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# Personality predicts the vibrancy of colour imagery: The case of synaesthesia

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ABSTRACT

In this study we show that personality traits predict the physical qualities of mentally generated colours, using the case of synaesthesia. Developmental *grapheme-colour synaesthetes* have the automatic lifelong association of colours paired to letters or digits. Although these colours are internal mental constructs, they can be measured along physical dimensions such as saturation and luminance. The personality of synaesthetes can also be quantified using self-report questionnaires relating, for example, to the five major traits of Conscientiousness, Extraversion, Agreeableness, Neuroticism, and Openness to Experience. In this paper, we bring together both types of quality by examining whether the personality of individual synaesthetes predicts their synaesthetic colours. Twenty grapheme-colour synaesthetes were tested with the Big Five Inventory (BFI) personality questionnaire. Their synaesthesia was also tested in terms of consistency and average colour saturation and luminance. Two major results were found: although personality did not influence the overall robustness (i.e., consistency) of synaesthesia, it predicted the nature of synaesthetes' colours: the trait of Openness was positively correlated with the saturation of synaesthetic colours. Our study provides evidence that personality and internal perception are intertwined, and suggests future avenues of research for investigating the associations between the two.



## 1. Introduction

Our study explores the relationship between personality and colour imagery by analysing a group of individuals with a unique experience of colour. *Synaesthesia* is a well-documented condition in which sensory or cognitive modalities interact, creating unusual quasi-perceptual experiences (for review see Simner & Hubbard, 2013). For instance, reading words might trigger tastes in the mouth (Jones et al., 2011; Ward & Simner, 2003) or hearing musical sounds might induce experiences of colour in the visual field (Marks, 1975). Brain imaging studies show structural and functional differences in the brains of synaesthetes (for review, see Rouw, Scholte, & Colizoli, 2011), often found in or near the sensory

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regions implicated in synaesthesia (e.g., V4 in colour-perceiving synaesthetes) as well as in more wide-spread regions implicated in other types of processes such as feature binding (e.g., right inferior parietal cortex; Rouw & Scholte, 2007).

This study focusses on *grapheme-colour synaesthesia* which affects between 1% and 2% of the population (Simner & Carmichael, 2015; Simner et al., 2006) and gives rise to unusual colour experiences triggered when the synaesthete reads or hears graphemes (i.e., letters or numbers). So reading letters and numbers, or listening to speech, or even thinking about letters and numbers triggers specific associations of colours. For example, the letter A might be, say, red for any given synaesthete, and B might be green, or the number 7 might be a particular shade of purple. Some grapheme-colour synaesthetes see their unusual colours as if they were veridical qualities in the outside in the world – for example, as colours superimposed on the written type-face when reading. Other synaesthetes see their colours as mental images in the mind's eye while others still simply have a strong sense of knowing exactly what the colours must be. These differences in the quality of the colour experience have been captured by the distinction between "projector" synaesthetes, who see colours as if they were external objects somewhere out in space, and "associators" whose synaesthetic colours are experienced only as 'knowing' or in the mind's eye (e.g., Dixon, Smilek, & Merikle, 2004). Both types of grapheme-colour synaesthete show differences in white matter structure compared to controls (Rouw & Scholte, 2007), as well as functional brain markers when experiencing synaesthetic colours (see Rouw et al., 2011 for review). The current study will examine whether these synaesthetic colours themselves are influenced by the personality profile of the synaesthete.

Pairings between graphemes and colours are largely idiosyncratic for each synaesthete but can be quantified using a *colour wheel paradigm* (e.g., Eagleman, Kagan, Nelson, Sagaram, & Sarma, 2007; Simner et al., 2006; Ward, Huckstep, & Tsakanikos, 2006). In this paradigm, synaesthetes are presented with a detailed colour-palette from which they can select the exact shade of colour they perceive for any given grapheme. These choices can then be quantified, for example as values of hue, saturation and luminance, and importantly, they can be validated by the fact that colours remain highly consistent over time (e.g., Eagleman et al., 2007; Simner & Carmichael, 2015). Hence a genuine synaesthete would tend to pick a similar saturation, luminance and hue for any given letter when he/she is repeatedly retested – across weeks, months and even years (e.g., the letter A might be a very certain specific shade of red every time the synaesthete is tested). This high level of consistency can be compared with the choices of a control group, who are given instruction to *invent* consistent colours but are considerably less consistent than synaesthetes when retested. In this way, the feature of consistency is a key diagnostic metric for synaesthesia, and in our study we ask whether consistency (treated here as a marker of the 'strength' of synaesthesia) is linked to the synaesthete's personality profile.

Personality is a construct that is influenced by genetics and experiences with the environment (Bouchard, 2004; Bouchard, Lykken, McGue, Segal, & Tellegen, 1990). Understanding personality allows predictions of how someone will think, feel, and behave in response to a given situation (Passer et al., 2009) and here we ask whether it can also predict a synaesthete's internal colour imagery. To measure personality traits we will use the Five Factor Model of personality (Costa & McCrae, 1992; Goldberg, 1993) which defines five domains of personality: *Openness to Experience* (a trait reflecting intellectual curiosity, imagination, and artistic interest), *Conscientiousness* (organization, self-discipline, dutifulness), *Extraversion* (gregariousness, assertiveness, sense of adventure), *Agreeableness* (compassion, helpfulness, modesty), and *Neuroticism* (anxiousness, emotional stability, impulse-control). The Five-Factor Model has been validated cross-culturally (McCrae, 2002) and has support from neuroimaging data, since at least four of the Big Five domains have been tied to the function and/or the structure of specific brain regions. For example, Conscientiousness is positively associated with brain volume in a region of the lateral prefrontal cortex that extends across the left middle frontal gyrus. This area is recruited during the execution of planned actions and self-regulation of behaviour, which corresponds with the description of the personality trait (DeYoung et al., 2010). To measure personality, we use the Big Five Inventory (BFI; John & Srivastava, 1999; John, Naumann, & Soto, 2008) which correlates with other the widely-used tests, including the NEO Five-Factor Inventory (NEO-FFI) and the Revised NEO Personality Inventory (NEO-PI-R) (Costa & McCrae, 1992).

There are several reasons to think that personality might be related to the strength of synaesthesia. Previous studies have concluded that synaesthetes have a distinct personality profile. For example, using the short-form NEO-PI-R (Costa & McCrae, 1992), Rouw and Scholte (2016) recently showed that individuals categorized as synaesthetes based on self-report scored higher on Openness to Experience and Neuroticism and lower on Conscientiousness, compared to a group of individuals classified as controls. Although no objective methods were used to verify synaesthesia in this study (usually an important step; see Simner et al., 2005) these findings overlap to some extent with those of Banissy, Holle, et al. (2013), Banissy, Tester, et al. (2013), whose self-referred synaesthetic sample was independently verified as genuine synaesthetes using our strength metric (i.e., consistency). Synaesthetes scored higher on Openness (as in Rouw & Scholte, 2016) and lower on Agreeableness (contrary to Rouw & Scholte, 2016) using the BFI personality questionnaire. Also in keeping with Rouw and Scholte's findings, there was a trend of higher Neuroticism in synaesthetes, but this did not reach significance after correcting for multiple comparisons. Chun and Hupé (2016) is a third study showing that (objectively confirmed) synaesthetes scored higher on Openness, as well as a related trait of absorption, an individual's' participation in and enjoyment of imaginative activities (measured using the Tellegen Absorption Scale; Tellegen & Atkinson, 1974). In summary, all three studies found evidence of higher Openness, two found a suggestion of higher neuroticism (one significantly, one at uncorrected significance only) and two studies each found one further trait: lower conscientiousness or lower agreeableness. This literature is therefore clearly mixed, and we return to this issue in the general discussion, but we note the studies appear to converge on the finding of high openness.

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