COGNITIVE NEUROPSYCHOLOGY, 2016
http://dx.doi.org/10.1080/02643294.2016.1261820

Social perception in synaesthesia for colour

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ABSTRACT
Synaesthesia is a rare phenomenon in which stimulation in one modality (e.g., audition) evokes a secondary percept not associated with the first (e.g., colour). Prior work has suggested links between synaesthesia and other neurodevelopmental conditions that are linked to altered social perception abilities. With this in mind, here we sought to examine social perception abilities in grapheme–colour synaesthesia (where achromatic graphemes evoke colour experiences) by examining facial identity and facial emotion perception in synaesthetes and controls. Our results indicate that individuals who experience grapheme–colour synaesthesia outperformed controls on tasks involving fine visual discrimination of facial identity and emotion, but not on tasks involving holistic face processing. These findings are discussed in the context of broader perceptual and cognitive traits previously associated with synaesthesia for colour, with the suggestion that performance benefits shown by grapheme–colour synaesthetes may be related to domain-general visual discrimination biases observed in this group.

ARTICLE HISTORY
Received 5 December 2015
Revised 2 November 2016
Accepted 4 November 2016

KEYWORDS
Emotion recognition; facial affect; identity processing; synaesthesia; synesthesia

Introduction

Synaesthesia is a rare phenomenon experienced by an estimated 4% of people (Simner et al., 2006), in which stimulation of one attribute leads to involuntary secondary percepts that are not associated with the first (Sagiv, 2004). For example, in grapheme–colour synaesthesia, seeing achromatic graphemes evokes a secondary percept of colour (Ward, 2013). While the majority of research in this field has focused on investigating the mechanisms driving synaesthetic experiences (e.g., see Ward, 2013, for review), a number of studies have also explored wider characteristics associated with synaesthesia. For instance, synaesthesia has been linked to broader differences in perceptual processing (Banissy et al., 2013; Banissy, Walsh, & Ward, 2009; Barnett et al., 2008; Terhune, Song, & Cohen Kadosh, 2015; Yaro & Ward, 2007); differences in memory abilities (Rothen, Meier, & Ward, 2012); and creativity (Ward, Thompson-Lake, Ely, & Kaminski, 2008).

There are also reports suggesting links between synaesthesia and other neurodevelopmental conditions, including autism spectrum disorder (ASD; Asher et al., 2009; Bouvet et al., 2014; Neufeld et al., 2013). For example, in a recent study Baron-Cohen and colleagues (2013) report that the prevalence of self-reported synaesthesia is more common among individuals diagnosed with ASD (18.9%) than in controls (7.22%). In that study, 17 out of 31 ASD participants that self-reported synaesthetic experiences were female, which is in line with prevalence studies suggesting a similar female-to-male ratio in synaesthesia (e.g., Simner et al., 2006). Baron-Cohen and colleagues (2013) speculate that similar mechanisms may underlie these conditions (e.g., increased neural connections between neighbouring brain areas). ASD is also associated with a range of behavioural characteristics, including but not limited to atypical social and sensory processing (Lane, Molloy, & Bishop, 2014; Uljarevic & Hamilton, 2012; Weigelt, Koldewyn, & Kanwisher, 2012). For example, individuals with ASD have shown impairments in the perception of facial identity and emotion (Hedley, Brewer, & Young, 2014; Uljarevic & Hamilton, 2012; Weigelt et al., 2012). Whether associations between synaesthesia and ASD are related to shared differences in atypical social perception, sensory perception, or other factors (e.g., attention) remains unclear. Basic sensory processing in synaesthetes has received some

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attention (e.g., Banissy et al., 2013; Banissy et al., 2009; Barnett et al., 2008; Terhune et al., 2015; Yaro & Ward, 2007), but there is little work examining whether synaesthetes show differences in processing social cues. Studying social perception abilities in synaesthetes can therefore help to constrain our understanding of broader phenotypic manifestations in synaesthesia.

One case of synaesthesia where social perception has been investigated is mirror-touch synaesthesia, where individuals experience tactile sensations on their own body when observing pain or touch to other people (see Ward & Banissy, 2015, for review). Recent findings have linked mirror-touch synaesthesia to heightened emotional empathy relative to non-synaesthetes and grapheme–colour synaesthetes (Banissy & Ward, 2007, in verified developmental mirror-touch synaesthetes; Goller, Richards, Novak, & Ward, 2013, in self-reported acquired mirror-touch synaesthetes; but see Baron-Cohen, Robson, Lai, & Allison, 2016, in self-reported mirror-touch synaesthetes) and enhanced emotion perception relative to non-synaesthetes (Banissy et al., 2011). It is of note, however, that while labelled as synaesthesia, the notion that mirror-touch synaesthesia relies upon similar mechanisms to those of more traditional forms of synaesthesia (e.g., grapheme–colour synaesthesia) is somewhat controversial (e.g., Rothen & Meier, 2013). In this regard a systematic investigation of social perception abilities in other types of synaesthesia (e.g., grapheme–colour synaesthesia) is lacking.

There are other reasons why studying social perception in synaesthetes who experience colour as their evoked sensation is interesting. For example, prior work has also linked grapheme–colour synaesthesia to broader differences in schizotypal personality traits (Banissy, Cassell, et al., 2012; Janik McErlean, & Banissy, 2016). In non-synaesthetes, schizotypy traits have been associated with deficits in emotion recognition (Abbott & Byrne, 2013; Morrison, Brown, & Cohen, 2013). Abbott and Byrne (2013) found an association between global and positive schizotypy and poor emotion recognition. Similarly, Morrison et al. (2013) found that individuals who score high on schizotypy compared to controls perform worse on a facial affect recognition task. When coupled with a potential relationship between synaesthesia and ASD suggested by other authors (e.g., Baron-Cohen et al., 2013; Neufeld et al., 2013) it is important to assess whether grapheme–colour synaesthesia is associated with atypical social perception abilities or with other aspects of cognition (e.g., attention; cognitive disorganization) that are shared between ASD and schizotypy.

With this mind, here, we sought to elucidate whether synaesthesia for colour would be associated with broader differences in social perception. To do so, we compared a group of grapheme–colour synaesthetes to a matched control group of non-synaesthetes on their abilities to perceive facial identity and facial emotion. In Experiment 1, we assessed participants' abilities to make fine-grained visual discrimination judgments related to facial identity and facial emotion. In Experiment 2, we sought to examine face-processing abilities of grapheme–colour synaesthetes and controls on a task that promoted the use of holistic rather than fine-grained visual discrimination.

Experiment 1: Processing of facial expressions of emotion and identity in the Cambridge Face Perception Test

Method

Participants

Twenty-one control participants (all female, $M_{age} = 23.09$ years, $SD = 4.74$) and 20 grapheme–colour synaesthetes (all female, $M_{age} = 26.25$ years, $SD = 5.14$) took part in this experiment. There was a significant group difference in terms of age, $t(39) = 2.042$, $p = .048$, and therefore age was included as a covariate in all analyses. In addition to grapheme–colour synaesthesia, 10 of the synaesthetes reported weekday–colour and month–colour synaesthesia, and three synaesthetes reported musical instrument–colour synaesthesia. Each synaesthete's grapheme–colour synaesthesia was verified using the Eagleman Synaesthesia Test Battery (Eagleman, Kagan, Nelson, Sagaram, & Sarma, 2007) where a score below 1 indicates the presence of synaesthesia. The controls were recruited from the student population via posters displayed at the university buildings or via acquaintances. Participants received £10 compensation for their participation.

Task

Facial identity perception. To measure facial identity perception, the Cambridge Face Perception Test (CFPT–Identity; note prior studies refer to this as

CFPT) was employed (Duchaine, Yovel, & Nakayama, 2007). Participants were simultaneously presented with a target image on top of the screen, consisting of a male face shown at a three-quarter angle, and six male, test faces shown as a frontal view underneath (Figure 1a). These images were constructed by morphing different degrees of the frontal view of the target face at 88, 76, 64, 52, 40, and 28% with six distractor individuals that vary in perceptual similarity to the target face based on pilot rating. Specifically, each target face was morphed at 88% with the most similar distractor, at 72% with the second most similar distractor, and so on (thus representing a gradual variation in similarity to the target face). Participants were required to sort the test faces in order of least to most like the target face. Participants had one minute to complete each trial. There were 16 test trials, eight using upright images and eight using inverted pictures of faces, preceded by two practice trials. Performance on this task was measured using an error score calculated by summing the deviations of each image from its correct location. For instance, if the picture was three spaces from its correct position the error score for that trial would be 3. The error score was then converted into percentage of correct responses. Chance performance is 36%.

Facial emotion perception. The Cambridge Face Perception Angry Expression (CFPT–Angry; Janik, Rezlescu, & Banissy, 2015) and Cambridge Face Perception Happy Expression (CFPT–Happy) tests were used in order to evaluate participants' facial emotion perception. In each trial, a row of six frontal view images of a model showing different degrees of emotion was displayed. For CFPT–Happy, the images were morphed from a neutral facial expression to contain 0, 3, 6, 9, 12, and 15% happiness, and for CFPT–Angry the images were morphed from a neutral face to contain 0, 8, 16, 24, 32, and 40% anger. The stimuli were generated using male and female pictures from the Radboud Faces Database (Langner et al., 2010). Participants were required to order the faces from the most to the least intense expression of the given emotion (Figure 1b). Each of the two tasks consisted of 10 test trials preceded by two practice trials. Participants had one minute to complete each trial. Performance on these tasks was measured using percentage of correct responses calculated in the same way as for CFPT–Identity. Chance performance is 36%.

Results

One control participant's score was removed from this analysis as they performed below chance (31.94%) on inverted CFPT–Identity trials: Their inclusion does not qualitatively change the pattern of data.

In order to examine facial identity and facial emotion perception in synaesthetes relative to controls, a 2 (group: synaesthetes, controls) × 4 (trial type: identity upright, identity inverted, angry, happy) analysis of covariance (ANCOVA) was conducted, with age included as a co-variate given the group level difference described above. This revealed a significant main effect of group, $F(1, 37) = 4.246$, $p = .046$, $\eta_p^2 = .103$, with synaesthetes showing better overall performance ($M = 73.78\%$, $SE = 1.52$) than controls ($M = 69.24\%$, $SE = 1.52$; Figure 1c). There was also a significant main effect of task, $F(3, 111) = 5.134$, $p = .002$, $\eta_p^2 = .122$, due to participants performing worse on identity inverted trials ($M = 55.25\%$, $SE = 1.38$) than in all other tasks (CFPT–Identity upright: $M = 76.87\%$, $SE = 1.18$; CFPT–Happy: $M = 73.66\%$; $SE = 1.73$; CFPT–Angry: $M = 80.26\%$, $SE = 1.28$), and overall performance on CFPT–Angry being better than that on CFPT–Happy. No other main or interaction effects were found (see Table 1 for individual means and standard deviations).

Discussion

Building on prior studies suggesting a link between colour synaesthesia and other traits (e.g., Banissy, Cassell, et al., 2012; Janik McErlean & Banissy, 2016) and conditions (Baron-Cohen et al., 2013; Neufeld

Table 1. Mean accuracy scores and standard deviations for CFPT–Happy, CFPT–Angry, CFPT–Identity upright, and CFPT–Identity inverted trials for controls and synaesthetes.

		Accuracy (%)	
Task	Group	*M*	*SD*
CFPT–Happy	Controls	70.42	12.27
	Synaesthetes	76.89	9.03
CFPT–Angry	Controls	77.24	7.18
	Synaesthetes	82.97	8.88
CFPT–Identity upright	Controls	74.00	9.19
	Synaesthetes	79.09	5.77
CFPT–Identity inverted	Controls	53.61	8.30
	Synaesthetes	56.89	9.22

Note: CFPT = Cambridge Face Perception Test.

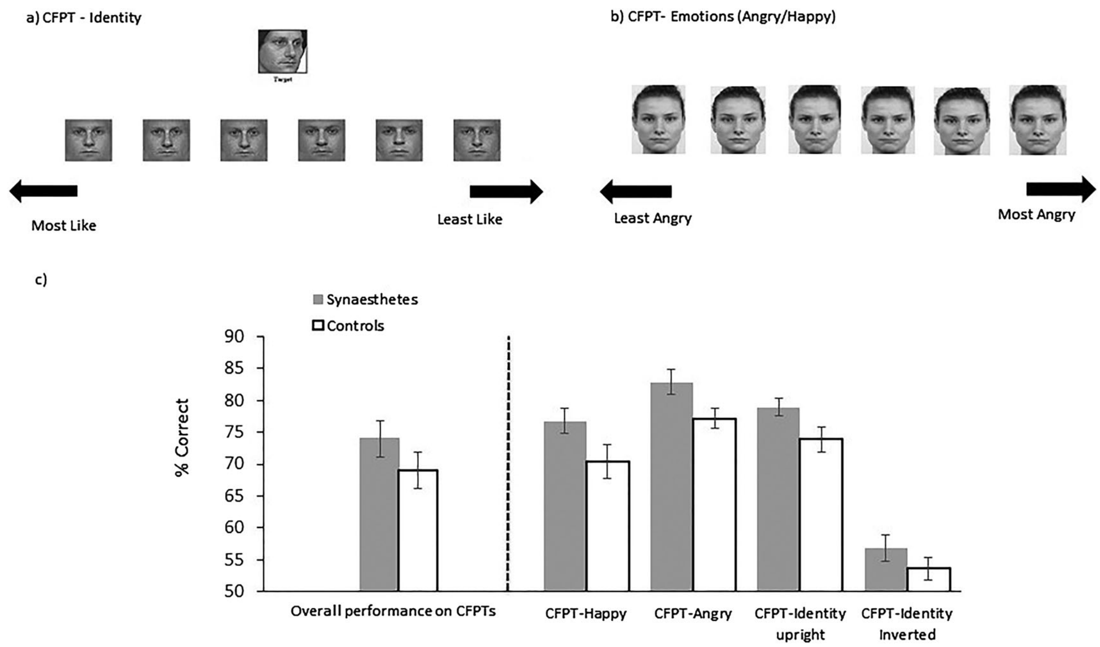

Figure 1. (a) Examples of trials of CFPT–Identity. CFPT = Cambridge Face Perception Test. Note that while upright faces are shown, half of the trials were inverted. (b) Examples of trials of CFPT–Angry. Note that the same format was used for CFPT–Happy, but the expression type differed. (c) Mean percentage of correct responses for synaesthetes and controls across CFPT–Happy, CFPT–Angry, CFPT–Identity upright, and CFPT–Identity inverted trials. Error bars show standard error of measurement.

et al., 2013) linked with atypical social perception abilities, this study sought to examine whether grapheme–colour synaesthetes differed from non-synaesthetes in their social perception abilities. We compared grapheme–colour synaesthetes to control participants in their ability to perceive facial identity and facial emotion (happiness and anger perception). Our findings revealed that, overall, grapheme–colour synaesthetes outperformed control participants both on facial identity and on facial emotion perception.

While these findings could reflect some level of advantage in processing of facial cues in grapheme–colour synaesthesia, there are at least two alternative explanations. Firstly, given that synaesthetes show enhanced performance across all tasks, one could argue that performance differences relate to greater motivation on the part of synaesthetes. Secondly, performance benefits across all tasks using the CFPT format may be related to domain-general task demands rather than domain-specific benefits in social perception. Prior work has suggested that colour synaesthetes show greater perceptual and cortical responsiveness to high spatial frequency information (e.g., Barnett et al., 2008; Terhune et al., 2015). For example, Barnett and colleagues (2008) report that synaesthetes who experience colour as their evoked sensation show enhanced sensitivity to high spatial frequency Gabor patches that bias parvocellular channels, but not low spatial frequency stimuli processed via magnocellular streams. Prior work suggests that such high spatial frequency information may be important for face perception by conveying fine-grained featural information (Vuilleumier, Armony, Driver, & Dolan, 2003). In the context of the tasks used in Experiment 1, this information may be of particular utility given that all tasks require participants to make fine-grained visual judgments regarding how well each image matches a target face or in order to detect small featural differences between images. In this regard, performance differences observed in Experiment 1 may relate to a domain-general bias for synaesthetes in processing high-spatial-frequency cues that aid fine-grained visual discrimination rather than a domain-specific advantage in face perception.

To address these issues we conducted a second study comparing the performance of synaesthetes and non-synaesthetes on another facial identity processing task that relies less heavily on high spatial frequency cues – the face composite task, in which joining the top halves of one face with bottom halves of another face leads to an illusion that identical top halves are different when aligned with different bottom halves but not when they are offset laterally (Young, Hellawell, & Hay, 1987). The face composite effect is absent when the two halves are misaligned and is thought to illustrate holistic face processing as aligning top and bottom parts of the face leads to a perceptual integration of these different halves into one face. A larger face composite effect has been reported for low-spatial-frequency faces than for high-spatial-frequency faces, suggesting that low-spatial-frequency information is particularly advantageous for holistic face processing in the face composite effect (Goffaux & Rossion, 2006; Rossion, 2013; Young et al., 1987). In this regard, unlike the CFPT used in Experiment 1, employing the face composite task permits investigation of face processing abilities in which any domain-general benefits for synaesthetes in using high-spatial-frequency visual information are less likely to aid performance.

Experiment 2: Processing of facial information using face composite task

Method

Participants

Sixteen control participants (all female, age $M = 30.56$ years, $SD = 3.57$) and 12 gender matched grapheme–colour synaesthetes (all female, age $M = 28.83$ years, $SD = 7.45$; six of whom participated in Experiment 1) took part in this experiment. The two groups did not differ in terms of age, $t(26) = 0.742$, $p = .470$. Synaesthetes had been previously verified using the online Eagleman Synaesthesia Test Battery (Eagleman et al., 2007) where a score below 1 indicates the presence of synaesthesia. The controls were recruited among acquaintances. Participants were given £10 gift vouchers for their participation.

Task

The face composite task was adapted from Experiment 3 in Susilo, Rezlescu, and Duchaine (2013). Composite faces were created by mixing same-sex top and bottom halves from 60 original faces (32 females), all of which were Caucasian, front-view, greyscale images with neutral expressions and similar skin tone. Lines at the edges of the faces indicated the halves. The top and bottom halves were either aligned to form a novel face, or misaligned. A black ski-cap was pasted on to cover hair cues. On each trial, a pair of composite faces was presented sequentially. The first composite face appeared for 200 ms, followed by a blank screen for 400 ms, and then the second composite face for 200 ms. The composite faces were both either aligned ("aligned" trials) or misaligned ("misaligned" trials). Example stimuli are presented in Figure 2. Participants were asked to indicate whether the top halves were the same ("same" trials) or different ("different" trials) while ignoring the bottom halves. There were 90 trials presenting upright stimuli (30 same aligned, 30 same misaligned, 15 different aligned, 15 different misaligned) and 90 trials presenting inverted stimuli. All 180 trials were randomized. Only "same" trials were included in the analysis as two different top halves are not perceived as more similar when they are aligned compared to being misaligned with identical bottom halves – that is, "different trials" do not produce a face composite effect (Rossion, 2013).

Results and discussion

We computed face composite effects considering accuracy and reaction time. For accuracy, the face composite effect was calculated by subtracting average correct score for the same aligned trials from the average correct score for the same misaligned trials. For reaction time, the face composite

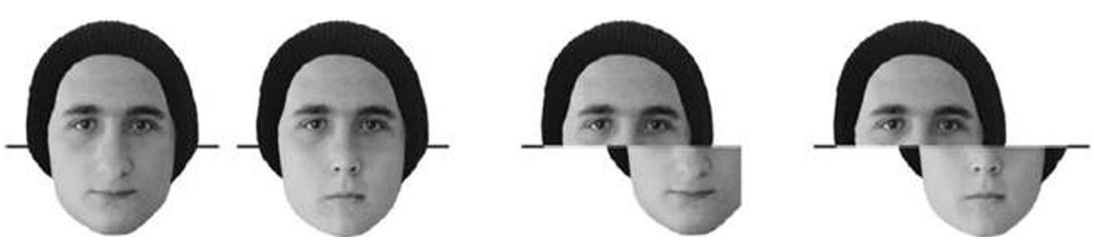

Figure 2. Example of stimuli used in the face composite task. All four top halves are identical; however, they appear different when aligned with different bottom halves (first pair) and similar when the top and bottom halves are misaligned (second pair).

effect was calculated by subtracting average reaction time for same misaligned correct trials from average reaction time for same aligned correct trials.

Synaesthetes and controls showed similar performance in the four conditions (upright aligned, upright misaligned, inverted aligned, inverted misaligned) of the face composite task (see Table 2 for means and standard deviations). Two separate 2 (group: synaesthetes, controls) × 4 (condition: upright aligned, upright misaligned, inverted aligned, inverted misaligned) analyses of variance (ANOVAs) conducted on accuracy and reaction times revealed no group differences or interaction effects on either measure [accuracy: group, $F(1, 26) = 2.529$, $p = .124$, $\eta_p^2 = .089$, interaction effect, $F(3,78) = 0.207$, $p = .891$, $\eta_p^2 = .008$; reaction times: group, $F(1, 26) = 1.218$, $p = .280$, $\eta_p^2 = .045$, interaction effect, $F(3, 78) = 1.141$, $p = .338$, $\eta_p^2 = .042$; Figures 3a and 3b]. As expected, a main effect of condition was found for both reaction times, $F(3, 78) = 8.441$, $p < .001$, $\eta_p^2 = .245$, and accuracy, $F(3, 78) = 16.459$, $p < .001$, $\eta_p^2 = .388$, due to participants being overall more accurate and faster on misaligned than on aligned trials for upright faces [accuracy: $t(27) = 0.637$, $p < .001$, Cohen's $d = 1.217$; reaction times: $t(27) = -3.460$, $p = .002$, Cohen's $d = -0.044$] and on aligned inverted trials than on aligned upright condition [accuracy: $t(27) = -4.236$, $p < .001$, Cohen's $d = 0.804$; reaction times: $t(27) = 4.067$, $p < .001$, Cohen's $d = 1.212$]. Both findings are in line with previous literature on the face composite effect (e.g., Rossion, 2013).

Table 2. Means and standard deviations on accuracy and reaction time data for upright aligned, upright misaligned, inverted aligned, and inverted misaligned trials of the face composite task and mean face composite effects for upright and inverted trials on accuracy and reaction time data for controls and synaesthetes.

		Accuracy (%)		*Reaction time (ms)*	
Task	Group	*M*	*SD*	*M*	*SD*
Upright misaligned	Synaesthetes	.83	.14	848.38	164.47
	Controls	.92	.09	932.47	214.92
Upright aligned	Synaesthetes	.65	.21	930.12	174.06
	Controls	.70	.18	1031.15	234.49
Inverted misaligned	Synaesthetes	.85	.14	854.46	191.59
	Controls	.90	.08	868.98	147.87
Inverted aligned	Synaesthetes	.83	.13	831.43	147.91
	Controls	.87	.10	922.04	214.06
FCE upright	Synaesthetes	.17	.19	−81.74	121.29
	Controls	.21	.14	−98.68	155.76
FCE inverted	Synaesthetes	.02	.15	23.03	115.40
	Controls	.03	.09	−53.06	111.58

Note: FCE = face composite effect.

To investigate potential group differences in the size of the face composite effect, we ran two 2 (group: synaesthetes, controls) × 2 (orientation: upright, inverted) ANOVAs with the face composite effect computed using accuracy and reaction time as dependent variables (see Table 2 for means and standard deviations). The first ANOVA conducted on accuracy data revealed a significant main effect of orientation, $F(1, 26) = 13.875$, $p = .001$, $\eta_p^2 = .348$, indicative of a larger face composite effect for upright faces than for inverted faces. There was no significant main effect of group, $F(1, 26) = 0.383$, $p = .541$, $\eta_p^2 = .015$, and no interaction, $F(1, 26) = 0.123$, $p = .728$, $\eta_p^2 = .005$ (Figure 3c). The second ANOVA on reaction time produced similar results: a significant main effect of orientation, $F(1, 26) = 4.418$, $p = .045$, $\eta_p^2 = .145$, indicative of a larger face composite effect for upright faces than for inverted faces, no significant group difference, $F(1, 26) = 1.917$, $p = .178$, $\eta_p^2 = .069$, and no interaction effect, $F(1, 26) = 0.683$, $p = .416$, $\eta_p^2 = .026$ (Figure 3d). In this regard, synaesthetes did not differ from controls in the face composite task.

General discussion

The current study sought to determine the extent to which grapheme–colour synaesthetes differed to non-synaesthetes in their social perception of faces. In Experiment 1, we compared grapheme–colour synaesthetes to control participants in their ability to perceive facial identity and facial emotion (happiness and anger perception) and found a general advantage in face processing (i.e., better performance for facial identity and facial emotion perception) for synaesthetes than for controls. There were at least three possible explanations for this pattern of data: (a) The findings reflected greater motivation on the part of synaesthetes, (b) the findings related to domain-specific improvements in face perception in grapheme–colour synaesthesia, or (c) the findings were a secondary consequence of domain-general differences in perception (i.e., not face specific) seen between grapheme–colour synaesthetes and controls. To assess these potential explanations, in Experiment 2 we compared facial identity processing abilities of grapheme–colour synaesthetes (including a proportion who took part in Experiment 1) relative to control participants on another face processing task

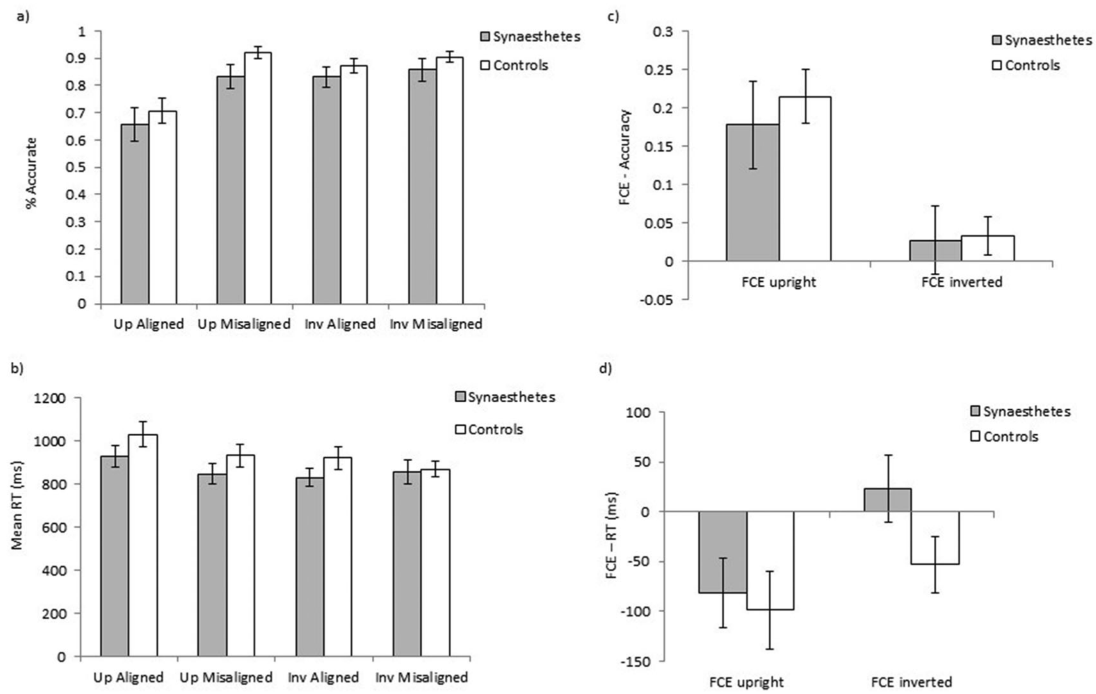

Figure 3. (a) Mean accuracy scores for synaesthetes and controls on the face composite task including upright aligned, upright misaligned, inverted aligned, and inverted misaligned trials. (b) Mean reaction times (RTs) for synaesthetes and controls on the face composite task including upright aligned, upright misaligned, inverted aligned, and inverted misaligned trials. (c) Face composite effect (FCE) computed on accuracy data for synaesthetes and controls on upright and inverted trials. (d) Face composite effect computed on reaction time data for synaesthetes and controls on upright and inverted trials.

– the face composite task (Rossion, 2013; Young et al., 1987). In that experiment we found no difference in the face composite effect between grapheme–colour synaesthetes and control participants, implying that benefits in performance observed in Experiment 1 were not related to domain-specific improvements in face processing or greater motivation shown by synaesthetes (as a proportion of synaesthetes took part in both Experiment 1 and Experiment 2).

Collectively, the findings from Experiments 1 and 2 indicate typical face processing abilities in grapheme–colour synaesthetes. At face value this may appear to conflict with recent work suggesting that the prevalence of synaesthesia may be more common in other neurodevelopmental conditions that are associated with reductions in the perception of social cues (Baron-Cohen et al., 2013; Neufeld et al., 2013). For example, recently an association between synaesthesia and ASD has been suggested (Baron-Cohen et al., 2013). ASD has been linked to reductions in the perception of facial identity and facial emotions (Hedley et al., 2014; Uljarevic & Hamilton, 2012). In this regard, the evidence that grapheme–colour synaesthetes show typical or (in some cases) superior social perception abilities conflicts with putative relationships between synaesthesia and autism. It should be noted, however, that differences in the perception of facial identity and facial emotion associated with ASD are somewhat controversial. For example, recent findings suggest that it may be comorbidity between alexithymia and autism rather than autism severity alone that is associated with facial emotion perception deficits in ASD (Cook, Brewer, Shah, & Bird, 2013). With this in mind, it may be the case that other shared behavioural characteristics (e.g., attentional differences, sensory perception) may be contributing factors to any relationship between synaesthesia and ASD.

In a similar vein, our own prior work has associated colour synaesthesia with heightened levels of positive schizotypy (Banissy, Cassell, et al., 2012; Janik McErlean & Banissy, 2016). While high positive schizotypy traits have on occasion been linked with reduced social perception abilities in typical adults, the most consistent finding has been a relationship between altered social perception and global schizotypy traits (e.g., Abbott & Byrne, 2013; Morrison et al., 2013). Our results imply that the more specific association between heightened levels of positive schizotypy and colour synaesthesia is unlikely to be associated with broader manifestations of atypical social perception abilities in synaesthetes.

The different pattern of results between Experiment 1 and Experiment 2 are also interesting in the context of recent work suggesting that synaesthetes who experience colour as their evoked sensations show performance advantages on tasks that privilege processing of high-spatial-frequency visual cues (e.g., Banissy et al., 2013; Barnett et al., 2008; Rothen et al., 2012; Terhune et al., 2015; Yaro & Ward, 2007). As noted above, prior work has suggested that synaesthetes who experience colour as their evoked sensation show neural and perceptual differences in the processing of high-spatial-frequency visual cues. In the context of the tasks used here, this information may be of particular utility for tasks employed in Experiment 1 given that they require participants to make fine-grained visual judgments regarding how well each image matches a target face in the case of CFPT–Identity or in order to detect small featural differences between images when performing CFPT–Angry and CFPT–Happy. In contrast, the face composite task does not require a similar level of fine-grained comparison. In fact, it has been suggested that the face composite effect relies predominantly on low spatial frequencies as they play a key role in processing global and coarse visual information, especially at the early stages of visual processing (Goffaux & Rossion, 2006; Rossion, 2013; Young et al., 1987). In this regard, differences observed on the CFPT tasks may relate to a broader sensitivity of synaesthetes who experience colour as their evoked sensation to high-spatial-frequency cues that aid fine-grained visual discrimination. (e.g., Barnett et al., 2008; Terhune et al., 2015). We note, however, that while the face composite effect may rely more on low-spatial-frequency information (Goffaux & Rossion, 2006), there are likely to be a number of other factors that might contribute to performance differences between the face composite task and CFPT measures. A lack of an effect on the face composite task may thus be a consequence of some other mechanism or a combination of mechanisms (i.e., spatial frequency alone may not fully explain differences in the pattern of data observed between Experiments 1 and 2). It is therefore important to examine the role of high spatial frequency in face processing in synaesthetes in a more direct manner in the future (e.g., by employing facial stimuli filtered with different spatial frequencies).

A final important caveat to note is that our sample consisted only of female participants. There is some evidence suggesting that females can show different patterns of performance on face perception measures than men (e.g., Bobak, Pampoulov, & Bate, 2016; Bowles et al., 2009). With this in mind, it remains to be established whether the same pattern of results would be obtained for male participants.

Conclusions

In summary, while prior work has linked colour synaesthesia with conditions and traits that are associated with reduced social perception abilities (e.g., ASD), the current study did not provide any systematic evidence of altered social perception abilities in grapheme–colour synaesthetes. This implies that while there may be relationships between colour synaesthesia and conditions/traits associated with reduced social perception abilities, these relationships are unlikely to be related to shared behavioural consequences on social perception.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

A.B.J.M. was supported by a PhD Studentship from the Economic and Social Research Council. C.R. is supported by a Marie Skłodowska-Curie Actions individual fellowship. M.J.B. was supported by the BIAL Foundation [grant number 74/12]; and the Economic and Social Research Council [grant number ES/K00882X/1].

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