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ScienceDirect
Consciousness and Cognition 17 (2008) 1032–1039
Consciousness and Cognition
www.elsevier.com/locate/concog

Short Report

Synaesthesia is associated with enhanced, self-rated visual imagery

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Received 14 March 2007
Available online 12 July 2007

Abstract

Although the condition known as synaesthesia is currently undergoing a scientific resurgence, to date the literature has largely focused on the heterogeneous nature of synaesthesia across individuals. In order to provide a better understanding of synaesthesia, however, general characteristics need to be investigated. Synaesthetic experiences are often described as occurring 'internally' or in the 'mind's eye', which is remarkably similar to how we would describe our experience of visual mental imagery. We assessed the role of visual imagery in synaesthesia by sampling a large group of synaesthetes and found that they report experiencing more vivid mental images than controls. These findings have important implications for our general understanding of synaesthesia and, in particular, emphasize the need to control for visual imagery in behavioural and neuroimaging paradigms.

Keywords: Synaesthesia; Visual imagery; VVIQ

1. Introduction

In 1880 Sir Francis Galton claimed to be occupied in eliciting the "degree and manner in which different persons possess the power of seeing images in the mind's eye" (Galton, 1880, p.252). He described a number of individuals who perceived numerals in elaborate spatial arrangement and reported some 'curious' cases of colour associations with numerals, noting the apparent heredity of such traits and the fact that the capacity was present from childhood. While Galton (1880) discussed these abilities with reference to visual imagery, over 120 years later, we now refer to these phenomena by the term 'synaesthesia'. Synaesthetes experience a sensory 'mixing', whereby a stimulus presented to one sensory modality elicits an illusory sensory-perceptual experience in another (Cytowic, 2002). The nature of synaesthetic experiences makes it likely that they share the neural substrates involved in normal perception and mental imagery. Earlier studies of synaesthesia exam-

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doi:10.1016/j.concog.2007.05.011

ined trends in inducer-concurrent associations (Marks, 1975; McKellar, 1957) but while there has been a resurgence of scientific interest in synaesthesia (for a review see Rich & Mattingley, 2002), the role that visual imagery might play in mediating such experiences has received little attention.

In terms of their phenomenology, synaesthetic experiences have much in common with mental imagery. First, visual mental imagery has been described as the ability to form 'mental pictures', or to 'see in the mind's eye' (Marks, 1973) and, similarly, many synaesthetes describe their experiences as internal, occurring in the 'minds eye' or 'inside one's head' (Baron-Cohen, Wyke, & Binnie, 1987; Dixon, Smilek, & Merikle, 2004; Grossenbacher, 1997). Furthermore, these conscious experiences occur in the absence of related external, sensory stimulation. For example, a colour can be either induced (as in synaesthesia) or imaged in the absence of stimulation of sensory colour receptors. Second, mental imagery is often reported as sufficient to induce a synaesthetic experience. In other words, simply imagining an inducer (e.g. the letter 'A') is sufficient to evoke the same concurrent as the physical inducer itself (Dixon, Smilek, Cudahy, & Merikle, 2000). Finally, synaesthetic inducers are often modality independent. For example, in its most common form, linguistic–colour synaesthesia (Barnett et al., in press; Cytowic, 2002; Rich, Bradshaw, & Mattingley, 2005), linguistic stimuli induce colour experiences when they are presented in either their orthographic/written, spoken or tactile (e.g. Newell, Kilroy, & Chan, in preparation) form. Since the concurrents are common to inducers from different modalities, this strongly suggests that linguistic information is either represented in a modality-independent manner or that it is recoded into a single modality that, in turn, triggers the synaesthetic experience. Ramachandran and Hubbard (2001) have argued that linguistic–colour synaesthesia arises in the grapheme area of the visual cortex which lies adjacent to V4, the area involved in colour information processing. If linguistic information from other modalities is recoded into vision then it is possible that mental imagery may mediate this recoding (e.g. Lederman, Klatzky, Chataway, & Summers, 1990; Sathian & Zangaladze, 2001; Zhang, Weisser, Stilla, Prather, & Sathian, 2004) and trigger common, crossmodal synaesthetic experiences.

Given the similarities between synaesthesia and mental imagery, and the potential role of imagery in synaesthesia, it is surprising that an investigation of general imagery ability in synaesthetes has not hitherto been conducted. It may be, for example, that synaesthesia is related to a general ability to imagine stimuli. If this were the case then we might expect that synaesthetes report experiencing more vivid mental images than non-synaesthetes. On the other hand, general imagery abilities may be unrelated to synaesthesia but instead enhanced mental imagery may be more specifically related to the set of stimuli that induce or are evoked through synaesthesia.

Although the role of imagery in synaesthesia has generally been overlooked in the literature (but see Ramachandran, Hubbard, & Butcher, 2004), several neuroimaging studies have investigated whether common neural substrates underpin perceived, imagined and synaesthetic colours. It might be expected, for example, that colours induced in linguistic–colour synaesthesia activate the same neural regions that process the perception of colour, namely area V4, and indeed this has been reported (Hubbard, Arman, Ramachandran, & Boynton, 2005; Nunn et al., 2002; Sperling, Prvulovic, Linden, Singer, & Stirn, 2005; Steven, Hansen, & Blakemore, 2005). In fact, both imagined and synaesthetic colours are associated with activation in cortical regions such as V4 that are also known to be involved in perception (Aleman, Rutten, Sitskoorn, Dautzenberg, & Ramsey, 2001; Kosslyn, Thompson, Kim, & Alpert, 1995; Nunn et al., 2002). However, a recent study has suggested that imagined and synaesthetic colours can activate different neural substrates. Rich et al. (2006) found that area V4 was activated in synaesthetes and non-synaesthete controls in response to *both* externally presented colour Mondrians and imagined colour. However, unlike previous reports, they found that synaesthetic colours selectively activated the left medial lingual gyrus, an area previously implicated in colour knowledge (Chao & Martin, 1999). Interestingly, Rich et al. (2006) did not report a difference in V4 activation in synaesthetes compared to controls during the colour imagery task, although their small sample size ($n = 7$) makes it difficult to make inferences about the absence of activation (see e.g. Thirion et al., 2007). However, what is not clear from the above studies is whether or not imagery ability is different across synaesthete and non-synaesthete groups and whether any such difference may underlie differential activation in brain areas associated with induced or imagined stimuli.

To investigate mental imagery ability in synaesthetes, we surveyed visual imagery in a large sample of naïve synaesthetes using the Vividness of Mental Imagery Questionnaire (VVIQ) (Marks, 1973) and compared their reported imagery ability to a control group of unrelated, age-matched participants. Given that there is a