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Hearing words and seeing colours: an experimental investigation of a case of synaesthesia

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Abstract. A case of 'chromatic-lexical' (colour-word) synaesthesia is described, and its genuineness confirmed using the criterion of stable cross-modality imagery across time. The synaesthesia could not be accounted for by a memory hypothesis, nor was it associated with any psychiatric condition. Further analysis did not identify any semantic relationship between real words and colours, but the colours of nonwords were determined by the colours of the individual letters. Numbers also had their own stable colours. The experience of synaesthesia was triggered by other auditory stimuli, but most strongly by words. Cortical electrophysiological recording failed to reveal any abnormalities. An unusual organisation of modalities in the brain is postulated to account for the phenomenon.

1 Introduction

The synaesthesias—those conditions in which a stimulus presented in one modality triggers imagery in another modality—were well described at the end of the last century (Binet 1893; Galton 1883), but virtually disappeared from the literature in the 1940s. One of the commonest forms of synaesthesia is 'colour-hearing' or visual-auditory synaesthesia (Bleuler and Lehmann 1881), and this has been reviewed by Marks (1975). Almost all such cases involve 'coloured vowels' and 'coloured letters'. Here we describe a 'chromatic-lexical' (coloured words) form of visual-auditory synaesthesia and such a case has only once before been reported (Ostwald 1964). In that instance, the subject was not free from psychiatric illness (she showed paranoia, sexual dysfunction, and social withdrawal), and nor was the genuineness of the synaesthesia thoroughly tested (eg, a memory strategy was not ruled out). In the present study this is specifically examined, and psychiatric status and memory are excluded as possible explanations.

1.1 *Defining synaesthesia*

Synaesthesia, which literally means 'experiencing together', has been variously defined. Vernon (1937) considered synaesthesia as a phenomenon in which "a stimulus presented in one mode seems to call up imagery of another mode as readily as that of its own". This emphasised the ease and speed of association in another modality. Simpson and McKellar (1955) simplified the definition as "imagery of one sense mode aroused by sensations of a different sense mode". They ignored the question of ease or speed, and instead focused on the relationship between the 'imagery experience' and the 'sensory experience', these being the two necessary components in synaesthesia. The terminology they adopted reflects this bipartite structure: for example, the experience of a person who sees images when hearing sounds is termed 'visual-auditory synaesthesia', the dash dividing the imagery (the first word of the pair) from the sensation (the second word).

This led Simpson and McKellar (1955) to search for different types of synaesthesia that could be classified with this terminology. They found naturally occurring cases of visual–auditory (this being the commonest), visual–tactile, visual–gustatory, tactile–visual, tactile–auditory, and kinaesthetic–olfactory synaesthesia. In addition, they found seven more types which only occurred when experimentally induced by drugs such as mescaline. These were: visual–olfactory, visual–kinaesthetic, visual–thermal, visual–algesic, tactile–olfactory, thermal–visual, and algesic–tactile.

The question of how synaesthesia is distinguished from other mental phenomena is of fundamental importance. Kerr and Pear (1932) correctly exclude verbal descriptions involving simile and metaphor (eg, describing a colour as warm, or a wine as dry, or a noise as penetrating). These are said to be poetic or linguistic, rather than true cases of synaesthesia. The key question therefore is how to demonstrate 'genuine' synaesthetic experiences as distinct from the poetic or linguistic descriptions. Simpson and McKellar (1955) propose that unless there is definite evidence for such imagery occurring at the time, the descriptions should not be classified as genuine synaesthesia. The usefulness of this criterion is limited, however, in that it still depends on the subject's verbal account that imagery is occurring.

1.2 *Aims of the study*

We had two aims. First, to use criteria other than self-report to determine genuineness of the condition. The criterion we used in this study is similar to that used in the previous case of chromatic–lexical synaesthesia reported (Ostwald 1964)—that the type of imagery evoked by specific sensations in another modality is stable over time—but we extended the criterion to include the stipulation that this stability could not be accounted for by a memory trace nor by a psychiatric condition. Ostwald (1964) did not control for either of these factors. If genuineness was confirmed with this extended criterion, our second aim was to explore the process involved in chromatic–lexical synaesthesia. In addition, the subject underwent electroencephalographic (EEG) and evoked potential studies.

2 The subject

EP came to our attention when she placed an advertisement in the British Psychological Society *Bulletin*, in which she described herself as "an artist who has experienced the life-long condition of hearing words and sounds in colour". She was interested to find out more about the phenomena she experienced. She is a 76-year-old widow who trained at the Chelsea School of Art (London), and who subsequently worked as a professional painter.

She told us that the colours she experienced appeared "automatically" whenever she heard a word. The colours also appeared extremely quickly—it seemed to her that she did not have to think about the word she had heard, she simply heard it and there was *its* colour. About this she was most emphatic: each word had its own colour, as did each letter of the alphabet. But, she told us, the colour of each word was not necessarily anything to do with the colours of the individual letters in that word.

She was clear that the colours were experienced inside her head—she did not see them outside of her body. She described them as images, and said that this experience was mostly confined to hearing words: it occurred to a lesser extent when she heard other sounds, and only rarely when she read words. She reported that it did not particularly interfere with her life, as she had never known any other kind of perceptual experience. Her earliest clear memory of colour–word synaesthesia was from the age of seven, but she believed it was present even before then. She explained that seeing words as colours was often of great help when she needed to remember something—for example, when meeting a new person she only needed to recall the colour of their name to be able to remember their name. But this unusual process also had its drawbacks: for instance, she might call someone Matthew rather than Andrew, because both were shades of red.

Four subtests of the WAIS-R showed her to be of superior intelligence (age-corrected scaled scores: vocabulary = 19, similarities = 15, picture completion = 13, and block design = 16). On testing she had an excellent memory for pictures, recalling eleven out of twelve objects after a 40 min delay, and reproducing the Wechsler designs perfectly after a delay of the same duration. Her memory for verbal material was less good, but still within the average range, as demonstrated on the Wechsler logical memory test. On the Farnsworth Munsell 100 hue test for colour vision (Farnsworth 1943) she demonstrated superior discrimination ability. No psychiatric features were found in a standard clinical interview. She does not take any type of medication.

3 Test of genuineness

Our first aim was to establish if the subject's experiences were 'genuine', ie whether she really experienced one *particular* colour for every word she heard. We tested this by investigating how stable her reporting colours for words were, over a 10 week interval, controlling for possible memory strategies by comparing her performance with that of a control subject.

The stimuli (described below) were presented aurally in a random manner, and the subject was asked to say the colour of each word. Subject EP was unaware of the memory test planned to follow the session, but the control subject was told about it (see section 3.2). The stimuli included:

(i) Fifty meaningful words, in five semantic categories (animals, place names, objects, occupations, abstract terms).
(ii) The seven days of the week.
(iii) Twenty christian names of people (both sexes).
(iv) The twenty-six letters of the alphabet.

There were thus a total of one hundred and three stimuli.

The subject gave detailed descriptions of the colours of each stimulus. She reported that seeing the colour in her mind's eye was an automatic phenomenon, and the only delay was putting it into words. An example of the degree of detail of the colour of each stimulus is given here: MOSCOW is darkish grey, with spinach-green, and a pale blue in places; FEAR is mottled light grey, with a touch of soft green and purple; DANIEL is deep purple, blue, and red, and is shiny; MARIA is deep violet-blue.

The subject found more difficulty in saying the colour of words that referred to 'concrete' objects (such as table and chair, the colours of which were both influenced by the woody-brown material of prototypical objects she imagined). For more abstract stimuli, there was no apparent relationship between the colour and the word. The relationship could be described as necessary, but it was arbitrary.

On retest of ten randomly selected stimuli 3 hours later, the colours given were identical. On retest of all one hundred and three items 10 weeks later, the colours given were also identical.

This perfect performance after $2\frac{1}{2}$ months suggested that this was a genuine case of synaesthesia, since a memory strategy alone was unlikely to result in such consistent responses. In order to be sure of this conclusion, the same one hundred and three stimuli were presented to a control subject, a 27 year-old female lawyer, of superior intelligence, and with an excellent memory. She was instructed to give colour words which she associated with the stimulus words, using any strategy of association she chose, and to try to make them memorable because she would be asked to give colour words for the same words at a later date. It was made very clear that the aim of the exercise was to see how many of the colour words she could accurately recall later.

On retest of ten randomly selected stimuli 3 hours later, the control subject was consistent on only three items. On retest of all one hundred and three items just 2 weeks later, she was consistent on only seventeen items, most of these being for words describing concrete objects such as table, refrigerator, etc, which could easily be imagined and associated with their everyday colours.

There was clearly a highly significant difference (100% after 10 weeks versus 17% after 2 weeks) between the experimental and the control subjects. This result was obtained in spite of the control subject's advantage in terms of age and explicit warnings to remember her responses. This supported the conclusion that the experimental subject's reports of synaesthesia were genuine, ie stable across time and not explained by memory strategies. Indeed, when followed up 8 months later, her colour terms to several words selected randomly from the original list were also perfectly consistent.

4 Process analysis

Our second aim was to explore the processes involved in the relationship between different stimuli and the colours elicited by them. This was tested by using semantically related words, phonologically related words, nonsense words, letters, proper names, numbers, pictures, and so on.

Results indicated that words that were semantically related were not related in terms of the colours they evoked. Thus, MAN, MALE, MASCULINE, etc, were all very different colours. Similarly, words that were phonologically related (MAN, MOON, MOAN, MEAN) were also not related in terms of their colours. Subject EP was then tested using three-letter nonsense words developed by Hilgard (1951). She was given two sets of nonsense words with an 'association value' (to real words) of 60% and 0% respectively. The colours these evoked turned out to be composites of the colours of the individual letters which they comprised. Thus, HUK was dark red (H), yellow (U), and purple (K). LIR was pale yellow (L), whitish (I), and dark green (R). This nonsense word effect was in stark contrast to the situation with real words, whose colours were not related to the colours of the letters in the words. Rather, each real word had its own colour, corresponding to its meaning, and only rarely did the individual letters influence the colour of the word.

It is relevant here to report subject EP's response to the letters of the alphabet. Each letter had its own distinct and complex colour: thus, H was dark red, M was blue-black, Q was greeny-yellow, etc. An unusual feature of the alphabet for this subject was that she reported that the colours of the alphabet were spatially represented in her mind when she thought of them. She drew them as shown in figure 1. The colours of the letters were not related to each other in any patterned way (eg, A and B were not different shades of the same colour). This general phenomenon is reported in other cases, and has been called 'number form' (see Hunter 1957).

Figure 1. The spatial representation of the letters of the alphabet in subject EP's mind.

The subject also reported experiencing numbers as colours. The numbers 0-10 had their own colours, and all other numbers, up to 100, were combinations of the colours of the individual numbers. Thus, the colour of 14 was a mixture of the colours of 1 and 4. It is of interest that this componential structure to the colours of digits mirrors the way in which the colours of nonsense words comprise the colours of their component letters, as described earlier. This type of structure was not seen in the colours of real words.

When the colours of different semantic categories were examined, no clear pattern was found. The concreteness of the object being described did, however, influence the colour evoked. Thus, the colour of the word ELEPHANT was grey, SAILOR was blue and white, SOLDIER was khaki, etc. All of these can be seen as colour 'clang-associations'. Predictably, these are the colour associations that the control subject was able to remember more easily. The experimental subject was tested on word associations (Russell and Jenkins 1954), in order to determine whether a word evoked a normal response. She gave common word associations for all words except colour words, to which she gave people's christian names. Thus, for YELLOW she said Philip, for RED, Andrew, etc, responses which are not recorded in the Russell and Jenkins (1954) data.

Our final investigations considered her response to a variety of other stimuli. Black and white pictures and shapes evoked no colours, and nor did written words. Voices of different pitch did evoke colours, and in a systematic way: female voices were in the blue range, those with higher pitch being paler and those with lower pitch being darker, whereas male voices were in the brown range, with higher and lower pitch variations similar to the ones for females. This suggests that nonchromatic visual stimuli do not evoke colour imagery, but a range of auditory sensations do, with lexical items triggering these most powerfully.

An EEG was also carried out, as well as studies on visual and auditory evoked potentials, in order to search for neural clues as to what might underlie the subject's unusual association between modalities. The tests showed her waking EEG to be within normal limits for her age, and there were no significant changes when verbal or visual materials were presented. Auditory and pattern-reversal evoked responses were also normal.

5 Discussion

The genuineness of chromatic-lexical synaesthesia has not been adequately investigated before, as neither memory nor psychiatric factors have been controlled in previous studies. The investigation reported here suggests that the subject presented is a genuine case.

It is of interest that the subject in the present study is a painter, which is consistent with reports that synaesthesia is more common among artists. Thus, Binet (1893) and Sokolov (1901) have suggested that synaesthetics possess a lively visual imagination and are often artistic. Indeed, Critchley (1977), in a study of synaesthetics in music, refers to Liszt, who saw colours when he heard musical notes, and Myers (1914) describes a similar phenomenon in the composers Scriabin and Korsakov. One of the most famous cases in the literature is that of Shereshveski, described by Luria (1968), for whom visual imagery evoked by auditory stimuli gave him extraordinary mnemonic abilities. Another important observation is that, for the few people who experience it, synaesthesia appears to have its onset in childhood (Riggs and Karwoski 1934), which is also the case for the subject reported here.

It is also important that for subject EP the alphabet was imaged in a particular spatial constellation. This turned out to be true also for the subject's image of the colours for the days of the week, which were seen as going clockwise, and the months of

the year, which went anticlockwise. Numbers were similarly visualised in a particular shape. We do not have an explanation for why lists of words should be seen primarily as shapes.

Two main psychological theories have been proposed to account for colour synaesthesia (Cytowic and Wood 1982). The first involves higher cognitive/cortical level processing, and assumes that colour synaesthesia is the product of a chain of mental associations, some of the intermediate links having dropped out of awareness (Peillaube 1904). An example of this would be that a trumpet sound triggers a red photism because it is associated with the red uniforms of brass bands. An alternative theory relates synaesthesia to the limbic system, and regards colour-hearing as a perpetuation of a primitive perceptual experience which in evolution was later differentiated into two separate senses (Myers 1911; Wundt 1874). This has been called the doctrine of the unity of the senses (Boring 1942), or linkage theory (Cytowic and Wood 1982). Marks (1978) has extended this notion in the study of correspondences between, for example, vowel pitch and colour.

Consistent with linkage theory, we also assume that synaesthesia reflects unusual neurophysiological organisation. In our case, the electrophysiological evidence did not disclose any abnormalities of the cortex. Cytowic and Wood (unpublished data, cited in Cytowic and Wood 1982) did find changes in blood flow in the cortex and the limbic system using PET scanning of a synaesthetic patient, and it may be that such a technique would have been more appropriate to reveal possible functional changes in these regions in subject EP. The unavailability of this procedure unfortunately precluded such an investigation in the present case.

The specificity of cases of chromatic–lexical synaesthesia raises the question as to why certain forms of synthaesthesia are found and others are not. Why, for instance, do people never experience hearing, smelling, or tasting things when receiving sensations in another modality? Cases of synaesthesia that have been found, both naturally occurring or experimentally induced, may be an important source for learning about representation and neural connection in the brain.

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