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Understanding grapheme personification: A social synaesthesia?

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Much of synaesthesia research focused on colour, but not all cross-domain correspondences reported by synaesthetes are strictly sensory. For example, some synaesthetes personify letters and numbers, in additional to visualizing them in colour. First reported in the 1890s, the phenomenon has been largely ignored by scientists for more than a century with the exception of a few single-case reports. In the present study, we collected detailed self-reports on grapheme personification using a questionnaire, providing us with a comprehensive description of the phenomenology of grapheme personification. Next, we documented the behavioural consequences of personifying graphemes using a congruity paradigm involving a gender judgement task; we also examined whether personification is associated with heightened empathy as measured using Empathy Quotient and found substantial individual differences within our sample. Lastly, we present the first neuroimaging case study of personification, indicating that the precuneus activation previously seen in other synaesthesia studies may be implicated in the process. We propose that frameworks for understanding synaesthesia could be extended into other domains of cognition and that grapheme personification shares more in common with normal cognition than may be readily apparent. This benign form of hyper-mentalizing may provide a unique point of view on one of the most central problems in human cognition – understanding others' state of mind.

Although synaesthesia is traditionally defined as an experience in one sensory modality elicited when a stimulus is presented in another modality, it soon became clear that some of the most common types of synaesthesia are actually elicited by ordinal

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sequences such as letters, numbers, or time units (e.g., Sagiv, 2005). Indeed, chromatic-graphemic synaesthesia (coloured letters and numbers) has been the focus of a multitude of recent studies. The perceptual reality of synaesthetic colours was demonstrated (e.g., Palmeri, Blake, Marois, Flanery, & Whetsell, 2002; Ramachandran & Hubbard, 2001; Smilek, Dixon, Cudahy, & Merikle, 2001) and sceptics could no longer dismiss synaesthetes' reports as confabulatory in origin. However, the emphasis on the perceptual reality of synaesthetic experience may have detracted attention from related phenomena in which the concurrent experience extends beyond purely sensory imagery and involves, for example, spatial, affective, or even social components.

For example, letters, numbers, and time units may be associated not only with colours but also with locations in space (e.g., Sagiv, Simner, Collins, Butterworth, & Ward, 2006; Jonas, Taylor, Hutton, Weiss, & Ward, 2011). Individuals with number forms can point to a precise location in space associated with each number, but not all of them visualize it. Like synaesthetic colours, the spatial patterns associated with ordinal sequences seem to be automatically and reliably evoked in a consistent manner (e.g., Jarick, Dixon, Maxwell, Nicholls, & Smilek, 2009; Smilek, Callejas, Dixon, & Merikle, 2007).

However, in addition to colours and spatial patterns associated with graphemes, some synaesthetes also report personifying them. A grapheme may be described as having gender (e.g., seven is a male, eight is a female) or in some cases – a rather elaborate biography including personality traits such as 'old-fashioned'; 'generous loyal friend'; 'unimaginative, interested in technical subjects, reliable'; and 'physically active, inclined to rush about'. Early reports of the phenomenon were provided by Flournoy (1893) and Calkins (1893, 1895), but it virtually disappeared from the literature for over a century.

At first glance such reports seem very unusual, but there are several good reasons to examine them more closely. First, synaesthesia and grapheme personification seem to co-occur (Simner and Holenstein, 2007). In addition, it appears to share some features with more familiar types of synaesthesia (the associations appear stable over time and elicited automatically; Simner and Holenstein, 2007; Smilek, Malcolmson, *et al.*, 2007). Finally, and perhaps most importantly, the phenomenon may shed new light on some common mechanisms underlying social cognition. Perhaps one reason that interest in synaesthesia is on the rise among cognitive neuroscientists may be that we are beginning to see how synaesthesia research can inform us about universal cognitive and brain mechanisms (Cohen-Kadosh & Henik, 2007; Sagiv & Ward, 2006). With this in mind, we embarked on the present project, aiming to better understand the phenomenology, behavioural manifestations, and mechanisms underlying grapheme personification.

Grapheme personification

In her surveys of the phenomenon, Mary Calkins referred to the tendency to personify ordinal sequences as 'dramatisation' – the endowment of physical and psychological characteristics to letters, numerals, and musical notes, 'so that they often become actors in entire little dramas among themselves' (Calkins, 1895, p. 100). In this early survey, the prevalence of dramatization and 'fondness' (like or dislike) for graphemes was estimated at 35% among synaesthetes ($n = 145$). It was also reported that numerals were more frequently liked or disliked than letters, which were more frequently dramatized. Upon the observation of a common aversion to prime numbers and that odd numbers were more often disliked, Calkins speculated that numerals rather than letters were more likely to become emotionally associated, as they require more intellectual effort.

Simner and Holenstein (2007) review the early literature and identify several characteristics that individuals might associate with graphemes, including gender, personality and cognitive attributes, physical appearance, occupation, as well as relational attributes such as family ties, friendships, and other associations, in addition to emotive responses to other units. This illustrates the richness of biographical information that may be attributed to graphemes. Admittedly, it may even be richer, covering a range of mental states, moods, attitudes, interests, and inclination. In addition, graphemes' relationship dynamics may not be limited to affection levels but could include behavioural attributes (such as 'P and Q hang out together quite often').

The term ordinal linguistic personification (OLP) was coined by Simner and Holenstein (2007) to describe such personification of letters, words, numbers, time units, or other sequences. They describe a new case of a 23-year-old female (AP) and showed that her gender and personality associations are consistent. They provided some objective correlates of the subjective report, including a Stroop-like paradigm utilizing a personal name gender decision task in which congruity or incongruity with the synaesthetic gender of the first letter speeds up or slows down reaction times (RTs), correspondingly. Such data show that OLP reports are real, not mere confabulation. OLP is believed to be a variant of synaesthesia in its own right since it co-occurs with colour synaesthesia and shares some characteristics including consistency over time, automaticity, and the involuntary manner in which it is evoked.

In another study, Simner and Hubbard (2006) showed that graphemes' colour and gender attributes interact: the synaesthetic colour Stroop interference occurs only when incongruent colours correspond to letters with a matching gender, indicating that different graphemes may be associated with a single gender node. They also showed that naming time for the genders associated with graphemes are slower when graphemes are coloured with an incongruent colour associated with a grapheme of a different gender (but unaffected when the colour is suggestive of a grapheme with the same gender). This indicates that colour may be implicitly associated with gender and further strengthens the conclusion that grapheme personification is just as real as grapheme colours.

Is OLP just a childish habit? Probably not: the attribution of seemingly arbitrary gender to linguistic constructs is in fact quite common. This is the case in all languages that have masculine and feminine grammatical genders, including, for example, Amharic, Arabic, French, German, Gujarati, Hebrew, Hindi, Manchu, Polish, Spanish, Welsh, and many more. The significance of the feminine–masculine distinction in grammar goes beyond the technicalities of conjugations and declensions; it seems to influence our thought such that gendered nouns do capture something of the essence of masculinity or femininity.[1] It is only when a speaker of one such language learns another that they are confronted with the horror of discovering that the things may have different genders in other

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[1] *Boroditsky, Schmidt, and Phillips (2003) review a series of studies that demonstrate this well. For example, when native speakers of German and Spanish are given a list of objects with different grammatical genders in the two languages and asked to generate adjectives to describe those objects – they show different patterns. The adjectives they generate for each object will be rated as more masculine (e.g., strong) or feminine (e.g., beautiful) depending on the grammatical gender of the corresponding noun in their native language, even when the test is conducted is English where the most nouns have no particular gender. It can therefore be said that grammatical gender is more than a mere convention (at least for native speakers). It should be noted that some languages have additional genders or classes: neuter is fairly common and additional classes could include distinctions such as human/non-human or a separate class for edible things; these may shape thought in different ways, but this is outside the scope of this paper.*

languages (e.g., a Hebrew speaker will be perplexed to find out that the grammatical gender of cheese is masculine in German, not feminine). Speakers of different languages with irreconcilably different noun genders may thus be likened to synaesthetes who disagree on the colours of the alphabet. The associations of nouns with gender, such as OLP associations, are idiosyncratic to specific languages and influence other cognitive processes. In our view, this suggests that we should perhaps be focussing not only on what makes people who personify graphemes different from others, but also try to understand what it may tell us about universal mechanisms common to us all.

Object personification

It should be pointed out that personification is not limited to linguistic constructs. Inanimate physical objects are sometimes personified as well. The relationship between grapheme personification and object personification is unclear, although they sometimes co-occur and it is plausible that they may share a common basis (Smilek, Malcolmson, *et al.*, 2007); in a single-case study, Smilek and his colleagues describe TE, a 17-year-old synaesthete who personifies not only letters and numbers but also household objects, such as furniture. The personalities reported by TE are consistent over time. Furthermore, they show that the emotional associations she has with graphemes can bias her eye movements. Smilek and his colleagues conclude that such personification can be understood as a synaesthesia variant involving complex semantic information. The data we provide here show that synaesthetes who personify graphemes quite commonly personify inanimate objects in their environment as well, like TE.

Is inanimate object personification a normal phase in cognitive development?

In '*The Child's Conception of the World*', Jean Piaget (1929) maintains that children exhibit a form of animism, that is, they attribute consciousness to inanimate objects.[2] The idea has been challenged since. In particular, it was unclear that animistic/anthropomorphic descriptions necessarily suggest genuine animistic thought and not immature language skills (for a review of the controversy, see Smeets, 1973). However, adults anthropomorphize inanimate objects too. Animistic ideas may be normative in some cultures, but they are also prevalent in Western poetry, children's stories, advertisements, myths, as well as modern fiction. Why should we retain a tendency to personify? The instinct to interpret what goes on around us as the actions of a living agent seems to be a very safe bet (e.g., Guthrie, 1995). You would not want to mistake the noise made by an approaching predator for the wind blowing a few leaves behind you, would you? It is easy to see why a tendency to personify will be a selected trait. Moreover, instinctively interpreting events within an intentional stance will also be beneficial for quick decision making while interacting with other humans.

With this in mind, both childhood animism and personified graphemes seem like a small price to pay for the advantages of a personification bias not only in childhood but

[2] *The idea that toddlers attribute agency to everything as a default assumption echoes the neonatal synaesthesia hypothesis (e.g., Maurer & Mondloch, 2005) – the idea that all babies experience some sort of synaesthesia-like mixing of the senses until they learn to differentiate them and superfluous synapses cross-wiring different senses are pruned. Such pruning may be at least partially lacking in synaesthetes, resulting in the hyperconnectivity seen in adult synaesthetes' brains (Rouw & Scholte, 2007). Animistic tendencies presumably cease when children can distinguish between living and non-living things.*

also later in life. Epley, Akalis, Waytz, and Cacioppo (2008) shed some light on factors that may contributed to personification in healthy adults and report that lonelier individuals anthropomorphize more; they suggest that this may compensate for social isolation. Furthermore, the tendency to anthropomorphize is common in old age (Zaitchik & Solomon, 2008).

The present study

In the present study, we aim to explore grapheme personification further by employing a variety of methods. We seek to estimate the prevalence of personification, and common characteristics of the phenomenon (including co-occurrence of object personification and some common synaesthesia variants). Next, we provide an objective behavioural correlate of personification using congruity paradigms requiring speeded gender judgements. We also report a measure of consistency in the synaesthetic attribution of gender and personality. Such behavioural measures are commonly used in synaesthesia studies and would thus be useful for assessing the extent to which grapheme personification resembles other synaesthesia variants. In addition, we provide some preliminary observations concerning the neural mechanisms underlying grapheme personification.

Another aim for the study is to examine whether personifying synaesthetes score highly on empathy. If personification is the result of generally lower thresholds for engaging social cognition mechanisms, then we could expect that these synaesthetes will exhibit heightened sensitivity to social cues with higher empathy scores, among other measures. High empathy has already been associated with mirror-touch synaesthesia (Banissy & Ward, 2007), supporting the view that we understand others by simulating their feelings. Although in personification of graphemes or inanimate objects, empathy is not directed at another human being, it nevertheless involves representing mental states or feelings. Higher empathy scores in these synaesthetes will support the view that personification represents an extension of normal function rather than flawed social cognition.

STUDY 1: CHARACTERISTICS OF GRAPHEME PERSONIFICATION

First, we sought to delineate some of the characteristics of the phenomenon, examine the presence of related phenomena or traits, and estimate how common grapheme personification is. Calkins (1895) has already noted that personification is fairly common among synaesthetes with coloured graphemes; therefore, we decided to survey a group of known synaesthetes who participated in some of our earlier studies.

Methods

Participants

Synaesthetes were recruited via our websites and have been tested for consistency of their colour correspondences with letters, numbers, and a list of words (for further details, see Ward & Simner, 2005). They filled out a general questionnaire enquiring about a variety of synaesthesia types, related phenomena, and demographic information. In a sample of 248 synaesthetes with coloured graphemes, we identified 81 who also reported personifying graphemes.

Procedure

We e-mailed those 81 synaesthetes a structured questionnaire on personification and report here data from 34 synaesthetes who responded to our request (eight males,

Table 1. General characteristics of grapheme personification in synaesthetes

(a) Type of stimulus personified
2 (6%) personified numbers only
4 (12%) personified letters only
28 (82%) personified letters and numbers
(b) Type of personification
5 (15%) attributed gender only
7 (21%) attributed personality only
22 (65%) attributed both gender and personality
(c) Number of graphemes personified
21 (64%) personified more than 20 grapheme
9 (27%) personified between 10 and 20 graphemes
3 (9%) personified fewer than 10 graphemes

26 females) by post or by e-mail (33 complete questionnaires, one incomplete). The items in our questionnaire were motivated by anecdotal reports of synaesthetic personification in literature (e.g., Cytowic, 2002; Day, 2005) as well as our hypothesis that the phenomenon may be utilizing some of the mechanisms underlying normal social cognition. We firstly asked synaesthetes to specify the genders and/or personalities attributed to individual letters of the alphabet (A–Z) and single-digit numbers (0–9), as well as rate on a 10-point scale how strong the experience is, from 0 (*no feeling*) to 9 (*very strong feeling*). We also asked about general features of personification, such as frequency of occurrence, the conditions under which graphemes were personified, and whether other symbols were personified. Synaesthetes were questioned about when they first began to experience personification, and we asked multilingual synaesthetes if they personified graphemes in other languages. Finally, we asked about the personification of inanimate objects (animistic thought) and other putatively related phenomena such as mirror-touch synaesthesia (e.g., Banissy, Cohen-Kadosh, Maus, Walsh, & Ward, 2009).

Results and Discussion

General features of personification

All 34 personifiers who completed the questionnaire were grapheme-colour synaesthetes. The frequencies of self-reported basic characteristics of grapheme personification are given in Table 1. Most participants attributed both personality and gender to (at least some) graphemes (Table 1a). Most of the participants personified both letters and numbers (Table 1b). Letters and numbers were largely personified in a similar manner (we did not find anyone who attributed gender only to numbers and personalities only to letters or vice versa).

The mean number of graphemes personified by synaesthetes was 26.6 (standard deviation [*SD*] = 11), but the number of graphemes personified varies widely (Table 1c – based on 33 responses; one incomplete questionnaire was excluded from this analysis). In addition, 42% of synaesthetes personified at least one punctuation symbol in addition to any graphemes they personified.

Many synaesthetes who reported personalities for graphemes remarked that they had found it difficult to write just one or two words describing a grapheme's personality, just as it would be 'difficult to sum up a person you know into just one word'. Indeed, many individuals did go into greater detail. For example, one of the respondents described

E as an 'even-tempered male who can be scholarly or bookish'; G as an older female, 'rather old-fashioned'; J as an 'extraverted sociable man'; O as a male who 'likes to be at the centre of a crowd, a bit showy'; R as a 'person who gets things done, determined, organised, keen'; S as a female who 'has a lot of friends, loves company, very popular'; Y as a 'good chap who will do anything for a friend'; and so on. Numbers had equally complex attributes. A number of personifiers reported 'knowing' some graphemes better than others, and many respondents also indicated they liked/disliked certain numbers and letters. For example, one of them explained that his fondness for a particular letter influenced its personality; he preferred the letters that elicited brighter synaesthetic colours, and disliked the darker graphemes to which he also attributed more negative personalities. This is an interesting comment because it highlights that at least some synaesthetes may experience graphemes' attributes as being under their control to some extent or subject to change, unlike synaesthetic colours where such a flexibility is typically not reported; rather, the colour are 'just there'.

Age of onset and frequency

Most respondents (85%) indicated that they personified as early as they can remember or before the age of 5 (i.e., it appeared to be in place from the early stages of literacy acquisition). A further 9% first started personifying between the ages of 5 and 7 years, making a total of 94% personifying since childhood – at least from the beginning of reading instruction. Only 6% of personifiers said they had not been 'aware' of their personification until being explicitly asked about it in the process of this research. Indeed, it is not uncommon in synaesthetes to 'discover' they have additional synaesthetic experiences only when they begin to pay attention or specifically look for certain features or variants, just as we may not notice unattended features in a scene ('inattentional blindness', 'change blindness', and other lapses of awareness demonstrate this well; e.g., Kim & Blake, 2005). An overwhelming majority of synaesthetes report experiencing personification on a daily basis (73%). The remaining participants personified less often. It is possible that the ease with which personification reaches awareness may vary between individuals. It may be rather automatic for many but only in the fringe of consciousness for some (this would also explain why two of them only discovered personification later in life).

The conditions under which individuals are likely to personify

Are graphemes personified regardless of the modality of presentation? Eighty-four percent report personifying imagined graphemes, 81% personified when visually presented with a grapheme, and 70% when they heard it. This is suggestive of a conceptually driven association. However, the majority of synaesthetes (65%) reported experiencing personification more strongly and more often when the stimulus is presented in written format. Twenty-nine percent reported no difference in the strength and frequency of personification when written compared to spoken, and a very small proportion (6%) personified more strongly when the stimulus was spoken, rather than written. This is not surprising since graphemes are after all units of written language.

Next, we enquired whether graphemes are still personified when embedded in a word or a number. Sixty-seven percent reported personification of individual letters when they saw a word, and 55% personified numerals upon seeing a multi-digit number. Indeed, this is consistent with Simner and Holenstein's (2007) demonstration that the synaesthetic gender interfered with gender judgement of male and female names. However, in follow-up interviews with a sample of our respondents, several individuals noted that they will need to focus on a particular word or number; they do not usually stop to think about graphemes' gender or personalities when reading whole sentences or longer passages).

What determines the gender or personality of a grapheme?

Participants were asked an open-ended question concerning any grapheme characteristics that may be predictive of the gender or personality. Seventy-nine percent of participants have noticed an association between the genders of personalities and other aspects of the graphemes: of these, 52% reported that the grapheme gender or personality was associated with the synaesthetic *colour* of the grapheme. Other associations where noted with the grapheme *shape* (26%), number *parity* (18%), and *sound* (12%). Note that some participants may have indicated more than one factor (e.g., colour and shape).

We have found the comments provided by synaesthetes particularly illuminating. For example, on colour, individual responses included 'graphemes with the same colours evoke similar feelings'; 'at the end of the alphabet, colours are duller so graphemes are older and more boring . . . letters and numbers with bright colours are fun or optimistic'; 'stronger colours influence the personalities of letters and numbers more'; 'green and warm colours are associated with cheerfulness and energy'; 'a dark colour is more likely to be male, a bright colour is more likely to be female'; 'those letters which I see as black in colour tend to be "irritable", "intolerant", "cold" etc'.

On grapheme shapes, individual synaesthetes said: 'it could be the pointiness of the shape'; 'open forms are associated with cheerfulness, angular ones with energy'; 'rounded letters tend to be more feminine'; 'the rounder the letter, the more trustful it is, but it goes along with boring and uninteresting'; 'male numbers and letters are usually made up of straight edges, whereas feminine ones are curved'; and 'I like sharp-shaped letters, those with curves are less likeable'. One synaesthete linked shape with the synaesthetic colour a grapheme evoked: 'Letters and numbers that have similar shapes have the same colour'.

The subjective reports of synaesthetes with regards to number personification are of particular interest: 'I feel that all numbers and letters are masculine, but vary in age, numbers in particular, 8 is an older version of 4'; 'I have a strong bias to see the females/odd numbers as having much better personalities . . . not only are they more likely intelligent and vivacious (and less arrogant or stodgy) they are also better looking'; 'All odd digits are female, even digits are male . . . in general, even numbers are good, odd numbers are bad'; 'The numbers developed their personalities when I was 6–7 years old, learning arithmetic. In some way, their personalities are related to the difficulty I had learning "math facts" or "arithmetic tables"'.

Some synaesthetes also reported that their personality attribution changed depending on contextual factors: 'The personality/gender/colour etc. often changes according to its context'; 'name colours alter extensively when connected to a personality and can alter again pertaining to moods'; 'there is a bit of a difference regarding capitals and small letters and size/style/font'. One individual also noted 'the frequency of letters in the English language may influence their personality' – a spontaneous observation recently corroborated by Simner, Gärtner, and Taylor (2011).

Thus, it appears that a number of factors may interact during development, leading to the reported correspondences between graphemes, gender, and personality. The interactions between colour and gender processing described by Simner & Hubbard

(2006) are consistent with this. However, the subjective reports highlight that colour is but one factor contributing to the complex representations personification entails.

Personification in other languages.

As expected, in our British sample, English was the first language of most individuals. Fifty-seven percent of our respondents spoke at least one other language (Range: 1–4, Mean = 2, *SD* = 1) and when asked if they personified alphanumeric symbols in these other languages, 88% of them reported anthropomorphizing graphemes in one or more of the following languages: French, German, Spanish, Portuguese, Japanese, Italian, Czech, Afrikaans, Greek, and Russian. One synaesthete reported that she had 'to get to know' the letters in her second language to see their personality. Interestingly, grammatical and synaesthetic gender may be in conflict (akin to the 'alien colour effect' described by Gray *et al.*, 2006).

Other forms of personification: Animistic thought

Eighty-two percent (28 individuals) of the synaesthetes who reported personifying graphemes also admitted attributing *gender* or *personality* to some inanimate objects. Fruits and vegetables were the most commonly personified object (57% of those 28 individuals), followed by computers (50%). Does this represent very elaborate personification (thinking of the object as a living thing with a mental life of its own) or more superficial labelling? Further observation supports the former. Seventy-one percent (24 individuals) attributed *feelings* to inanimate objects with plants being the most commonly reported (79% of those 24), followed by household objects (62%). For example, one synaesthetes explained that after she moved to a new flat, she felt sorry for many of her household objects who must have been 'disoriented and disgruntled'. Similarly, she was compelled to consider whether the remaining coffee mugs in a set would miss their broken companion who was no longer with them. It is important to note that synaesthetes are not delusional. Just as they know that the colours they see may be visualized very vividly but are not really there, they are also well aware that inanimate objects do not really have feelings, and yet they quite instinctively think of them *as if* they did. The remarkable association of grapheme personification with animistic thought (and mirror-touch discussed in the next section) may suggest generally lower threshold for activation of social cognition mechanisms, and a more diffused hyperconnectivity involving the social brain circuitry (rather than restricted cross-wiring, e.g., between processing graphemes and mechanisms involved in personality judgement as suggested by Simner and Hubbard, 2006).

The prevalence and co-occurrence of grapheme personification with other variants of synaesthesia

Thirty-three percent ($n = 81$) of the synaesthetes identified previously ($n = 248$) reported experiencing some form of personification: the attribution of gender, personality, or both to graphemes. Compared to non-personifying synaesthetes, personifiers were more likely to associate a spatial pattern/form with the alphabet (66% synaesthetes vs. 77% personifiers), with numbers (56% synaesthetes vs. 68% personifiers), and in particular with days/months arrangement (37% synaesthetes vs. 77% personifiers).

Finally, personifiers were more likely to like or dislike certain letters (66%) compared to non-personifying synaesthetes (45%).

Can we estimate the prevalence of grapheme personification from our results? We find that nearly one in three synaesthetes in our database also report grapheme personification. Given that the best estimates of synaesthesia prevalence, we currently have (Simner *et al.*, 2006) range from 1.2% (for coloured graphemes) to 4.4% (for multiple variants), our data suggest a prevalence estimate of 0.4–1.5% for personification. The data may represent an overestimate given that the group of synaesthetes (from which the sample of personifiers is drawn) may not be representative of synaesthetes in the general population. For example, synaesthetes with multiple types of synaesthesia or more unusual variants may be more likely to contact us and volunteer to participate in research than those who have a single common variant of synaesthesia (e.g., coloured weekdays) and do not give it much thought. Although only a small sample of participants in our questionnaire study were tested further (see next section), we are fairly satisfied that the responses are genuine. The rather detailed and typical responses given in our questionnaire (e.g., lengthy grapheme descriptions) leave little room for doubt, although we cannot be certain with respect to the two thirds of the 81 synaesthetes who indicated they personified graphemes on a general synaesthesia screening questionnaire but for whom we have no further details. On the other hand, although we have not looked for non-synaesthetes who personify graphemes; such individuals will increase the estimated prevalence of personification. Simner and Holenstein (2007) found two such individuals in a survey of 219. This should add an additional 1% to our estimate, bringing the total to a conservative estimate of at least 1.4%. However, a large-scale study of the general population will be required in order to provide more precise estimates.

Finally, 50% also reported mirror-touch synaesthesia, an exceedingly high proportion ($\chi^2(1) = 54.33, p < .05$) compared with an expected proportion of 10.8% of the general population who report mirror touch in initial screening similar to ours (Banissy *et al.*, 2009), although it should be noted that upon further testing and verification 1.4% of the population are confirmed as genuine cases. Although we have not subjected individuals to follow-up tests concerning mirror-touch reports, given the large difference between the numbers initially reported, it seems likely that the prevalence of mirror touch may indeed be higher in individuals who personify graphemes (even more so considering that synaesthetes usually fill out our questionnaire with greater care than individuals drawn from an undergraduate participant pool, we expect fewer false positives). The high proportion we find is also higher than the 37% self-reported mirror-touch synaesthetes among a sample of 46 synaesthetes who filled out our general synaesthesia questionnaire since we have added a question on mirror touch, although this difference failed to reach significance.

To conclude, in this section, we provided a detailed account of the characteristics of grapheme personification in the largest group of such subjects studied to date. The self-reported data provide us with a tentative list of factors that contribute to or interact with grapheme personification (e.g., colour, shape, letter frequency, or parity for numbers). Whether one is inclined to define grapheme personification as a type of synaesthesia or not, the co-occurrence of grapheme personification with other variants of synaesthesia is consistent with the suggestion that there may be some common underlying mechanisms. Before developing this line or argument further, let us examine more closely additional behavioural and neuroimaging evidence.

STUDY 2: ARE GENDER AND PERSONALITY ASSOCIATIONS WITH GRAPHEMES CONSISTENT OVER TIME?

Consistency is a fairly common finding in synaesthesia studies (e.g., Cytowic & Eagleman, 2009). It is typically shown that synaesthetes are far more consistent than non-synaesthete controls who are asked to come up with similar correspondences. At least, this is the case for many types of synaesthesia studied so far, such as coloured-grapheme synaesthesia, gustatory-lexical, and others (e.g., Sagiv & Ward, 2006); however, thorough investigation of personification has been limited to single-case studies so far. Thus, it is difficult to say whether personification also follows a highly consistent pattern in all individuals. To assess consistency, we retested all synaesthetes who participated in our behavioural studies, comparing their gender/personality-grapheme associations with those they initially noted in their questionnaire responses.

Methods

Participants

Of the 34 individuals who completed our questionnaires, 11 synaesthetes (nine females and two males) who personify graphemes were available to participate in further behavioural studies in our lab. Their mean age was 43. A control group of a further 11 participants (mean age = 29) was also tested.

Procedure

Synaesthetes and controls were given a sheet of paper with the letters A–Z and digits 0–9. Synaesthetes were asked to provide gender and personality descriptions where appropriate (i.e., leave personality blank if they only associated gender). The control group participants were also asked to associate a gender and a brief personality description with each one. The following instruction was given: 'We would like you to think about letters and numbers as if they were people and describe below the gender and some personality traits that you think may go best with each letter and number'. The synaesthetes' responses were compared against their questionnaire responses given at least 4 weeks earlier (several months for some participants). Control participants repeated the test after a period of between 24 hr and 1 week from the initial testing. Therefore, synaesthetes performance was tested under more demanding conditions (longer test-recall intervals).

Data analysis

Gender consistency simply represents the percentage of 'same' gender responses. Personality similarity rating was conducted by three independent observers. They were asked to provide us with a binary decision regarding each pair of descriptions – whether or not it seemed reasonable that the two descriptions referred to the same person. The personality consistency score thus refers to the proportion of positive responses (e.g., the raters found it reasonable that descriptors such as 'ordinary' and 'boring] referred to the same person, but rejected the pair 'strong' and 'indecisive' given by a participant on separate occasions). The majority decision was accepted when rating was not unanimous.

Results and Discussion

Synaesthetes consistency scores are given in Table 2. Synaesthetes who personify graphemes scored within a relatively wide range of 42–97%. This is comparable with what Simner *et al.* (2011) have found in a sample of five individuals. Using a similar methodology for rating consistency, we also find that personality consistency scores (average 70.4%) were significantly above the level obtained by the control group; $t(8) = 3.98$, $p < .01$. The complexity of personality descriptions probably contributed to the fact that personality consistency scores were lower than those typically found for colour consistency. It should be noted that the higher scores reported by Smilek *et al.* (2007) in their single-case study were obtained using a different methodology – a four-alternative forced-choice test using different descriptions initially given by participants for graphemes. In contrast, the gender consistency scores for synaesthetes (70.5%) were not significantly higher than controls (67%), although both scored above chance. Although some synaesthetes were highly consistent, the scores varied widely. The relatively high scores for gender consistency obtained by control group participants may be due to the relatively short time elapsed between the test and retest for controls (only 24 hr for some) and the relatively simple nature of the task (essentially a two-alternative forced-choice task: male/female). It is also possible that control subjects have used certain heuristics in order to generate grapheme genders (e.g., graphemes with sharp angles are masculine and rounder shapes are feminine), thus making it possible for them to perform well on the task.

Although traditionally, consistency has been accepted as a diagnostic criterion for synaesthesia, there is no *a priori* reason to assume that all synaesthesia variants are characterized by high consistency, or that less-consistent individuals excluded from previous studies (in the interest of obtaining a conservative estimate of prevalence) do not experience synaesthesia. Indeed, concerns have recently been raised regarding the circularity in arguing for consistency as an essential feature of synaesthesia (Simner, 2011). We find it unlikely that synaesthetes with reliable synaesthetic colour associations confabulate only when it comes to talking about grapheme personification. It may be that personification is more flexible than synaesthetic colour associations. Just as one can

Table 2. Individual EQ and SQ scores

Participant	Sex	Type of personification	Gender consistency	Personality consistency	Colour consistency
GP	F	Gender only	50	-	93
AA	F	Gender only	100	-	100
JD	F	Personality only	-	42	93
SK	F	Personality only	-	83	100
VR	F	Personality only	-	73	93
KB	F	Gender + personality	87	61	94
JH	M	Gender + personality	80	97	96
BM	F	Gender + personality	85	66	89
SR	M	Gender + personality	42	80	95
JT	F	Gender + personality	38	65	100
LD	F	Gender + personality	82	67	78
Mean (synaesthetes)			70.5	70.4	93.7
Mean (control group $n = 11$)			67.0	49.9	-

add on to what they know about a person, how they judge their character or feel about him or her – one can presumably also update the persona associated with a grapheme. This may be expected when higher level processing is involved.

Importantly, three of the 11 synaesthetes have indicated to us that their personification was rather fluid compared with other synaesthetic correspondences (two on their questionnaires, and one spontaneously noted this during the re-test). Two of them have noted they were aware that changes in grapheme personification depended to some extent on their mood and stress level. This undoubtedly contributed to the wide range of scores and lower consistency rates in some cases. Having interviewed the synaesthetes who report personification, we are confident that they did understand our questions and instructions and have no reason to doubt that these are genuine cases. However, we did proceed with caution and have only incorporated consistent grapheme-gender pairs in the following RT study.

STUDY 3: REACTION TIME STUDY: THE BEHAVIOURAL CORRELATES OF GRAPHEME PERSONIFICATION

Synaesthetes have provided us with a wealth of insights into the phenomenon, including the conditions under which grapheme personification occurs, what influences the features associated with graphemes, and what are some of the associated conditions. However, it is important to accompany self-reports with objective measures in order to corroborate the reports.

One feature that distinguishes between synaesthesia and ordinary mental-imagery is the automaticity with which synaesthetic experiences are elicited (e.g., Sagiv & Ward, 2006). This appears to hold in the case of personification based on self-reports as well as behavioural studies (Simner & Holenstein, 2007; Smilek, Malcolmson, *et al.*, 2007). To demonstrate the automaticity of synaesthetic correspondences, researchers have often used congruity paradigms (e.g., Beeli, Esslen, & Jäncke, 2005; Sagiv, Heer, & Robertson, 2006; Ward and Sagiv, 2007). In a typical experiment, the synaesthetic experience (e.g., synaesthetic colour) either matches or mismatches a property of the target stimulus or an irrelevant prime/distractor stimulus (e.g., surface colour on the screen); it is expected of course that RT will be slower in the mismatching than in the matching condition.

We developed a simple novel paradigm for assessing the automaticity of grapheme personification. Participants were presented with an irrelevant grapheme prime, followed by a cartoon face (see Figure 1). The task was to judge whether the cartoon face was a male or a female face. The target face was either congruent or incongruent with the gender they associated with the grapheme prime. We expected that synaesthetes who personify graphemes (but not controls) will show a slowdown of RT in incongruent trials compares with congruent ones.

Methods

Participants

Of the 11 individuals who were tested in our lab (Table 2), we invited those synaesthetes who consistently associate gender with at least some graphemes to take part in this experiment. Data from five synaesthetes (AA, KB, BM, JH, GP) are presented (an additional synaeasthete was tested but subsequently excluded owing to a high error rate >20%). Two sex-matched control groups were tested, both drawn from a student participant pool. Five individuals in group 1 (mean age: 22), and eight in group 2 (mean age = 20).

Stimuli and procedure

Participants were seated 50 cm away from a 14″ cathode ray tube (CRT) monitor. Stimuli were presented centrally. Grapheme primes extended to a visual angle of $2^\circ \times 2^\circ$ and face targets extended $6^\circ \times 6^\circ$. Participants were instructed to indicate whether the target face was a male or a female. Four different graphemes were used (two 'male' and two 'female' graphemes). These were tailored to each synaesthete; we only used graphemes that were consistently associated with a gender and that were ranked as inducing a strong experience in our questionnaire. Grapheme-gender association was verified a third time, just prior to testing. We avoided using the letters F and M to avoid priming due to a linguistic, rather than synaesthetic effect (with one exception – where the associations were the other way around – F was a [friendly] male, and M a [motherly] female). Each control participant in the first control group was assigned to grapheme-gender pairing of one synaesthete (thus, we have used the same five variants of the test in synaesthetes and controls.

The second control group participants were encouraged to assign gender to graphemes and provide us with two graphemes that they thought are most suitable to have a male gender and two graphemes that seem to them most suitable to have a female gender. We then used the pairing given to us by each subject to define the congruent and incongruent conditions for each one.[3]

Four cartoon faces (two males and two females) were generated on an Internet-based application (http://www.magixl.com/). On each trial, following an inter-trial interval of 1 s, a fixation cross appeared for 400 ms, followed by the letter prime for 250 ms, followed by the target face presented until a response was made, for a maximum of 2 s (see Figure 1). There were 96 trials (half congruent and half incongruent). The responses were indicated by pressing the left or right mouse buttons (for female and male faces, respectively). Another synaesthete (FC) was tested using a version of the experiment with a ratio of 1:2 congruent to incongruent trials in order to assess the presence of any strategic effects.

Data analysis

Error trials were excluded from the analysis. Outlier trials were also excluded from the analysis (RTs beyond 2.5 *SD*s from the condition mean for each participant). Mean RTs in each condition (congruent, incongruent) of all participants were analysed using a mixed ANOVA with Congruency as a within-subject factor (congruent/incongruent) and Group

[3] *The rationale for testing a second control group is that while both synaesthetes and the first control group participants were unaware of the specific hypotheses and purpose of the experiment, synaesthetes did have a general idea that this had something to do with their grapheme personification and may have been primed to process this information although it was task-irrelevant. Furthermore, the first control group participants were simply assigned to pairing of grapheme-gender chosen by synaesthetes; thus, they could not have 'benefitted' from any associations they may have had between graphemes and gender. If, however, there is nothing special about people who personify grapheme and anyone could choose to think of certain graphemes as males or females, then our second control group participants – who were allowed to choose their own grapheme-gender pairs – should show a pattern similar to that shown by synaesthetes. We thank Lynn Robertson for this suggestion.*

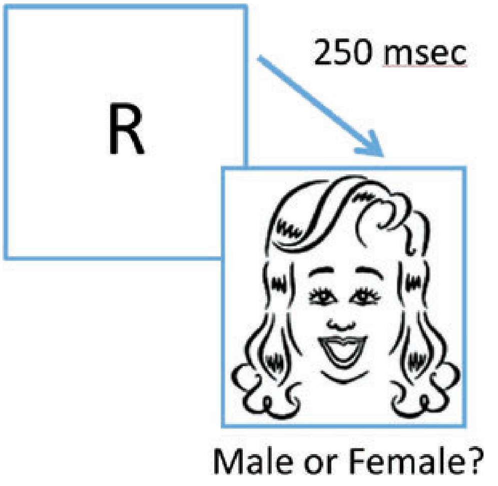

Figure 1. A schematic representation of the trial structure.

as a between-subjects factor (synaesthetes/controls). In the version of the experiment in which we varied the ratio of congruent and incongruent trials testing a single subject, a recursive outlier rejection method was used (Van Selst & Jolicoeur, 1994).

Results and Discussion

RTs in the gender judgement task are shown in Figure 2. On average, control subjects were faster (481 ms) than synaesthetes who personify graphemes (589 ms), $F(1,8) = 13.12$, $p < .01$. Across groups, congruent trials were faster (millisecond) than incongruent trials (millisecond), $F(1,8) = 13.14$, $p < .01$; however, this difference was

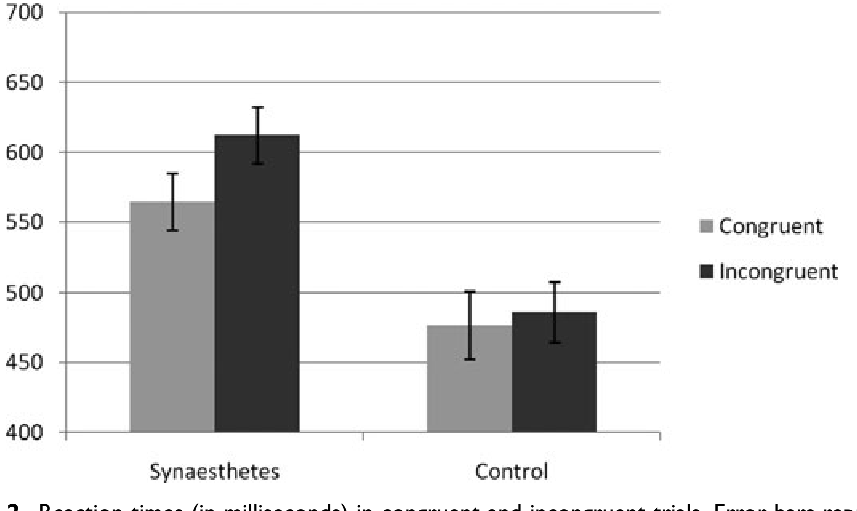

Figure 2. Reaction times (in milliseconds) in congruent and incongruent trials. Error bars represent the standard error of the mean.

much more pronounced in the synaesthetes (a 48 ms slowdown) than in the control group (a mere 9 ms difference). Indeed, the interaction of *Congruity* and *Group* was significant: $F(1,8) = 5.92, p < .05$. A planned comparison showed that for synaesthetes, congruent trials were significantly faster than incongruent ones (565 and 612 ms, respectively), $t(4) = 3.54$, $p < .05$. These results show that the gender synaesthetes associate with graphemes produces a reliable interference with subsequent gender judgements even when graphemes are task-irrelevant. This confirms synaesthetes' self-report that personification occurs automatically. Indeed, all five synaesthetes show this effect (with mean RT differences ranging from 20 to 99 ms). The paradigms provide a simple and reliable behavioural index of grapheme personification that does not require interference effects to transfer from single letters to whole words – something that Simner and Holenstein (2007) find in a single case, but may or may not generalize to other synaesthetes.

There are, however, a number of alternative explanations that we must rule out before proceeding. First, is it possible that synaesthetes are showing this effect merely because they were allowed to choose their grapheme-gender correspondences, while controls were not? This is unlikely because our second control group participants (who did choose their own pairs) do not show the congruity effect shown by synaesthetes. In fact, the opposite is true: their congruent trials were 5 ms slower than incongruent ones (523 and 517 ms, respectively); however, this difference was not significant ($t(7) = 1.33$, n.s.). This is consistent with our conclusion that grapheme personification entails more than deliberate engagement in mental imagery.

A second concern is that the congruity effect may be due to strategic effects. Synaesthetes may prepare their responses based on the prime gender even though they are told that the prime is irrelevant. This is unlikely to be the case given the short inter-stimulus interval (250 ms). Furthermore, we also observed the priming effect in an additional synaesthete (FC) who was given a modified test with a higher proportion of incongruent trials. In such a case, it would be to the participant's advantage to ignore the letter prime and forsake any strategic preparations to respond based on the gender of the prime (he was alerted that there would be more incongruent trials and it is to his advantage to completely ignore the prime). However, he still showed a decent congruity effect of 128 ms (Congruent mean RT = 1,003 ms; Incongruent RT = 1,131 ms). This congruity effect was not smaller than the one observed with an equal number of congruent and incongruent trials (an 87 ms different).

A third concern is that it is difficult to trace the origins of the association of gender and specific graphemes. For example, might the effect be mediated by colour? Although colours were not presented or referred to in our experiment, is it still possible that the association between gender and letters we observed was in fact secondary to an association between the synaesthetic colour and gender? Our participants do indicate that colour may bias gender associations with graphemes, alongside other factors. For example, darker colours might be associated with masculinity. We find it unlikely that gender priming is secondary to the synaesthetic colour because it is at odds with the self-reported experience of synaesthetes. These explicitly include gender. Furthermore, some individuals associate gender with graphemes but not colour (Simner & Holenstein, 2007); hence, the two phenomena can exist independently.

Nevertheless, we cannot rule out altogether the possibility that such effects were due to certain strong associations between colour and gender or associations of the letters with names of familiar individuals. In the Appendix, we provide a full breakdown the letters used in the experiment and their associated colours. It is evident that a dark-male/light-female association could have contributed to all but AA's congruity effects.

Whatever their source might be, the observed congruity effects support the conclusion that gender is automatically primed by graphemes. There may well be a role for learned associations here but we suspect that such association bias the correspondences between certain graphemes and genders, but do not necessarily exclude the possibility of a direct linkage between graphemes and genders.

STUDY 4: IS GRAPHEME PERSONIFICATION ASSOCIATED WITH HEIGHTENED EMPATHY?

If personification relies on some of the same mechanisms underlying normal social cognition, it would be useful to probe these skills in individuals who personify in order to constrain possible explanations for the phenomenon. We chose to begin by focusing on empathy. At first glance, heightened empathy or excessive concern for understanding or considering the feeling of others could account for a tendency to personify. This may be expected given the relatively high rate of mirror-touch self-report in personifiers (heightened empathy has been demonstrated in mirror-touch; Banissy & Ward, 2007). However, the relationship between empathy and personification may not be straightforward: could personifying objects come at the expense of normal social cognition? If the 'concern' for inanimate things is drawing resources that could have otherwise been used in a social context, we may see lower empathy scores.[4] Alternatively, the impact may be restricted to the domain of processing graphemes. This may be turn out to be the case if grapheme personification is due to localized cross-wiring between otherwise normally developed modules. In such a case, empathy scores may be in the normal range. Individual differences may yet present additional challenges to the interpretation of empathy scores.

To assess whether empathy played a role in grapheme personification, we have asked participants to complete the Empathy Quotient (EQ; Baron-Cohen & Wheelwright, 2004; Lawrence, Shaw, Baker, Baron-Cohen, & David, 2004). Participants also completed the Systemizing Quotient (SQ; Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003), quantifying the tendency to analyse or construct systems. Both tests were developed in the context of the study of autism spectrum conditions. In previous research, females were shown to score higher than males on the EQ and low on the SQ; furthermore, individuals with Asperger syndrome or high-functioning autism show an extremely low EQ and extremely high SQ scores (Lawson, Baron-Cohen, & Wheelwright, 2004).

[4] *Although causality is difficult to establish, it is possible that, in some cases, synaesthesia might develop at the expense of other functions. For example, there seems to be an association between synaesthesia and arithmetic difficulties (Cytowic, 2002; Ward, Sagiv, & Butterworth, 2009), although it should be noted that and that there may be substantial individual differences. For example, coloured-graphemes could pose certain challenges during learning for some children (Green & Goswami, 2008) but the same type of synaesthesia may not be a significant hindrance to others; on the contrary, the late physicist and Nobel laureate Richard Feynman found it helpful to see equations in colour (Day, 2005). In addition, synaesthesia may well confer some advantages, for example, in memory (e.g., Yaro & Ward, 2007).*

Methods

We tested 10 individuals (eight females and two males) who took part in our behavioural studies. Participants were given a paper copy of the EQ and SQ. Half of them were given the EQ first and half were given the SQ first. Scoring was done in accordance with Baron-Cohen & Wheelwright (2004) and Baron-Cohen *et al.* (2003). Mean scores were compared against the normative data from those studies. Male and female participants were considered separately.

Results and Discussion

The individual scores are shown in Figure 3 and present a complex picture. The two male participants both scored fairly low – an average of 22.5 on the EQ (1.3 *SD*s below the normal male average of 38.8). Only one of them SR also has an exceptionally high SQ score (61; some 2.7 *SD*s from the normal male average of 30.3). The female group presents a more heterogeneous picture with five participants scoring above the expected female average (47.7) on the EQ (ranging from 53 to 63); one obtained an average score

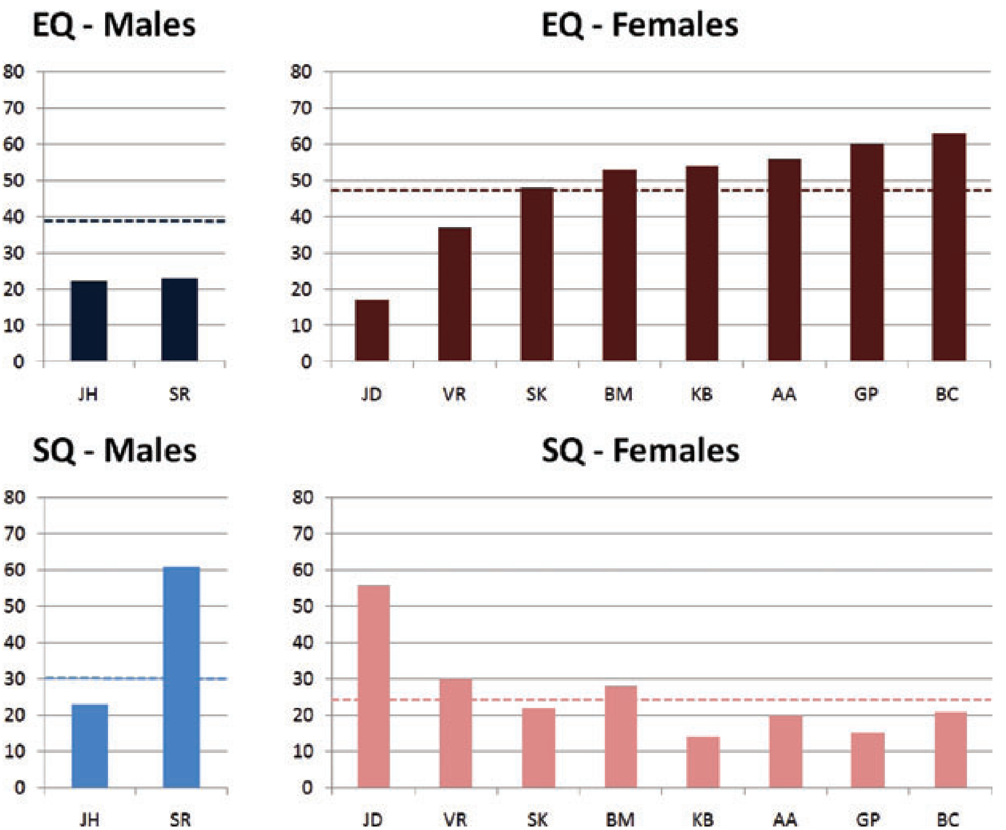

Figure 3. Individual EQ scores (upper graphs) and SQ score (lower graphs) for two male synaesthetes (on the left) and eight female synaesthetes (on the right). The dashed horizontal lines represent population averages obtained by Baron-Cohen, Richler, Bisarya, Gurunathan, and Wheelwright (2003; sample sizes were 114 males and 164 females).

(48) and two participants scored below average on empathy (one of them JD scores exceptionally low – 2.8 *SD*s below the average female EQ score and exceptionally high on the SQ – 3.4 *SD*s from the average female score of 24.1). On average our eight female participants scored 48.5, only slightly the average EQ score 47.7 reported by Baron-Cohen *et al.*, (2003); however, this difference was not significant ($t(7) = 0.151$, n.s.). The male sample ($n = 2$) is admittedly too small to be considered representative of synaesthetes who personify.

From this mixed pattern of results, we cannot conclude that as a group, personifying synaesthetes exhibit heightened empathy. Three of 10 participants scored substantially lower than the average. At the very least, this demonstrates that heightened empathy is not necessary for personifying graphemes. The presence of the extreme scores obtained by JD in such a small sample hints that we may not be sampling from a normal distribution (although a larger sample will be required to properly assess normality). This highlights once again the importance of individual differences in synaesthesia (Barnett *et al.*, 2008; Rouw & Scholte, 2010; Dixon & Smilek, 2005; Ward, Li, Salih, & Sagiv 2007). Future studies attempting to probe social cognition in synaesthetes or the mechanisms of personification should not ignore these individual differences.

It is an intriguing possibility that there may be two different developmental pathways to grapheme personification resulting in a bi-modal distribution: one group with highly sensitive mechanisms for social cognition indulges in personification in unusual contexts. Individuals in the other group exhibit poorer social skills, grapheme personification may represent an inadequate mentalizing process; a failure to pick up crucial behavioural cues in human interaction may result in indiscriminate personification of both human and inanimate things. In these individuals, the attribution of feelings or intentions may be based on more superficial features of the evoking stimulus).

It is fair to say that these hypotheses are somewhat speculative; however, they are testable. In the future, we should seek to test larger samples, attempt to eliminate possible sampling biases (the present sample is self-referred), and test directly a range of social skills. We feel that the most promising approach may be a prospective developmental study following up on samples of children with poor, average, and high social skills.

STUDY 5: NEURAL BASIS OF GRAPHEME PERSONIFICATION

If cross-wiring any two sensory brain areas results in some variety of synaesthesia (e.g., Hubbard, Brang, & Ramachandran, 2011), what would be the outcome if a similar process were to link other neural systems? Given the similarities between coloured-grapheme synaesthesia and grapheme personification, it is tempting to hypothesize that personification is one possible outcome: a synaesthesia-like process linking grapheme recognition with some of the mechanisms underlying social cognition.

Previous neuroimaging studies (e.g., Castelli, Happe, Frith, & Frith, 2000) demonstrate that we utilize similar mechanisms when personifying human agents and non-human objects. Smilek, Malcolmson, *et al.* (2007) list a number of candidate areas for the anthropomorphization of objects, including the fusiform gyrus, anterior temporal lobe/amygdale, posterior parts of the temporo-parietal junction (TPJ) (angular gyrus), and the medial frontal cortex. All areas have been implicated in certain aspects of social cognition including face and gaze perception, theory of mind, and processing of information concerning the self. The majority of individuals we interviewed so far do not seem to associate faces with objects and therefore may not involve the fusiform face area (Kanwisher, McDermott, and Chun, 1997). The amygdala may serve a modulating function in signalling significance of socially relevant information (Haxby, Hoffman, & Gobbini, 2002) and may well be implicated in anthropomorphism (Heberlein & Adolphs, 2004). The medial prefrontal lobe is associated with 'theory of mind' (e.g., Siegal & Varley, 2002), although it may not be necessary (Bird, Castelli, Malik, Frith, & Husain, 2004). One of the functions associated with the posterior TPJ besides theory of mind is the 'feeling of presence' (e.g., Arzy, Seeck, Ortigue, Spinelli, & Blanke, 2006). We may add to this list three additional areas: the insula, implicated in empathy (for a review, see Decety & Jackson, 2006); the precuneus, associated with self-reference and self-reflection (Cavanna, 2007; Lou, Nowak, & Kjaer, 2005); and the retrosplenial cortex, implicated in access to biographical information about familiar individuals (e.g., Shah *et al.*, 2001). The latter may be particularly relevant in the case of grapheme personification given that letters and numbers are associated with rich biographical information such as gender, age, occupation, etc. We present here data from a single case of a synaesthete who personifies graphemes, providing us with some preliminary insights into the possible neural mechanisms of personification.

Methods

Participant

AA is a 38-year-old right-handed female. She is highly educated (PhD in the humanities) but mildly dyscalculic and right–left confused but has superior verbal skills. She has colour-grapheme synaesthesia, number forms, and attributes genders to about half of the letters of the alphabet. This makes her an ideal case study since we are able to compare brain activation to letters that are either associated with a gender or not (i.e., contrast personified letters with a control condition utilizing stimuli that are closely matched in every aspect except personification).

Procedure

We presented AA with letter stimuli (shown for 1,000 ms, followed by 200 ms blank screen). Sixteen blocks with 16 letter stimuli within each block were presented in one experimental session. We alternated between blocks in which all the letters had genders and blocks in which letters did not have genders. AA's task was to detect the presence of letter repetition (one–back task) to maintain attention. Since grapheme gender was task-irrelevant, any activation we may find there represents automatic processing that may be associated with personification.

Data acquisition and analysis

Brain images were acquired with a 3T MRI scanner (Siemens Magnetom Trio: www.siemens.com) equipped with an eight-channel array headcoil. Functional images of the entire brain were acquired continuously during each experimental run with a standard gradient-echo, echoplanar sequence (TR 2,000 ms, 34 slices, voxel size $3 \times 3 \times 3$ mm, 64×64 matrix, axial orientation). These were acquired continuously during each experimental run. A high-resolution (1 mm) three-dimensional anatomical scan (MP-RAGE, Siemens) of the whole brain was also acquired. The data were analysed using SPM5 (http://www.fil.ion.ucl.ac.uk/spm/). To correct for head motion, each functional volume was realigned to match the first volume acquired. Anatomical and functional scans were normalized to the standard Montreal Neurological Institute (MNI) stereotactic space. Finally, the spatially normalized functional scans were smoothed with a 6-mm isotropic Gaussian filter. Models of the expected timecourses were generated with SPM5, utilizing the standard haemodynamic response function. The resulting statistical images were thresholded at $p < .05$ (Family-wise error (FWE) correction).

Results and Discussion

Figure 4 shows brain activation found when we contrasted letters with and without gender. The comparison of those closely matched stimuli only yields precuneus activation (MNI coordinates [0, −69, 39]; $p = .003$ FWE corrected), suggesting that OLP may represent an aberration of self-reflection and/or mental imagery, although the absence of additional activations in a single-case study should always be interpreted with caution.

AA only attributes gender to letters, but not very elaborate mental states. As noted earlier, the precuneus is associated with self-reference and self-reflection. Is it possible that personifying graphemes (or inanimate objects) serve the function of projecting one's own feelings? This suggestion would be consistent with observations and comments provided by some of our participants who indicated that while some features were stable (such as graphemes' gender or colour), other aspects, such as graphemes' moods

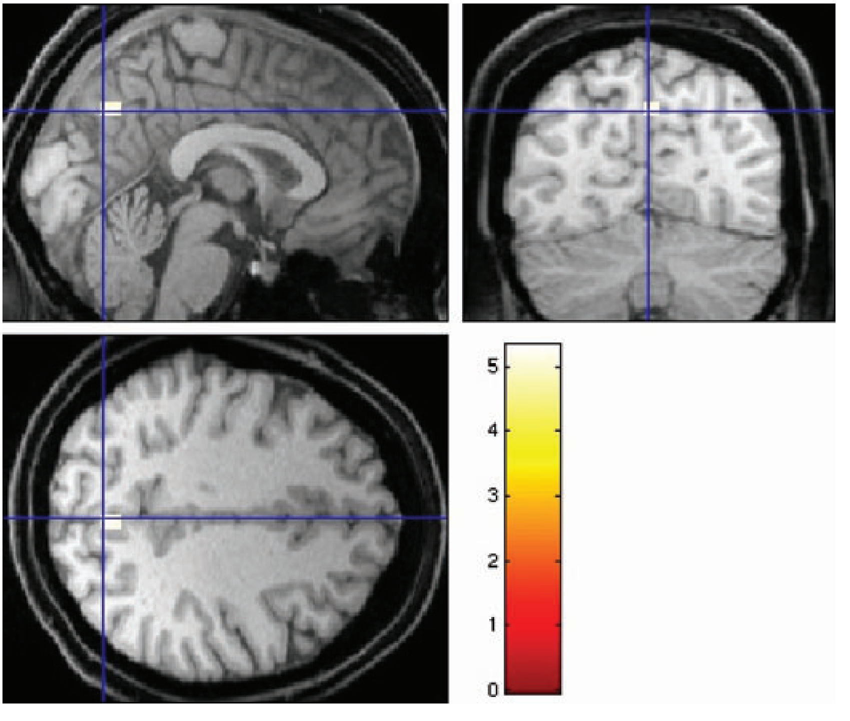

Figure 4. Brain activation in AA, comparing letters with which she associated gender with letters with which she does not associate gender ($p < .05$ FWE corrected). Cross-hair shows precuneus activation located at MNI coordinates (0, −69, 39).

tended to vary with their one mental state. This would certainly be an interesting line of investigation; however, a more straightforward explanation is that the observed precuneus activation is related to polymodal mental imagery (for a review, see Cavanna & Trimble, 2006). The process of personifying graphemes certainly requires imaginative capacity (regardless of whether it is intentional or an automatic process as seems to be the case in our participants). The precuneus has recently been implicated in other types of synaesthesia involving visual (Nunn *et al.*, 2002; Specht & Laeng, 2011; Steven, Hansen & Blakemore, 2006; Weiss, Shah, Toni, Zilles & Fink, 2001) and gustatory experiences (Jones *et al.*, 2011). Jones and her colleagues showed that the precuneus activation co-varied with the intensity of synaesthetic taste reports and speculated that the precuneus may be associated with the intensity but not the specific nature of the experience. The fact that we see in AA activation of the precuneus without additional unimodal areas is consistent with AA's descriptions: when she personifies letters, she 'just knows' whether they are males or females without imagining seeing them or hearing them.[5] The activation of the precuneus also reinforces the idea that grapheme personification may well be a variant of synaesthesia, sharing a core underlying mechanism with other more conventional types of synaesthesia.

It is premature to conclude from this single case that activation in other nodes in the social cognition network is absent. In particular, it remains to be seen whether other synaesthetes with more elaborate OLP descriptions, including personalities and attitudes do engage additional brain areas such as the medial prefrontal and temporal-parietal regions or perhaps inferior parietal and inferior frontal regions engaged in personality judgements (Heberlein and Saxe, 2005) as suggested by Simner and Hubbard (2006). Preliminary results from our on-going study indicate that the insula is also activated, in addition to the precuneus, in individuals who attribute both gender and personality (Sobczak, Sagiv, & Williams, 2011). At the very least, this case study reinforces our conviction that peculiar as it may first appear, grapheme personification can be studied systematically in the laboratory and may provide new insights into creative processes in the human brain.

GENERAL DISCUSSION

We have known for over a hundred years that some individuals attribute gender or personality to letters and numbers (e.g., Calkins, 1895). Individuals who personify graphemes are more likely to experience coloured-grapheme synaesthesia (Simner & Holenstein, 2007). Our data also suggest that such an association of the two phenomena is likely – one in three coloured-grapheme synaesthetes also appear to personify graphemes. Our prevalence estimates point to a conservative prevalence estimate of 1.4% of the population. This is a non-negligible minority but this would need to be corroborated in a larger scale survey.

We also find an association with other synaesthesia variants including mirror-touch synaesthesia and spatial variants such as number forms. Personification not only co-occurs with synaesthesia variants, it also shares much in common with synaesthesia. Personification is induced by ordinal sequences, it is present from early childhood, it is automatically elicited and influences processing of concurrent-related information

[5] *We have only come across anecdotal reports of individuals who actually visualize a face when they personify but have not been able to follow these up in the laboratory due to geographical constraints.*

(in this case gender). Personification patterns appear to be consistent at least in some individuals, although at present we cannot rule out that in some instances of grapheme personification, the specific correspondences between letters and gender/personality may vary with time. Some synaesthetes' comments indicate that their graphemes' state of mind may vary with their own. Others have noted that the specific characters associated with each grapheme may depend on their synaesthetic colour.

We provided here data from a simple novel behavioural paradigm for corroborating synaesthetes' reports. Our data (from a group of five individuals) strongly suggest that grapheme personification occurs automatically, supporting the conclusions reached by Simner and Holenstein (2007) and Smilek, Malcolmson, *et al.* (2007) in their single-case studies.

Now that we have a better grasp of the phenomenology of grapheme personification, and we have been able to provide objective correlates of the reported experiences, the biggest challenge remains explaining how personification occurs and what the cognitive and neural mechanisms are. Our preliminary brain imaging data investigation in a single subject reveals activation in the precuneus, an area previous associated with mental imagery as well as self-referential processing (e.g., Cavanna & Trimble, 2006). Both of these functions may provide some clues to understanding grapheme personification. Mental imagery received surprisingly little attention in the recent synaesthesia literature with few exceptions (e.g., Rich *et al.*, 2006). However, synaesthesia could be considered a special case of mental imagery that happens to be elicited automatically, involuntarily, has a well-defined trigger and seems to be more constrained and restricted to specific modalities. It remains to be seen whether mental imagery is the missing link between ordinary perceptual experience and synaesthesia; however, we should note that evidence is mounting for precuneus involvement in other types of synaesthesia (for a discussion, see Jones *et al.*, 2011). An alternative explanation links personification with self-processing. The idea that grapheme personification may represent an unusual form of projecting one's own mental states remains speculative at this stage, but at the very least, it reminds us the grapheme personification provides a very interesting test case for our understanding of certain key social skills – how people encode and represent their own and other people's intentions, beliefs, and feeling.

Considerable efforts are devoted to understanding the course of development of these capabilities and their underlying neural bases (e.g., Frith & Frith, 2007). It has been suggested that a failure to intuitively interpret and predict other people's behaviour on the basis of their mental states is a key feature in autism (for a critical review, see Tager-Flusberg, 2007). Indeed, we have learnt a great deal from studying failures to understand other minds in atypically developed populations; however, the 'fantasy world' of otherwise normal individuals who consistently attribute mental states to non-living things is virtually ignored. We propose that grapheme personification and animistic thought represents instances of benign hyper-mentalizing that must be accounted for if we are to understand mentalizing.

Our attempt to determine whether heightened empathy can account for grapheme personification has revealed a complex picture highlighting substantial individual difference in our group of synaesthetes with grapheme personification. We suggested that there may be two different developmental routes to grapheme personification, one representing an exaggeration or extension of normal processes (from the domain of human interaction to other domains), while the other could represents impaired criteria for personification, or sensitivity to the 'wrong' cues. This is another line of study that we are currently exploring.

Another problem for future research is to understand better animistic thought and its relationship to normal cognition, to grapheme personification (and experiences such as sense of presence; e.g., Blanke, Arzy, & Landis, 2008). Animism may represent a sense of presence that is triggered by and projected onto objects in the environment. As such, it may well present us with another clue to the involvement of self-processing in personification (self-projection has been linked with a sense of presence; Brugger, Regard, & Landis, 1997).

In conclusion, grapheme personification is a fascinating phenomenon co-occurring with synaesthesia. It appears to be a variant of synaesthesia albeit a non-sensory one. The phenomenological, behavioural, and neuroimaging data we present here also support this conclusion. We suggest that grapheme personification, rather than a peculiar set of claims to be dismissed, is a goldmine for social cognitive neuroscientists and cognitive neuropsychologists alike.

We would like to end with this final thought: could other categories be personified besides ordinal sequences? We suspect that the useful term OLP might prematurely narrow the search for other types of personification. Since concluding this study, we have heard from individuals who personify categories such as the violin strings, or body parts, including, for example, teeth and fingers. We suspect that personification of the genitalia may be relatively common albeit not a topic of conversation in polite company (teenage boys excluded). It became clear from our questionnaire study that many individuals also personified various object categories. We have not asked about food (except fruits and vegetables) but while browsing Chef Paul Bertolli's cookbook we could not help but notice that the book ends with a short play in which the characters are not people but different foods and wines. He notes that if food and wine could talk, 'any meal could become theater' (Bertolli, 2003, p. 253). Indeed, like personified graphemes, different foods and wines get along with some but certainly not all of their peers. In Bertolli's play, the Barolo accuses the oxtails 'you are too soft for me', but the oxtails reply 'Any meat would be' (Bertolli, 2003, p. 258). If this is not a novel type of personification, it is certainly an interesting exercise in demonstrating the universal appeal of make-believe personification.

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Appendix

Synaesthetic associations of the letters used in the reaction time study

Participant	Letters used	Gender	Colour
AA	A	Female	Red-pink
	X	Female	Blue
	B	Male	Yellow
	P	Male	Blue
BM	E	Female	Pink
	L	Female	Yellow
	G	Male	Silver
	P	Male	Brown
GP	G	Female	Pink
	K	Female	Dark purple
	E	Male	Mid blue
	N	Male	Rust brown/tan
JH	G	Female	White-grey
	K	Female	Yellow-ochre
	J	Male	Blue dark
	N	Male	Black
KB	L	Female	Mid green
	8	Female	Pink smooth
	Y	Male	Pale
	P	Male	Black with dots