v., 14.3), alcohol 224.3 (m. v., 16.5); second hour, normal 228.9 (m. v., 15.6), alcohol 227.4 (m. v., 14.5).

The difference is again hardly perceptible, but so far as it appears, the effect of the alcohol is a quickening of the work during the first hour, followed by a slowing during the second hour. As regards the quality of the work, the results are uncertain.

In summary of all these psychophysical tests it may be said that the effects of the alcohol are slight, but that in adding, which is mainly an association process, the alcohol seems to produce in general a slight quickening which lasts nearly to the end of the second hour, and in reading and writing, which involve more muscular action, the effect resembles that found with the ergograph, namely, a period of quickening followed by a period of retardation. These results do not confirm Kräpelin's conclusion that the 'sensory' process (adding is regarded by him as a "sensory" process) is depressed by alcohol from the start, while the motor process alone is at first stimulated. In fact the opposite seems to be true. The association process is quickened while the motor processes appear to be more likely to be slowed by the alcohol. It could not be discovered in any case that the depressing effect of the alcohol persisted until the following day.

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TWO CASES OF SYNÆSTHESIA.

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Many accounts have been published, in scientific and popular form, of the phenomena of synæsthesia, and chiefly of the form known as colored hearing. While the popular accounts are, as usual, untrustworthy and meagre, even the scientific publications are, with the exception of a few detailed descriptions, rather attempts at cataloguing than systematic investigations into the nature of the individual cases treated. For this reason it seemed worth while to make a careful and extended study of the two cases which form the subject of this paper. Although similar tests were given to both subjects, the reactions were so dissimilar that the treatment must needs be separate.

CASE I.

The first case is that of *M* (Miss M. F. McClure), a senior student in the Department of Psychology. While serving as subject in an experiment upon the qualitative discrimination of clangs as conditioned by time interval, *M* developed a form of judgment which was clearly based upon secondary visual criteria. The two given tones of the Appunn tonometer were followed by the appearance in the visual field of the closed eyes of light lines arranged horizontally against a luminous background, at times vaguely tinged with color, usually with pink or green. The higher tone generally appeared as a horizontal line above the lower; at times the line of the lower tone was darker. Later, in the course of experimentation, the ladder formation was less frequent. The tones, however, as a rule occasioned clouds of color, though the colors themselves did not always form a basis for judgment.[1] The frequency and vividness of these visual concomitants suggested the systematic investigation of the case.

[1] The variety of combinations reported is too large to admit of detailed mention. The following is a piece of introspection taken at random from the record: "The first tone was high up in the visual scale, of greenish color (while the tone lasted), with the impression of a ladder formation. The second took its place below the first and determined the judgment."

§ 1. *Historical.*

No trace of colored hearing can be found in the other members of the family. The hypothesis of heredity[1] seems also to be refuted by the fact that the first instance of the phenomenon was quite sudden and hallucinatory in character, and of late origin. In *M's* own words:

"In 1894, at the age of 16, I heard Melba sing the casket (jewel) song in *Faust*. My eyes were wide open. Suddenly I saw a greenness, rich and flowing. It seemed to move as if it were almost liquid, and occasionally it sparkled. It flowed downward obliquely from right to left, and seemed to correspond to the character of Melba's voice. I was not looking at her at the time. The color was not a tint of green of which I am especially fond, but it was very vivid and beautiful. I had been anticipating Melba's singing for some time. Shortly before, I had heard Nordica, but had no visualizations."

After this experience colored hearing, especially with emotionally stirring music, became quite frequent. The colors are not obtained by a deliberate attempt to see them; indeed, such an attempt rather tends to prevent their appearance. In general they are luminous, diaphanous clouds of color (though at times in definite figures) floating over a dusky background; and they are always seen projected[2] to a position about 20 cm. from the eyes. They rarely cover the whole field.

The photisms seem to have been neither a hindrance nor yet any particular help to the subject (apart from their use in discrimination, as above mentioned); yet they are pleasant, and add considerably to the enjoyment of music. That they are unequivocally conditioned by tones is evident from the fact that *M* never experiences colors of the kind in daylight, except when hearing music, and that they appear and disappear with the appearance and disappearance of the tones which call them up.

It may be further said that the phenomena are but one feature of a general mental tendency to rich and varied associative supplementing, which is exhibited, as will be shown later, by abundant personifications, metaphor and simile. The linking is obviously emotional. "This tone makes me 'feel' like this color." "When I try to feel like the letter C, I feel that it must be very pleasant and good-natured."

M has a generally keen and vivid visual imagery. She is able, *e. g.*, to analyze the color tones of grayish objects. Thus sand is not seen as silver-gray alone, but also as tinged with

[1] Bleuler u. Lehmann, Zwangsmässige Lichtempfindungen durch Schall, p. 49.

[2] This stamps Case I as belonging to the first type of Flournoy (Les phenomènes de synopsie, p. 9), in which the induced photism is objective.

blue and yellow and a little red. Oiled floors often have beautiful blues and reds. Her limen for the discrimination of gray figures in episkotister work is lower than the average. Nearly all shadows are colored. *M* has actually seen the "purple cow," —a red cow standing in a shadow which was bluish, in contrast to the yellow tone of the illuminating light. This tendency to analysis makes the subject see the landscape somewhat as an impressionist would paint it. As might be expected, colors have for her a high degree of affective tone—a certain corridor finished in browns is, for example, very depressing. This fact is of significance in view of the further fact that the photisms are conditioned by the affective value of the correlated sounds.

§ 2. *Experimental.*

(1.) *Retinal colors.* In order to differentiate the photisms from the retinal light, several series of tests were made, in which *M* was seated in a noiseless dark room. After a wait of several minutes, for adaptation, the changes in the visual field were telephoned to the experimenter in another room, who recorded them, together with their time of appearance and duration as indicated by a stop-watch. One such series will suffice.

TIME. MIN.	SEC.	VISUAL PHENOMENA.[1]
0	0	Very faint G.
0	20	G gone.
0	30	Dappled background of brightness.
1	00	Strip of B of high Satn.
1	05	Strip of B losing Satn.
1	35	Two strips of brightness in continuous slow movement,
1	50	One strip gone.
2	00	YG welling up.
2	10	YG gone.
2	30	Faint B.
2	35	Faint B gone.
2	45	Faint B back.
2	53	B changed to G.
3	10	G changed to YG.
3	18	YG gone.
3	33	Faint horizontal strip B.
3	55	B, high Satn. Pretty in spots. The rest as through a veil.
4	20	B spreading.
4	35	B lighter. Some G.
4	45	G more extended, greater Satn.
5	18	Eyes feel bulging and big.
5	55	Faint spot of B.
6	00	Spot of B and some G.
6	05	G, high Satn.
6	10	YG.
6	20	YG getting thinner and thinner.
6	30	More background.
6	45	Faint spot of B.
7	00	B gone.
7	30	G and B faint but very pleasant, in the form of a straggling S.
7	55	G and B, but spotted.
8	00	G.
8	05	G moving (as often, the color sweeps over the field, then closes up in a bunch, and disappears as if going down a spout).
8	35	B, ultramarine, surprisingly beautiful.
9	10	B moving away.

[1] The following abbreviations are used: Red—R; Blue—B; Yellow—Y; Green—G; Purple—P; Violet—V; Saturation—Satn.

TIME. MIN.	SEC.	VISUAL PHENOMENA.
9	15	G very faint, appearing above the B.
9	30	G light with B around the edges.
9	40	Mere background.
9	50	G very faint.

These colors are constantly shifting. Some (G and B) are very pure, corresponding to the standard saturation, and always luminous. Y and R are conspicuously absent. Y is never seen, except as a tinge in YG. R is experienced very rarely in the form of heliotrope, though not reported in the particular series just given. Evidently the assimilative retinal processes strongly predominate. When "no color," or "mere background" is indicated, the visual field is not a dead black, but something which is always described as a "mottled, muddy background." If a color tone extends or contracts, its saturation varies inversely with its extent.

(2.) *Photisms: (a) with simple noise and tone.*[1]

Noises, such as a single tap on the table, cause either mere winking or a general disturbance in the visual field. The darkness expands in waves from the center, as the ripples of water about the place where a pebble has been dropped. This is usually termed a "feeling of visual struckness."

Single tuning-fork tones. The vibration rates from 40 to 56 were given by Appunn's wire forks, held close by the ear; the rates from 128 to 1,152 by a set of Koenig forks on resonance boxes; those from 2,048 to 32,768 (?) by Appunn's high forks, actuated by bowing. The subject usually got a settled photism only after the upper partials had died away. Unless otherwise characterized, the colors are as described above, cloudy diaphanous forms projected before the face. It will be noted that the noise of striking the Koenig forks gave a visual disturbance similar to that caused by tapping upon the table. The colors are quite spontaneous, and usually surprises to the subject. They have the brilliancy of transmitted light through colored gelatines, and not the deadness of reflected colors.

[1] In the following experiments the subject was blindfolded and seated facing the source of sound. When after-images had disappeared the stimulus was given, preceded by the usual 'ready' signal. The stimulus lasted (except for noise) about ten seconds; at the end of that time the blindfold was removed, and the subject gave a detailed introspective report, picking the associated color from the six plates of the Prang *Standard of Color* (Popular Edition, No. 1, Boston, 1898). Although these color plates are too 'dead' to give exact representations of the photisms, some such classified and readily accessible scheme of color was felt to be serviceable not only for the publication of results, but also for avoidance of the large error (mentioned by other writers) of mere verbal description. Plate I of the *Standard of Color* contains seven horizontal rows of 24 colors each. The upper row gives the 24 most saturated color tones, ranging from red (R) through orange (O), yellow (Y), green (G), blue (B), and violet (V), to the purples (V R V, R V and R R V). The intermediate tones are lettered by combinations: *e. g.*, very blue violet (B B V), blue violet (B V). Below this upper row there are six rows giving graded 'tints' of the saturated colors of the upper row, row six being palest. This scheme of Plate I is repeated over again in each of the six following plates (II-VII), except that the whole plate is successively dulled or "broken" by the addition of black. Plate VII is, therefore, the darkest.

TABLE I.

Single Tuning Forks.

r. NOTE.	r. VIB.	COLOR. PLATE.	COLOR. QUALITY.	INTROSPECTIVE REPORT.
E_1	40	V.	B	Surprised. Aroused verbal "mosquito." Horrid tone. The blue gray went through my head from one ear to the other.
G_1	48	V.	YYO	
B_1	56	—	—	Movement in visual field. Tone unpleasant.
C	128	I.	G	A very pleasant, luminous green seen through black. Not like any 'material colors'. Only came after upper partials had died away.
c^1	256	I.	G / BV	Striking caused a flash of brightness. Then a green veil spread for a moment over the whole field. Next a horizontal strip of B V which spread out and got thinner till the tone ceased. The tone was pleasant.
d^1	288	IV.	VRV	Lasted exactly as long as r.
e^1	320	—	—	Striking gave 'visual movement.' No color as tone was not specially pleasant; not big enough.
f^1	341.3	I.	G_4	As seen through black veil. Tone quite pleasant.
g^1	384	I.	B_3 / BBG_4	
a^1	435	I.	GYG_3	Appeared with the tone, but persisted slightly after it had stopped.
b^1	480	—	—	'Struckness' only. No color as tone was somehow indifferent.
c^2	512	I.	G_3	
e^2	640	I.	RV / R	These colors were not seen projected, but merely 'suggested.' R was nothing but verbal "red." Surprise at pitch of r being considerably higher.
e^2	640	I.	GYG_4	
g^2	768	I.	YYG_3	Color got clearer and more saturated as the tone cleared.
—	896	I.	BBG_6	
c^3	1012	I.	G_4	Very, very thin color.
d^3	1152	I.	VBV_3	Visual movement and a "suggestion" of the violet.
e^3	1280	I.	VRV_1	Striking caused a momentary flash of green, then the violet appeared in a wide horizontal band, which contracted and became more saturated as the tone cleared.
c^4	2048	I.	YYG_3	Sour, horrid, unpleasant tone and color.
g^4	3072	I.	B_3	Tone less unpleasant. Color fairly pleasant.
c^5	4096	I.	YYG_4 / Y_4	YYG_4 seen through Y_4. Color unpleasant.
g^5	6144	—	—	YYG grits the teeth. Tone shrill and unpleasant.
c^7	16384	—	—	Tone very horrid.
g^7	24567	—	—	
c^8	32768	—	—	Chills.

(*b.*) *Fusions.* Table II gives the photisms resulting from various tuning-fork fusions. Many of the combinations were repeated at different points in the series, but are grouped together for convenience. It will be seen that there is very little constancy in the reactions, but this is to be expected in view of the emotional link which forms their basis.

TABLE II.

Tuning Fork Fusions.

r.	COLOR. PLATE.	COLOR. QUALITY.	INTROSPECTIVE REPORT.
c^1–c^2	—	——	'Struckness.' Opening of the darkness.
c^2–c^3	I.	GYG / BBG	BBG seen behind GYG.
c^2–c^3	—	——	
c^1–e^1	—	——	Field got surprisingly and intensely black.
c^1–e^1	I.	GYG—G	Between the two. At the last began to get bluer.
c^1–f^1	—	——	Simple struckness.
c^1–f^1	I.	GYG—G	Between the two. A pleasant fusion.
c^1–g^1	I.	GYG_1	
c^1–g^1	I.	BBG_8	This was seen only with the left eye! Very unpleasant and quite unexpected to feel it so.
c^2–e^2	—	——	
c^2–e^2	IV.	BG_4	(Fusion given much more intensively.)
c^1–d^1	—	——	
c^3–e^3	—	——	

Table III gives the photisms resulting from the same fundamentals given simultaneously upon the piano. The experiment was intended to test the influence of the greater complexity of the resultant tone compound and of the piano 'color' upon the visualizations.

TABLE III.

Piano Compound Clangs.

r.	COLOR. PLATE.	COLOR. QUALITY.	INTROSPECTIVE REPORT.
c^1–c^2	—	——	Nothing at all.
c^2–c^3	—	——	Struck feeling only.
c^2–c^3	II.	B_6	And struck feeling also.
c^1–e^1	—	——	Struck feeling very plain. The visual 'opening' was complex as though several pebbles (three?) had been thrown into water.
c^1–e^1	I.	G_4	
c^1–f^1	III.	B_6	But even paler than this.
c^1–g^1	—	——	'Struckness'.
c^1–d^1	I.	GYG_4	'Struckness' followed by the color.
c^2–e^2	II.	B_6	
c^2–e^2	II.	GYG_6 / B_6	Very indefinite.
c^3–e^3	—	——	'Struckness'. Rather unpleasant.
c^1–d^1	I.	GYG_4	'Struckness' followed by the color.
c^1–d^1	II.	B_5	Quite unpleasant.

Comparison of Tables II and III shows a tendency to less saturated colors with the piano clangs. No color in Table III is assigned a place above row 4 in the chart, and most belong to plates darker than Plate I. The piano clangs were not so pleasant as the tuning-fork fusions. That this difference is due to the piano timbre rather than to the more complex nature of the auditory stimulus is shown by Table IV.

(*c.*) *Church organ.* Through the kindness of Mr. G. M. Chadwick, the University organist, we were able to try the effect upon the photisms of the various pitches in the varied tonal colorings of the different organ stops. The colors thus seen are much richer and more abundant than those obtained either from piano notes or phonographic selections.

For the sake of uniformity the same chord c-e-g was played in every instance, and was held until the subject announced the photisms clearly set,—usually about 5 seconds. This series was taken under slight fatigue which, contrary to the opinion of Flournoy, hinders rather than favors the photisms.

TABLE IV.

Church Organ.

STOP.	LENGTH. FEET.	COLOR. PLATE.	COLOR. QUALITY.	INTROSPECTIVE REPORT.
Bourdon,	32	——	——	
Bourdon,	16	——	——	Movement of the background from left to right.
Open Diapason, Pedal,	16		VRV	Solid heavy color.
Violon,	16	I.	G_3	
Full Pedal A,	16	——	B	Went in waves. Pleasant at first.
Contra Gamba,	16	I.	BBG_2	
Gamba,	8	I.	G_4	
Open Diapason,	8	I.	YYG_3	
Melodia,	8	I.	BBG_1	Very pleasant tone and color.
Great Diapason,	8	I.	G_3	
Violina,	4	I.	YG_4	
Violina (Octave lower),	4	I.	GYG_1	
Octave (Principal),	4	I.	YYG_4	Color unpleasant. Tone too shrill.
Fifteenth,	2	I.	G	Shivering clouds of G. Very thin. Located in top of head.
Vox Celeste and Octave Coupler,	8	I.	VBV	Both color and tone very pleasant.
Vox Celeste, Coupler, Violina and Contra Gamba,	16, 8, & 4	I.	VRV	Very luminous.
Concert Flute,	8	I.	YYG_3	
Flute d'Amour,	4	I.	G_3	Luminous color. Very pleasant tone.
French Horn,	8	I.	BBG_1	
Oboe,	8	I.	V	In a horizontal streak. This often occurs with V.
Cornopean (Small Trumpet),	8	I.	YG_2	Not so pleasant as Oboe.
Clarinet,	8	I.	BBG_4	But 'sharper' than this color.
Contra Fagotta (Clarinet bass),	16	III. / II.	ORO / VBV	
Contra Fagotta (an octave lower),	16	—	——	Mere roughness.
Cor. Anglais,	8	I.	GYG_4	Very clear.
Trumpet,	8	I.	YYG_3	Not very pleasant tone or color.
Clarion,	4	I.	Y_5	Clearer tone than Trumpet.

Table IV shows that the photisms developed by organ tones are 'clearer' than piano photisms, but 'paler' than fork photisms.

(*d.*) *Successive fork tones.* In these experiments two or four forks were hit successively at intervals of about three seconds, and then the resulting fusion was allowed to run for ten seconds. Usually each tone (especially when two forks were used) aroused its own color; during the tonal fusion these colors would intermix (not fuse) like two paints

stirred together upon a palette. Table V contains the results. Where two tones and two colors are given the first color is to be assigned to the first tone.

TABLE V.

Successive Fork Tones.

TONES.	COLOR. PLATE.	COLOR. QUALITY.	INTROSPECTIVE REPORT.
c^1, c^2.	I.	YG_3 / BBG_2	During the fusion the two were intermingled yet each was distinct.
c^1, c^3.	I.	RV_2 / YYG_5	YYG_5 appeared and persisted much higher, spatially, than RV_2.
c^2, c^3.	I.	BBG_1 / G_4	Expected that the colors would fuse, but they did not, though less separate than in the preceding test.
c^1, c^1.	I.	—— / RV_1 / YYG_6	The fusion was RV_1 seen through YYG_6. First note gave nothing. The second the RV_1.
c^2, c^2.	I.	YG_6 / B	Intermingled during fusion, but still distinct.
c^3, e^3.	I.	B	Very thin and faint. Came with 1st tone.
c^1, d^1.	III. YYO_1 / II. YYG_2		Intermingled, giving an unpleasant, muddy effect. Surprised at low tones.
c^1, f^1.	III. RRV / II. GBG_2		Colors more separate during tonal fusion than with the c-c or c-e fusions.
c^1, g^1.	I.	B_1 / G_5 / YG_8	
c^2, g^2.	I.	——	Nothing with the second tone, probably owing to lack of attention.
c^1, e^1, g^1, c^2.	I.	B_1	Blue appeared only when all had sounded. Surprised not to have other colors.
c^2, g^1, e^1, c^1.	I.	G_4 / B_1	G_4 came with the first tone. It changed to a very luminous B_1 when all had sounded.
c^1, f^1, a^1, c^2.	I.	GYG_4 / B	Whole chord gave bright B in the middle of GYG_4.
c^2, a^1, f^1, c^1.	I.	G_1 / B	Both thin and floating over the dark background.

(*e.*) *Continuous Tone Change.* This form of stimulus was supplied by Stern's blown bottle apparatus. The range was from 224 to 308 vibrations, *i. e.*, a movement of 84 vibrations, which was traversed in 42 seconds, or at the rate of 2 vibrations per second. This experience was rather unpleasant to *M*, and the induced colors were correspondingly rare, and when present usually of an unpleasant yellow-green quality.

Moving up produced in the first test B G, which changed to G B G, and finally to G Y G. This test was fairly pleasant. A second test gave no color at all; a third induced, only near the close, Y Y G_2 modulating into a faint Y_3.

Moving down produced in the first test, at the start, no color; then Y Y G, and finally Y G. It was quite unpleasant. The second test started at Y_2, which faded into black. Next Y G_8 appeared, and faded into black, and finally B G_2 came.

(*f.*) *Intensity.* As to the effect of intensive variations upon the subject's photisms, it was found by general observation that on the whole greater intensities produced more saturated and more luminous, but rarely, if ever, more extended colors. Specific tests were made with

the f^1 tuning-fork. It was struck by a wadded hammer, and the tone allowed to die away. It aroused a very luminous strip of violet, which became more saturated and brighter as the tone cleared. The dying away of the intensity from this optimal point, at which the partials have just ceased, was correlated with a spreading and thinning of the photism. In a second test the fork was suddenly brought close to the ear when it had nearly died away. The photism and its changes were exactly like those of the first test, except that the sudden intensification increased the saturation without altering the extent of the violet. A third test, exactly like the second, induced a yellow-green light which behaved in similar manner to the violet of the second test.

(*g.*) *Musical Selections.* These were given upon the piano, the phonograph and the church organ, under essentially the same conditions as the preceding tests. As would be expected, the induced visualizations were more complicated and more irregular than those experienced with single tones or chords. The church organ aroused richer colors than the phonograph, when the same selections were heard on each during the same hour; but the phonograph, when removed from this 'dulling' effect of contrast, afforded as rich and pleasing colors as the organ: everything depended upon the emotional effect at the time. All the phonograph selections were repeated at intervals from a few seconds to several months. The results of immediate repetition are as likely to be divergent as those of repetition after the lapse of a considerable time.

1. *Piano.* "The Two Roses" played in the key of a (220 vibs.), gave Plate VI, R R V, vertically on the right side of the field of regard, and Plate VI, B on the left side. At the highest point reached by the melody, there arose Plate II, O Y O_4.

The same selection, played one octave higher (a-440 vibs.), was less pleasant; it gave as photisms Plate IV, B_4 in moving clouds, and some Plate IV, G_3, which slowly came and went.

2. *Phonograph.*

1. *Bridal March from Lohengrin* (brass band). The notes seemed to be separately visualized, each instrument being represented by countless little light points which moved in and out with their rhythm. Later, some Plate I, G and B appeared, which also fluctuated with the time.

The same selection, repeated five weeks later, gave indefinite and grayish colors, Plate III, G_2, B_2, and R_3. A tremolo effect roughened the colors. The horns aroused Plate I, Y Y G_2 and Y G, colors which seemed bitter to the subject.

The same selection, a few minutes after it had been heard on the church organ,[1] gave Plate I, Y G and B, not very pretty, unsteady, and spotted with black.

2. *Intermezzo from Cavalleria Rusticana* (orchestra), a very highly pleasing selection, gave extremely vivid and complex colors, all in Plate I. At first there was a very solid G, shifting to B, in which there were occasional flashing specks of O. These colors were in the upper visual field. Toward the end, where the trombone bass was prominent,

[1] See below, p. 388.

there appeared a very rich R R V or R V in the lower visual field. The high repeated attacks of the violins in this part gave B_3. The visual experience was very pleasant, but the auditory more so.

Five weeks later the same piece aroused Y[1] with the violin passage of the introduction, immediately succeeded by B and G and some Y_3. At the end R R V_2 appeared below the others, as in the first experience. After listening to it on the church organ, the *Intermezzo* on the phonograph gave G, B, Y (with the high violin passage) and V B V (with the trombones).

3. *Pilgrim Chorus* (band) induced R_4 for a short time, also R R V_4, B B G_4, G_3 and Y_4 (with a high note). These colors were less vivid than those aroused by the *Intermezzo*, more vivid than those of the *Bridal March*, but not especially pleasant to see.

Four weeks later it induced G, Y G_2, R R V_3, and B_2 on Plate I; B_1, B G_2, R R V_2, and O_2 on Plate III. The higher notes aroused colors higher in the visual field, together with eye strains of glancing upward. The trombones and bass horns aroused the R R V photisms. After the church organ the *Chorus* gave Y_1, R V_1, G Y $G_{1, 2, 3}$, and B B $G_{1, 2, 3}$.

4. *March from Carmen* (orchestra). A very vivid G appeared with the sound of the cornet and piccolo, and vibrated when they played a rapid staccato time; with other instruments (perhaps strings) appeared Plate II, R V_3, and jumping splashes or spots of Plate II, Y_2.

A few weeks later the subject experienced with this march a sudden flashing of the colors, chiefly G, at the first sound of the music. Throughout the selection, which is very exhilarating and accentuated in character, the whole visual field vibrated with the music, even the background taking up the movement when the colors were faint. The color-clouds were Plate IV, G, B, and B_1, and Plate III, G_1. Once there appeared a rainbow effect,—straight bands of R, G and B stretching across the field.

After the church organ *Carmen* occasioned merely faint greens and blues. An accidental pinching of the rubber ear-tube during the experiment brought about a sudden closure of the visual field and total disappearance of the photisms.

5. *Yankee Doodle* (banjo with piano accompaniment) produced dull, 'dead,' solid colors, a sort of background,—and not at all pretty. These colors were dark greens, blues, and yellows, which kept beating in the background with the twanging of the banjo, like little hammers hitting against the field.

This general setting was repeated in the photisms for the same selection a few weeks later. At the sudden loud start *M* winked, and the visual background jumped and stirred. The colors were at first indefinite, but throbbing distinctly in time with the banjo. Then they became more intense, taking on a striped appearance instead of the usual vaporous clouds. There were about six stripes of alternating Plate IV, R_3 and Plate IV, B_1. When the piano took up the melody it appeared visually as Plate II, Y Y O_2.

6. *I Fear No Foe* (bass solo with piano accompaniment). This song was distasteful to *M* because she did not like the voice of the singer. The colors were dull, rough and dead, like those of Plate VI of the Color Standard. The lowest note reached gave R R V of Plate VI.

The second hearing furnishes a good illustration of the emotional type of associative supplementing. While the colors obtained vary radically from the above they are still faint, dull and unpleasant. They were G Y G_3 and G B G_4. The very low note this time induced a thin green overlaid with an unpleasant brown.

[1] When no plate number is assigned Plate I is to be understood.

7. *Sally In Our Alley* (tenor solo with piano accompaniment) was pleasanter than the bass solo. It occasioned G Y G_3, G_4, G B G_3 and B_6. The turns produced a visual figure like a twice coiled spring.

8. *Grand March from Tannhäuser* (band) was, except in the fatigue test to be mentioned later, tried only after it had just been heard on the organ. On the phonograph it gave B, G, R R V, and flashes of brightness.

2 a. *Projection Experiments—Phonograph.* These tests differed from the preceding in that the eyes were open and looking, though without steady fixation, at a large black or colored screen hung about 20 cm. before the face.

I. *Black Screen.* Simply staring at the black screen for a length of time equal to that consumed by the musical selections gave Plate II G_3 (trembling like a drop of water), Plate I G Y G_4 (in a band) and Plate I B_4 (in the upper part of the field). These colors were all exceedingly faint and distinctly different from those projected by the music.

The *Bridal March* caused suffusion of the dead black with the following colors: R V_2, R V_3, V B V_2, B_4, and G Y G_4. They were not so strong as those seen with closed and bandaged eyes, and constantly changed. The reddish violet appeared in the form of a half-arch, about 15 cm. high, leaning over to the right.

II. *Red Screen.* Without the music no other colors appeared on the screen.

The *March from Carmen* induced photisms described as very thin veils through which the strong red background could always be seen. Y was quite frequent; a rather stronger B less frequent. This B made the area of the red on which it was projected appear V B, but the two colors were analyzable into the red background and the blue "veil." There was an occasional green. The B came with the horns and lower passages; the G and the Y with the higher passages.

III. *Green Screen. Grand March from Tannhäuser.* The principal veiling was yellow. A particular feature of the music induced a blue, which at one place narrowed into a small but quite thick and satured strip.

Green alone was seen without auditory stimulation.

IV. *Yellow Screen. Intermezzo from Cavalleria Rusticana.* The only projection observed was a faint horizontal blue strip which was correlated with the trombone, and which descended step by step down the screen with the descending trombone passages. Without music there were no projections.

V. *Blue Screen.* The *Intermezzo* repeated here caused a great deal of green, a single fleeting dirty yellow, and again a descending photism correlated with the trombones. This was a blue-violet effect, during which the blue background lost nearly all its saturation. Here, also, auditory stimulation was required to produce projected colorings on the background.

3. *Church Organ.* These selections comprised a repetition of the

principal phonograph pieces and, in addition, three pieces which had aroused photisms for *M* during organ recitals given by Mr. Chadwick.

A slight fatigue on the day selected for the experiment somewhat reduced the brilliancy of the photisms. They were, however, as already pointed out, more brilliant than those aroused by the same selections on the phonograph during the same hour.

Handel's Largo, the first of the extra pieces, was rendered with diapason and melodia stops in the introduction, and with melodia, concert flute and small diapason as the solo stop. The introduction was seen as G B G, B B G, and V B V arranged above one another in horizontal bands, the solo stop as Y G. Besides this, V and V R persisted throughout. Both the music and the colors were 'sweet' and very pleasant.

A *Chorale* was next tried, with a 'round'[1] stop setting, with later a sudden addition of reeds and mixtures[2]. The round stops induced blue; the addition changed this to green. The same selection was repeated, except that the full organ was added. This addition occasioned a burst of vivid green.

Chopin's Funeral March was colored Y G. Here again the sudden addition of the full organ was correlated with a luminous green, which burst close to the eyes.

The effect of the rendition of the standard phonograph music upon the church organ is given in Table VI. These photisms may be compared with those already mentioned as occasioned by the phonograph during the same hour.

TABLE VI.

Church Organ.

SELECTION.	COLORS AND INTROSPECTION.
Pilgrim Chorus,	With the violins a very luminous BBG_2; with full orchestra effect YG over RV. At other times B and G.
Grand March,	Mostly VRV_1 and G. Also G_1, G_2, G_3, and B_4. All the colors thin.
Intermezzo.	VRV, V, G, and a very high, pretty and luminous B_3. The colors all shivered and trembled (owing to the influence of the Vox Celeste and Tremolo stops).
Bridal March,	A predominance of blues, and also RV_2, VRV, G, and YG.

(*h.*) *Centrally Excited Photisms.* Several deliberate attempts were made to induce photisms from centrally excited melodies. Although the process of imaging the music was pleasant, no photisms could be secured. The pieces attempted included popular airs and some of the phonographic selections used in the previous experiments. Careful observation also has failed to disclose any colorings in centrally excited music at any time in the subject's life.

(*i.*) *Fatigue.*[3] Other authors have asserted that fatigue tends to produce greater frequency and brilliancy in synæsthetic phenomena. In order to test this a successive fork series and four phonograph selections were given to the subject when she was in a state of considerable fatigue. The results showed that the music was then soothing and restful rather than exhilarating in character. The photisms were *not quite so frequent*, and though pleasant were almost invariably *much paler*, corresponding to the 3rd, 4th or 5th rows of the Color Standard plates.

[1] *I. e.*, melodia, flutes, etc.
[2] Full swell organ, coupled with octaves.
[3] These results were so constant that details may be omitted.

(3.) *Photisms with other Senses. Taste and Smell.*

Before these tests the subject had never experienced colored taste or colored smell, and felt confident that no colors would be aroused. The results showed, however, that both these photisms were present, though in much less developed form than the others. The colors were always rather slow to appear and were flatter, deader, more like reflected light, than those with sound.

(*a.*) *Taste.* The results with tastes tried upon two occasions nearly a year apart, are not very concordant. Certain features of them will be found, however, to exhibit very close similarity with the taste-colors of Case II, later to be mentioned. The solutions were sugar 20%, salt 2%, tartaric acid .5%, quinine (hydrochlorate) .2%. Enough of each solution was taken to cover the whole tongue.

The following results were obtained in the several trials:

Sweet. (1.) No color. Taste was pleasant at first then sickening.
(2.) No color. Taste not recognized at first. Called up verbal "cool" and "high."
(3.) GYG_3, B_2, and GBG_2. The first was a line only; it spread out, growing bluish. The taste was not very pleasant.

Acid. (1.) YYG_2. Shivered, drew up whole body. Mouth puckered. A clean taste.
(2.) YYG_3 and associated visualization of some green grapes picked in childhood.

Salt. (1.) No color. Very unpleasant.
(2.) BBG. Taste quite weak.

Bitter. (1.) O_2. Over a blackish background.
(2.) YG_3. Tastes like some kind of medicine.

Sweet and Acid. BBG_4. This color was not projected at all, and was rather a 'suggested' color.

(*b.*) *Smell.* Although the subject's sensitivity for odors is quite poor, colors were very certainly incited by smell stimuli. They appeared at about the second inhalation, and lasted till the stimulus was removed. The following results were taken one week apart, each odor thus being twice tested.

1. *Wormwood.* (1.) Very faint red. Vague visualization also of a flower.
(2.) Yellowish green. Neither odor nor color pleasant. Visualization of a brook and dusty green peppermint growing beside it.

2. *Cinnamon.* (1.) Very faint green. Smell seemed cool at first, then warmer.
(2.) Warm blue. Smell was pleasant and warm.

3. *Asafœtida.* (1.) No color. A clean 'hospital' smell. Visualization of rows of beds.
(2.) No color. A cold smell. Same 'hospital' complex plus a doctor with gray hair.

4. *Anise.* (1.) Faint reddish-violet. Quite pleasant.
(2.) Green. And then a visualization of green pickles, also a store, and a woman by the pickle barrel (a childhood scene). Pleasant but funny smell.

5. *Camphor.* (1.) Ice green photism, and visual and auditory "camphor."
(2.) Faint but pretty pearl gray, and later saw a dentist. The dentist was unpleasant, but the smell was clean and pleasant.

6. *Crab Apple Blossom.* (1.) Small faint green photism. Then a visualized candy store of childhood.
(2.) Very faint green, undulating and pleasant. Visualization, a scene from a book she had been reading of a room in a country house, all hung in white—muslin curtains blowing in the breeze and lilacs upon the table.
7. *Bisulphide of Carbon.* (1.) Dark orange brown with light gray in it. Very unpleasant.
(2.) Sickly orange yellow. "Very horrible" color and smell.
8. *Wood Alcohol.* (1.) No color. Visualization, a physician. Smell was at first sniff unpleasant, then became pleasant.
(2.) Green. Pleasant. It has some very strong association, but can't get at it.
9. *Rose.* (1.) No color. Odor very faint and cool. Visualization, a garden with shady green walks.
(2.) No color. The smell was unknown. Very pleasant. It aroused a verbal "choir invisible" and a visualization of the dainty lady who was like "Rosemary and faded rose leaves, between the sheets of old music."

(4.) *Miscellaneous Synæsthetic Phenomena.*[1]

M has no phonisms, and no visual forms for numbers, days, months, etc. She visualizes additions, multiplications, etc., only as numerals. The only other phenomena analogous to those described are the personifications given to numerals, letters, and inanimate objects, and the converse tendency to see resemblances between persons and other things animate and inanimate. Thus, for example, one person appeals to *M* as a log of wood, another as a toad, a third as a mosquito, a fourth as a walrus.

Personified numbers and letters are not usually visualized as persons, but endowed with human characteristics. In childhood, 7 was unpleasant, cross, always fighting with 8. The two were, unfortunately, too close together. 5 is a pleasant number, 3 very unpleasant.

There remains to be mentioned the coloring of words and individual letters. Excepting the auditory word "horn," which is orange yellow from the color of brass instruments, and an occasional associative supplementing of especially affectively toned christian names—such as Bernice,—blue,—the subject never has photisms with words.

Individual letters are never heard or seen as colored. The following list contains a list of colors which seemed to the subject what they *ought to be* and *must be*, if they have any color at all. On the other hand, the affective tones and the personal characteristics of the letters are quite real, and in some cases very vivid and decided. The entire alphabet was canvassed twice. The second time was nearly a year after the first, so that it is but natural that many of the reactions differ. In fact they might, according to the subject, be different from day to

[1] Many writers have pointed out that colored hearing is often associated with number forms, personifications, etc. Flournoy, *op. cit.*, p. 14. Calkin's, Experimental Psychology, at Wellesley College. This *Journal*, V, p. 260.

day. In general, *M* visualized a printed capital letter, and then thought for 10 or 15 seconds before announcing the report, in order to feel herself just like the letter in question.

TABLE VII.

Alphabet.

LETTER.	AFFECTIVE TONE.	COLOR.	OTHER CHARACTERISTICS.
A	Pleasant,	Red,	
A	"	———	
B	Less pleasant,	Blue,	
B	Neutral,	Blue,	Fat.
C	Unpleasant,	Greenish yellow,	
C	Very pleasant,	Green,	Good natured.
D	Unpleasant,	Brown,	Stupid.
D	———	———	Nice, happy, jolly, fatter than B. A man with red cheeks, bright eyes, hopping around with his hands in his pockets.
E	Pleasant,	Reddish,	
E	Neutral,	———	
F	Unpleasant,	Green,	
F	———	———	
G	———	Dull bluish green,	Rough. A log of wood.
G	———	———	
H	Pleasant,	Something rich,	Unhealthy.
H	———	———	The width is pleasant.
I	Less pleasant,	Thin yellow,	Feels aristocratic but is n't.
I	———	———	Thin.
J	Unpleasant,	Yellow green,	Like Uriah Heep.
J	"	" "	Ugly.
K	———	Cold blue,	Not nice. I don't like it. Never have much.
K	———	———	Hard (sound).
L	Pleasant,	Reddish,	Has been an outsider in the letters, but is now trying to get along with them.
L	"	Blue,	But less than A.
M	Very pleasant,	Violet,	Refined, quite nice. A very elegant person.
M	———	———	Liked because it is my initial.
N	Pleasant,	Bluish,	" " " " " Quite nice.
N	"	———	
O	"	Something rich and extended,	Agreeable. Generous.
O	"	Yellow,	
P	———	Green and dirty brown,	Jolly and full of fun. Mean, selfish.
P	———	———	
Q	Pleasant,	———	Dignified and a little conservative. [rano.
Q	———	———	Bizarre. Fine qualities under it. Like Cy-
R	Pleasant,	Yellow green,	A genius. Erratic and unusual.
R	———	Rich green,	
U	———	———	Ordinary. Not neat. Like a woman who dresses in second-class style, but puts on the airs of the first-class.
U	———	———	Disappointing. Attempts to be a beautiful red, but falls short of it. [natured.
V	———	Orange (?),	Happy. Stout, but not like D, not so good
V	———	Dark gray,	Dignified.
W	———	Delicate blue,	Aristocratic. Very dignified and feminine.
W	Pleasant,	Red and purple,	Jolly. "Hail fellow well met." [thrift.
X	Unpleasant,	Green,	Generous. Good hearted, and yet a spend-
X	———	Rough blue,	[to be one.
Y	———	Dark gray,	Like an ordinary working man who tries not
Y	Pleasant,	Blue,	Dignified.
Z	"	Yellow and green,	Like music.
Z	———	———	

For further general remarks upon Case I, see the final résumé.

CASE II.

§ 1. *Historical.*

The subject of the second case is *R.* (Mr. E. C. Roberts), an undergraduate student of the arts department. *R's* father is musical. He himself is fond of music, and both plays and sings. At the age of 15, he read an article on Colored Hearing in a paper, and then noted that he had associations of color with tones, tastes, and temperatures.[1] In spite of discouragement from members of his family he continued to observe the photisms, and found a good deal of pleasure in determining the correlations. At the same period he noted phonisms of pain. These, however, were not prominent until the summer of 1899, when a badly injured finger gave occasion for a series of determinations of the 'pitch' of the pain. *R's* colors differ radically from *M's*. They are but rarely vivid enough to be projected,[2] yet they are very detailed and very constant. *R* uses the word "match" to describe the relations of the correlated sensations.[3] That the color is, however, consciously present, and not a mere verbal association, is evinced by the discriminating manner in which *R* chooses the color tone from the Prang plates, and further by the fact that in the process of 'matching' a certain color tone and only one in the chart 'affects' him just as the sound did. Despite the use of this word, the link which forms the basis of *R's* synæsthesia does not seem to be an *affective* link. As a rule, the whole process is indifferent.

§ 2. *Experimental.*

The following tests, with the exception of the Galton whistle and of the experiments upon phonisms, are duplicates of those already mentioned.

(1.) *Retinal Colors.* The following list shows that the dark-room visual phenomena of *R* are essentially similar to those of *M*. The 'nothing' reports indicate merely absence of coloring; the field during these periods is generally disturbed by spots, lines, and mottlings of gray. The "dull blue" is Plate VI, BBV, the dull green Plate IV, YYG, the bright blue a luminous Plate III, B.

TIME.		VISUAL PHENOMENA.
M.	S.	
0	0	Muddy G.
0	20	Dark B.
2	45	Dull G.

[1] The plunging of the hands into cold water, *e. g.*, was always 'red.'
[2] All colors which are projected are indicated in the Tables by an exclamation point.
[3] Oddly enough, both types may be present, and the colors projected may be dissimilar to those which would be 'matched' or 'assigned' to the stimulus. See Table IX, Second Test.

TIME.		VISUAL PHENOMENA.
M.	S.	
3	00	Dull B.
3	15	Nothing.
4	00	Faint brightness.
4	35	Very dull B.
5	00	Gray and G. Well defined patterns.
5	20	Brighter gray.
5	50	Nothing.
6	18	Dull B.
6	40	Nothing.
7	00	Dull B.
7	08	Dull G.
7	24	Brighter B.
7	53	Very bright B. } Uniformly spread and fringed with a zig-
8	10	Exceeding bright B. } zag green border.[1]
8	20	B.
8	45	Nothing.
9	35	Dull B.
9	55	Brighter B.
10	20	Momentary spots of very bright B.
11	50	Bright B.
11	55	Bright B in a cloud with a green border.
12	05	Bright G.
12	08	B.
12	20	G. Cloud spread over the B.
12	32	A succession of these colored clouds of different shapes.
13	08	Bright B spots on B ground.
13	45	Flash of G over the B ground.
14	10	B ground changed to black.
15	00	All black with one or two bright spots.

(2.) *Photisms: (a) with Simple Noise and Tone.*

Noises. A sharp rap on a table aroused a faint but distinct narrow flash of brightness, running from left to right across the field.

Single tuning-fork tones. One complete and one partial series are represented in Table VIII. The duplicate members were retaken after one month to test the constancy of the association. The prevalence of R and V—colors absent from the retinal lights—is noteworthy.

Tests with the Galton whistle gave a brightness streak, the inclination of which varied with the intensity of the whistle. Another series produced nothing but unpleasantness.

(*b.*) *Fusions.* Table IX gives the results of tests for the photisms of tuning-fork fusions. We were unfortunately not able to use the Prang chart for this particular series.

(*c.*) *Church Organ.* The test for stop effects gave with *R* the results in Table X. With a single exception these colors were matches. The rather light-gray tones assigned to the 32 and 16-foot stops is of interest in contrast to the idea generally prevalent that very low tones should be dark.[2] The clarion stop, which at the pitch used (circa 512 vibs.) gave G, turned through red to a brown-gray when the pitch was successively lowered by octaves. Neither *R* nor *M* shows any definite correlation of color and tonal register.

[1] A phenomenon of this sort is often seen (!) with organ music.
[2] Stumpf, *Tonpsychologie*, II, 526, 531.

TABLE VIII.

Single Tuning Forks.

r.		COLOR.		INTROSPECTIVE REPORT.
NOTE.	VIB.	PLATE.	QUALITY.	
E_1	40	II.	V_5	Light copper color. Rather uncertain.
B_1	56	—	——	
c	128	I.	RO / RRV_5	Changed to RRV_5 as the fork died out.
c^1	256	I.	RRV_6	
c^1	256	—	——	A dull gray.
d^1	288	I.	V_4	
e^1	320	I.	RV_2	
e^1	320	—	——	A dull red.
f^1	341.3	I.	RRV	
f^1	341.3	II.	R_4	
g^1	384	I.	RRV_1	
g^1	384	I.	RV	
a^1	435	I.	R	
a^1	435	I.	RV	
b^1	480	II.	R	
c^2	512	I.	RV	
c^2	512	I.	BV	
e^2	640	I.	VRV	
e^2	640	I.	BV	Quite bright. Saw a little cloud of white light go across the field when the fork was struck.
g^2	768	I.	V	
g^2	768	I.	B	
c^3	1012	I.	VBV	
c^3	1012	I.	B	B shading into G.
d^3	1152	I.	VBV	
d^3	1152	I.	B	Very clear B.
e^3	1280	I.	V	Very bright.
e^3	1280	I.	BV	
c^4	2048	I.	BG	
g^4	3072	I.	GBG (!)	Surprised actually to see this color.
c^5	4096	—	——	
g^5	6144	I.	VG_4 (!)	In splashes upon a dark background.
c^6	8192	V.	G_4	

TABLE IX.

Tuning Fork Fusions.

r.	INTROSPECTIVE REPORT.
c^1–c^2	Between reddish brown and coffee color.
c^1–d^1	Bright red gray, but also saw (!) little rapidly vibrating spots of light, mostly blue, which vibrated with the beating of the forks and described forms like Lissajou's figures.
c^1–e^1	Dull red.
e^1–f^1	Dull red.
c^1–g^1	Matches reddish gray, but also saw (!) a pale cloud of yellowish green. The two felt incongruous.
c^1–a^1	Rather bright pleasant red gray.
d^1–g^1	A pale red violet with gray. At the striking of the forks saw (!) little clouds of bright blue.
c^2–e^2	Bright blue-violet.
c^2–c^3	Pure violet.
c^2–d^3	Matches RV, but saw (!) an indefinite disturbance in the visual field.
c^2–g^2	RV not so bright as the preceding.
c^3–e^3	(e^3 struck slightly first.) With the first, saw (!) clouds of bright blue, with the second a cloud of greenish yellow. The two clouds remained distinct and appeared alternately.

TABLE X.

Church Organ.

STOP.	LENGTH.	COLOR.		INTROSPECTIVE REPORT.
		PLATE.	QUALITY.	
Bourdon,	32	VI.	R_4	
Bourdon,	16	VI.	R_6	
Open Diapason (Pedal),	16	II.	VO_6	
Violon,	16	—	——	Medium gray.
Full Pedal,	16	V.	RRO_5	
Contra Gamba,	16	I.	V_6	
Open Diapason,	8	II.	RO_1	
Melodia,	8	I.	RV	
Great Diapason,	8	I.	RRV	
Violina,	4	I.	BG	
Violina (octave lower),	4	I.	GBG_3	
Octave,	4	I.	R	
Fifteenth,	2	I.	G	Very solid G.
Vox Celeste and Octave Coupler,	8	III.	R_3	Muddy.
Vox Celeste, Coupler, Violina and Contra Gamba,	16, 8, & 4	III.	R	
Flute d'Amour,	4	I.	BV	Bright.
Concert Flute,	8	II.	RRO	
French Horn,	8	I.	G_2	
Oboe,	8	II.	R_1	
Cornopean,	8	I.	R	
Clarinet,	8	I.	R_2	
Contra Fagotta,	16	II.	RO	
Contra Fagotta (octave lower),	16	IV.	RO_4	
Cor. Anglais,	8	II.	R_1	
Trumpet,	8	II.	RRO_1	Saw (!) green spots.
Clarion,	4	I.	G	

(*d.*) *Successive Tones* (tuning forks). Table XI shows *R's* coloring for successive tone complexes of three and four constituents. No pairs were tried. This form of stimulus was found to be decidedly pleasant; a fact which possibly accounts for the projected photisms in three out of the eight cases. All the colors are found in Plate III.

TABLE XI.

Successive Fork Tones.

r.	COLOR.		INTROSPECTIVE REPORT.
	PLATE.	QUALITY.	
c^1, e^1, g^1, c^2.	III.	VBV	This was the color of the whole complex.
e^1, g^1, a^1, c^2.	III.	VBV	" " " " " " "
d^1, g^1, b^1.	III.	RV / R_1	b^1 was RV; the whole R_1.
b^1, g^1, d^1.	III.	BG / BV	All seen (!) in the lower right hand corner. The fork is always 'placed' visually in the center of the field. (These tones were given rapidly and quite intensively.)
b^1, g^1, d^1.	III.	BG / BV	The same projected visualization. (The tones were given less rapidly and less intensively.)
c^2, g^1, e^1, c^1.	I. / III.	VRV / RO	c^2 was RO, the complex VRV.
c^2, a^1, f^1, c^1.	III.	BG / BV	f^1 was BG, c^1 was BV, both were seen (!). These colors coincided spatially with the 'placing' of the fork. Each fork when struck makes a flash in the field.

(*e.*) *Continuous Tone Change.* A steady tone of 224 vibrations was denominated Plate V, O_6, one of 308 vibrations, Plate II, V_4.

As the tone moved down from 308 to 224 vibs. the violet gradually shifted. First the blue faded out; then the red which remained became lighter and grayer till it reached the Plate V, O_6. *R* thought that if the tone had gone considerably lower it would have become clear white.

The moving up of the tone produced an exactly reverse effect, except that the entrance of the blue which carried the red over into violet was quite sudden. None of these colors were projected. This test well illustrates the greater uniformity of the photisms of Case II, as compared with Case I.

(*f.*) *Intensity.* The variation of *R's* colored hearing with the intensity of the Galton whistle has already been noted. The outcome of the other tests, with the f^1 tuning-fork, was quite dissimilar to that with *M.* A moderate intensity aroused (!) Plate III, B G_3; a weak intensity gave a brighter and smaller photism; and a strong intensity a more extended one. Silence is white.

(*g.*) *Musical Selections.*

1. *Piano.* The same tests were employed as with *M.* At the lower pitch *R* saw (!) red and green bands (Plate V, Y G and R R_0) at an angle of 60°. They appeared almost with the first note, and varied with the intensity of the music. At one place the angle of inclination changed slightly. At the higher pitch the same colors were seen (!), but in narrower bands and in a more vertical position.[1]

2. *Phonograph.* The musical selections upon the phonograph were at first quite unpleasant (owing to scraping sounds, and emphasis of partial tones), but after four or five selections, this affective reaction passed away.

(*a.*) *Bridal March* (1). No colors seen (!). Unpleasant. The prevailing color matches reddish brown (Plate III, RO), with green for the trombones.

(2.) Saw (!) a tube with flaring mouth sending out puffs of "music smoke" with the rhythm of the music. The 'matched' color for the whole selection is still a reddish brown, though clearer than before. (Plate II, RRO.) The music much less unpleasant.

(3.) Immediately after it had been heard upon the church organ,[2] the Bridal March occasioned no visualization, and matched Plate I, R, except the high violin part, which was RRV.

b. Intermezzo. (1) No colors seen (!). The color was bright red,

(2.) After the organ: matched RV with high violins B.

c. Pilgrim Chorus. (1) Slightly unpleasant, no association.

(2.) After the organ: saw (!) stripes of Plate III, R and Plate IV, G, arranged either in parallel oblique bands or in concentric arches piled one on another.

d. March from Carmen. (1) The whole selection matched Plate II, R. The flutes were of a very bright red.

[1] This is a good instance of a feature of *R's projected* photisms. They tend to appear not as clouds or veils (as in *M's* case), but in rather detailed and specific forms, *e.g.*, as puffs of color from a 'tube' of definite size and inclination.

[2] See below, p. 397.

(2.) After the organ: the subject had the tubular visualization above mentioned, save that the faster time produced a narrower tube. Besides this he saw (!) one spurt of R, and G stripes, in the lower visual field.

e. Grand March. (1) This march aroused the same phenomenon as the Bridal March (2) and the Carmen March (2). Here the emitted 'puffs' became narrower and longer where the music was higher. The prevailing volume of the puffs, and hence the size of the tube, was in this march midway between the same dimensions in the other two instances.

(2.) After the organ: 'matched' Plate I, R.

f. Marble Halls (song from the Bohemian Girl, with piano accompaniment). The piano interludes were a bright violet, the singer's voice a very bright green.

g. Yankee Doodle matched Plate II, RRO.

h. I Fear no Foe was generally Plate III, G. The deepest notes of the singer's voice were YG of the same Plate.

i. Sally in Our Alley, a tenor solo, was assigned a brighter green (Plate I, YG).

3. *Church Organ.*

These tests included only four of the standard phonograph pieces. They are significant in comparison with the phonograph renderings heard during the same hour. The greater wealth and intensity of the church organ aroused actual projections of specific form, which are in marked contrast to the general sterility of the phonograph visualizations.

(1.) *Pilgrim Chorus.* This matched Plate II, VRVY. During the orchestral passage of descending 16th notes, the subject saw dropping rain. The violin and horn stops excited projections of broad B and narrow RRV stripes running obliquely upwards from left to right, the violin and fagotta stops similar projections running obliquely downward from left to right.

2. *Grand March.* Here R saw (!) concentric red and blue arches, and towards the close the phenomenon of smoky rings of brightness running up a tube in tune to the music.

3. *Intermezzo.* This was assigned a match,—horizontal strata of red and violet. There was no projection.

4. *Bridal March.* Again the 'puffing' visualization (!) was called forth. The 'angle' of the 'horn,' as in the piano selections, approached the vertical with the higher pitches. Finally a very high note made the 'horn' disappear in a momentary burst of colors (B, V, and Y).

(*h.*) *Centrally Excited Sensations.* In marked contrast to Case I is *R's* ability to obtain what he calls 'matches' from centrally excited sensations. An imagined sweet is as blue as the actual taste. His phonisms are likewise centrally excitable. Indeed, when he tried to rethink the pain of the injured thumb above cited, he found its 'pitch' much more available than its ache. After a few seconds' trial at the piano, *R* announced that this pitch was the discord of d^2 and e^2 simultaneously and faintly sounded.[1]

(*i.*) *Fatigue.* No laboratory tests upon the dependency of *R's* synæsthesia upon bodily fatigue were undertaken. He himself thinks,

[1] The reliability of this rather astonishing phenomenon is attested by the fact that *R* had picked out the pain of this injury several months before the above test was taken as starting out at a^2, and descending to d^2 as the pain lessened. He had forgotten the first test completely when the second took place. He does not know the piano keys by name

with *M*, that fatigue rather hinders than favors these experiences. Thus sleepiness prevented him from getting any colors at a certain organ recital at which he was anxious to observe colored hearing.

(3.) *Photisms with other Senses.*

(*a.*) *Smell.* *R* found few projected colors, when stimulated by odors, and the assignment of colors to smells was less natural, less spontaneous, than to tones. Especially, he often debated whether the color should be red or green. On the first day's trial, *R* suffered from a bad cold, and the stimuli were given in small bottles. The odors were thus in many cases too weak. On the second trial, the fluids were poured out into flat trays. The increased intensity sufficed to afford the following results.

TABLE XII.

Odors.

ODOR.	ASSIGNED COLOR.	SEEN COLOR.	FURTHER INTROSPECTION.
Camphor,	YG	——	Pleasant odor. Color doubtful.
White Rose,	RV	——	Very pleasant.
Carbon Bisulphide,	Dirty O	——	Unpleasant. "Take it away."
Crab Apple Blossom,	Clear / Red Gray	Plate I. B	Very pleasant. The bright blue seen (!) was in the form of little lights, and was due to the odor. They were more pleasant than the "nice red gray" assigned, yet the "red gray idea" corresponds to "that odor idea."
Cinnamon,	——	Brightness,	A light cloud rising in the lower part of the field. "Sunrise on a small scale."
Anise,	R	——	Fairly pleasant.
Asafœtida,	B	——	Pleasant. Doubtful assignment,
Orange,	Deep R	——	Pleasant.
Peppermint,	RV	——	Pleasant.
Cloves,	RO	——	"Associated roast beef for some reason."
Oil of Citronella,	Deep unpleasant R,	——	Odor unpleasant.

(*b.*) *Taste.* *R* has always had colored taste along with his colored hearing. The laboratory tests were confined to the four standard solutions employed in Case I. The assignment of colors was subjectively considerably more natural and definite than for odors, and even than for tones, and was extremely uniform. The time which elapsed from the first introduction of a solution to the expression of its color was recorded by a stop-watch. This time approximated to 4 seconds. This may seem to give evidence of a deliberative form of judgment; but it must be remembered that some time was required for the spreading of the solution over the tongue, and an appreciable time for the functioning of the nervous processes underlying the sensation,—and further that *R* is generally slow in

expression. Moreover, his introspection bears out this assertion of spontaneity; *e. g.*, when salt was tried, the report was: "The color ($R\ O_2$) came as soon as the taste was nicely round my mouth. Then it gradually faded. This color is part of my 'salt consciousness' just as much as the name 'salt.' The color, the taste, and the name are parts of a whole, like the separate notes of a chord."

Table XIII contains results for each taste and for combinations of tastes obtained at three different times. The time of reaction is included in the majority of cases. Like tastes are grouped without regard to the day upon which they were tested. The only lapse from uniformity is the single instance of acid as red. This may be due to the fact that acid was unpleasant in this one trial.

TABLE XIII.

Tastes.

r.	TIME. SECS.	COLOR. PLATE.	COLOR. QUALITY.	FURTHER INTROSPECTION.
Sugar,	3.5	I.	B	r pleasant. A clear, bright B.
Sugar,	3.0	I.	B	r getting sickish. B still pleasant.
Sugar,	——	I.	B	
Acid,	4.0	I.	G to GBG	r pleasant after the first moment. Bracing. Recognized as acid.
Acid,	7.0	IV.	R_2	Acid, unpleasant. (Large mouthful.)
Acid,	3.5	I.	G to GBG	Pleasant.
Acid,	——	III.	GBG_2	Less bright than previous acid green, because r tasted differently.
Acid,	——	I.	BG	r not so biting as before,
Salt,	3.0	IV.	R_2	Pleasant, salt. A dull R.
Salt,	4.0	II.	RRO	" " " " "
Salt,	3.0	I.	RO_2	Color came as soon as the taste.
Bitter,	——	II.	RO	
Bitter,	10.0	II.	YO_3	Color a yellow brown. r too weak, hence the long time.
Bitter,	4.0	III.	RO	Pleasant, bitter. Color is a nice, dark brown.
Sugar and Acid,	4.5	III.	BG	A greener blue than with sugar. Recognized the two elements in the solution but not until the color had been assigned. (By mistake, the beaker had not been rinsed of acid. Sugar only was intended.)
Sweet and Salt,	7.0	IV.	B_1	r very unpleasant, sweet and salt. A dull, muddy blue.

Beside these photisms with the standard tastes, *R* assigns colors to many dishes; but their colors are often due to the actual color of the things themselves. Some of these assignments are given in Table XIV.

(4.) *Phonisms.* We have already mentioned an instance of tonal pain. A similar case occurred to *R* during experimentation. He suffered from a stiff neck, which 'sounded' like f^1 and g^1 simultaneously struck upon the piano. *R* had tried pressures at home, but not systematically. He thought he could have picked out piano tones to go with them.

TABLE XIV.

Dishes.

FOOD.	ASSIGNED COLOR.
Meats,	Dark yellow, dark red, and dark brown.
White bread,	Pale sickish white.
Graham bread,	Rich red.
Milk,	Light yellow.
Bread and Milk,	The color of a cup of cocoa.
Apples,	Some are Plate III, G. Other (riper) are reddish violet.
Peaches,	Rich dark red.
Bananas,	Light yellow.
Grapes,	Blue grapes taste reddish violet.
Ice Cream,	Chocolate or coffee ice cream is the brown which is assigned to bitter. All other ice creams are blue.
Cocoa,	Has no color, but if there were any match it ought to be like pale reddish violet light thrown on a brown screen. (This effect has never been seen by *R*, but he thought that it ought to be the proper thing.)

In the laboratory we found it easy to arouse in *R* mild clear tones of definite and determinable pitch with pain, pressure, and temperature stimuli. These tones were subjectively indistinguishable from the tones aroused by imaging or recalling music.

(*a.*) *Pain.* The algometer, pressed between the palms of both hands till pain was sensed, produced at 3 kg. d^1, at 5.2 kg. $b^{flat\,1}$. A pressure of 2 kg. on the sternum occasioned a pain equated to e^3, one of 2.1 kg. a c^4. After the hand experiments *R* involuntarily looked at his hands to see what the tone should be.

(*b.*) *Pressure.* Stimuli for pressure were obtained by the application upon the forehead (median area) of a single Griesbach æsthesiometer point, either with the rounded or the sharpened terminal. A preliminary series with the rounded terminal disclosed the fact that, within certain limits, duration of pressure was equivalent to intensity of pressure. Upon application of a given constant pressure a tone was at once heard which moved up steadily about an octave and a fifth during the first seven or eight seconds of the pressure. After this the tone remained upon the niveau which it had gained, for the remainder of the period of application.[1] Accordingly, a second series was undertaken in which that tone was recorded which corresponded to the pressure at the end of 10 seconds. In every case the tone had reached a level at the time judgment was pronounced. The subject picked out the tone from the piano, so that the error of recording cannot exceed a half-tone. He was especially cautioned not to confuse his estimation by an octave, and he felt confident that this error did not appear. In every instance in which the progressive tone series broke with the progressive pressure series, the apparent discrepancy was elucidated by the introspective report that the pressure actually sensed (owing to

[1] We did not experiment with any pressures of over 20 seconds.

irregularities in the sensitivity of the points stimulated) was a variation from the general progression of the series. Once a cold spot was excited, and no tone was heard. The highest tone given in Table XV (f^1) was louder than the others. In general, the tones were so mild that in order to pick them out, the soft pedal of the piano had to be kept down, and the keys to be struck pianissimo.

TABLE XV.

Pressures. (Blunt.)

r. GRAMS.	TONE.	REMARKS.
10	e^1	
20	f^1	
30	—	Struck a cold spot.
30	d^1	
40	a^1	
50	e^1	
60	a^1	
70	$b^{flat\,1}$	This pressure seemed to change suddenly at the removal.
70	b^1	(20 seconds pressure.)
80	d^1	r felt much less intense than the preceding one.
90	c sharp 1	
100	e^1	
110	f^1	

The lower tones ascribed to the last four pressures are due to a lessened sensitivity, probably from general or local fatigue. The tones were all localized at the point of application of the pressure.

The sharpened terminal was applied on the same forehead areas with pressures of from 10 to 50 grams. The stimuli, as Table XVI shows, were generally painful, especially at the first moment of application, when *R* often involuntarily shrank away from the point. The tones, though louder than those of Table XV, were still mild and pleasant, with the exception of one discord which the introspection entirely explains.

TABLE XVI.

Pressures. (Sharp.)

r. GRAMS.	TONE.	INTROSPECTION AND NUMBERS.
10	a^2	Tone fairly loud, pure and pleasant. Pressure slightly painful.
20	a^2	Slightly painful when first felt.
30	d^2+e^2	Tone was a jarring discord. The pressure was more intense, slightly painful, and unsteady. It associated the scratching of a cat. (Due to sidewise movement of the point?)
30	b^1	Tone localized in a small round spot just above the stimulus. The pressure aroused a fine pain at the very point of application, but the pressure was less than in the preceding trial. (The point was applied to the left of the median region.)
40	d^2	Less painful than some of the above.
50	c^1(?)	Pain sharp. Pressure obscured. Tone uncertain.
50	e^2	Sharper pressure. Painful.

(*c.*) *Temperature.* We have mentioned that *R* thinks of the plunging of his hands into cold water as bright red. A very slight warmth matches a very low tone, but this match is mediated through the pale yellow color of the Appunn low forks. Aside from these two instances of colored temperature, all the associations with cold and warm sensations are those of tone. *R's* right hand, *e. g.*, became quite cold during one of the experiments. After feeling it with the left hand, he assigned to it the tone a^1. It is significant that cold hands are bright red and that a^1 is also bright red.[1] On another occasion the cold left hand felt g^1. Curiously enough, *R* asserted that he was utterly unable to pick this note upon the piano when striking the keys with his right hand, but got it easily enough with his left. The following are the experimental results.

(I.) *Warm.* The stimuli were given with the point or the butt end (1 cm. diameter) of a Goldscheider brass temperature cylinder, heated in most tests to 45° C.

(a.) *Warm Areas.* Preliminary tests with lesser warmth gave repeatedly upon areal stimulation of the back of the hand the note A_1. A much warmer rod, rather unpleasantly hot, gave the fusion f^1–a^1.

More extended tests with areal stimulation at exactly 45° C. gave upon the forehead B, a, e^1, f. Despite the constancy of the objective stimulus, the variations in sensitivity were very great, and the subjective intensity of the warmth varied directly as the pitch of the tone which was heard. In the next test, the stimulus was repeatedly applied upon a single place, giving in succession the tones a, B, c, d, b. The right cheek gave c^1; the plantar side of the wrist gave only a slight warmth and the correspondingly low tone g^1; the back of the hand gave scarcely any sensation of temperature and no tone.

(b.) *Warm Spots.* The exploration for warm spots was performed with the Scripture temperature cone. Two spots stimulated with a temperature under 45° C. gave c^1. With a temperature of 45°, every warm spot found gave f^1. Upon the cheek, three warm spots gave c^1.

(II.) *Cold.* The cold stimuli were given with a Goldscheider cylinder which had been cooled in melting ice.

(a.) *Cold Areas.* Areal cold stimulation upon the forehead was heard as f^3, $c^{\text{sharp }3}$, and $e^{\text{flat }3}$, upon the cheek as f^2 and $c^{\text{sharp }2}$; upon the back of the hand no tone resulted.

(b.) *Cold Spots.* Upon the forehead cold spots afforded the tones b^2, f^2, f^3, upon the cheek e^2 and g^2.

While these phonisms of temperature are necessarily irregular, in view of uncontrollable variations in the intensity of the sensations excited at different places and at different times by the same objective stimulus, it is not difficult to see that departure from the physiological zero in either direction produces a phonism which rises in pitch with the increasing intensity of the cold or warmth.

(5.) *Miscellaneous Synæsthetic Phenomena.* Again in contrast to *M*, *R* has no tendency to personify and no coloring of the alphabet; with the exception of two verbal associations

[1] See Table VIII.

("e" is yellow, the sound "ou" is blue). He has no coloring of voices, words, or dates, and no alphabet form. But he has a month form, in which the year rises from January to December in a steep curve.

Discussion of the Results.

The systematic investigation of these two cases of synæsthesia has brought out several facts which seem to us to be of importance.

1. A subject may declare himself to be possessed of colored hearing or similar secondary sensation systems, and yet be quite unconscious of the variety, depth, and uniformity of these associations until complete laboratory tests are instituted. For these reasons, the questionnaire, which has hitherto been practically the only method applied to these phenomena, is essentially inadequate and unsatisfactory.

2. Investigators must be prepared not only for a considerable degree of variation as between different individuals, but also for variation within the same individual.

3. The determination of the genesis of synæsthetic phenomena is difficult. Even serious laboratory investigation, supplemented by a more than ordinary introspective ability upon the part of the subjects, has not enabled us to discover the essential basis for many of the facts which have been cited. It can only be said that *R's* secondary sensations are directly, *M's* indirectly conjoined to their primary sensations. The mediating link for *M* is an affective process, probably based upon a mass of organic sensations.[1]

4. As a corollary from these propositions it follows that generalization is at present to be avoided.

As an illustration of this point we may note the lack of concordance of our results with some of the generalizations of Bleuler and Lehmann.[2]

a. "Bright photisms result from high pitches, intense pains, sharply defined touches." For *M* the highest Appunn forks gave no photisms. For *R* the highest notes are essentially characterized by the introduction of green into the series, while the highest note gave a Plate V color.

b. "The same secondary sensation always corresponds to a given primary impression, but it may be modified by the prevailing ideas." This proposition is plainly negatived by the very vivid but very irregular photisms of Case I.

[1] *Cf.* the opinions of Féré and Flournoy as summarized by Clavière, L'Année Psychologique V, p. 173.

[2] The passages designated by quotation marks are not intended to be literal quotations of Bleuler and Lehmann. See especially *op. cit.*, p. 96.

c. "Taste and smell photisms are located in the mouth and nose."[1] *M* projects clouds of light as with tones. *R's* colors are not localized.

d. "The order of frequency in colors is red, yellow, brown, blue; violet or green is seldom had." *M's* colors are predominately green if anything. *R's* list abounds with violet. Yellow is quite rare in both cases.

e. "Louder notes give more extended photisms." This has already been shown not to hold good in Case I.

f. "Pleasant delicate odors and tastes make pleasant, little saturated colors."[2] *R* had colors of the greatest possible saturation with tastes which were so weak as to be hardly recognizable.

5. The taste photisms of *R* seem to be worthy of special mention. Flournoy[3] mentions a few scattered instances of taste colors. Eberson[4] sees sour as blue, bitter as red or yellow. Bleuler and Lehmann[5] give bitter as dark brown or black; salt and sweet as bright colors; and add that mixed colors are never obtained. We have already noted that *R* gives uniformly sweet as blue, sour as green, bitter as orange-brown, and salt as dull red, and that mixed tastes induce mixed colors.

6. The phonisms to pain, pressure, and temperature possessed by the subject of Case II are, so far as we are aware, without parallel in the published accounts of synæsthesia.[6]

In view of the scattered nature of this literature, it is, however, quite possible that previous investigations upon this point may have escaped our notice.

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[1] *Op. cit.*, p. 42.
[2] *Op. cit.*, p. 40.
[3] *Op. cit.*, 109 ff.
[4] Ueber colorirten Geschmack, Wiener Presse, 1897, No. 49, p. 1542.
[5] *Op. cit.*, pp. 41–2.
[6] Attempted classifications of synæsthesia have, of course, recognized the possibility of these, as well as of many other correlations between the various modalities. Note, for example, the exhaustive schema of Suarez de Mendoza (L'Audition Colorée, Paris, 1890), to which Clavière refers. *Op. cit.*, V, p. 162.

THE SYNTHETIC EXPERIMENT.

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§ 1. Analysis and Synthesis.

Nothing is more striking in the pages of current psychological literature than the extensive record of analytic work. Analysis is, certainly, one of the essential ingredients of the atmosphere of science; and it is not therefore surprising that, with the splendid examples of physics and biology before it, psychology should seriously attempt the reduction of its material to the lowest convenient terms. Although its errors in this regard have been eagerly pointed out from time to time, it is safe to say that the necessity for psychological dissection is not likely to be called in question. But the matter stands differently with the interpretation of analytical results; upon this point turn many disputes. One psychologist contends that analysis is an end in itself: that one goal of the science is to know how mind is made up; what the ultimate bits of mind are. Another, that analysis is an indispensable aid to the study of genesis. Another, that it sets forth the psychophysical couple, and by its help indirect causal explanation is made possible.

Instead of discussing these various views, the writer wishes to point out still another way in which analysis may be turned to account: namely, in breaking ground for a constructive treatment of consciousness.

If an analytic result shows the true elemental constituents, it should be possible, at least in a good many cases, by adding the elements one by one, to rebuild the original experience. Surely no better test of the accuracy of an analysis is possible than the reinstatement of the whole through synthesis of the products of dissection. It is, to put it in another way, theoretically possible to devise and carry out a synthetic experiment on the same plan as an analytic experiment is conducted. If we take advantage of special and constant conditions for the dissection of mind, why may we not as well make use of these conditions in building up mind again? To make the matter concrete: why should we not, if we find that liquidity is a perception made up of a number of known elements, bring these elements together artificially and produce the perception in