

Synaesthesia: An Account of Coloured Hearing

John Harrison and
Simon Baron-Cohen

The condition of synaesthesia (from the Greek *syn* [union] plus *aisthesis* [sensation]) is one in which a stimulus received in one sensory modality gives rise to an experience in another. Descriptions of the condition have been a feature of scientific literature for almost 300 years, beginning with Woolner's description of a blind subject who reported perceiving sound-induced coloured experiences [1]. A similar account was given by the philosopher Locke, who described "a studious blind man who bragged one day that he now understood [that] scarlet was . . . like the sound of a trumpet" [2]. However, no systematic studies of synaesthesia were reported until the end of the last century, when Galton described experiences of people claiming to have synaesthesia [3]. Forms of synaesthesia other than coloured hearing have been reported, but the vast majority of available reports concern this phenomenon. Our article will deal almost exclusively with the coloured hearing form of the condition.

As scientists, what strikes us most forcefully in relation to this condition is that the principal (if not the only) source of data is the subjective accounts of those individuals who report having the experience. This understandably prompts skepticism, since such self-reported data do not allow us to distinguish between metaphorical talk and genuine synaesthesia.

This question of metaphor versus synaesthesia is neatly captured by Luria's account of a mnemonist [4]. This individual, who exhibited a remarkable ability to recall information, often appeared to use metaphoric/synaesthetic references. For example, he described the voice of an acquaintance as "yellow and crumbly." The question here is whether this is a description of synaesthesia or simply an imagistic mnemonic device. Metaphor is, of course, also widespread in language and frequently includes references to something like synaesthesia. For instance, an individual may say that the experience of listening to Dvorák's *New World* symphony is one of "greenness," or of reading Keats one of "purpleness." However, these uses of metaphor are different from descriptions of genuine synaesthesia: only in the latter do people affirm that these stimuli result in the individual *actually seeing* these colours. It is this distinction between metaphor and genuine synaesthesia that is problematic for us in a scientific examination.

HISTORICAL ACCOUNTS OF SYNAESTHESIA

Music

Synaesthesia as a condition appears to have a notable pedigree in the fields of art, music and literature, and there are claims that it has a role in artistic creativity. For example, in the field of music, Myers described his examination of the

coloured hearing of Russian composer Alexander Scriabin [5], who added colour dimensions to live performances of his work *Prometheus*. This piece, also known as the "Poem of Fire," was written for voices and instruments. What was unusual about the score was the inclusion of notation for a "colour organ" (*clavier à lumière*) [6]. This keyboard was constructed such that the striking of keys would, instead of producing a sound, project colours onto a screen: for example, C was red, D yellow and A green according to Scriabin's system. Myers reports that Scriabin planned his piece *Mystery* to include the same colour dimension, with the addition of odours. Scriabin himself, in his account of a concert he attended with Rimsky-Korsakov, implied that his colleague also had synaesthesia: when Scriabin described a movement in D major as yellow, Rimsky-Korsakov commented that, for him, the colour seemed golden. Myers, reporting on Scriabin's perception of colour when listening to music, said that "he has only a 'feeling' of colour; only in cases where the feeling is very intense does it pass over him to give an 'image' of colour" [7].

Other writers have pointed to the many references to synaesthesia made by the composer Messiaen [8]. In a particularly florid passage in his own writings, Messiaen mentions blue and orange chords in the piano part of the second movement of *Quatuor pour la fin du temps* [9].

Anecdotal accounts of the composer Liszt's synaesthesia include him allegedly demanding "more pink here, if you please" of members of his orchestra during rehearsal [10].

John Harrison (neuropsychologist), Academic Unit of Neuroscience, Charing Cross and Westminster Medical School, 10th Floor, East Wing, Charing Cross Hospital, London, W6 8RF, United Kingdom.

Simon Baron-Cohen (psychologist), Departments of Psychology and Child Psychiatry, Institute of Psychiatry, Denmark Hill, London, SE5 8AF, United Kingdom.

Received 7 February 1994.

Invited Review articles provide up-to-date reviews of topics of current interest from authorities in the field. Readers are invited to suggest topics that should be covered.

ABSTRACT

The condition of synaesthesia, in which sensory stimulation in one modality gives rise to sensations experienced in another, has been known to the scientific community for nearly 300 years and yet has remained relatively unexplored. In the first part of the following article, the authors discuss historical accounts of the condition and investigate its impact upon the fields of art, music and literature. Recently, a number of experiments have been conducted that allow for a more objective investigation of the condition. The authors discuss accounts of the nature of the condition with reference to these experiments. They conclude by attempting to characterise synaesthesia and its impact on those individuals who possess this unusual condition.

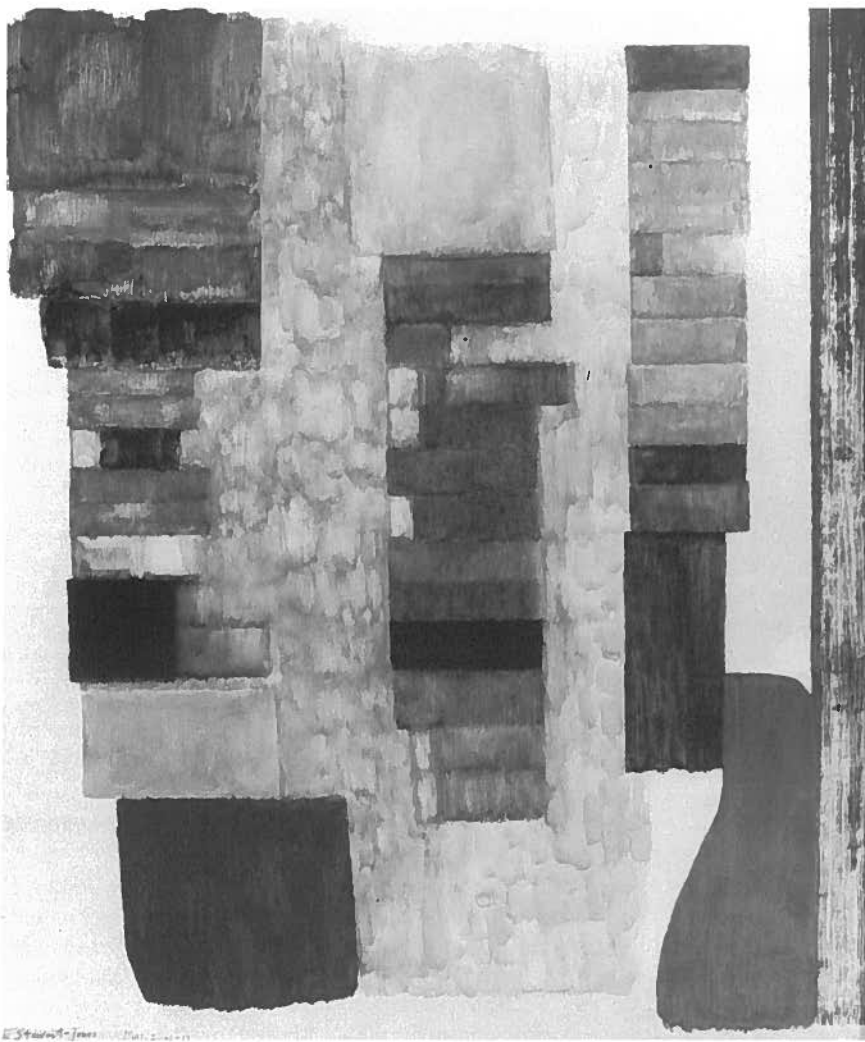


Fig. 1. Elizabeth Stewart-Jones, *Lineage of Christ from Abraham to Mary*, gouache, 30 × 35 in, 1976. The painting depicts the synaesthetic percept experienced by the artist on hearing the names of the individuals who feature in Christ's lineage from Abraham to Mary. Stewart-Jones explains that the painting represents the Word of God falling low over Abraham (top left corner) and then shooting down as the spirit on Mary (bottom right). Abraham is followed by Isaac, Jacob, etc. The tones of the painting are predominantly muted browns and tans broken by occasional bright patches: Jesse and Solomon are yellow, David is green and Mary is pictured as blue.

Poetry

There are suggestions that a number of writers may have had synaesthesia. Baudelaire's "Correspondances" appears to provide us with evidence of his belief in the unity of sensation, particularly in the second stanza, in which he writes, "Comme de longs échos qui de loin se confondent/Dans une ténébreuse et profonde unité/Vaste comme la nuit et comme la clarté/Les parfums, les couleurs et les sons se répondent" (Like long echoes that mingle from far away/In profound and shadowy unity/Vast like the night and like clarity/Scents, sounds and colours respond to one another) [11].

This suggests that he believed there was a natural correspondence between the senses. Reference to a similar corre-

spondence is also found in Rimbaud's "Le sonnet des voyelles," in which the poet attributes a colour to each of the vowels: A is black, E is white, I is red, O is blue and U is green [12]. However, Marks points out that Rimbaud later described this correspondence as his "invention," suggesting that this usage was simply metaphorical [13].

Reference to synaesthesia is not limited to French fin de siècle poets. For instance, Odin [14] devotes an entire article to synaesthesia in Asian (particularly Japanese) as well as European writers. He cites the haikus of Japanese poet Basho (1644–1694): "As the bell tone fades/Blossom scents take up the ringing/Evening shade" is, for Odin, "an intensely synaesthetic experience of nature" [15]. He continues:

The reverberating sound of a fading bell tone merges with the fragrant perfume of flower blossom, which in turn blends with the shadowy darkness of evening shade. The Japanese verb *tsuku*, which means "to strike" or "to ring," is here juxtaposed with the phrase *hana no ka*, or "scent of blossoms," in such a manner that the cherry blossoms are said to ring their scent [16].

Synaesthesia continues to have an influence on contemporary poetry, as illustrated in Cilla McQueen's poem "Synaesthesia," which begins, "the lines the eye can see the mind can hear/the sounds the eye has found the ear can see/the landscape sings inside my inner ear/invisibly its silent harmony" [17].

Novels

References to the condition also appear in both late-nineteenth-century and contemporary novels. For example, J.K. Huysmans, in his notorious *A rebours* (the famous "yellow book" in Wilde's *The Picture of Dorian Gray*) describes an episode in which the antihero Des Esseintes creates an "infernal symphony" by using "an elaborate assemblage of liqueurs": anisette, for instance, is described as being "the flute, sweet and poignant," while whisky has the effect of "deafening the palate with trombones" [18]. Reference to synaesthesia is also made by the novelist Vladimir Nabokov, who often referred to his possessing "this rather freakish gift of seeing letters in colour," a condition he claims to have shared with his mother [19]. Synaesthesia is also alluded to by A.S. Byatt in *Still Life*, which relates a dinner party discussion concerned with the use of synaesthesia in writing:

Crowe said there was an odd passage in Proust where he associated letters of the alphabet with colours. . . . Hodgkiss said it brought to mind Henry James simile for the dress of Sarah Pocock, "scarlet like the scream of someone falling through a skylight" [20].

Contemporary author Andrea Newman is another writer who not only appears to have synaesthesia, but also claims to use it in her creative process. She has told us that, when faced with a choice between words to include in a sentence (e.g. "confused" or "bewildered"), she selects the one whose colour best fits the other word colours. Similarly, she will tend to give strong characters names that, for her, are strong colours, as well as giving weak characters names that are pale and insipid.

An interesting expression of the rela-

tionship between synaesthesia and creativity is conveyed by the impact that Japanese Kabuki theatre appears to have had on the work of filmmaker Sergei Eisenstein. Explaining why he chose to use what he termed “colour-sound montage” to achieve a “multisensory ensemble,” Eisenstein wrote,

In experiencing Kabuki one involuntarily recalls an American novel about a man in whom are transposed the hearing and seeing nerves, so that he perceives light vibrations as sounds, and tremors of air as colours, he hears *light* and sees *sound*. This is also what happens in Kabuki [21].

Finally, for phenomenologist Merleau-Ponty synaesthesia was the “natural” way to perceive the world. In *Phenomenology of Perception*, he wrote: “Synaesthetic perception is the rule, and we are unaware of it only because scientific knowledge shifts the centre of gravity of experience, so that we unlearn how to see, hear, and generally speaking, feel” [22].

SCIENTIFIC INVESTIGATIONS OF SYNAESTHESIA

The historical accounts of synaesthesia given above are all anecdotal. As such, we simply have no means of deciding if these are examples of metaphor or genuine synaesthesia. The psychologist Humphreys suggested that synaesthesia is all too frequently subsumed under the banner of “romantic neurology” because tools for examining the condition have not been available [23]. Our examination of the condition has utilised three very different approaches: one designed to test the experience objectively with a rigorous behavioural methodology, a second that examines the experience subjectively and a third that uses a neuro-imaging technique known as positron emission tomography (PET).

Behavioural Criteria for Genuineness

The Test of Genuineness is a behavioural method devised by Baron-Cohen, Wyke and Binnie to distinguish “pseudo-synaesthesia” from genuine synaesthesia [24]. This test requires the subject to describe in detail the colours he or she claims are triggered by over 100 lexical items. At a later date, and without prior warning, the subject is retested on the list. The two sets of responses are then compared in order to test for consistency. The first use of the

test by Baron-Cohen et al. showed that a certain subject with what we termed “chromatic lexical” synaesthesia, Elizabeth Stewart-Jones, was 100% consistent when retested after a 10-week period, as compared with a rate of 17% consistency for a control subject (who had the advantage of being prewarned that she would be retested). Both subjects were retested only once. This was the first demonstration that synaesthesia was a real phenomenon, since this total consistency across time is not easily accounted for by either mnemonic or metaphorical association.

Having established the genuineness of the condition (at least according to their criteria), Baron-Cohen et al. suggested that synaesthesia may be the result of unusual neural connectivity. In all the studies carried out in recent years, a substantially larger number of women than men have been found to have synaesthesia. This implies the existence of a genetic mechanism through which differences in biology give rise to synaesthesia, though no direct evidence in support of this is currently available. However, it is interesting to note that a preponderance of synaesthetic females has been found in both the United States, where Cytowic reported a ratio of 2.5 to 1 [25] and in the United Kingdom, where Baron-Cohen et al. reported a ratio of 4 to 1 from two independent samples [26].

In 1993, Baron-Cohen, Harrison, Wyke and Goldstein went on to test a group of nine people claiming to have coloured speech perception, using an extended version of the Test of Genuineness that contained 130 items, including letters and homophones [27]. All tests involved the subjects listening to material. Intelligence quotients (IQs) of all subjects were determined according to the National Adult Reading Test [28] and all subjects also took the Wechsler Logical Memory Test [29]; these scores served to match the synaesthetes as closely as possible with the control subjects, who also matched the synaesthetes in age and gender. The group of control subjects was tested 1 week after the initial test, while the group with synaesthesia was tested 18 months later. The synaesthetes performed almost perfectly (the average percentage of correct answers on the retest was 92.7). This was substantially more accurate than the control subjects, who achieved an average of only 37% correct answers on the second test, in spite of the fact that they had been

prewarned about the retest and encouraged to try to learn their word-colour associations.

An interesting difference emerged between the responses of this group of nine women with synaesthesia and those of the original subject, Elizabeth Stewart-Jones. Whereas, for Stewart-Jones, each word had a detailed and unique colour, for the group with synaesthesia tested in the above experiment, the colour of the word appeared to be determined by the colour of the dominant letter, usually the first one. For example, if “penny” triggered blue, so did “pound,” “pig,” etc. In contrast, for Elizabeth Stewart-Jones, all of these words had their own unique colour. We were therefore drawn to distinguish between Stewart-Jones’s form of chromatic-lexical synaesthesia and the synaesthesia of these other nine subjects, who showed what we called “chromatic-graphemic” synaesthesia. Elizabeth Stewart-Jones is a particularly interesting subject in this respect—not only because of her apparent uniqueness so far, but also because, as an artist, she is able to graphically depict her synaesthetic percepts. Figure 1 depicts the percept resulting from her hearing the names of Christ’s lineage from Abraham.

Interview Data

Further evidence of the genuineness of synaesthesia has been obtained from interviewing individuals on the nature and developmental history of their condition. For instance, irrespective of the form of the synaesthesia, most people with synaesthesia report a similar pattern to their condition. They almost all report having mentioned their experiences to others at an early age, prompting ridicule or disbelief. Many report that, as a consequence, they said no more about their synaesthesia until having heard or read about the condition as adults. Despite attempts to keep these experiences private, they clearly remained as vivid, automatic and irrepresible as ever. Other consistencies are apparent, especially regarding the quality and nature of the synaesthetic percepts and the words or letters that elicit the colour. Typically, people with synaesthesia will report that the percept has remained the same since their first memory of it. In many cases, this will have been since the age of 4 or even earlier, as all subjects have a strong conviction that they have had synaesthesia for as long as they can remember.

Neuro-imaging Studies

The results obtained so far suggest that these individuals do indeed have some kind of colour experience in connection with words. If this is the result of some unusual neural connectivity, we reasoned that this might be detectable using PET scans. We predicted that subjects with synaesthesia would show differences in regional cerebral blood flow while listening to words, as compared with the cerebral blood flow of control subjects.

This study was carried out by Paulesu, Harrison, Baron-Cohen, Watson, Frith, Goldstein and Frackowiak [30]. Analysis of the experiment confirmed this prediction, the group with synaesthesia showing increased blood flow in areas implicated in the perception of colour [31] when listening to words, relative to the group without synaesthesia. This experiment has shown for the first time that differences in neural activation can be observed in synaesthetic subjects. The observed differences in blood flow appear to reflect fundamental differences in neural connectivity in the brains of people with synaesthesia. The scientific study of synaesthesia may inform our understanding of the development of perceptual systems in the normal brain.

The studies reported so far have raised a number of further questions. For instance, does synaesthesia have any implications for our understanding of the nature of reality [32]? Also, because colours are evoked by letters rather than words in many subjects with synaesthesia, we are currently engaged in a developmental study of the condition by examining young synaesthetic subjects. This is designed to detect whether a shift occurs with the acquisition of reading skills (although reading does not elicit synaesthesia) such that colours may be related first to phonemes in pre-reading subjects, then to letters after these subjects learn to read.

The results of our studies have tended to show that coloured hearing synaesthesia is the most commonly found form. Richard Cytowic has recently published an account of a subject with polymodal synaesthesia called *The Man Who Tasted Shapes* [33]. We also plan to examine individuals with synaesthesia who show other sensory combinations, especially those with coloured smell. Our hope is that the combination of the phenomenological accounts we have, together with the continued use of the techniques available to neuroscience, shall lead to a better understanding of this condition.

References and Notes

1. Woolner is cited in R.E. Cytowic, *Synaesthesia: A Union of the Senses* (New York: Springer-Verlag, 1989).
2. J. Locke, *An Essay Concerning Human Understanding*, Book 3 (London: Basset, 1690).
3. F. Galton, *Inquiries into Human Faculty and Its Development* (London: Dent & Sons, 1883).
4. A. Luria, *The Mind of a Mnemonist* (New York: Basic Books, 1968).
5. C. Myers, "A Case of Synaesthesia," *British Journal of Psychology* 4 (1914) pp. 228–238. For further information on Scriabin, colour and music, see also Alan Wells, "Music and Visual Color: A Proposed Correlation," *Leonardo* 13 (1980) p. 101. [Editor's Note: Scriabin's use of colour in music composition is also mentioned in this issue in the context of "light-music," a genre that developed out of early-twentieth-century Russian experiments in the creative synthesis of sound and colour. See the article by Bulat Galeev in the Art/Science Forum section.]
6. For a discussion of colour-organs, see K. Peacock, "Instruments to Perform Color-Music: Two Centuries of Technological Instrumentation," *Leonardo* 21 (1988) p. 397.
7. Myers [5].
8. J. Bernard, "Messiaen's Synaesthesia, the Correspondence between Colour and Sound Structure in His Music," *Music Perception* 4, No. 1, 41–68 (1986).
9. O. Messiaen, *Technique de mon langage musicale* (Paris: Alphonse Leduc, 1946).
10. See Cytowic [1].
11. C. Baudelaire, *Les paradis artificiels* (Paris: Gallimard, 1860).
12. A. Rimbaud, "Le sonnet des voyelles," in William Rees, ed., *The Penguin Book of French Poetry* (London: Penguin, 1992).

13. L. Marks, "On Coloured-Hearing Synaesthesia: Cross-Modal Translations of Sensory Dimensions," *Psychological Bulletin* 82, No. 3 (1975).
14. S. Odin, "Blossom Scents Take Up the Ringing—Synaesthesia in Japanese and Western Aesthetics," *Soundings* 69 (1986) pp. 256–281.
15. Odin [14] p. 256.
16. Odin [14] p. 261.
17. C. McQueen, "Synaesthesia," *Landfall* 41, No. 3, 324–325 (1987).
18. J.K. Huysmans, *A rebours* (Paris: Cres, 1884) p. 58. First translated in English as *Against Nature*.
19. V. Nabokov, "Strong Opinions," *The Listener* (22 November 1962) p. 17.
20. A.S. Byatt, *Still Life* (London: Penguin, 1985) p. 80.
21. S. Eisenstein, *Film Form: Essays in Film Theory* (New York: Harcourt, Brace and World, 1949) pp. 21–22.
22. M. Merleau-Ponty, *Phenomenology of Perception* (Hillsdale, NJ: Humanities Press, 1962) p. 229.
23. G. Humphreys, "Higher Sight," *Nature* 343 (1990) p. 30.
24. S. Baron-Cohen, M. Wyke and C. Binnie, "Hearing Words and Seeing Colours: an Experimental Investigation of Synaesthesia," *Perception* 16 (1987) pp. 761–767.
25. See Cytowic [1].
26. See Baron-Cohen et al. [24].
27. S. Baron-Cohen, J. Harrison, L. Goldstein and M. Wyke, "Coloured Speech Perception: Is Synaesthesia What Happens When Modularity Breaks Down?" *Perception* 22 (1993) pp. 419–426.
28. H. Nelson, *National Adult Reading Test* (Windsor: NFER-Nelson, 1982).
29. D. Wechsler, *Wechsler Memory Scale* (Revised) (San Antonio, TX: Harcourt Brace Jovanovich, 1967).
30. E. Paulesu, J. Harrison, S. Baron-Cohen, J. Watson, C. Frith and R.S.J. Frackowiak, "The Functional Anatomy of Synaesthesia" (forthcoming).
31. See M. Corbetta, F. Miezin, G. Shulman and S. Petersen, "Selective and Divided Attention During Visual Discrimination of Shape, Color and Speed: Functional Anatomy by Positron Emission Tomography," *Journal of Neuroscience* 11 (1991) pp. 2383–2402.
32. See J. Harrison and C. Kennard, "The Neurological Boundaries of Visual Reality," in E. Critchley, ed., *The Neurological Boundaries of Reality* (London: Farrand Press, 1993).
33. R.E. Cytowic, *The Man Who Tasted Shapes* (New York: Putnam, 1993).