Synaesthesia, Color Terms, and Color Space: Color Claims Came From Color Names in Beeli, Esslen, and Jäncke (2007)

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Commentary for *Psychological Science*

Synaesthesia, colour terms and colours space: Colour claims came from colour names in Beeli, Esslen & Jancke (2007).

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Shortened title: Colour names and colour space in synaesthesia

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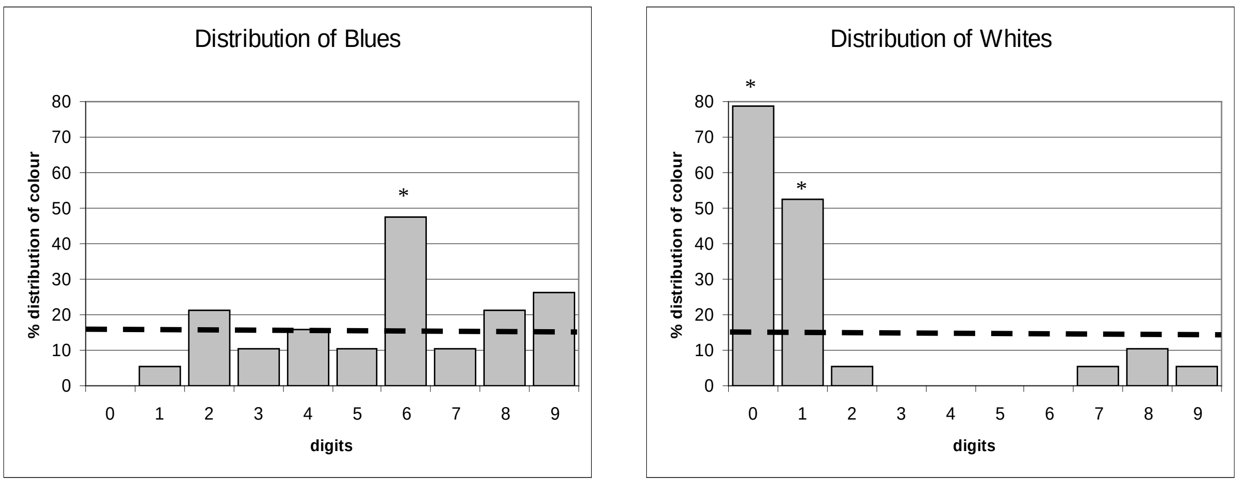
Grapheme-colour synaesthesia is an unusual condition in which letters and digits generate involuntary experiences of colour. In this paper we show that grapheme-colour synaesthetes make non-random associations that are best described by an understanding of colour-language, and that different measures of these associations converge to illustrate a non-arbitrary relationship for all people between colour names and colour space. Our commentary focuses on a recent study (Beeli, Esslen & Jancke, 2007) that presented the ostensibly novel finding of a link between grapheme frequency and colour choices in groups of grapheme-colour synaesthetes. However, a paper published two years earlier by Simner et al. (2005), not cited by these authors, had already established that grapheme frequencies were important. Simner et al. showed that high frequency graphemes tend to pair with high frequency colour-names (e.g., *a*→red) in verbal reports of synaesthetic associations. Beeli and colleagues measured the hue, saturation and luminance (HSL) of synaesthetic colours and showed (inter alia) that grapheme frequency was correlated with saturation. In this commentary we compare these studies and empirically demonstrate that synaesthetic colours are better understood in terms of colour naming (following Simner et al., 2005), but that the similarity across studies may be indicative of an independent relationship between colour naming and colour space for all people.

Our approach was to re-analyse the data from Beeli et al. in order to demonstrate three facts: that, as in Simner et al. (2005), their synaesthetes share preferences for certain grapheme-colour combinations (e.g., *a* is significantly likely to be red); that, as in Simner et al. (2005), these grapheme-colour pairings reflect a positive correlation between grapheme frequency and colour-name frequency; and finally, that certain aspects of the HSL colour space (upon which Beeli and colleagues based their conclusions) may be predicted from colour naming. We converted each of the synaesthetic colour choices from the grapheme-colour synaesthetes of Beeli et al. (2007; their Figure 1) into the 11 irreducible colour terms from Berlin & Kay (1969; black, white, red, yellow, green, blue, brown, orange, purple, pink, grey). Our coding was performed by two independent assessors, with any disagreements resolved by a third coder. We then performed upper-tail binomial analyses to show that certain grapheme-colour combinations (e.g., a→red) were occurring significantly more often than would be predicted by chance. For example, Figure 1 below illustrates the distribution of blue and white across digits 0-9, and shows that these colours favour 6 and 0/1 respectively ($ps<.05$). (The full set of significant grapheme-colour associations from the 19 synaesthetes of Beeli et al. is available from J. Simner, and equivalent published data is found in Simner et al., 2005, and Rich et al., 2005 from 70 and 150 synaesthetes respectively).

Figure 1



* p<.05

Within these associations from Beeli et al., we next ranked each letter/digit and each colour-term for their respective frequencies within the language of these synaesthetes (German). German letter- and digit-frequencies were taken from Beeli et al. (2007) and colour-term frequencies were taken from the CELEX Mannheim German word-form counts; which produces the ordering: *white*, *black*, *red*, *green*, *blue*, *pink*, *yellow*, *grey*, *brown*, *purple*, *orange*. Spearman rank correlations showed that higher frequency graphemes tend to pair with higher frequency colour-terms, both for digits ($\rho=.60$, $p<.02$) and letters ($\rho=.32$, $p=.05$). This same finding was demonstrated empirically by Simner et al. (2005; see also Simner, 2007).

The key to linking the study of Simner et al., based on colour-names, and the recent study, based on the physical properties of colour, may come from the proposal that the naming of colours is dependent on certain properties of colour space. Jameson and D'Andrade (1997) propose that ‘hue interacts with saturation and lightness to produce several large ‘‘bumps’’ in colour space’ (Jameson and D’Andrade 1997; p. 312) and that colour-name categories emerge in a way that allows for optimal divisions of this irregular shape. Recent work (Regier, Kay & Khetarpala, 2007) has supported this hypothesis by observing colour-naming patterns across languages. In the current paper, we propose an additional link between names and colour space, in that similarities between Simner et al. and Beeli et al. suggest a relationship between colour-term frequency and colour saturation. We tested this hypothesis by comparing the frequencies of colour-terms within a language, with the mean centroid saturation of those colours provided by speakers of that language (using English and the 11 irreducible colour terms above; from the CELEX lexical database, and Sturges & Whitfield, 1995). We found a significant negative correlation between saturation and colour-term frequency ($r = -.62$; $p < .05$) indicating that colours with the highest linguistic frequency are those that are least saturated.

This correlation, which is independent of synaesthesia, may partially explain the link between the findings of Simner, Beeli and colleagues. However, the precise relationship remains unclear because the precise function of saturation for Beeli et al.’s synaesthetes is itself uncertain. Beeli et al. report a strong negative correlation between grapheme-frequency and saturation for digits (of a type consistent with the negative correlation we found between colour-tem frequency and saturation) but a slight positive correlation for letters. By removing the lower digits (0 and 1) the authors switched their digit correlation from negative to positive, now mirroring that from letters. However, the *ad hoc* nature of this manipulation might suggest that a saturation-based account of synaesthesia is less predictive than a linguistic colour-frequency account. This latter provides a united effect for both digits and letters, as well as allowing a theoretically sensible explanation in which graphemes and colours pair along the same dimension of linguistic frequency.

Outwith any proposed similarity with Simner et al. (2005), Beeli and colleagues make an additional contribution by showing that lower frequency graphemes generate darker synaesthetic colours, and this luminance aspect of the physical signal appears to be independent of colour-naming. (Smilek, Carriere, Dixon and Merikle, 2007 extend this to non-synaesthetes, and a comparable finding has been reported previously; Cohen Kadosh & Henik, 2006; see also Simner et al., 2005.) It may yet be the case that their saturation model proves independent from, or yet superior to, the frequency hypothesis in Simner et al. (2005), but we leave it to the authors of this recent work to show that their findings are truly independent from those already demonstrated in the literature.

Acknowledgments

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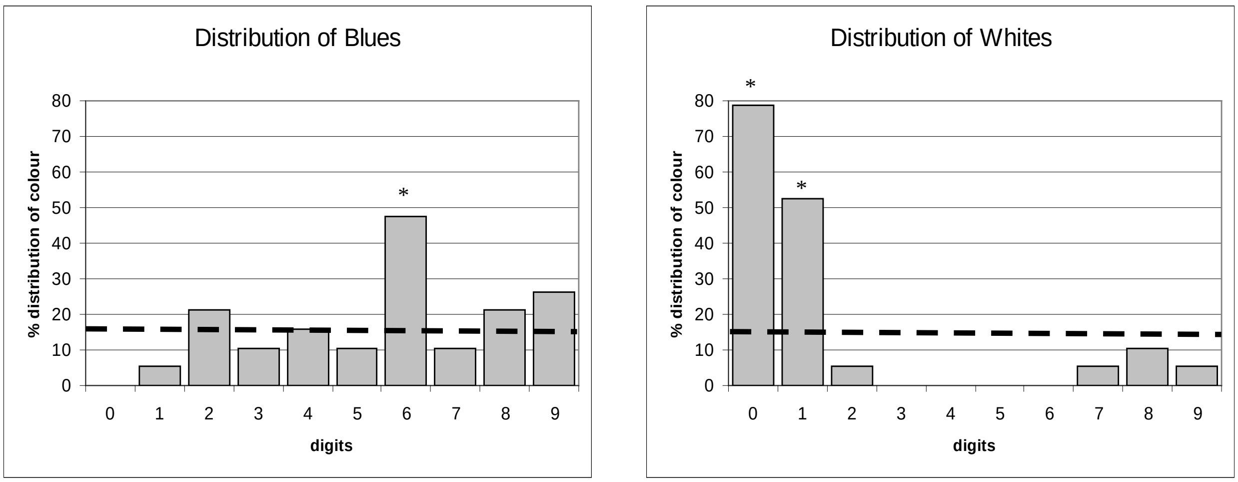
Figure 1. The percent (%) distribution of colours within the categories of blue and white across the digits 0-9. Dashed lines represent the % distribution of each colour that would be predicted by chance, given the overall proportion of blue tokens and of white tokens within the data set.



* p<.05