Consciousness and Cognition 31 (2015) 73–85

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

Beyond visual imagery: How modality-specific is enhanced mental imagery in synesthesia?

Mary Jane Spiller [a,*], Clare N. Jonas [a], Julia Simner [b,c], Ashok Jansari [a,d]

[a] School of Psychology, University of East London, Water Lane, London E15 4LZ, U.K
[b] Department of Psychology, University of Edinburgh, 7 George Square, Edinburgh, EH8 9JZ, U.K
[c] School of Psychology, University of Sussex, Falmer, Brighton, BN1 9QH, U.K
[d] Department of Psychology, Whitehead Building, New Cross, London SE14 6NW, U.K

ARTICLE INFO

Article history:
Received 14 June 2013
Available online 15 November 2014

Keywords:
Synesthesia
Mental imagery
Visual imagery
Auditory imagery
Gustatory imagery
Tactile imagery
Olfactory imagery

ABSTRACT

Synesthesia based in visual modalities has been associated with reports of vivid visual imagery. We extend this finding to consider whether other forms of synesthesia are also associated with enhanced imagery, and whether this enhancement reflects the modality of synesthesia. We used self-report imagery measures across multiple sensory modalities, comparing synesthetes' responses (with a variety of forms of synesthesia) to those of non-synesthete matched controls. Synesthetes reported higher levels of visual, auditory, gustatory, olfactory and tactile imagery and a greater level of imagery use. Furthermore, their reported enhanced imagery is restricted to the modalities involved in the individual's synesthesia. There was also a relationship between the number of forms of synesthesia an individual has, and the reported vividness of their imagery, highlighting the need for future research to consider the impact of multiple forms of synesthesia. We also recommend the use of behavioral measures to validate these self-report findings.

1. Introduction

Individuals with synesthesia ('synesthetes') have anomalous perceptual experiences: sensory stimulation in one modality induces additional atypical experiences within the same or different modality. Sound-color synesthetes, for example, experience colors in addition to sound when hearing auditory stimuli (Ward, Huckstep, & Tsakanikos, 2006). Synesthesia can also be induced by cognitive concepts, with one common form being grapheme-color synesthesia, in which color perceptions are induced by reading, hearing or thinking about letters, numbers and words (Ward, Li, Salih, & Sagiv, 2007). Other documented examples include word-taste synesthesia (taste experiences from words), sound-taste synesthesia (taste experiences from non-linguistic sounds), auditory–visual synesthesia (experiencing visual geometric shapes from sound) and so on (e.g., Beeli, Esslen, & Jancke, 2005; Chiou, Stelter, & Rich, 2013; Ramachandran & Hubbard, 2001; Smilek, Callejas, Dixon, & Merikle, 2007; Ward & Simner, 2003; Ward et al., 2006). In the majority of cases synesthesia is developmental, and has been present for as long as the synesthete can remember, though in a minority of cases synesthesia can be acquired after sensory loss (e.g. Steven & Blakemore, 2004) or neurological damage (e.g. Fornazzari, Fischer, Ringer, & Schweizer, 2012). Importantly, these additional synesthetic experiences occur without effort and are generally consistent over time (but see Simner, 2012).

* Corresponding author at: School of Psychology, University of East London, Water Lane, London, E15 4LZ. Tel.: +44 (0)20 8223 4004; fax.: +44 (0)20 8223 4937.

E-mail addresses: m.j.spiller@uel.ac.uk (M.J. Spiller), c.n.jonas@uel.ac.uk (C.N. Jonas), j.simner@sussex.ac.uk (J. Simner), a.jansari@gold.ac.uk (A. Jansari).

http://dx.doi.org/10.1016/j.concog.2014.10.010
1053-8100/

Over the past ten to fifteen years, our understanding of synesthesia has grown considerably (Hubbard, Brang, & Ramachandran, 2011) and there now exists a large body of research showing a range of neural and behavioral traits associated with the condition. For example, there are differences between the brains of synesthetes and non-synesthetes, with synesthetes having greater structural connectivity in several different regions (Jancke, Beelie, Eulig, & Hanggi, 2009; Rouw & Scholte, 2007, 2010; Zamm, Schlaug, Eagleman, & Loui, 2013; for review see Rouw, Scholte, & Colizoli, 2011). There are also reported differences between synesthetes and non-synesthetes in the early sensory processing of visually presented stimuli (Barnett et al., 2008). Yet more research has started to explore the impact that synesthesia has on an individual's cognitive and perceptual abilities, with some data suggesting that synesthetes may show enhanced abilities in certain aspects of memory (for a review see Rothen, Meier, & Ward, 2012) and sensory perception (Banissy, Walsh, & Ward, 2009). In the current study we ask whether synesthesia is also accompanied by enhanced abilities in mental imagery.

Clearly, the key difference between synesthetes and non-synesthetes is that synesthetes have quasi-perceptual experiences in the absence of the usual external stimulation (e.g. they experience colors in the absence of visual stimulation). The *quality* of these experiences differs from synesthete to synesthete, with some describing their synesthetic experience (termed the "concurrent") as vivid and tangible and others describing them as simply a 'feeling of knowing' (Dixon, Smilek, & Merikle, 2004; Hubbard, Arman, Ramachandren, & Boynton, 2005; Ward et al., 2007). Even so, descriptions of synesthetic percepts often seem similar to descriptions of mental images, and while there are some differences between synesthetic concurrents and mental images per se (e.g., synesthetic concurrents are typically reported to arise in a very involuntary manner, while at least some types of mental images are more effortful in character) we might nonetheless investigate the mental imagery abilities of synesthetes as compared to those of non-synesthetes. Specifically, since mental imagery can be thought of as "seeing in the mind's eye in the absence of appropriate immediate sensory input" (Kosslyn, Thompson, Kim, & Alpert, 1995, p. 1335), and since this description could also be applied to at least some synesthetic experiences, one might ask whether synesthetes' mental imagery abilities are different to those of non-synesthetes (see also Simner, 2013).

A small number of studies have started to explore the question of mental imagery in synesthesia. Barnett and Newell (2008) focused on self-reported vividness of visual imagery, comparing a group of synesthetes to a group of non-synesthete matched controls. Strength of visual imagery was reported using the Vividness of Visual Imagery Questionnaire (VVIQ, Marks, 1973), a self-report measure which asks respondents to generate a series of visual images of various scenes, and to rate how clear and vivid particular elements of these scenes are in the 'mind's eye'. The results showed that as a group, synesthetes reported significantly more vivid visual imagery than the control group. Following on from this, Price (2009) looked at the self-reported imagery of *sequence-space synesthetes*. These individuals experience sequenced units such as letters, numbers and months in particular spatial arrays, for example, envisaging months in an ellipse shape surrounding the torso (Sagiv, Simner, Collins, Butterworth, & Ward, 2006). Using a different measure to the VVIQ, the Object-Spatial Imagery Questionnaire (OSIQ, Blajenkova, Kozhevnikov, & Motes, 2006), Price too found that sequence-space synesthetes reported stronger visual imagery than a control group (the same result was later found by Rizza & Price, 2012). Furthermore, Price found that compared to non-synesthetes, synesthetes reported using imagery more frequently on an everyday basis.

Price's study therefore supported Barnett and Newell's conclusion that enhanced visual imagery may be a common trait associated with synesthesia. However, most of the synesthetes in the Barnett and Newell study had grapheme-color synesthesia, and the synesthetes in the Price study were sequence-space synesthetes, limiting their conclusions to only forms of synesthesia with visual–spatial concurrents. Furthermore, the self-report questionnaires used by these authors are themselves limited to visual–spatial forms of imagery. However, it is possible to form mental images across all sensory modalities, for example to form images of sounds, smells, tastes or tactile experiences. In the current study we therefore widen the assessment of synesthetes' mental imagery to include different forms of synesthesia and different types of mental imagery (i.e., involving other sensory modalities).

If individuals with visual forms of synesthesia have enhanced visual imagery, this could be due to their everyday experiences of visual concurrents – a sort of practice effect – since improvements in imagery with practice have been shown elsewhere (Noll et al., 1985; Rodgers, Hall, & Buckolz, 1991). If so, we would expect the enhanced imagery to be restricted to the modalities of the synesthesia. For example, a grapheme-color synesthete may report enhanced visual imagery, but would not be expected to report enhanced taste imagery. The idea that imagery enhancement may be restricted to the modalities involved in an individual's synesthesia is supported by a recent study showing that synesthetes with visual concurrents showed enhanced visual perception but not enhanced tactile perception, and vice versa for synesthetes with tactile concurrents (Banissy et al., 2009). Of course it should also be noted that enhanced mental imagery within one modality could also be the *trigger* for synesthesia, rather than a consequence (see Price, 2013).

Alternatively, synesthetes may experience enhanced imagery across all sensory modalities and this general enhanced imagery could result from more widespread structural or functional brain differences. As argued by Rouw et al. (2011), in their review of studies exploring brain areas involved in different forms of synesthesia, a broad network of areas is involved in synesthesia, extending beyond the modality-related sensory areas to other regions (e.g., those involved in feature binding and cognitive control). Rouw et al. concluded that a general 'synesthetic constitution' is likely to have effects beyond synesthesia. This broad constitution might affect imagery more broadly, given what we know about the neurological basis of imagery. Studies looking at the neural activity of mental imagery in the general population have shown both modality-specific and modality-independent activation. For example, although creating a visual image triggers neural activity in visual areas of the brain (and auditory images in auditory areas and so on), there may also be a 'default mode network', or core