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Principle component analyses of questionnaires measuring individual differences in synaesthetic phenomenology

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ABSTRACT

Questionnaires have been developed for categorising grapheme-colour synaesthetes into two sub-types based on phenomenology: associators and projectors. The general approach has been to assume a priori the existence of two sub-types on a single dimension (with endpoints as projector and associator) rather than explore, in a data-driven fashion, other possible models. We collected responses from 175 grapheme-colour synaesthetes on two questionnaires, the Illustrated Synaesthetic Experience Questionnaire (Skelton, Ludwig, & Mohr, 2009) and Rouw and Scholte's (2007) Projector–Associator Questionnaire. After Principle Component Analysis both questionnaires were comprised of two factors which coincide with the projector/associator distinction. This suggests that projectors and associators are not opposites of each other, but separate dimensions of experience (e.g. some synaesthetes claim to be both, others claim to be neither). The revised questionnaires provide a useful tool for researchers and insights into the phenomenology of synaesthesia.

1. Introduction

For individuals with synaesthesia, an 'inducer' in one modality (percept or concept) triggers a 'concurrent' experience in another modality. One of the most common types of synaesthesia is grapheme-colour (GC) synaesthesia (Simner et al., 2006), where viewing a letter, number or even grammatical symbol can induce a consistent (Eagleman, Kagan, Nelson, Sagaram, & Sarma, 2007) and automatic (Mattingley, Rich, Yelland, & Bradshaw, 2001) colour experience. Although the experiences of individual synaesthetes are internally consistent, there are large differences between synaesthetes as to how they experience the colour. Each synaesthete has their own colour palette, the specific colours that they link with each grapheme, and although there are trends such as 'A' frequently being red (Simner et al., 2005) the actual colour that a synaesthete links to each grapheme, or the number of graphemes they have colour associations for, are not the only differences within this population.

GC synaesthetes have been roughly subdivided in previous research according to where they see their colour (Dixon, Smilek, & Merikle, 2004). Projectors are classified as those who 'see' the colour on the grapheme itself where it is located, for example if looking at a letter presented in black font on a piece of white paper, they would see the colour superimposed onto the grapheme on the paper. The associator category is wider, encompassing those who: 'see' the colours in their minds eye (irrespective of whether the colour is the same shape as the grapheme or a block of colour), 'see' the colour floating in

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space between the grapheme itself and the person, and people who simply 'know' that a grapheme is a certain colour. Two questionnaires have been developed and used extensively within synaesthesia research to determine which end of a continuous projector–associator dimension synaesthetes lie on. These are the Illustrated Synaesthetic Experience Questionnaire (ISEQ; Skelton, Ludwig, & Mohr, 2009) and Rouw and Scholte Projector–Associator Questionnaire (RSPA; Rouw & Scholte, 2007).

Support for this sub classification of GC synaesthesia has come from behavioural differences. Interference is found on a synaesthetic Stroop task when participants are presented with coloured graphemes that are incongruent with their synaesthetic experience (relative to congruent). This occurs for both projectors and associators. However, there are differences between projectors and associators depending on whether the task is to name the real colour (and ignore their synaesthesia) or name their synaesthetic colour (and ignore the real one) (Dixon et al., 2004). The authors predicted that projectors would demonstrate greater interference effects from photisms when having to name real colour, which they indeed observed. Projectors were faster at naming their photisms, whereas associators were faster at naming the real colour, which was also in line with their predictions. The results were presented as corroborating evidence for differences in synaesthetic phenomenology depending on the location of the concurrent photism. Other behavioural differences include a generally stronger correlation between similarly shaped graphemes (such as 'b' and 'd') and their concurrent colour in projectors compared to associators (Brang, Rouw, Ramachandran, & Coulson, 2011).

Differences in brain function, using fMRI, have also been found between projector and associator synaesthetes when presented with inducing relative to non-inducing graphemes. Associators activated areas linked to memory processes, and projectors activated more perceptual processing regions (Rouw & Scholte, 2010). Differences in functional connectivity with area V4 (involved in colour perception) also differ between synaesthetes with the fusiform gyrus implicated for projectors and the parietal lobe for associators (van Leeuwen, den Ouden, & Hagoort, 2011). Structural differences have also been measured with projector synaesthetes having greater inferior temporal cortex connectivity than associator synaesthetes, the subtypes were measured via Rouw and Scholte's (2007) Projector–Associator questionnaire. Therefore there is a range of evidence that differences, both behavioural and neurological, exist between the synaesthetic subtypes.

Although some differences have been measured between these sub groups, there are also instances where such a differentiation has not been observed. In one example, participants had to indicate the colour of a colour patch or black digit which was primed by the other (a colour primed a digit, or a digit primed a number) (Gebuis, Nijboer, & Van der Smagt, 2009). Incongruent pairings caused increased reaction times and P3 latency and amplitude differences in the ERP signal however no differences were found between projector and associator synaesthetes (note participants were only classified from direct questioning, not a specific questionnaire). Ward and colleagues found no significant difference between groups in an embedded figures test, where a global shape (square, rectangle, diamond or triangle) made up of local graphemic elements has been hidden within an array of graphemic distractors (Ward, Jonas, Dienes, & Seth, 2010). Although projector synaesthetes were more likely to report seeing a colour, there was no difference in behavioural performance. The evidence for behavioural differences between projectors and associators is therefore inconsistent.

Ward, Li, Salih, and Sagiv (2007) have argued that that the projector–associator distinction, as it is typically articulated, fails to account for more nuanced phenomenological reports. The term "mind's eye", for instance, tends to be used very inconsistently to describe a range of experiences. Some GC synaesthetes claim to see their colours inside their body (literally), others on a screen that has no physical location, and others claim to know the colour. All three would tend to be subsumed by the label 'associator'. Similarly, some synaesthetes claim to experience colours externally but 'in the air' (at a fixed location from the body) and others experience it on the text itself (i.e. at a location defined by the inducer itself). Both of these experiences tend to be classed as 'projector' but there is some evidence that they can be dissociated behaviourally (Ward et al., 2007). Rather than a dichotomy, Ward et al. (2007) argued for a multiplicity related to different spatial frames of reference (object-centred, body-centred, image-centred) and those who simply 'know' the colour. In a similar vein, van Leeuwen, Petersson, and Hagoort (2010) found differences using fMRI between those who project on a 'mental screen' (but not the grapheme itself) and those who have knowledge of colour associations.

The present research has two purposes: one methodological, and one theoretical. In terms of methodology, we will explore the factor structure and statistical reliability (inter-correlations of items) of two published questionnaires using Principle Component Analysis (PCA). At present it is assumed, but not proven, that the responses to all questions related to being, say, an 'associator' are highly inter-correlated. It is also assumed, but not proven, that all questions load on to a single factor solution (with endpoints of projector and associator). For instance, on the RSPA a synaesthetes' status as projector or associator is determined by subtracting the scores for associator questions from the projector questions. This tacitly assumes that all questions load on a single dimension rather than several dimensions. The analyses would also increase our theoretical understanding of synaesthetic phenomenology. For instance, some theories predict multiple sub-types of spatial phenomenology (Ward et al., 2007).

A more recent measure of synaesthetic experience is the Coloured Letters and Numbers (CLaN) questionnaire which is the only currently published synaesthesia questionnaire that has been analysed using Factor Analysis (more precisely, Maximum Likelihood Estimates) (Rothen, Tsakanikos, Meier, & Ward, 2013). This produced four distinct factors, localisation, automaticity/attention, deliberate use, and longitudinal changes. The localisation factor relates specifically to experiencing the colours localised on the grapheme ('projector') but, interestingly, questions that one might expect to relate to being an associator (e.g. knowing but not seeing the colour, less intense colours) were not negatively loaded on to the same factor (instead they tended to be excluded from the factor structure). This does not support the view that an associator is, statistically or