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Commentary

Synaesthesia in its protean guises

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This article is a commentary on the article 'Defining synaesthesia' (Simner, 2012).

Synaesthesia is a condition characterized by unusual perceptual or cognitive pairings – for example, words might trigger tastes (Ward & Simner, 2003), letters may trigger the sensation of texture (Eagleman & Goodale, 2009), or music may induce the sensation of shapes and colour (Ward, Huckstep, & Tsakanikos, 2006). To date, there are estimated to be up to 150 reported forms of synaesthesia (Cytowic & Eagleman, 2009).

Perhaps because of its varied incarnations, synaesthesia has proven difficult to capture under a single definition that rigorously marks the boundaries of inclusion and exclusion criteria. Adding to the bewilderment is the problem that almost every paper on synaesthesia examines a single sub-type, and the temptation is great in young fields to extrapolate the findings from single studies to the field more generally.

In an article in this issue, Julia Simner aims to build scaffolding for a 'single shared understanding of the definition of synaesthesia'. Taking a nuanced approach, she identifies the key qualities that would compose a working definition.

First, Simner points out that synaesthesia should not be over-simplistically defined as a 'merging of the senses'. That is, the criteria should not be limited only to sensory categories, but instead be broad enough to encompass conceptual categories. For example, colours can be triggered by the *concept* of a letter (rather than simply the physical form, Dixon, Smilek, Cudahy, & Merikle, 2000); in another sub-type, a number can trigger the conceptual experience of *gender* or *personality type* (Simner & Hubbard, 2006). Thus, Simner argues, *joined sensation* (the root words of *syn* + *aesthesia*) might represent a misnomer.

Second, Simner asks important questions about the method by which researchers test for synaesthesia: consistency testing. This involves asking participants to pick, for example, the colour that best matches their synaesthetic perception for a particular letter. Participants are tested multiple times with all letters, and their colour choices are

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compared for consistency across trials (Asher, Aitken, Farooqi, Kurmani, & Baron-Cohen, 2006; Eagleman, Kagan, Nelson, Sagaram, & Sarma, 2007). This sort of testing can be performed within a single session or across distant time intervals.

In my laboratory, we perform such testing on thousands of participants through an online battery (synesthete.org; Eagleman *et al.*, 2007). We do not find a clear bi-modal distribution that separates synaesthetes from controls, but instead a distribution with high-consistency scores and a long tail that represents worse scores. For our analysis, we set a draconian threshold to accept only the most highly consistent synaesthetes – those we feel certain are truly synaesthetic (Eagleman & Cheng, 2011). But, as Simner correctly points out, this embeds the assumption that it is appropriate to exclude from analysis those people with mid-range scores – that is, those who claim to be synaesthetic but cannot pass the test. And this may mean, we have been placing inappropriately tight restrictions on what we include.

Third, Simner calls into question the definitional requirement that synaesthetic concurrents have a spatial location to them. Often they do not. As Simner documents, many synaesthetes simply 'know' their colour for a letter, with no spatial component at all.

Simner's attempt to straighten out the labelling in synaesthesia comes at the right time. Already, the field has seen the introduction of labels to which time may prove unkind. For instance, the desire to categorize is seen with the proposed distinction between two types of colour-experience synaesthetes with proposed labels 'associators' and 'projectors'. The associators label describes synaesthetes who have an internal experience of a colour, while projector is meant to capture those who experience their colours 'projected' onto the page. The problem is that a synaesthete's description may be biased by the phrasing of the questioning: it is easy to accidentally lead a synaesthete into answers that put them in one category or the other. Even if there are differences in spatialization among individuals, there exists no good evidence that it is binary. In 2007, Rouw and Scholte set out to develop a test to cleanly distinguish associators from projectors, and they ran 19 participants through a series of questions (Rouw & Scholte, 2007). Their result, published in their supplementary material, was that people scored smoothly along a spectrum rather than in a bimodal distribution. Strangely, the dichotomous labelling is still often used. There are circumstances, of course, in which it can make sense to study the ends of a spectrum (say, obese and anorexic people), but it is the mark of a young field to embrace the notion that the ends represent two fundamental categories, with everyone in the middle simply representing the difficult-to-classify. In a mature science, we would not say that people of average weight are *actually* obese or anorexic, their true category merely obscured by measurement noise.

In her paper, Simner's potential concerns about a purely behavioural definition drive her to suggest that a biological definition could be proffered for synaesthesia – one in which hyper-connectivity between regions is measured (say, by neuroimaging). With this definition, Simner suggests that other, non-reported synaesthesias may be found, including, for instance, people with hyper-connectivity in language processing areas who are unusually articulate.

While I am in favour of biomarkers to buttress our behavioural measures, there is an interesting consequence to Simner's suggestion: it means that her goal of achieving a clear definition for synaesthesia may never be realized. This is because hyper-connectivity is not all-or-none; its spectral. In the hyper-connectivity framework (which may indeed be the correct one), the definition of synaesthesia bleeds off at the edges: there is no sharp cut-off point at which one is included or excluded. Indeed, an understanding of synaesthesia as a spectral condition would align it with other conditions – such as

autism spectrum disorder, a term that was forced into existence by the recognition that autism is not all-or-none. Indeed, the trend in the upcoming *Diagnostic and Statistical Manual* (DSM-V) moves in the direction of understanding many disorders as spectral, not binary – so it is perhaps with good timing that this possibility is explored in the case of synaesthesia.

Beyond a spectral nature, synaesthesia may turn out to be even more complex. It is an open possibility that synaesthesia will turn out to be a collection of diverse neural phenomena all swept (at the moment) under a single rubric (Eagleman & Cheng, 2011). In this sense, synaesthesia would be analogous to a condition such as deafness, in which many different underlying mechanisms (e.g., damage to the tympanic membrane, malformed hair cells, a lesion of the eighth cranial nerve), all result in the same outcome. Likewise, the end result of synaesthesia may spring from several fundamentally different neural processes (e.g., neuronal overgrowth, under-pruning, imbalanced inhibition, and excitation) all of which happen to converge on the similar result of unusual perceptual or cognitive pairings.

In fact, this hypothesis of multiple provenance has data to support it: my laboratory has been engaged in a family-linkage analysis to understand the genetic basis of a single sub-type, coloured-sequence synaesthesia (CSS; letters, numbers, weekdays, or months that trigger colour experience), and found five families in which CSS runs through the pedigree. Our preliminary results have implicated a region on chromosome 16 – and the important point here is that only two of the five families mapped to this hotspot. Thus, our first lesson was that even *within* a single sub-type of synaesthesia, there is likely to be a large genetic heterogeneity. That is, even a single sub-type of synaesthesia may have convergent biological mechanisms. Across synaesthesia in all its varieties, there may be a great number of different genetic changes that can lead to the same end result.

The field will remain in its infancy as long as we are over-restrictive or naive with our labelling. As Simner's article emphasizes, we must treat the heterogeneity of the condition as an interesting clue rather than an inconvenience to be swept under the rug.

References

Asher, J. E., Aitken, M. R., Farooqi, N., Kurmani, S., & Baron-Cohen, S. (2006). Diagnosing and phenotyping visual synaesthesia: A preliminary evaluation of the revised test of genuineness (TOG-R). *Cortex*, *42*, 137–146.

Cytowic, R. E., & Eagleman, D. M. (2009). *Wednesday is indigo blue: Discovering the brain of synesthesia*. Cambridge, MA: MIT Press.

Dixon, M. J., Smilek, D., Cudahy, C., & Merikle, P. M. (2000). Five plus two equals yellow. *Nature*, *406*, 365.

Eagleman, D. M., & Cheng, S. (2011). *Is synesthesia one condition or many? A large-scale analysis reveals sub-groups*. Manuscript submitted for publication.

Eagleman, D. M., & Goodale, M. A. (2009). Why color synesthesia involves more than color. *Trends in Cognitive Sciences*, *13*, 288–292. doi:10.1016/j.tics.2009.03.009

Eagleman, D. M., Kagan, A. D., Nelson, S. S., Sagaram, D., & Sarma, A. K. (2007). A standardized test battery for the study of synesthesia. *Journal of Neuroscience Methods*, *159*, 139–145. doi:10.1016/j.jneumeth.2006.07.012

Rouw, R., & Scholte, H. S. (2007). Increased structural connectivity in grapheme-color synesthesia. *Nature Neuroscience*, *10*, 792–797. doi:10.1038/nn1906

Simner, J. (2012). Defining synaesthesia. *British Journal of Psychology*, *103*, 1–15. doi:10.1348/000712610X528305

Simner, J., & Hubbard, E. M. (2006). Variants of synesthesia interact in cognitive tasks: Evidence for implicit associations and late connectivity in cross-talk theories. *Neuroscience*, *143*, 805–814. doi:10.1016/j.neuroscience.2006.08.018

Ward, J., Huckstep, B., & Tsakanikos, E. (2006). Sound-colour synaesthesia: To what extent does it use cross-modal mechanisms common to us all? *Cortex*, *42*, 264–280.

Ward, J., & Simner, J. (2003). Lexical-gustatory synaesthesia: Linguistic and conceptual factors. *Cognition*, *89*, 237–261.

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