Defining synaesthesia

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Abstract

Studies investigating developmental synaesthesia have sought to describe a number of qualities that might capture in behavioural terms the defining characteristics of this unusual phenomenon. The task of generating a definition is made more difficult by the fact that any description of synaesthesia must be broad enough to capture the 61 different variants of the condition already reported to date. Given these difficulties, the current literature now contains a number of conflicting assumptions about the nature of this condition. Here I attempt to address several of these divisive areas from a set of contemporary definitions. I present evidence that might argue against previous claims that synaesthesias is (a) a 'merging of the senses', which (b) gives rise to consistent synaesthetic associations over time, with (c) synaesthetic associations that are spatially extended. I then investigate the possible benefits of moving from a behavioural definition to a neuro-biological one and explore the ways in which this might force a rethink about the potential outermost boundaries of this fascinating condition.

Introduction

The history of synaesthesia research is approaching its 200th year since the first known account by Georg Tobias Ludwig Sachs in 1812 (see Jewanski, Day & Ward, 2009). In recent decades the field has experienced a resurgence of interest, and this revived focus has provided a contemporary source of study for a broad range of scientists. Inherent in any broad sustained interest is the importance of establishing a clear definition of the focus of study, although remarkably, the literature contains a number of conflicting assumptions about the very definition of synaesthesia. Across studies, and across labs, scientists have taken subtly different approaches in their description of this condition, and of the necessary and/or sufficient characteristics required to recognize and safely catergorise any given case as a clear instantiation. The aim of this paper is to highlight several key areas within this literature that might divide the research community when defining synaesthesia, and which I take as the basis for closer inspection.

All accounts of synaesthesias are based on a set of core facts: that a small percentage of the population report extra-ordinary sensations of colours, tastes, shapes etc., triggered by everyday activities such as reading, listening to music, eating, and so on. Synaesthetes might see colours when they hear sounds, for example (known as *music–colour synaesthesia*; Ward, Huckstep & Tsakanikos, 2006) or experience tastes in the mouth when reading or speaking (known as *lexical–gustatory synaesthesia*; Ward and Simner, 2003). These sensations are explicitly experienced in that synaesthetes are consciously aware of them in daily life. The synaesthetic sensations supplement, but do not replace, the usual modality-specific perceptions. So for example, synaesthetes seeing colours when exposed to musical

sounds experience those colours along side the usual, everyday auditory sensations that those sounds would trigger in the average person.

A single shared understanding of the definition of synaesthesia might be considered especially important because it is a multi-variant condition, incorporating a number of extremely diverse phenomenological experiences. At least 61 different manifestations of the condition have been reported to date (Day, 2005; 2009), each with its own profile of triggering stimulus (known as the *concurrent*) and resultant synaesthetic experience (known as the *inducer*; Grossenbacher, 1997). For example, synaesthesia might be triggered by inducing stimuli as diverse as tasting flavours in the mouth, or imagining the meaning of words, and it might trigger concurrent experiences as different as sounds, shapes, colours, tastes, smells, feelings of touch and so on. This wide range of experiences presents a challenge for any researcher aiming to generate a single definition that covers all variants, and it is perhaps for this reason that differences in definitions have arisen within the literature. In aiming to address these conflicts, I will necessarily paint a picture of my own interpretation of synaesthesia, and so I will end this article with a brief summary of what is agreed upon within the community, as well as those particular characteristics that my own experience in this field has led me to consider as the key qualities of this unusual condition.

This article is divided into sections according to four areas of consideration on which we might work towards a unified definition of synaesthesia. My summary will necessarily focus on a relatively small set of core definitional criteria, rather than attempting to describe all characteristics of the condition. For example, one known characteristic of synaesthesia appears to be that experiences tend to mimic the implicit associations felt by most people

(e.g., Harrison & Baron-Cohen, 1997). In music-colour synaesthesia, for example, both synaesthetes and non-synaesthetes pair high-pitch sounds with light/bright colours, although synaesthetes experience these colours to a conscious or perceptual degree, while non-synaesthetes feel them only intuitively (Ward et al., 2006; see Simner, 2009 for other examples). In other words, there may be a common mechanism accounting for cross-modal associations in both synaesthetes and non-synaesthetes, which is simply more pronounced in the former group. This type of characteristic, however, is not included in my list of definitional qualities because this feature may be an emergent characteristic of the condition (perhaps arising from some underlying psychological mechanism) rather than being clearly a definitional feature.

Issues in the Definition of Synaesthesia

Synaesthesia as a 'Merging of the Senses'

The history of synaesthesia research is rife with accounts that describe the condition as a 'merging of the senses' or as some type of 'cross-sensory' experience in which *sensory/perceptual* stimuli trigger unusual *sensory/perceptual* experiences. Asher et al. (2009; p. 279) for example define synaesthesia as 'characterized by anomalous sensory perception' (see also Simner & Ward, 2006; Asher et al., 2006; Baron-Cohen et al., 2007 etc.). This definitional criterion of synaesthesia as a sensory phenomenon, triggered by, and evoking sensory/perceptual events likely stems back to the early naming of the condition as *syn-* (joining) and *–aesthesia* (sensation). However, a wealth of evidence now shows that describing synaesthesia in purely sensory-perceptual terms is only able to partially capture the nature of this multi-variant condition (and at worse, it may be a misnomer that misdirects the focus of study in significant ways). Hence, while there are indeed variants of

synaesthesia that seem to be truly cross-sensory (e.g., visual perceptions of colour triggered by auditory pitch variations in sound), a very large number of synaesthesias are not. This latter group comprises those synaesthesias that are triggered by, or give rise to, higher-order cognitive constructs. For example, the overwhelming majority of synaesthesias appear to be triggered by the high-order cognitive constructs involved in language comprehension and production. One recent prevalence study, for example, showed that 88% of synaesthesias were triggered by language units such as graphemes, phonemes, and words (Simner et al., 2006). A closer inspection of these sub-variants confirms that most appear to be triggered by linguistic processing per se, rather than by the low-level sensory/perceptual functions used in the detection of written forms or spoken sounds, and this distinction is addressed in more detail below.

To appreciate the role of high order cognition in synaesthetic inducers, we might take as our starting point those synaesthetes who experience colours from alphabetic letters (e.g., *a* = red). The question here is whether letter-colour synaesthetes are triggered by the visual curvatures and junctures of the written form on the page (or the acoustics of the speech sounds made when pronouncing these letters aloud), or whether they are triggered by the associated higher-level linguistic category. In the former case, the condition might be truly sensory/perceptual; in the latter, it would have a trigger that is high-level conceptual. One way to determine this is to assess whether synaesthetic sensations are sensitive to the specific visual form of the particular instantiation of the letter (e.g., to its font, or to whether it is upper-case or lower-case, or to whether it is italicized or bold, and so on). It appears that the majority of those with coloured letters are largely *in*sensitive to such variations. Hence, for most synaesthetes, visually distinct forms can induce the same colour

so long as they are members of the same linguistic category (e.g. ‘a, *a*, A, a’ and ‘**a**’ might all be experienced as red; Grossenbacher & Lovelace, 2001; Smilek, Dixon, Cudahy, Merikle, 2001). Equally, an ambiguous symbol (e.g., l) can induce different colours depending on context (compare l2345 vs. lmnop; Myles, Dixon, Smilek, Merikle, 2003; Dixon, Smilek, Duffy, Zanna, Merikle, 2006). In other words, the colour of each letter appears to be reliant in the *category* of the letter, rather than its perceptual features, and this allows synaesthetes to declare that ‘a is red’ rather than ‘one particular lower case non-italic ‘a’ is red, but the others are not’.

The facts above suggest that for a large number of synaesthetes, the condition is not purely sensory/perceptual (with respect to the inducer at least), and that any definition reliant on this claim might overlook the overwhelming majority of (linguistic) manifestations of synaesthesia. At the same time, the picture is somewhat more complicated and we might wish to avoid a simplification of the facts. There are three points to consider here for a more measured approach. Firstly, since synaesthesia is a heterogeneous condition, there are, in fact, *certain* letter-colour synaesthetes who may indeed be sensitive to the low-level visual form of triggers, and these are called ‘lower synaesthetes’ (compared to the conceptually driven ‘higher synaesthetes’; Hubbard & Ramachandran, 2005; Hubbard, Arman, Ramachandran & Boynton, 2005). A true lower synaesthete would have colours for letters that are wholly dependent on their particular visual instantiation (e.g., the letter ‘a’ may be different in colour to the letter ‘a’). Nonetheless, initial observations suggest that lower synaesthetes may constitute only a very small proportion of synaesthetes overall; instead, most appear to be triggered by the conceptual notion or categorization of the inducer. (This has been observed by others, and appears to me to be true simply by observation across

the many letter-colour synaesthetes encountered in the literature, and encountered in my own lab, but it is important to note that no study to date has systematically and empirically addressed this question.) A second consideration is that, even for higher synaesthetes, it might yet be the case that changes in the visual form (e.g., font changes) could indeed have at least *some type of* influence on the colour of letters, albeit a very subtle one. To understand this point we need to consider that most of our published knowledge on the synaesthetic colours of letters has come from asking synaesthetes to name their colours. If a synaesthete states that two very different visual instantiations of the letter 'a' are both red, we might initially assume that the visual form plays no role. However, it would remain unclear whether there might be more subtle colour changes in the synaesthetic concurrent arising from the subtle visual changes in switching font (and this was first noted by Witthoft & Winawer, 2006). For example, synaesthetes may reply in both cases that 'a' is red, even though one red may be more luminant or saturated than the other. One study (Ramachandran & Hubbard, 2003) suggests this might be the case, since at least one synaesthete reported that high-frequency fonts (e.g. Times) elicit more 'vivid' synaesthetic colouring than low frequency fonts. This effect has been empirically validated for another synaesthete, reported by Witthoft and Winawer (2006), for whom font changes caused significant differences in the saturation of synaesthetic colours. This synaesthete, AED, experiences colours that are significantly more saturated in Times compared to Sand font, and similarly, she experiences uppercase letters as significantly more saturated than lowercase. Hence for two synaesthetes at least, purely visual (non-cognitive) characteristics such as font and case do appear to influence synaesthetic colours. Nonetheless, whether this is an unusual characteristic limited to very few synaesthetes, or one typical of many synaesthetes more broadly is unknown.

One third piece of evidence that perceptual/sensory factors may subtly influence otherwise conceptually-triggered synaesthesias comes from Eagleman (2010). Eagleman has recently shown that the visual form of letters may have an impact on their colouring. His data suggest that letters that are similar in shape (e.g., b, d) may be closer in colour than those that differ in shape (e.g., b, x). In a similar way, Mills et al. (2002; also Witthoft & Winawer, 2006) have shown that visual similarities in letters can dictate how colours are transferred across alphabets in bilingual synaesthetes (e.g., the Cyrillic letter И and the Arabic letter N tend to be coloured similarity for English-Russian bilingual synaesthetes, as do Я and R). In other words, synaesthetic systems appear to be built around perceptual features at least to some degree. However, the exact nature of this visual influence remains unclear. It is possible that perceptual/visual influences may play absolutely no role whatsoever in the actual *triggering* of the synaesthetic experience. Instead, the colouring of letters according to shape may occur at some very early stage during development when synaesthetic colours are first established. Once these connections are formed, however (i.e., once letters are now paired with their corresponding colours) the synaesthetic experience may become largely insensitive to low-level visual features. In other words, an adult synaesthete experiencing colours from letters may yet be triggered by the higher level conceptual category of that letter, even if the original pairing of letter and colour during childhood was based on perceptual features (see Simner & Ward, 2006 and Simner & Haywood, 2009 for a comparable account of how developmental processes may differ from adult mechanisms in lexical-gustatory synaesthesia).

Thus far I have argued against the notion of synaesthesia as a 'merging of the senses' due to apparent cognitive influences in the nature of the inducer. I now turn to a similar argument relating to the synaesthetic concurrent. The concurrent, too, might also involve wholly cognitive (non-perceptual) constructs. Since the late 19th century, accounts of synaesthesia have included the phenomenon of sequence-personality mapping (also known as *Ordinal Linguistic Personification* (OLP) synaesthesia; Simner & Holenstein, 2007). In this condition, ordered linguistic sequences, such as letters, numbers, days of the week, months of the year (etc.) give rise to the automatic and overwhelming impression of a personality type or gender. So for example, the letter 'a' might be a busy mother while the number '9' may be a devoted husband (e.g., Flournoy, 1893; Simner & Holenstein, 2007; Simner & Hubbard, 2006; Smilek, Malcolmson, Carriere, Eller, Kwan, & Reynolds, 2007). Simner and Holenstein (2007) provide a series of arguments for why this condition should be considered a synaesthesia, even though it is clearly something *other* than 'a merging of senses'. First, as in other variants of synaesthesia, OLP involves the pairing of dimensions from two otherwise unrelated modalities, which become automatically and developmentally associated (and Simner & Holenstein provide evidence for the automaticity of these associations using a modified stroop task; see Simner & Holenstein, 2007, for details). Second, Simner and Holenstein point out that sequence-personality mappings are triggered by what is elsewhere known to be the most common triggers of synaesthesias in general (i.e., ordered linguistic sequences, which themselves trigger 82% of synaesthesias overall; Simner et al., 2006). Third, Simner & Holenstein show that individuals with sequence-personality mappings are significantly more likely than the average person to have a second variant of synaesthesia. In particular, those with OLP were over ten times more likely than the average person to have grapheme-colour synaesthesia. This fact is particularly

significant since it is known elsewhere that individuals with one variant of synaesthesia are significantly likely to have another, and the co-occurrence of OLP and grapheme-colour synaesthesia suggest the former may represent a variant of synaesthesia in its own right. Fourth, Simner & Holenstein show that the way in which synaesthetic sensations spread throughout words in OLP (words tend to take the personality of the initial letter) mirrors the mechanisms at work in other sequence-based synaesthesias (e.g., words tend to take the colour of the initial letter, in grapheme-colour synaesthesia; e.g., Simner et al., 2006). This suggests a shared underlying psychological mechanism of the kind we might expect if both were different manifestations of the same condition. Finally, Simner & Holenstein point to other similarities between OLP experiences and those of a range of other, accepted synaesthesias, such as their stability over time, their vividness, their early onset, their intricate detail, and so on. For all these reasons, it appears that OLP strongly resembles a true variant of synaesthesia, suggesting in turn that synaesthesias need not be limited to purely sensory phenomena.

Finally, I point out that a number of other, well-accepted variants of synaesthesia also have cognitive rather than perceptual concurrents. In lexical-gustatory synaesthesia, for example (e.g., Ward & Simner, 2003; Ward et al, 2005; Simner & Ward, 2006; Simner & Haywood, 2009) in which words trigger associated food experiences, these experiences may be either sensory (i.e., a perceptual sensation of flavour in the mouth) or may be non-perceptual/cognitive in nature (i.e., a 'mental link' to a food-type, which automatically enters into consciousness when the inducing word is encountered). For example, while synaesthete MM experiences the name 'John' as the perceptual flavour of food (cornbread) in the mouth, synaesthete PS experiences the overwhelming *notion* of food (orange-

flavoured jelly) when he encounters the word ‘shoulder’. In this way too, therefore, even well accepted variants of synaesthesia can involve what are clearly non-sensory conceptual constructs as their concurrents.

In wrapping up this section I turn to my final and perhaps most important point, which relates to the neurological roots of the condition. Any theory of synaesthesia that seeks to limit cases to only those instances involving sensory constructs must provide a plausible underlying neurological mechanism for this type of restriction. Brain imaging studies have shown the neurological basis of synaesthesia. Functional magnetic resonance imaging (fMRI), shows that individuals experiencing synaesthetic sensations have atypical brain activity that mirrors their synaesthetic reports. For example, those who report colours from words or letters (grapheme–colour synaesthetes) show activity in colour selective regions of the visual cortex during language comprehension (Aleman, Rutten, Sitskoorn, Dautzenberg, Ramsey, 2001; Hubbard et al., 2005a; Hubbard & Ramachandran, 2005; Sperling, Prvulovic, Linden, Singer & Stirn, 2006; Nunn et al., 2002). Moreover, this activity has been linked in one study (Rouw & Scholte, 2007) to increased structural connectivity in the synaesthetic brain using the technique of diffusion tensor imaging (DTI). This methodology indicates the presence of white matter fibre pathways by tracking the diffusion patterns of water molecules in the human brain. Evidence from DTI (Rouw and Scholte, 2007) showed that synaesthetic experiences were linked to pockets of hyper-connectivity in a group of grapheme-colour synaesthetes, and it is this hyper-connectivity that may mediate the type of neurological ‘cross-talk’ that is inherent in synaesthesia. Any account of synaesthesia that seeks to limit its definition to only sensory variants must present a plausible neurological

mechanism which would allow pockets of hyper-connectivity in perceptual regions only, but in no other. This author knows of no such selective mechanism.

In this section I have presented a number of arguments for why synaesthesias might be considered more than a 'merging of the senses', and suggest that a clear definition should avoid generating the suggestion that it is. Any forward-looking definition would incorporate the very wide range of synaesthesias attested to date, in which both inducers and concurrents can apparently constitute either low-level perceptual, or higher-order cognitive constructs, and it should be based on a plausible neurological mechanism. Barnett, Finucane, Asher, Bargary, Corvin, Newell & Mitchell (2008), for example, apply the term synaesthesia to 'a range of different sensory-perceptual and cognitive experiences' (p. 871) and this type of definition would seem to be appropriately inclusive. Nonetheless, the description 'a merging of the senses' is of course a hugely useful coin of phrase when describing synaesthesia to the layman, although there is a danger in allowing a literal interpretation of this definition. It may, for example, have biased early academic treatments to especially focus on the sensory characteristics of synaesthesia (see Simner, 2007 for discussion). In this way, the expression has been something of a double-edged sword: it has both greatly improved the dissemination of knowledge about the condition, while at the same time introducing a potential fallacy about its very nature.

Synaesthetic Associations are Consistent over Time?

A second defining characteristic of synaesthesia has been that synaesthetic associations are consistent over time. For example, if the letter 'a' is carmine red, it is consistently that same colour when the synaesthete is asked on repeated occasions. This characteristic been

proposed among a series of explicit definitional criteria (e.g., Cytowic, 1997; 2002) as well as being repeated in almost every paper in the contemporary literature to date (e.g., Brang & Ramachandran, 2010; Baron-Cohen, Burt, Smith-Laittan, Harrison, & Bolton, 1996; Baron-Cohen, Wyke, & Binnie, 1987; Palmeri, Blake, Marois, Flanery, & Whetsell, 2002; Rich, Bradshaw, & Mattingley, 2005; Simner, 2007; Ward, Jonas, Dienes, Seth, 2010; Ward & Simner 2003). The consistency of synaesthetic experiences has been described as so central that it constitutes "a fundamental characteristic of synaesthesia" (Simner, 2007; p. 696) and the test of consistency has come to be considered as the behavioural "gold standard" for determining the genuineness of the condition (Rich et al., 2005; p. 55). As such, synaesthetes tend to be included in empirical studies only after having passed a consistency test (Baron-Cohen et al., 1987) and those who fail are excluded. In a typical consistency test, synaesthetes first provide a set of their synaesthetic associations (e.g., the colours for each of their letters) and are then given a surprise retest some considerable time later (e.g., after 6 months; Ward & Simner, 2003). Their consistency is compared to a group of control non-synaesthetes, who invent analogous associations and then recall them by memory alone, often after a far shorter interval (e.g., 2 weeks) and sometimes with a monetary incentive to perform well (e.g., Ward & Simner, 2003). Only those potential synaesthetes who significantly outperform controls are considered genuine, and included for further study.

Given this trend for consistency verification in current scientific research, it is now the case that virtually all synaesthetes reported in the literature are precisely those who show consistency. This certainly has its uses. The consistency test allows us to rule out malingerers, for example. In one large-scale study of synaesthesia, only one in six people who initially reported synaesthesia went on to be ultimately classified as a synaesthete

(Simner et al., 2006), and this is because the vast majority were in fact not synaesthetic at all, by their own admission. For example, a very large number were individuals who had misunderstood the nature of synaesthesia despite careful descriptions (e.g., they were artists, who mistook synaesthesia for a heightened appreciation of colour). Another large group were self-confessed malingers who initially claimed to fit the description of a synaesthete, but then subsequently retracted their claims in full when asked again at a later date. Crucially, however, a smaller minority were individuals who appeared to understand the nature of the condition, and who felt strongly that they experienced it, and who did not change their mind at a later date, but who failed to pass the test of consistency. For example, the typical synaesthete is around 80-100% consistent over time and controls are around 20% consistent, while the group in question fell somewhere in between. This would make them too inconsistent to statistically outperform controls, while still showing a slight tendency to repeat the same descriptions over time. Finally, a further smaller population reported synaesthesia but claimed from the start that their sensations may *never* be consistent, and who accordingly performed very poorly.

What then should we make of these individuals who fail the consistency test while reporting synaesthetic sensations? There are two interpretations: either these are malingerers reporting phenomenological experiences that are simply untrue, or they are genuine synaesthetes, but where the condition cannot be fully captured by a consistency requirement. Put differently, individuals who claim to have synaesthesia while failing the consistency test raise the issue of whether synaesthesia is truly consistent over time *as a definitional criterion*, or whether, instead, consistency over time merely characterizes a subset of synaesthetes only. Indeed it might be argued that the criterion of consistency over

time is something of a circular definition; it fits the profile of those synaesthetes in the literature precisely because they have been selected as such. In essence then, the literature has been self-selecting a biased sample of *consistent* synaesthetes, while at the same time claiming that consistency is a necessary feature. A very similar argument about biased selection has been made by Eagleman (2009; see also Cohen Kadosh & Henik, 2007) who points out a similar circularity in defining a variant of synaesthesia known as sequence-space synaesthesia (SSS; or visuo-spatial forms; Sagiv, Simner, Collins, Butterworth & Ward, 2006). Sequence-space synaesthetes see ordered linguistic sequences (e.g., days of the week, letters of the alphabet) arranged in particular spatial arrays. For example, the months of the year might be arranged in an ellipse around the body. These arrays are often described as non-linear and convoluted (e.g., figures of eight; zig-zags etc.) and this convoluted quality has become almost a defining feature of SSS. Nonetheless, in one recent large-scale assessment (Eagleman, 2009), a considerable portion of 571 self-reported sequence-space synaesthetes in fact described their forms as linear. Eagleman points out that this high prevalence of straight lines suggests that straight lines might be entirely compatible with the condition, and that

> "[this] suggests the interesting possibility of selection bias in previous reports on spatial sequence synaesthesia: often, when investigators are trying to determine whether a subject is synaesthetic, they are impressed by striking and unusual shapes and pursue such reports further. On the other hand, when a subject testifies, ''In my mind, the months proceed from left to right in a line,'' she is often dropped from further analysis given the uncertainty of whether she is simply reporting what has been previously seen on a calendar" (Eagleman, 2009; p. 1270).

Therefore, in the same way that the literature may have been biased in selecting synaesthetes with idiosyncratic sequence-space forms (while claiming this is a general characteristic), it may also have been biased in selecting synaesthetes who are consistent over time. Given this, we might call for a more careful assessment of the role of consistency in synaesthetic reports, and this might in turn lead to alternative tests of genuineness that do not rely on the questionable quality of consistency.

Synaesthesia is Spatially Mapped?

One influential defining characteristic of synaesthesia has been that synaesthetic concurrents are spatially extended (e.g., Cytowic, 2002) meaning they have a particular location in space. For example, individuals with SSS for days of the week can often point to the location in space where each day resides (see Simner, 2009 for links to many examples). Equally, those who experience coloured photisms from listening to music can often describe the direction of the movement of these photisms (Ward, Moore, Thompson-Lake, Salih & Beck, 2008). Moreover, some individuals with coloured letters can point to the particular location in space where these colours are found (e.g., they may be superimposed on the type-face of written text). It is clear then, that a number of synaesthetes indeed experience a spatial quality to their concurrent sensations. What is *not* clear, however, is whether this is a *defining* characteristic of the condition. Indeed, it has long been known that synaesthetes differ in the nature of their concurrent experiences, and the distinction of *projectors* versus *associators* describes, respectively, synaesthetes who experience their concurrents projected into space, and those who do not (Dixon, Smilek & Merikle, 2004). In this latter group, there are yet some cases where non-projected concurrents might still be spatially defined. For example, a synaesthete who sees colours from music only ‘in the

mind's eye' (not projected into space) can still describe the movement of colours, and their relative positions within a *mental* space. Crucially, however, there is also a set of synaesthetes who appear to have no spatial component to their associations whatsoever. For example, some associator grapheme-colour synaesthetes simply *know* the colours of their letters, without any impression or location in space (see Ward, Li, Salih, & Sagiv, 2007, where these are termed 'know-associators'). Edquist, Rich, Brinkman & Mattingley (2006), for example, present a careful analysis of the subjective locations of synaesthetic colours in a group of grapheme-colour synaesthetes, and show that a portion of these individuals simply cannot describe the colours as being in any particular location, neither in the mind's eye nor projected outside the body. In a similar way, there are cases of lexical-gustatory synaesthetes (see above) who have no spatial component to their synaesthesia either. These 'associator' lexical-gustatory synaesthetes have food associations for words which they experience as 'mental links' rather than as perceptual experiences located in the mouth. In this way, I suggest that the criterion of spatial location be dropped now from definitions of synaesthesia, and considered instead as simply a useful early attempt to focus research, but one that has failed to capture all manifestations of the condition on further scrutiny.

Synaesthesia Neurologically Defined?

To end this discussion I return to the roots of synaesthesia in neurological terms, to ask what, if anything, the biological basis of this condition might tell us about how to approach the task of setting a definition. We have seen above that synaesthesia represents a type of atypical cross-talk between brain functions (e.g., between functions of letter and colour awareness) and that this may be reflected in neurological terms by some type of hyper-

association between brain regions (perhaps by an excess of white matter fibres; Rouw & Scholte, 2007). The exact interpretation of what this neurological 'hyper-association' involves (i.e., hyper-connectivity, or some other mechanism) is not strictly relevant to the discussion at hand, and I direct the reader to the excellent discussion by Bargary and Mitchell (2008) who examine the roots of synaesthetic cross-talk as either functional or structural mechanisms. Equally, the current discussion is not concerned either with the neuro-*developmental cause* of this hyper-association. It may be the result of a failure to prune early abundant connections in the normal infant brain (Baron-Cohen, 1996; Maurer 1993; Maurer & Mondloch, 2005; see also Blakemore, Bristow, Bird, Frith, & Ward, 2005; Cohen Kadosh & Henik, 2007; Hubbard & Ramachandran, 2005). Alternatively, it may be the result of anatomical reorganization following the disinhibition of existing pathways which are normally masked in the brains of average adults (e.g., Cohen Kadosh, Henik, Catena, Walsh, & Fuentes, 2009). For the purposes of the current debate, we need simply to acknowledge that some type of underlying neurological event gives rise to some type of neurologically-mediated cross-talk. I refer to this here for simplicity (but without a strong theoretic position) as a neurological 'hyper-association', and this hyper-association may reflect either 'extra wires or altered function' (Bargary & Mitchell, 2008; p. 335).

Taking this neurological hyper-association as our starting point, I here ask whether synaesthesia might reasonably be *defined* in these neurological terms, and what, if anything, this might do to limit or extend our understanding of the condition. Assume then that (developmental) synaesthesia becomes defined in biological terms as an inherited condition which gives rise to neuro-developmental differences leading to excess association between otherwise separate regions. Assume also that this type of biological underpinning might be

clarified in future studies across a range of different manifestations (and it is at least reasonable to expect that the phenomenological cross-talk that generally defines synaesthesia in behavioural terms will indeed have some parallel neurological cause across a range of variants). Let us now ask what implications might arise from taking this biological characteristic as the definitional criterion of synaesthesia.

One advantage of a biological definition, in terms of unusual neurological cross-talk, is that we might begin to understand the full potential of synaesthesia, and the full range of manifestations it might incorporate. At present, the current count of synaesthetic variants lies at 61, and these variants are being expertly collected by Day (e.g., Day, 2005; 2009) each time a new case presents itself to the American Synesthesia Association. However, one problem with counting cases in this way is that we open ourselves up to a self-report bias. Individuals might only seek to contact researchers (or synaesthete associations) if they realize that their experiences are unusual. They might also only present themselves if their experiences clearly match the widely circulated definition of a 'merging of the senses'. In other words, we may be counting only the more extreme cases (e.g., tasting words, seeing music), or a skewed proportion of cases that have a specifically perceptual bent. In contrast, there may be a myriad of more subtle, more abstract, more hidden variants that fail to come to light because of existing definitional problems, or for reasons relating to the degree to which an individual can ascertain that they differ from the average person (Sinha, 2010). This type of self-referral bias, if it exists, would at the same time perpetuate itself because the condition would become defined by those cases that become known, and not by those that remain hidden.

To avoid this circular evidence of what synaesthesia is and is not, we might instead define synaesthesia in terms of it neurological basis, and then allow ourselves to consider what types of variants this synaesthesia might then include. If indeed the condition were defined by inherited atypical cross-talk, we might find synaesthesias in unexpected places. For example, if an inherited predisposition for neurological hyper-association manifested itself, say, in the fronto-temporal language regions that mediate semantics, lexical-forms and syntax (e.g., see Tyler & Marslen-Wilson, 2008 for review) what would this mean? It might mean we could find 'synaesthetic' individuals with unusually strengthened connections in spoken language processing. Such an individual would perhaps be extraordinarily verbally adept; and if the hyper-connectivity were in regions responsible for language production, (s)he might be a prodigious writer, speaker or thinker, and be able make automatic and extra-ordinary connections between words. This type of experience would never usually be linked to synaesthesia, but might reasonably be hypothesized if we were to naturally explore the limits of a biological definition.

One clear prediction from this approach is that such individuals would have relatives who share their hyper-associative inheritance, but have it manifested as a more typical synaesthesia. In other words, the 'verbal synaesthetes' hypothesized here arising from hyper-association in fronto-temporal regions might be more likely than the average person to have siblings, parents or children with grapheme-colour synaesthesia, or sequence-space synaesthesia, or any other of the more typical variants of the condition. Additionally, because individuals with one manifestation of synaesthesia are significantly likely to have another (Simner et al., 2006) any individual with this type of 'verbal synaesthesia' may herself also show additional, more typical variants of the condition. An assessment of

whether any such 'hidden' synaesthesias exist and how they might cluster with other variants would make a vital contribution to this debate, and may provide support for the proposal that synaesthesia could be usefully defined in hyper-associative neurological terms. However, it would still be a question for debate whether such 'hidden' synaesthesias should indeed be considered as types of synaesthesia *in their own right*, or whether they should simply be considered co-lateral features caused by a similar neurological root (see Ward, 2008 for discussion).

In this section I have explored the possibility of a biological definition of synaesthesia and proposed ways in which this might extend our understanding of the condition and its manifestations. Whether or not the biological definition has merit is both a theoretical and empirical question, which I leave now for the consideration of the reader.

Summary

In this article I have proposed a series of issues for debate concerning the definition of synaesthesia. In doing this, I have also presented my own thoughts from an interpretation of the literature as it has developed in recent years. I have suggested four areas for consideration in regards to how this literature might seek to define synaesthesia, and I raise these issues in order to trigger a debate about how to best approach this fascinating phenomenon. First, I have suggested that a number of known (and accepted) variants of the condition resist being described by the ubiquitous moniker of 'a merging of the senses', and that any attempts to continue defining the condition in these terms (other than for its useful shorthand) must address the following points. First, we must reconcile this definition with the very many variants of synaesthesias that are triggered by, or give rise to, high order

cognitive constructs such as language, personality and other abstract notions. These facts suggest that for most synaesthetes, the condition is not purely sensory/perceptual, and that any definition reliant on this suggestion would overlook the overwhelming majority of synaesthesias attested to date (Simner et al., 2006). To inform this debate, we might invite a closer consideration of how low-level perceptual features might drive otherwise cognitive variants, and of any higher level contributions on otherwise sensory/perceptual variants. The second task for anyone wishing to promote a view of synaesthesia that is solely sensory/perceptual would be to provide a plausible neurological mechanism to explain exactly how such a condition could operate. Specifically, they would have to explain how hyper-connectivity (or other hyper-associative neurological mechanisms) come to link perceptual regions only.

A second point raised here concerns definitions of synaesthesia that rely on the proposal that synaesthetic associations (e.g., a=red) are consistent over time. I have suggested here an alternative view, that synaesthesia may not be limited to this definition. Following a type of argumentation from Eagleman (2009) I suggest that the science literature might be creating a circular self-selection bias in recruiting only those synaesthetes who are consistent over time, and then presenting this body of participants to suggest that consistency is a necessary feature of the condition. One fact at least is true: large scale sampling studies have shown that even when self-confessed malingers or disabused individuals are removed from study, there still remain those individuals who claim to have otherwise typical synaesthetic experiences, but whose experiences are not necessarily consistent over time. Future study might provide some assessment of the extent to which these individuals fall short of the 80-100% consistency usually reported. It is possible we

may yet find that consistency is indeed a characteristic of the condition, but definitionally speaking only consistency at a far greatly reduced level. In other words, perhaps all synaesthetes do show consistency over time, but this consistency may vary between the 100% typically implied in definitions, and a far reduced level that may not be *significantly* different to groups of non-synaesthete controls.

A third issue raised here is that definitions of synaesthesias have specified that the synaesthetic experience is spatially defined, and I have suggested that while this is true of some variants, it does not seem to be a definitional requirement. The reports of a wider range of synaesthetes suggest that synaesthetic experiences *may be* spatially afforded, but can also occur in a way that is devoid of a spatial location. Some variants of the condition may simply resist any notion of spatial affordance whatsoever because they produce wholly cognitive constructs (e.g., a personality type or gender) and other variants may generate the notion of a percept (e.g., the sense of redness) without a spatially defined co-ordinate.

The final point raised here was to provide one possible approach to defining the condition which might be drawn from our emerging knowledge about the neurological basis of synaesthesia. Here I propose that one interesting approach might be to define the condition in its neuro-biological terms, and then allow this definition to inform us about the possible range of synaesthesias that may exist. One advantage of this approach is to provide a clear definition that resists the confusions arising from a behavioural approach. However, the merits and drawbacks of this type of definition are not yet known, and of course it rests on the assumption that a unifying neuro-biological cause will indeed be found (i.e., for all variants). We may yet find that the evidence for hyper-connectivity, say, shown thus far for

grapheme-colour synaesthetes does not extend to other variants, or that the developmental hyper-connectivity account is too broad in allowing conditions that show a phenomenological profile so significantly different from other variants that it should be excluded from what we understand as 'synaesthesia'. Nonetheless, the biological definition presented here might yet allow us to expand our knowledge, and could inform us in ways that a behavioural definition might otherwise fail to do.

In ending this article, I return to those facts on which we tend to agree as a scientific body. Synaesthesia is characterized by the pairing of a particular triggering stimulus with a particular resultant experience. It affects a relative minority of people, and so appears to be defined by the fact that synaesthetes *differ* in their experiences to the average person. Synaesthesia has many manifestations but across all variants, the synaesthetic experience arises spontaneously, without effort, and in ways that the synaesthete tends to accept as normal within their own realm of experience. It is hoped that the suggestions presented here might help us come closer to a shared understanding about the limits of how to define this condition, and provide a platform for future research.

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