State of the art
Synaesthesia

What's it like to smell pain and taste words? **JAMIE WARD** *on the unusual world of the synaesthete.*

WHAT colour is the letter *A*? What does the number *1* taste of? Does listening to music, speaking or eating food produce colours, shapes or textures?

For most people, questions such as these will either yield a look of bewilderment or an emphatic 'No!' However, when I have posed this question to our intake of psychology undergraduates at University College London, as many as 1 per cent are certain that they experience something like this. These students may well have synaesthesia.

Synaesthesia is often described as a joining of the senses (Cytowic, 1989). Sensations in one modality (e.g. hearing) produce sensations in another modality (e.g. colour) as well as in its own. This standard description, however, is a simplification, because synaesthetic experiences are often driven by symbolic rather than sensory representations, such as letters, numbers and words. Synaesthesia is also often experienced in the absence of external sensory input, such as thinking in colour when doing mental arithmetic.

Synaesthesia has been a topic of interest to psychologists ever since psychology emerged as a discipline in its own right in the late 19th century (e.g. Galton, 1883/1997). It is an intriguing phenomenon because it challenges the tacit assumption that other people's perceptual experiences of the world are the same as our own. Philosophers may lose sleep over whether my experience of green is the same as your experience of green, but people on the street do not. This is because we can use language as a common currency to agree upon our experiences. But what are we to make of someone claiming that the letter *A* is red, when most of us do not experience this at all?

Well, one solution to the problem is to dismiss subjective reports as having no place in science or psychology. The behaviourist movement did just this, and the number of publications devoted to synaesthesia plummeted in the mid-20th century as a direct result (Harrison, 2001). But times have changed, and understanding how the brain creates our conscious experience of the world is a hot topic. Synaesthesia research is enjoying its renaissance. But can we really be sure that these subjective reports are for real, and what is synaesthesia going to reveal to us about the workings of our own minds?

In the mind of a synaesthete

What is it like to have synaesthesia? The synaesthete Pat Duffy puts it this way:

> *Other people don't see what we see and they're not convinced that we see it ourselves. But what each of us sees is the reality we know. I am at no more liberty to change the white colour of the letter O than I am to change its circular shape; for me, the one is as much an attribute of the letter as the other.* (Duffy, 2001, p.4)

The coloured letters on these pages accord to Pat's synaesthetic alphabet. Every synaesthete has their own selection of colours, and often different types of trigger. Carol Steen is a synaesthetic artist and describes her experience thus:

> *There have been times when I have had one sensation such as toothache and observed the color of the pain, its taste and smell. All these synaesthetic perceptions are aspects of one overall experience. I perceive them as related in the same way that windows, a door and front steps combine to become the image of a house.* (Steen, 2001, p.205)

Carol uses her synaesthetic experiences as inspiration for her artwork. 'Vision' (opposite) shows the colour images that were evoked during an acupuncture session. Her descriptions imply a richness of colours, movement and texture:

> *Lying there, I watched the black background become pierced by a bright red color that began to form in the middle of the rich velvet blackness. The red began as a small dot of color and grew quite large rather quickly, chasing much of the blackness away. I saw green shapes appear in the midst of the red color and move around the red and black fields.* (Steen, 2001, p.205)

As a synaesthetic artist, Carol is in good company. Other famous figures with synaesthesia include the painters Wassily Kandinsky and David Hockney, the composer Olivier Messian, and the writer Vladimir Nabokov (Harrison, 2001). Kandinsky certainly tried to create a synaesthetic dimension to his work. For example, he wanted his canvases to evoke sounds.

In order to appreciate the diversity of synaesthetic experience, consider the answers given to the question 'Where are your synaesthetic colours?' Some synaesthetes 'project' their synaesthetic colours on to the stimulus itself. Thus, the synaesthetic colours appear in the same location and have the same shape as the

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actual typeface of the letter or word being attended to, although they can still report the 'true' colour of the text (Ramachandran & Hubbard, 2001). However, most synaesthetes do not report seeing their synaesthetic colours as being in the normal visual field but on an inner screen. Consider the following three descriptions in response to the question above. Case AD: 'On different "screens", mainly on the inside of my forehead.' Case JG: 'They permeate the centre of my brain – a warm feeling about 5–8cm square.' Case KA: '[Coloured] words scroll in from right to left, and fade to black at centre screen. They seem to be behind my right eye and do not interfere with vision.' The colours occur automatically, cannot be suppressed, and pervade almost every aspect of mental life. Synaesthetes cannot imagine life without them.

It is not clear why colour is the most common synaesthetic experience, but it is (Day, 2002). If it is not triggered by words and letters then it can be triggered by music, tastes, smells, pains and emotions. Even though it is rarer, synaesthesia can nevertheless be found in every other sensory modality. For the last year I have been working with a man, JIW, who experiences tastes whenever he hears, reads, speaks or thinks about words (Ward & Simner, 2002). The tastes have a subjective location on his tongue and in his mouth. The experiences are rich in texture and can even have thermal properties. For example, the word *safety* tastes of lightly buttered toast, and *jail* is hard, cold bacon. The tastes elicited by particular words do not change over time, although the range of tastes exhibited do to some extent reflect his dietary habits. For example, the taste of fish is absent from both his synaesthesia and his diet. For JIW, the presence of certain tastes can distract him from the content of a conversation, and he has to coin nicknames for acquaintances with disagreeably tasting names!

'Vision', a painting created by a synaesthetic artist and based on an experience in an acupuncture session (© Carol Steen)

In the brain of a synaesthete

What makes some people synaesthetic but not most other people? The answer to this question almost certainly lies in the development of the brain under the guiding influence of our genes. Synaesthesia runs in families, and it may be linked to the X-chromosome (Bailey & Johnson, 1997). It is more common in women, and there are no known cases of it being inherited from father to son. Intriguingly, the sensory modality that is affected by synaesthesia does not seem to be strongly inherited. For example, the taste-synaesthetes whom I have studied typically have relatives who experience colours or have other types of synaesthesia, and many synaesthetes have more than one type. This implies that the hypothetical 'synaesthesia gene' may code for something quite general (e.g. degree of neural connectivity) rather than an exact phenotype.

The familial segregation of synaesthesia provides some indication that it is a genuine phenomenon with a biological origin. It is unclear why familial segregation would occur if, say, these people were simply remembering coloured alphabet fridge magnets. Empirical studies of synaesthetes confirm that synaesthesia is both automatic and perceptual in nature. Modern research in the UK was kick-started by a notice placed in the *Bulletin of the British Psychological Society* in the mid-1980s by a synaesthetic artist who was willing to be a research guinea pig. The gauntlet was picked up by Simon Baron-Cohen, who took the view that the existence of synaesthesia is an empirical question rather than a matter of personal opinion. He noted that in this synaesthete, as in others, the same stimulus tends to elicit the same percept over time (Baron-Cohen *et al*., 1987). This has been used as a 'test of genuineness' in its own right, because one can show that synaesthetes outperform non-synaesthetes who are asked to generate colour associations under memory and imagery conditions. One can also use the fact that they are consistent to construct 'Stroop-like' experiments. If a synaesthete experiences the letter *A* as red, then they will be slower at naming the ink colour when it is incongruent with their synaesthesia (e.g. when *A* is printed in

green ink) than when it is congruent (when *A* is printed in red ink). In this instance their synaesthesia is irrelevant to the task, so the fact that it interferes with it provides strong evidence that it is automatically rather than strategically elicited (e.g. Mattingley *et al*., 2001). But the Stroop effect does not prove that the phenomenon is perceptual in nature, because it could arise from response competition at an output level.

A recent functional imaging study by Nunn *et al.* (2002) has provided strong evidence that synaesthesia is a perceptual rather than a purely memory phenomenon. In their group of synaesthetes, words but not tones evoke colour sensations. Brain activity was indeed engendered in the left hemisphere colour region (area V4) when listening to words but not tones. The left hemisphere lateralisation may reflect the fact that language appears to be the inducing stimulus in this group. No such activity was found in a non-synaesthetic control group, even when they were trained to learn word–colour associations and engaged in colour imagery at retrieval. However, when the control group were asked to view coloured patterns, this region was activated. Thus, synaesthetic colour perception appears to tap the same neural circuitry that, in non-synaesthetic individuals, is used to process colour derived from external visual input. This provides objective support for the synaesthetes' claims that the phenomenon feels more like perception than imagination or memory.

Are we all synaesthetes?

Most researchers believe that studying synaesthesia could tell us something about the brain and cognition more generally. It is well accepted that each and every one of us engages in cross-modal perception and integration. For example, there are neurons in our brain that respond to sensory attributes from different modalities – such as colour, taste and smell. At a behavioural level, a series of experiments has shown that when non-synaesthetic individuals are asked to make cross-modal matches between pitch and colour, then the higher the pitch the lighter the colour (Marks, 1982). Interestingly, the same trend is found for synaesthetes who have an actual conscious experience of colour in response to music and sounds (Marks, 1975). So is synaesthesia just a simple extension of these normal cross-modal processes? Possibly, but the final explanation of synaesthesia is likely to be more complex, for reasons outlined below.

It is widely acknowledged that synaesthesia can exist in acquired forms, and this could be taken as providing supportive evidence for the notion that synaesthesia itself reflects an exaggeration of sensory mechanisms that we all, to some degree, possess. Certain hallucinogenic drugs, such as mescaline, LSD and psilocybin (from 'magic' mushrooms) can produce transient forms of synaesthesia. Albert Hoffmann was the first person to note the psychoactive properties of LSD when he accidentally ingested or inhaled the drug. His lab notes from 19 April 1943 clearly describe synaesthesia:

> *It was particularly striking how acoustic perceptions such as the noise of a passing auto, the noise of water gushing from the faucet or the spoken word, were transformed into optical illusions.* (Hollister, 1968, p.34)

Given that the effects of the drug occur quickly and last a period of hours, it is reasonable to assume that they are stimulating existing pathways in the brain. The other way of acquiring synaesthesia is through sensory deafferentation, such as that arising from progressive blindness due to retinal or optic nerve atrophy (e.g. Armel & Ramachandran, 1999). These patients may experience colours in response to touch and sounds, as well as experiencing spontaneous visual hallucinations (the Charles Bonnet syndrome).

The very existence of acquired synaesthesia implies that we all have the potential to be synaesthetes in one form or another. However, opinion is still divided over whether these acquired forms have any bearing on our interpretation and understanding of developmental forms (e.g. Grossenbacher & Lovelace, 2001).

UNANSWERED QUESTIONS

- Why is colour the most common synaesthetic experience?
- Why do some people experience synaesthetic colours externally in space, but others see them as internal?
- Can you have a synaesthetic experience without being aware of the stimulus that is triggering it?
- In what circumstances is synaesthesia an aid or a hindrance?
- Can a single explanation account for the diversity of synaesthetic phenomena?
- How does the putative synaesthesia gene(s) exert influence on the brain?
- Do metaphors in language have anything to do with synaesthesia?
- How does the pattern of synaesthesia change early on in life as a result of environmental factors?

Significant differences between acquired and developmental types of synaesthesia certainly do exist. Acquired synaesthesia is most commonly triggered by 'simple' sensory stimuli (e.g. pure tones) whilst in developmental synaesthesia the eliciting stimulus is often learned linguistic material such as letters, numerals and words. There is no evidence to suggest that people can acquire a coloured alphabet such as Pat Duffy's through taking drugs or going blind.

In my opinion, the key difference between acquired and developmental synaesthesia may simply lie in the age of onset rather than in the underlying mechanisms. In the developmental form the mechanisms which give rise to the synaesthesia are in place before the onset of language acquisition, and when the brain itself is immature and malleable. The type of synaesthesia exhibited could evolve from the more basic cross-modal type (e.g. pitch–brightness) to those involving speech sounds and eventually letters, over a period of time and as a result of experience. There would be little, if any, scope for this to occur in the acquired forms, which typically occur after language and literacy acquisition and often have transient effects. The more basic cross-modal forms may only be found in these cases.

There are very few known facts about how synaesthesia develops. But given that it tends to run in families, it could be possible to find and study candidate synaesthetes from an early age, despite the relative rarity of the phenomenon. Researchers are, however, finding good evidence to suggest that synaesthesia can be influenced by language, context and the environment. Researchers at the University of Waterloo, Ontario, have shown that the colour of an ambiguous grapheme (5) depends upon the linguistic context. When flanked by numerals (e.g. 34 5 67) then the grapheme takes on the colour appropriate for the number *5*, but when flanked by letters (e.g. MU 5 IC) it takes on the colour appropriate for the letter *S* (Myles *et al*., in press).

My own research with people who experience synaesthetic tastes suggests that language can even shape the relationship between the word triggering the synaesthesia and the resultant taste (Ward & Simner, 2002). Bizarrely, there are often phonetic relationships between the triggering word and the name that is used to describe the taste that is elicited. For example, *cinema* may taste of cinnamon rolls, and *Chicago* may taste of avocado. We have observed this in five different cases that we are in touch with, and have also found similar reports in the early synaesthesia literature almost a hundred years ago (e.g. Ferrari, 1907). The results suggest that vocabulary knowledge of food can be used to shape the synaesthetic associations. Given that one's vocabulary knowledge and one's diet are tied to experience (the culture one is born in to), it suggests a role of environmental influences in synaesthesia that may hitherto have been underestimated. Synaesthesia, like so many other psychological phenomena, is likely to be an outcome of both nature and nurture.

'Now that most psychologists are believers, the hard work is yet to be done'

What is synaesthesia research going to tell us?

State-of-the-art research has shown, beyond reasonable doubt, that synaesthesia is a genuine phenomenon in search of an explanation. Previous reports of synaesthesia, even by distinguished people such as Galton (1883/1997) and Luria (1968), have been subject to scepticism because they rely on little more than case descriptions. Establishing that synaesthesia is real may seem like a modest achievement, but without it there is no foundation for further serious research in this field. It is also of fundamental importance to synaesthetes themselves, all of whom are likely to have received ridicule and disbelief at some point in their lives.

Now that most psychologists are believers, the hard work is yet to be done, with many unanswered questions remaining (see box opposite). However, synaesthesia research is starting to yield some answers to important questions in psychology. It is enabling us to disentangle the experiential aspects of perception from the more basic sensory mechanisms that normally trigger them. Research into synaesthesia has the potential to link different levels of explanation from gene to neuron to cognition. It may even tell us something about how we, as humans, have evolved language and abstract thought that is not normally tied down by our concrete sensory experiences of the world.

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