Z, F, 4 and 9 are brown; N, U, V, A and E are gray. This fact we will refer to again in an attempt to explain these phenomena.

B.—Explanatory.

Believing that the scientific method is the only legitimate one, we have sought in the first place to present the facts as found before advancing any explanation. The disclosure of

facts is ever the best critique. First describe, then explain is certainly the best law for method of procedure. Before submitting our own view we desire to present a sort of résumé of the explanations already advanced.

Some have sought to find their explanation in the contiguous relations of sensorial centers on the cerebral cortex; in anastomosis between their different nerve fibres; in the reciprocal agitation, motion and disturbance of their individual cells. Others believe it to be due to reflex action and still others attribute it to a confusion of ideas.

Carnaz held that it is a *visual* trouble, a hyperesthesia of the sense of color—pathological and due to some optical lesion. Prof. Wartmann and Dr. Marce also accepted this as an explanation.

Perroud (in 1863) was the first to say that it is not at all a pathological condition, not depending on material lesion, neither constituting an illusion or hallucination.

Chabalier, while he recognized the physiological explanation of the phenomena of pseudo chromesthesia, does not consider the phenomena as pathological, but allied to a light confusion of ideas and still more regarded it as a sort of psychic perversion, "an illusion belonging to that class of illusions compatible with reason."

H. Kaiser presents the idea that the subject himself puts the color into an intimate relation with the words in order to better engrave these words upon his memory. He says that it partakes then of the nature of association of ideas, going back to the earliest infancy and in virtue of which certain colors would be united to words voluntarily and then by long custom become spontaneous. Schenkel also offers the same as an explanation.

In 1875, Lussana wrote that the sensorial centers of sound and color in the human brain could be contiguous and thus influence each other in perceiving. Prof. Nuel has a kindred view. A year later, 1876, he writes that false secondary sensations might be due to a central nervous irradiation deterring the sensorial afferent currents. And still in the same line Pouchet and Taurrieux hold that it is due to an abnormal crossing of certain afferent or sensory fibres. But to this Pedrono objects that, according to the Young-Helmholtz theory, an immense number would have to be turned aside in order to do the great amount of work. This assumes the validity of the theory of Young-Helmholtz. Pedrono himself would rather admit the existence of sensorial cerebral centers located somewhere in the gray cortex and would explain on the basis of the contiguity of the chromatic and acoustic centers. This

explains only a portion of the facts—those of color *audition* alone.

Baratoux, in 1883, states that the chromatic center can be excited, not only by impressions from the retina but by deliverances through the other organs of sense. Is the stimulus always directly carried to the chromatic center or via the auditory fibres at times? He thinks these pseudo sensations of color due to anastomose of fibres, rudimentary in ordinary men, but in certain cases highly developed.

Prof. Steinbrügge maintains that this class of phenomena arises, in the earliest youth perhaps, from direct double perception. In later years the corresponding disposition of the brain which the double perception aroused has been impressed once upon the organic memory so that the associated color returns when the vowel or word is recalled. He says there are two possible explanations:—either the sensory stimulus of one sensory nerve passes to another sensory nerve in the course to the brain and thus reaches a cortical center other than that for which it was headed, or it spreads out beyond the limits of its own proper center, reaching a second center, by means of which a second perception is freed.

Rochas explains by assuming a sort of unconscious connection of cortical cells that have to do with hearing and vision. He adduces the case of Gautier, in which certain excitants, e. g., hasheesh, can establish such connections or relations which do not ordinarily exist. Feré believes colored vision to be entirely due to the particular tone of the nervous system, which is obtainable by different excitants and presentations. He rejects the theory of anastomosis between the two cortical centers and tangling of fibres. Professor Urbanschitsch considers these pseudo sensations as *reflex* sensorial phenomena.

Prof. Stevens' theory may be taken as a type of that large class who rest entirely upon "psychical association" as basis of explanation, when he says my own explanation of the matter is this: When we are learning to spell we associate certain colors with certain words and those words give us the idea of color. These words may be said to be chromopoetic and this property cannot be dissociated from them. For example, D is associated in my mind with dog, and when I think of a dog it never is a white dog, but always a black one; hence, D is black, I brings up ink and black ink; J, a jug of a brown color; V is a vulture, which I always think of as brown."

Thus there are a large number of investigators who claim that the physiological does not fill the bill, and that the only explanation is to apply the law of association of ideas and

they do it with a vengeance. They ask, why could these phenomena take place in the blind, in the darkness, when the eyes are open or shut, when the appearance of the colored image is equally sudden and spontaneous? But to our mind there are objections just as insuperable against the associational theory. While we cannot accept the purely physiological explanation, we can neither regard the theory of "psychic association" as satisfactory. The facts themselves present difficulties in which such a theory cannot over-ride or surmount. Before making a statement of these difficulties we wish to call attention to the general fact that as yet no settlement has been effected with reference to a theory of color. The Young-Helmholtz theory cannot account for some of the simplest facts, e. g., the phenomena of contrast. The evidence from histology is mainly against this theory. There is a tendency at present to accept a "four color" rather than a three color theory. Hering's hypothesis seems also to involve certain unwarrantable assumptions. His assumption of the "destruction" and "construction" of the visual substance is the most difficult article of his "color-creed" to believe. We adopt the conclusions of von Kries rather than those of Wundt, Hering or Helmholtz. After a careful and painstaking examination he finds it necessary to say that "the photochemical facts compel us to adopt a theory of component elements rather than one of changes qualitatively alike and arranged in a continuous series. Only by aid of assuming the varied combinations of such elements can we explain the phenomena of exhaustion, contrast, the mixing of colors from fundamental color tones and the phenomena of after images. The articulation and adjustment of these combinations we would assign to the central organs. We wish now to call attention to the following facts of pseudo chromesthesia.

In the majority of cases it seems to attach itself to a special condition of the nervous system, as well as to a well developed faculty of the imagination. Very rarely is there a defect of the eye or ear. It is remarkable that the younger Nussbaumer was equipped with a very keen ear, for he was able to distinguish eleven partial tones in a klang without using resonators, and without any practice. To be able to do this, of course, requires not only intact end organs of sense but also perfect condition of the central organs. Most of these phenomena, with notable exceptions, however, date from the early years of the subject. The larger number color sounds, especially speech. Some color *only* the graphic forms of letters. The secondary impression is so intimately bound with the perception that it is impossible to separate the two.

Then heredity plays an important part. It is *very infrequent* that a single member of a family alone experiences pseudo chromesthesic impressions. These impressions of colors become more intense, vivid, and striking when the person is fatigued. The intensity and clearness of these color sensations are different with the right and left eye of the subject. There seems to be a perfect agreement in the testimony to the effect that it is the form or sound and *not the meaning* of the word that calls up the color. To a certain extent these phenomena can be produced artificially by means of drugs, etc. The larger number of the subjects are women, who as a class can hardly be called *introspective*; at least they are less so than men—but they are more observant. These secondary color impressions remain constant in their relation to the primary perception. That is, the same colors are always called up by the same excitant or stimulus. In experiments we have made upon such subjects with view to ascertain the reaction time, we find no measurable difference between the time it takes to announce the letter and to announce its color. Thus with the ordinary "Fallapparat" connected with a Hipp chronoscope, you expose the letter D. It takes no longer for the subject to say "tan-color" upon seeing this object than it does to say "D." There are *very few* exceptions to this rule. Indeed there are many cases in which the color is recognized before the letter or figure.

To us it seems plain that the theory of "psychic association" cannot account for all the above facts even if it may be satisfactory as an explanation in a few cases. We must, for sake of convenience, divide the phenomena into two classes. (1) Those that occur within the limits of the same sense, pseudo chromesthesia of optical origin, and (2), those phenomena which find expression in a different sense from the one primarily excited, for example—color audition. In no case would we feel warranted on the basis of our present knowledge in attributing these phenomena to the retinal elements—to the rods and cones—though there is a temptation to do so, especially in those cases where similar graphic forms produce similar color impressions. It may be that in some cases the phenomena could be rightly attributed to the crossing of certain afferent or sensory fibres. Pedrono objects to this by saying that it would take such a large number of such fibres. He seems to be ignorant of the fact that the number of optic fibres alone is between four hundred and thirty-eight thousand (Salzer) and one million (Krause). The optic nerve fibres lie in layers, but in the region of the *macula lutea*, they are finer and in fewer layers and anastomose freely. The rods and cones, it may be said in this

connection, are estimated to be seven times as numerous as the optic nerve fibres.

While it may be that a few of the cases can be best accounted for by applying the theory of psychic associations as in the case of number forms, we are inclined to attribute the majority of cases to the cerebral centers themselves and only on the basis of the facts involved. We might even say that the majority of those cases regarded as purely "psychic" can, in the last analysis, be traced to causes most intimately related to the cerebral centers themselves. For example, in the case instanced. Did Prof. S. come to regard D as black because he thought of a black dog, or did he think of a black dog because the letter D appeared black, and thus, as the initial letter, gave the color to the word? Why are there no cases of *dissociation* of these color impressions, as is often the case with purely psychical associations, such as some of the number forms? Paul Raymond instances certain clinical cases which go to show that there is a close relation or connection between the cerebral centers. It must also be remembered that, *anatomically*, almost every pathway is open to all the incoming impulses, and that the cerebral cortex is a physiological continuum made so by the so-called "fibers of association." The auditory and visual centers are the closest to each other of any of the cortical centers on the brain surface. As to whether there is any such thing as a "chromatic center" we know only the following: With reference to the perceptions of light, color and form, it occurs, of course, that the loss of light perceptions necessarily involves the other two—but either of these alone—form or color may be lost independently. Noyes cites a case from Graefe's Archiv of a person who could read words, but not count figures. The hemianopic loss of sight had respect only to perception of form, but not to perception of light. There was also a slightly reduced color sense in the remaining half of the fields. We know that the centers for light, form and color sense are all in the cortex of the occipital lobe. Wilbrand and Rheinhart place them one above the other; the light sense external, form sense intermediate, and color sense internal. Sequin, Verry and Nothnagel think them to be side by side. It can easily be seen that in any case the nervous afferent impulse could either by increased intensity, inhibition or irradiation call up a secondary impression. This relation is more frequent, when not within the limits of the same sense, between color and sound, because these centers are adjacent. On this so-called physiological basis we can explain those cases artificially produced as well as the intensifying of the color impressions

through fatigue. In other words, in such cases, the amount and nature of the blood supply has undergone a modification. After going carefully over the data furnished by several hundred cases of persons who possess the faculty of pseudo chromesthesia, we sum up our position as follows: Some few may depend somewhat upon the association of *ideas* dating from youth, developed in a manner conscious or unconscious, and thus ordinarily we may be said to arrive at the coloring of the days of the week, epochs of history, etc., similar to the phenomena of number forms. Even such are called "*automatic* associations." What is the real difference between perceptions through a sensation and one through an "*automatic* association?" In adult life we have no such thing as pure sensation. The content of our perceptions is supplied by the afferent impulse and the reproductive brain processes aroused. Every perception of a thing or quality is the sensation plus remembered sensations,—generally, organically or physiologically remembered—at least the process is a sub-conscious one. In the greater per cent. of cases the pseudo chromesthesic phenomena arise from some sort of cerebral work which is the outcome of the close relation of the cortical centers, which are connected by numerous associational fibers, notably the visual and auditory centers. Whether this is done by anastomosis of fibres or irradiation, or by direct stimulus of the fibres of associations, it is evident that in some cases at least it takes place within the centers themselves. It is a notable fact that the weaker the color impressions the more "psychic" and "ideal" it seems. There are still other cases which would have a certain analogy with optical illusions and still others that partake more of the nature of hallucinations.

The writer will continue his psychometric as well as other close tests and publish tables later.

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