A DESCRIPTIVE REVIEW OF THE LITERATURE ON SYNESTHESIA WHICH EMPHASIZES COLOR HEARING (CHROMESTHESIA) IN MUSICAL EXPERIENCES

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We hereby recommend that the thesis prepared under our supervision by Laura Nell Harris Mitchell entitled A Descriptive Review of the Literature on Synesthesia Which Emphasizes Color Hearing (Chromesthesia) in Musical Experiences

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This paper is lovingly dedicated

to my son

James

STATEMENT

A re-study of synesthesia, a much-discussed subject in the early days of psychology, is up-dated and compared to perceptual experiences in the drug-addicted culture of today's youth. A brief comparison of the two is made in this thesis, which brings a new idea to early studies made within a vast amount of literature written over a century ago. Colored hearing, or chromesthesia, is emphasized herein, in regard to music, or tonal perception. Examples are given of famous composers who were also famous synesthetes.

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CHAPTER I

INTRODUCTION

The purpose of this paper is to review the literature about synesthesia. This review emphasizes one particular type of synesthesia--chromesthesia, or "colored hearing." One possible value is to relate the subject to drug-induced experiences of today's youth.

Many of the present "turned on" generation of young people are seeking their way, through drug and narcotic usage, into experiences which only the natural synesthete has been able to experience. Visual photisms of bright, psychedelic colors in kaleidoscopic array attuned to musical fortissimo, with primitive beat, give an introduction into the phenomenon of colored hearing which occurs in many individuals, precluding the use of drugs. Today's young people are exceedingly aware of the many sensory experiences offered them through drug usage. The state of mind sought by the users of marijuana or LSD in which the senses seem to combine and work as one, reflects the actual experiences of the natural synesthete. So it seems appropriate to renew acquaintance with an old and almost forgotten subject in psychology--synesthesia.

Webster defines synesthesia:

> a sensation or feeling produced in one part of the body by the stimulus applied at another part. It is a concomitant sensation; especially a subjective sensation or image of another sense than the one being stimulated. The commonest instance is colored or color hearing in which sounds, especially those of the letters of the alphabet seem to have characteristic colors. Such a secondary sensation, if visual, is called photism or chromatism; if auditory, a phonism.[1]

Warren's Dictionary of Psychology states:

> Synesthesia, a phenomenon characterizing the experience of certain individuals in which certain sensations belonging to one sense or mode attach to certain sensations of another group to appear regularly whenever a stimulus of the latter type occurs. There are various types, of which colored hearing (synopsia) is the most common; e.g. the vocal sound O may appear red.[2]

In A Dictionary of Psychology by James Drever the following definition is given:

> Synesthesia, phenomena in which sensations in one sense department carry with them, as it were, sensory impressions belonging to another sense department, as in colored hearing.[3]

Drever also gives the following definition for colored hearing:

> Phenomena occurring in the experience of certain individuals where sounds--tunes, vowels,

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[1]Webster's International Dictionary of the English Language, unabridged, 2nd ed. (Springfield, Mass.: G. & C. Merriman Company, 1960), p. 2559.

[2]Howard C. Warren, Dictionary of Psychology (Boston: Houghton Mifflin, 1934), p. 270.

[3]James Drever, A Dictionary of Psychology, revised by Harvey Wallerstein (Baltimore: Penguin Books, 1964), p. 291.

> names, etc. appeared to be coloured--commonest form of synaesthesia.[1]

Another definition of more recent date is given by Lehman in his dissertation on synesthesia:

> Some persons, when presented with a stimulus in one sense modality, often experience sensations or images associated with another sensory mode. Thus, an auditory stimulus may produce a visual image. This type of intermodal phenomenon is known as synesthesia. It can be defined as the tendency for a stimulus in one mode to elicit subjective images of another mode. A slightly different and more objective definition is used here: synesthesia is the interpretation or description of a stimulus associated with one sensory mode in terms that are appropriate to some other mode. Following the definition of synesthesia, chromesthesia is the interpretation of auditory stimulation in terms of color.[2]

A review of the literature about synesthesia which particularly emphasizes color hearing will be found in Chapter Two. There are many forms of synesthesia. Chromesthesia, the form most closely related to music, is the subject of this paper.

Chapter Three will give a summary of the paper and the conclusions reached as a result of this study.

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[1] Ibid., p. 45.

[2] Richard S. Lehman, "Synesthesia: A Cognitive Model" (unpublished Ph.D. dissertation, University of Colorado, 1965), p. 1.

CHAPTER II

REVIEW OF THE LITERATURE

There was a vast amount of literature written in the past century and the early part of the present century about synesthesia. The psychologists of the nineteenth century were intent in their investigations of sensations from the different sense modalities. Early studies of synesthesia were made by interviewing individuals who claimed to experience visual imagery while hearing tone, or listening to music. The responses seemed to vary with each individual. Some persons had colored hearing for only isolated tones; some saw color when hearing certain noises, others for music generally, and some for chords; many saw color when hearing vowel sounds and a few, when hearing consonants. Certain words which brought on a color sensation were names of people, days of the week, months of the year, seasons, digits, and dates.

Because synesthesia relates so closely to some LSD experiences, one reasons the subject of synesthesia should be of current topic. However, Wicker[1] suggests in his recent dissertation, that the study of synesthesia has become less popular in recent years, stating:

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[1]Frank W. Wicker, "A Scaling Study of Synesthetic Thinking" (unpublished Ph.D., Princeton University, 1966), p. 10.

> It is not surprising, then, that as emphasis within psychology has shifted from the study of experience to the study of behavior, toward the use of terms that can be operationally defined and the search for relationships that are verifiable, that synesthesia has become a less popular object of study among psychologists in recent years.

Wicker[1] lists three special difficulties with the study of synesthesia which contributed to this trend:

1. The problem that synesthetic phenomena, which were easily integrated with the theoretical constructs of the introspective period, are much more difficult to handle with the constructs of modern psychology.

2. If the phenomenon is as rare as has often been assumed, the application of large sample research techniques is not feasible.

3. The most serious of these problems is a difficulty of measurement: the difficulty of basing inferences about synesthetic relationships on measures that are quantitative, precise, and relatively free from the influence of a multitude of uncontrolled variables.

A thorough review of the early literature written about synesthesia was made by Raymond H. Wheeler in his monograph, The Synaesthesia of a Blind Subject.[2] Wheeler wrote a brief resume of each of the many articles written years ago in French, German, and English.

Possibly the earliest record of the study of synesthesia was made by Hoffman[3] in 1786. The case of a Swiss

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[1]Ibid., p. 11.

[2]Robert H. Wheeler, The Synaesthesia of a Blind Subject, I, No. 5 (University of Oregon Publications, 1920).

[3]L. Hoffman, "Versuch einer Geschichte der malerischen Harmonie," U.S.W., Halle (1786).

magistrate and painter who had numerous varieties of colored hearing was described. In 1843, Gautier[1] described his own colored hearing and found it could be stimulated by hasheesh. Perroud[2] objected to the prevalent view in 1863, that colored hearing was pathological. He suggested that the laws of association would explain colored hearing.

Chabalier[3] disagreed with the pathological view (in 1864), and believed synesthesia to be due to a psychic perversion, or a confusion of ideas. As examples, he cited his own experience where letters were so brightly colored their meanings entered his consciousness only after the colors appeared. The same was true with proper names, which he often forgot although he never forgot their corresponding colors. Chabalier felt colored hearing was an illusion.

In 1873, Nussbaumer,[4] also a natural synesthete, attempted an explanation about the origin of colored hearing. He observed effects on the photisms of sending reduced electric currents through different portions of the brain. This test stimulated much writing on the subject of synesthesia. Nussbaumer found that the origin of synesthesia

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[1]T. Gautier, "Le club des Haschichins, Romans et Contes," (Paris, Charpentier; La Presse, July 10, 1843).

[2]Perroud, "Mem. de la soc. des scl. med. de Lyon," (1863).

[3]Chabalier, Journal de Medicine de Lyon, VIII (1864).

[4]J. A. Nussbaumer, "Uber subjectiv Farbenempfindugen," (Wien, 1873).

could be traced to early childhood and that colored hearing was dependent upon auditory stimuli.

During the years 1876-1878, a physiological point of view was introduced by Nuel.[1] His theory includes the fact that functionally, and perhaps anatomically, there is a close relation between the reflex arcs and brain areas which control the primary and secondary sensations. Nuel thought the afferent nerve currents were deterred from their usual course to the brain areas adjacent to their normal endings. When these currents reached the adjacent area they aroused a molecular disturbance causing the secondary sensations. The theory that colored hearing was a result of abnormal crossings and unitings of afferent fibers was advanced by Pouchet and Taurrieux[2] in 1878. However, this point of view lost its importance when more recent theories of irradiation and summation in reflex arcs were brought forth.

Epstein[3] suggested afferent impulses could be deterred into other channels at the corpora quadrigemina or in other basal ganglia. There could be a certain blood distribution in the appropriate areas of the brain resulting from emotional experiences, shock, or an unknown physiological cause.

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[1]J. Nuel, Dictionary Encyclepedia des science medicine (Article on the retina) (1896).

[2]Pouchet et Taurrieux, Prec. d'histol. humaine et d'histog., 2nd ed. (Paris, 1878).

[3]S. S. Epstein, "uber die Modifikation der Gesichtswahrnehmunger unter den gleichzeitung Einfluss von Toneindrucken," Zsch. f. Bio., N.F. XV (1896), pp. 28-43.

Affecting the functioning of the areas concerned, energy in the form of heat could be so distributed between these two areas as to stimulate them into simultaneous functioning. This blood distribution in the brain could facilitate irradiation or increase the results of a lack of differentiation of function.

Evans[1] presented the idea of the balance in bilateral functioning of the body and the linking up of synesthesia not only with conditions of stimulation but also with conditions of response or motor expression. Synesthesia could depend upon the functioning of entire reflex arcs as well as upon specifically localized functions in the centers of the brain.

In a detailed study of synesthesia Bleuler and Lehmann[2] described some interesting new cases. This study included descriptions of visual photisms of various angles and their correlating colors, colored tastes, colored odors, and colored tactile sensations. In the same year (1881) Kaiser[3] wrote his opinion that many synesthetes made a voluntary effort to improve their memories while very young by associating colors with letters, sounds, and words.

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[1] T. Evans, "Some Curious Psycho-sensory Relationships," Monist, XVII (1907), pp. 128-138.

[2] E. Bleuler u. Lehman, "Zwangmassige Lichtempfindungen durch Schall," u.s.w. (Leipzig, 1881).

[3] H. Kaiser, "Uber Association von der Worte und Farben," Arch. f. Augenhk. (1881), XI, 96, Comp. der physiol. Optik. (Wiesbaden, 1872).

In 1882, Pedrono[1] discovered the localization of colors associated with musical sounds varied with individual subjects. Colors could be localized above a sounding instrument, localized in front of it, or suspended in mid-air. If the instrument or voice was not visible, the colors were localized in the direction of the sound of the music.

Galton's[2] study of the various forms of synesthesia in 1883 caused him to conclude that most types of synesthesia are inherited. He found that number forms, vowels, and synesthesia were compatible. Vowels were more likely to be colored than consonants and numbers might possess permanent colors.

Holden[3] investigated the study of synesthesia in 1885, using his daughter as subject. These studies continued until 1906 with tests being given at ages seven, eight, ten, fourteen, seventeen, and twenty-one. Only very minor changes in color were manifest for colored letters, digits, and days of the week.

In the early 1890s, Gruber[4] wrote about some remarkable cases of synesthesia. One example, the associations of

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[1]Pedrono, "De l'audition coloree," Annual d'occul., VIII (1882), 224ff.

[2]F. Galton, Inquiries into the Human Faculty (New York: Macmillan, 1883), 145ff.

[3]E. S. Holden, "Color Associations With Numerals," Science, VI (1885), p. 252.

[4]E. Gruber, "L'audition coloree," Cong. inter. de psychol. (Paris, 1889).

colors with digits, was so exact that the subject was able to perform mathematical operations by means of colors. Another example was that of a singer who was able to judge pitch accuracy by the differences in shades and tints of his colored tones.

Following Gruber's descriptions of synesthesia, Schooling[1] devised the creation of a new art--color music. His instrument was an electrically operated "color organ," using a set of vacuum tubes which, when illuminated, gave combinations of colored lights, operated from a key-board.

A history of the various theories of synesthesia, published by Krohn[2] in 1893, described prominent cases and examples. He also described one of his own investigations. His subject was a young musician whose synesthesia was partly of acoustic and partly of associative origin. The colors were dependent upon the sound and meaning of the letters and numbers. The colors of music were determined by the key in which the composition was written. Krohn came to the conclusion that certain forms of synesthesia were due to association.

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[1]William Schooling,"Color Music," 19th Century, XXXVIII (1893), pp. 125-134.

[2]W. O. Krohn, "Pseudo-chromaesthesia, or the Association of Color with Words, Letters, and Sounds," American Journal of Psychology, V (1893), pp. 20-41.

Reporting his own sense of colored hearing, Thorp[1] in 1893 stated it was such an annoyance to him in his music that he had to discontinue his musical education.

Calkins[2] conducted a series of investigations on synesthesia using various tests on hundreds of subjects. She presented numerous tables of facts found as a result of her testing so many subjects. These studies were made in 1893, 1893, and 1894.

In 1896, Hennig[3] wrote a paper on synesthesia classifying secondary sensations as physiological and as psychological, according to origin. The practical value of colored hearing was emphasized. He illustrated examples of painters, musicians, mathematicians, and poor spellers, who, if they are synesthetic, use their color sense to great advantage. He believed them to possess superior mental endowments.

During 1900, Whipple[4] tested two subjects with highly complicated forms of synesthesia. He obtained more accurate information from his subjects with the questionnaire method than had ever been obtained to this date. With the help of

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[1]G. D. Thorp, "Color audition and its relation to the Voice," Edin. Medical Journal, XL (1893), pp. 21-25.

[2]M. W. Calkins, "Experimental Psychology at Wellesley College," American Journal of Psychology, V (1892-93), pp. 260-271.

[3]R. Hennig, "Neuere Forschungen uber Mi tempfindungen insbesondere Synopsien," Naturwiss. Woch., XXVIII (1913), pp. 609-613, 625-630.

[4]G. M. Whipple, "Two Cases of Synesthesia," American Journal of Psychology, XI (1900), pp. 377-404

standard laboratory apparatus he studied colored odors, tastes, and cutaneous audition. He found that fatigue hindered the appearance of the colors.

Urbantschitsch[1] made a study of synesthesia in 1903. He stimulated each ear separately on his subjects to compare the relative strengths of the associations between colors and tones. In 1907, he made another investigation in which he found that the colors of sounds could be modified voluntarily by the subject and that external factors could also be made to modify the colors. In another study, made in 1908, Urbantschitsch found that certain objective visual stimuli, given a certain tone and its color equivalent, might be made to suppress the original association.

There were many other investigations on synesthesia made in the early 1900s. Each reported unusual case histories of synesthetic subjects and their conclusions. The point at issue seemed to be whether synesthesia originated through association or physiology.

Bleuler[2] wrote a criticism of the association theory in 1913. For the following reasons, Bleuler accepted a physiological theory of synesthesia:

1. Dark or dull colors are associated with low tones, bright colors are associated with high tones.

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[1]V. Urbantschitsch, "Uber die Beeinflussung subjectiver Gesichtsempfindungen," (Leipzig, Barth, 1903).

[2]E. Bleuler, "Zur Theorie der Sekundarempfindungen," Zsch. f. Psychol., LXV (1913), pp. 1-39.

2. The size and shape of the colors vary in the same direction as the pitch of the tones.

3. Consonants are generally paler than vowels.

4. Variations in the primary sensation uniformly produce variations in the secondary sensations.

5. Colors are associated with other sensations so early in childhood as to precede the development of meaning or recognition.

Wehofer,[1] a musician and a student of Berlioz, wrote a review of the argument for and against the association and physiological theories in 1913. He suggested that correlating the facts of colored hearing with the facts and theories of audition rather than with the facts and theories of vision should be investigated. He and a friend who likewise had colored hearing attended many musical recitals together and studied the behavior of their photisms while they listened to the music.

In 1914, Myers[2] wrote about his beliefs that the color associations were neither sensory nor imaginal, but imageless and verbal. He thought associations were formed in childhood when primary perceptions were still vague and undifferentiated. The Russian composer, Alexander Scriabine, was one of Myers' subjects. Myers states:

> During his recent visit to England, the well-known Russian composer, Alexander Scriabin, kindly allowed me to carry out an examination of his

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[1] F. Wehofer, "Farbenhoren (Chromatische Phonopsien) bei Musik," Zsch. f. angew. Psychol., VII (1913), pp. 1-54.

[2] C. S. Myers, "Two Cases of Synesthesia," British Journal of Psychology, VII (1914), pp. 112-117.

> coloured hearing. Scriabin's attention was first seriously drawn to his coloured hearing owing to an experience at a concert in Paris, where, sitting next to his fellow-countryman and composer Rimsky Korsakow, he remarked that the piece to which they were listening (in D major) seemed to him yellow; whereupon his neighbor replied that to him, too, the colour seemed golden. Scriabin has since compared with his compatriot and with other musicians the colour effects of other keys, especially B, C major and F# major, and believes a general agreement to exist in this respect. He admits, however, that whereas to him the key of F# major appears violet, to Rimsky Korsakow it appears green; but this deviation he attributes to an accidental association with the colour of leaves and grass arising from the frequent use of this key for pastoral music. He also allows that there is some disagreement as to the colour-effect of the key of G major. Nevertheless, as is so universally the case with the subjects of synaesthsia, he believes that the particular colours which he obtains must be shared by all who are endowed with coloured hearing.
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> As will have been gathered by now, Scriabin's chromaesthesia refers to the tonality of the music. As the tonality changes in a piece, so the colour changes. Scriabin explains that the colour underlines the tonality; it makes the tonality more evident.

Scriabin did not associate color with individual tones but with the harmony of music and with musical tonality. The composer presented his "Prometheus and Mystery" with colored lights and odors so that the visual, auditory, and olfactory sensations could blend into one great, harmonious effect upon the audience. Scriabin believed a psychical struggle took place between a tone and its overtones or, in other words, a contest for the fundamental sound, or pitch. Scriabin's strongest color associations related most strongly to the keys of C major, D major, B major and F# major, placed respectively in the red, orange, yellow, blue, and violet. Passing from

hue to hue, the colors corresponded to tonalities rising by a series of fifths. Myers[1] made a scale for the colors and tonalities which illustrated this association of color and key sound:

Red	Orange	Yellow	Green	Blue	Violet
C G	D	A	E	B	F#

> Thus the key of C is red, of G red to orange-red, of D orange to yellow, of A yellow to green, of E green to blue, of B blue to violet, and of F# violet. The colours of the remaining keys Db, Ab, Eb, Bb, and F are believed by Scriabin to be extra-spectral,--either ultra-violet or infra-red. Thus the key of F is on the verge of red giving often the effect of a metallic lustre.

Myers felt there had to be a strong tendency to a certain kind of association for a complete development of synesthesia. He concludes by stating:

> Such a tendency may readily yield the above diagram, where consecutive scales are associated with consecutive spectral colours, and may also result in the strong inclination towards mysticism which is characteristic of Scriabin. For him the (red) key of C relates to matter, and is redolent with the odour of the soil, whereas the (violet) key of F# is spiritual and ethereal. He believes that colours have their over-colours, as tones have their overtones.[2]

Richard Freed writes[3]:

> Both Scriabin and Rimsky-Korsakow devised tables to systematize the relationships between colors and corresponding musical scales. In the Rimsky-Korsakow table, for example, the key of C major is white; in Scriabin's it is red. D major is yellow in both,

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[1] Ibid., p. 114.

[2] Ibid., p. 115.

[3] Richard Freed, "Colors We Hear," House Beautiful (May, 1967), pp. 109, 194.

and among the remaining keys there are examples of both divergence and near agreement.

The composer Cyril Scott[1] compares the diatonic scale to the seven colors of the solar spectrum and suggests a color scale of the following character for the scale of C:

C	red
D	orange
E	yellow
F	green
G	blue
A	indigo
B	violet

Olivier Messiaen, the contemporary French composer, wrote briefly about tone and color when making an analysis of his "Chronochromie" for large orchestra. He wrote[2]:

> Colour: the sounds colour the durations because they are, for me, bound to colour by unseen ties. When I listen to music, and even when I read it, I have an inward vision of marvellous colours--colours which blend like combinations of notes, and which shift and revolve with the sounds. For example, a certain series of chords may be red touched with blue--another will be milky white, decorated with orange and edged with gold--another will be green, orange and violet in parallel stripes--another will be pale grey, with reflections of green and violet--yet another will be entirely violet or entirely red. There will also be complementary colours, simultaneous

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[1]Dorothy M. Schullian and Max Schoen, Music and Medicine (New York: Henry Schuman, Inc., 1954), pp. 374-377, citing Cyril Scott.

[2]Olivier Messiaen, "Analysis by the Composer" for recording of "Chronochromie," B.B.C. Symphony Orchestra, Antal Dorati, Conductor.

> contrasts by resonance, colours fading towards white, shaded by black, the chords and timbres of hot or cold colours.

From the Life-Science Library: The Mind,[1] the following statement is made:

> Many of us go through life unaware of the subtlety and range of our senses, since we need only a fraction of their data to perceive the world well enough for our purposes. The handicapped show us how rich the senses really are. The astonishing discovery of two women in Russia and one in the United States who can distinguish colors with their fingertips suggests that our sensory powers may well be far greater than anyone previously dreamed.

The "unity of the senses" theory, advanced by Werner,[2] suggests that, in the process of evolution, man's different sensory abilities grew from a primitive, general sense. Tendencies from this primitive sense in modern man result in the phenomena of sensory interdependence. Von Hornbostel[3] in 1931 argued the existence of sensory attributes, such as intensity and brightness, both common to all the senses. Through experiments, he found transitivity of equality for brightness in olfaction, vision, and audition. He illustrated that if odor A was matched in brightness with color B, and was next matched with tone C, then color B matched with tone C.

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[1]John Rowan Wilson, Life-Science Library: The Mind (New York: Time Incorporated, 1964), p. 44.

[2]H. Werner, "Lunite des sens," Journal de Psychologie, 31 (1934), pp. 190-205.

[3]E. M. von Hornbostel, "Uber Geruchshelligkeit," Pflugers Archiv fur die gesamte Physiologie des Menschen und die Tiere, 227 (1931), pp. 517-538.

In 1934, Cohen[1] attempted to replicate this experiment and was unsuccessful in achieving von Hornbostel's results. Cohen not only failed to obtain intermodal transitivity, but he found very little evidence of stability in the matches that were made. Cohen felt the stable matching achieved by von Hornbostel was a chance result of a particular choice of stimulus values.

Wicker[2] discusses the unitary sense doctrine in his dissertation on synesthesia:

> In fact, the unitary sense doctrine, in its strict form, is probably untestable, because the notion that several different sensory attributes can in some sense be the same attribute is essentially a metaphysical one. However, the identities, analogies, or associations implied by this doctrine have been treated purely as intervening variables, and, in this more flexible form, the doctrine has generated useful preductions.

Von Schiller[3] experimented with fish to prove that cross-modal generalization of discriminative responses could be obtained. He trained two groups of fish. One group was trained to choose the brighter of two chambers while another group was trained to choose the darker one. The fish choosing the brighter chamber were exposed to two odors (musk and indol) in a darkened chamber. They chose the brighter of

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[1]N. E. Cohen, "Equivalence of brightness across modalities," American Journal of Psychology, XLVI (1934), pp. 117-119.

[2]Wicker, Scaling Study, p. 4.

[3]P. von Schiller, "Interrelation of Different Senses in Perception," British Journal of Psychology, XXV (1935), pp. 465-469.

the two odors, musk. The fish trained to choose the darkened chamber were exposed to the same two odors and chose the darker odor, indol. A third, control group of fish without visual training showed no preference between the odors. The results of such testing would certainly indicate associations between attributes in the different sense modes.

From many years of observed experiences and from information expressed by a synesthete, known personally to the author, the following explanation was made:

> There are certain color-tone-taste elements, divisions of the sensorial spectrum, which are in resonance with each other. It is the compatibility of all these areas of sensory perception resonating with each other, which instantly permeates meaning and information of something transcending totally beyond semantics. It is a pure mental code by vibrations and impulses from the music itself.

To fulfill this person's requirements for the greatest amount of satisfaction in hearing music, tones and colors must be pure (according to vibrations per second), with the most illustrative musical instrument for these purposes, the pipe organ, which brings out the metallic colors in his perception of tone. There is definite association of tone, color, and taste with letters of the alphabet--and some numbers--which occurs instantly when a particular letter is read or sounded. The long vowel sounds are the most intense sounds. There is difficulty hearing consonants because the vowels are too intense for him. Consonants must be over-emphasized when

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[1]James Royce Mitchell, Jr., Dallas, Texas, 1968.

speaking with him. His colors for the vowels are:

A	red
E	yellow
I	white
O	black
U	blue

It is very disturbing for him to see letters in colors which are not in his synesthetic code. So intense is this sensation for letters to be seen in his color scale that even the black and white printed page is disconcerting. However, the black and white is not so "bothersome" as the use of "incorrect" colors for the letters of the alphabet. It should be mentioned, perhaps, that this person is a trained musician, a pianist, who has absolute pitch.

Tests have been given to this young person over a period of ten years with the same results as indicated on Table 1. Colors, tones, tastes, and numbers have related, invariably, to the same letters of the alphabet. He also has a color response to the months of the year and the days of the week. People have certain color "auras" which describe their personalities to him.

Perhaps this state of mind is being sought by the young drug users. It is interesting to discover that the use of marijuana and LSD (lysergic acid diethylamide) arouse similar responses regarding the senses as those of the natural synesthete.

TABLE 1

SYNESTHETIC RESPONSE

LETTER	COLOR	NUMBER	TONE	TASTE	INTENSITY
A	red	8	A (below middle C)	cherry	---
B	brown	--	B (below middle C)	milk chocolate	---
C	bright silver	--	C (middle C)	---	---
D	intense blue-white	--	D (above middle C)	ozone	very strong
E	yellow	3	E (middle)	lemon	---
F	crystal clear	--	F (middle)	distilled water	---
G	orange	--	G (middle)	orange	---
H	green	--	C# & E together	lime	---
I	white	5 or 9	random high frequency	milk	---
J	dark, muddy red	--	distorted tones close to A	---	weak
K	dark red	--	distorted tones	---	weak
L	purple	12	F#	grape	strong
M	dark brown	--	Bb	peanut butter	strong

TABLE 1--Continued

LETTER	COLOR	NUMBER	TONE	TASTE	INTENSITY
N	sandy brown	--	tone cluster BbBE-high	butter	strong
O	black	--	random bass	tar	---
P	yellow-pink	--	tone cluster BbBDbEFA	taffy	---
Q	blue-violet	--	C# & F# together	blue-grape	---
R	red-orange	--	G & C (below middle C)	hot	---
S	translucent grey (like F)	--	---	---	---
T	very metallic	--	harmonics	---	---
U	blue	2	C#	blue flavor	very strong
V	light grey	--	---	---	---
W	dark grey	1	random sounds	---	---
X	---	--	---	---	very weak
Y	light grey	9	random high frequencies	---	---
Z	---	--	---	---	---

A pamphlet about LSD, issued by the National Institute of Mental Health[1] gives the following description of an LSD experience:

> The first effects are likely to be sudden changes in their physical senses. Walls may appear to move, colors seem stronger and more brilliant. Users are likely to "see" unusual patterns unfolding before them. Flat objects seem to stand out in three dimensions. Taste, smell, hearing, and touch seem more acute. One sensory impression may be translated or merged into another; for example, music may appear as a color, and colors may seem to have a taste.

The explanation continues:[2]

> Just how LSD works in the body is not yet known. But it seems to affect the levels of certain chemicals in the brain and to produce changes in the brain's electrical activity. Animal experiments with LSD suggest that the brain's normal filtering and screening out process becomes blocked, causing it to become flooded with unselected sights and sounds. Studies of chronic LSD users indicate that they continue to suffer from an overload of stimulation to their senses. Researchers believe this may explain the regular user's inability to think clearly and to concentrate on a goal.

Another pamphlet, about marijuana, also issued by the National Institute of Mental Health,[3] describes its effects on the senses:

> When smoked, marihuana quickly enters the bloodstream and acts on the brain and nervous system.

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[1]National Institute of Mental Health, "LSD, Some Questions and Answers," Public Health Service Publication No. 1828 (1969).

[2]Ibid.

[3]National Institute of Mental Health, "Marihuana, Some Questions and Answers," Public Health Service Publication No. 1829 (1969).

> It affects the user's mood and thinking. The drug's effects on the emotions and senses vary widely, depending on the amount and strength of marihuana used. A scientist observed that a dose equal to one cigarette of the United States type can make the smoker feel excited, gay or silly. After an amount equal to four, the user notices changes in what he can perceive. He reports colors seem brighter, his sense of hearing keener. After a dose equal to ten cigarettes, other reactions set in. He experiences visual hallucinations (seeing things that are not there), illusions (seeing or imagining shapes in objects that are not there), or delusions (beliefs not based in reality). His mood may swing from great joy to extreme anxiety.

One of the latest studies on how marijuana affects the senses[1] describes the reactions of young collegiate users of the drug. These are listed on Table 2 under the headings of the five senses and only the reactions which are pertinent to synesthesia are used, or quoted.

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[1]Charles T. Tart, "Work with Marijuana: Sensations," Psychology Today (May, 1971), pp. 41-44.

TABLE 2

TABLE OF REACTIONS UNDER THE INFLUENCE OF MARIJUANA

VISUAL	AUDITORY	TASTE	TOUCH
I can see patterns, form, figures, meaningful designs in visual material that does not have any particular form when I'm straight, that is, just a meaningless series of lines or shapes when I'm straight.	I can hear more subtle changes in sounds, for example, the notes of music are purer and more distinct, the rhythm stands out more.	Taste sensations take on new qualities.	My sense of touch is more exciting, more sensual.
When looking at pictures they may acquire an element of visual depth, a third-dimensional aspect.	If I try to have an auditory image, it is more vivid.	If I try to imagine what something tastes like, I can do so vividly.	Touch sensations take on new qualities.
I can see new colors or more subtle shades of color.	With my eyes closed and just listening to sounds, the space around me becomes an auditory space, a space where things are arranged according to their sound characteristics instead of visual, geometrical characteristics.	SMELL	The termperature of things takes on new qualities.
There is a sensual quality to vision, as if I were somehow "touching" the objects or people I am looking at.		Smell sensations take on new qualities.	I can experience vivid tactual imagery.
		Smells become richer and more unique.	Objects seem heavier, more massive when I lift them.

CHAPTER III

SUMMARY AND CONCLUSIONS

The origin of synesthesia is still questionable despite the voluminous amount of writing and theorizing done about it in the past century. No irrefutable facts have been found to give testimony as to why Subject A sees yellow when he hears tone E, or why Subject B sees purple when he hears music in the key of F# major. Three different theories have finally evolved. They are the physiological theory, the psychological or associative theory, and the theory of the unity of the senses.

The physiological interpretation was advanced by Nuel and for almost one hundred years many supplements have been made by numerous writers. Nuel's theory includes the fact that functionally, there is a closeness in relationships between reflex arcs and brain areas which account for primary and secondary sensations. Pouchet and Taurrieux theorized that colored hearing resulted from abnormal crossings and unitings of afferent fibers. They upheld the theory that each fiber of an afferent nerve determined a sensation of specific quality. There are four facts which support a physiological view: (1) the adjacent brain

areas involved in synesthesia; (2) simultaneous reactions to stimuli by primary and secondary sensations; (3) the appearance of synesthesia in early childhood; (4) the stimulating effects of drugs.

The psychological or association theory related responses to familiar areas. Bleuler and Lehmann found cases whose synesthesia depended on optical stimuli. Kaiser supported the association theory suggesting many subjects associate colors with sounds, letters, words, to improve their memories. Perroud gave the first important psychological explanation of synesthesia. His theory associates an experience in one sense field with an experience in another sense field for the reason that both experiences have attendant circumstances. The weakness of the association theory results in an inadequate way of covering a majority of cases and must finally rely upon a physiological explanation.

There are four generally accepted instances of the association theory: (1) the experiences relating to an unusual event; (2) visual photisms which correspond to the colors of the object; (3) photisms whose colors are suggested by a letter in a word designating a colored object; (4) photisms corresponding to the natural colors of objects tasted or smelled.

Werner and von Hornbostel championed the theory of the unity of the senses. They argued the existence of

sensory attributes, such as intensity and brightness, which are common to all the senses. The theory is that in the process of evolution, man's different sensory abilities grew out of a primitive, general sense. Tendencies from this primitive sense in modern man result in the phenomena of sensory interdependence.

Very few generalizations can be made about synesthesia. The visual color responses to music or tonal frequencies are as individual as the persons responding. A few truths were gleaned from the multitudinous amount of testing done so that some generalizations about synesthesia can be made. These accepted generalities are: (a) synesthesia begins in childhood; (b) tones of high pitch are related to light or bright colors, and tones of low pitch, to dark or dull colors; (c) synesthetic associations remain the same and do not reverse; (d) the brain areas involved in synesthesia are adjacent.

Considering the amount of testing done to generalize color-hearing responses, synesthesia is too basically introspective to be considered a study in generalized behavior. Tests conducted on subjects who are non-synesthetes seem to be mere guessing games in choosing colors to match tones and adjectives. While it is true that a general feeling is manifest with most subjects in placing high tones with bright colors and low tones with deeper hues, this type of color sense does not place them in the category of those

who experience an instantaneous visual-color reaction when hearing music or tonal frequencies.

The color response to music of the natural synesthete is something so innate to that particular person that he often supposes others to have the same color responses he experiences. The synesthete makes no specific effort to associate colors with tones or keys. The colors appear visually and as readily as the sounds are heard. This is true, also, regarding the sense of taste with color and tone, although it is not so frequent. The theory of association seems to be on more solid ground in relating taste to color than tone to color. Visualizing numbers in color, or in relation to letters of the alphabet, would seem to be held firmly in the association theory. The reasons for associating months of the year and days of the week with color are as individual as the reasons for associating colors with tones.

The physiological point of view seems to give a more thorough explanation of synesthesia. The fact that it appears in early childhood gives one cause to investigate the reasons for that early appearance. Perhaps there is some similarity in the brain chemistry of the natural synesthete and that of the drug user which causes changes in the brain's electrical activity. In the future, it may be wiser to attempt testing for color-hearing responses of non-synesthetes while they are under the influence of LSD

or marijuana. It is possible that more pertinent information may be gained about sensory perception than the "guessing games" testing in the past.

Perhaps, with the new "drug culture" of the young and the amount of testing being done to investigate the drugged reactions of their perceptions, it is time to rethink or re-test some of the old reasoning on the causes of synesthesia. It is entirely possible that chemical analysis may give an answer for the origin of synesthesia.

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