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Seeing it both ways: Openness to experience and binocular rivalry suppression

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ABSTRACT

Openness to experience is characterised by flexible and inclusive cognition. Here we investigated whether this extends to basic visual perception, such that open people combine information more flexibly, even at low-levels of perceptual processing. We used binocular rivalry, where the brain alternates between perceptual solutions and times where neither solution is fully suppressed, mixed percept. Study 1 showed that openness is positively associated with duration of mixed percept and ruled out the possibility of response bias. Study 2 showed that mixed percept increased following a positive mood induction particularly for open people. Overall, the results showed that openness is linked to differences in low-level visual perceptual experience. Further studies should investigate whether this may be driven by common neural processes.

1. Introducion

Trait *openness to Experience* (hereafter, openness) represents a scientific frontier in personality psychology —it was the last of the five major personality domains to gain acceptance, and is still the least well understood (for a recent review see DeYoung, 2014). A common theme linking the various characteristics described by Openness is flexible and inclusive cognition: Open people are more curious, creative (Kaufman et al., 2016; Silvia et al., 2008) and motivated to explore the world and engage with possibilities (DeYoung, 2014; McCrae & Costa, 1997). People high in openness may even *experience* the world differently to the average person as a result of their "breadth, depth, and permeability of consciousness, and ...[their]... recurrent need to enlarge and examine experience" (McCrae & Costa, 1997, p. 826). In this paper, we ask whether this tendency toward inclusive cognition — which we could think of as increased flexibility in binding of different representational elements in the brain — extends to basic visual perception. This objective is in line with recent research showing that stable difference in personality mirror differences in structural and functional properties of the brain (Passamonti et al., 2015). Our interest here is to determine whether similar relations between personality and visual perceptual processing exist.

Several previous studies indirectly suggest that open people experience things differently: For instance, openness predicts performance on divergent thinking tasks (Kaufman et al., 2016; Silvia et al., 2008), which require one to identify multiple diverse uses for ordinary objects. For open people this seems to happen effortlessly, suggesting a more flexible way of combining information, perhaps even at low-levels of perceptual processing. For example, people high in openness display reductions in *latent inhibition* (i.e., attenuated attentional processing following repeated stimulus exposure) suggesting individual differences in pre-conscious attentional mechanisms (Peterson & Carson, 1999; Peterson, Smith, & Carson, 2002). Latent inhibition reflects an adaptive attentional 'gating' system for screening out irrelevant information, but for open people this system appears to be more flexible, resulting in continued processing of stimuli from which the average individual has disengaged. However, we are aware of no previous research examining whether openness relates to how people actually *see* visual stimuli.

To address this question, we examined how openness relates to the well-known perceptual phenomenon called *binocular rivalry*, where contrasting stimuli are presented simultaneously to each eye (for a review see Tong, Meng, & Blake, 2006). When faced with this incompatible visual information, observers typically report alternation or 'flipping' between these two continuously presented stimuli every few seconds. Interestingly, another perceptual experience called 'mixed percept' occasionally occurs between these serial alternations. In these cases the two stimuli appear fused into one, and complete suppression of either stimulus is inhibited

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(Yang, Rose, & Blake, 1992). The processes underlying mixed percept remain unclear, with some authors suggesting a role of neural plasticity (Klink, Brascamp, Blake, & van Wezel, 2010) and others emphasizing an imbalance of excitatory and inhibitory neural activity (Said, Egan, Minshew, Behrmann, & Heeger, 2013). One interesting feature of mixed percept, however, is that it shows between-person variability and within-person stability over time (Miller et al., 2010), suggesting a possible relation with personality.

In this paper, we hypothesised that the susceptibility to the mixed percept experience may be related to openness. Because openness reflects the tendency to actively explore information and engage with complex possibilities (DeYoung, 2014), people high in openness may also be more likely to experience creative solutions to the incompatible rivalry stimuli. Furthermore, the sustained processing of non-instrumental stimuli by open people during latent inhibition (Peterson & Carson, 1999; Peterson et al., 2002), may also occur during rivalry, thereby impeding the complete suppression of either percept. If openness does indeed predict mixed percept, it would constitute the first empirical evidence that open people may have different *visual* experiences to the average individual.

To investigate this in study 1 we conducted two experiments. In the first experiment we presented individuals with a simple binocular rivalry task (red and green orthogonal gratings to alternate eyes) and administered the Big Five Aspects Scales (BFAS; DeYoung, Quilty, & Peterson, 2007) which includes a measure of Openness/Intellect (O/I). This compound label reflects an early debate about how to best conceptualise the fifth personality domain (see Saucier, 1992), and the full scale can be divided into separate openness and intellect sub-scales. While intellect is conceptualised as engagement with semantic or abstract information, openness is conceptualised as engagement with aesthetic or perceptual information (DeYoung, 2013, 2014). In line with this, intellect (but not openness) predicts working memory performance (DeYoung, Shamosh, Green, Braver, & Gray, 2009) while openness (but not intellect) predicts implicit learning of patterned sequences (Kaufman et al., 2010). Given the inherently perceptual nature of the mixed percept phenomenon, we therefore hypothesised openness more so than intellect would be associated with mixed percept.

In the second experiment (study 1b) we sought to rule out the possibility that open people report more incidence of mixed percept simply because they have a more lenient response threshold for reporting more mixed. To do so, we manipulated the size of the visual stimuli. The incidence of mixed percept reported during a 'typical' rivalry task is characterised by individual differences (Miller et al., 2010). However, the *absolute duration* of mixed percept is also sensitive to the stimulus characteristics. Specifically, the overall incidence of mixed percept increases with larger stimulus size, reflecting physiological properties of the visual cortex (for a more detailed description of the phenomenon see Blake, O'Shea, & Mueller, 1992). Thus, by using larger stimuli we predicted that the increased contribution of low-level properties of the visual cortex would lead to a reduction of the influence of personality on one's perceptual experience when viewing the task.

In study 2, we administered the same rivalry task following a positive mood induction procedure involving perceptually and aesthetically pleasing imagery, to which open people appear particularly responsive (Fayn, MacCann, Tiliopoulos, & Silvia, 2015; McCrae, 2007; Silvia & Nusbaum, 2011). This served the purpose of exploring whether differences in one's perceptual experience may be influenced not only by stable factors (personality) but also by transient states (mood). With respect to the effects of mood on perceptual rivalry, a number of studies have shown that mood can alter the competition for visual awareness by favouring the stimulus congruent to one's mood (Anderson, Siegel, & Barrett, 2011). In addition, positive mood tends to specifically decrease observers' inhibitory control in filtering unattended information, favouring more inclusive processing (Rowe, Hirsh, & Anderson, 2007). Finally, contextualised perspectives on personality (e.g., DeYoung, 2015; Tett & Guterman, 2000) suggest that effects of personality will be most pronounced in the context of trait-relevant stimuli or situations. In the case of the current study we were interested in whether one mood condition in particular would act as a trait-relevant cue especially for open people. This would be expected to increase the relative impact of factors associated with openness on perceptual processing and lead to an increased susceptibility to experiencing the mixed percept for open people.

2. Study 1

2.1. Method

2.1.1. Participants

We recruited 134 University of Melbourne undergraduate students, who participated in the research for course credit. All participants had normal or corrected to normal vision. We excluded 11 participants prior to analysis: 5 because they did not report alternating stimuli, indicating that rivalry did not occur, and 6 because they responded for less than 50% of the total duration of the trial. There was therefore a final N of 123 participants (30% Male, aged $M = 19.49$, $SD = 2.92$). This sample provides 80% power to detect the average effect size in personality psychology (i.e., $r \sim 0.25$; Fraley & Marks, 2007). All studies were approved by the University of Melbourne Human Research Ethics Committee, in accordance with the Declaration of Helsinki.

2.1.2. Personality questionnaire

The Big Five Aspects Scales (BFAS) DeYoung et al. (2007) is a 100-item measure of the Five Factor Model (McCrae & Costa, 1987). It provides assessment of each of the five *domains* (Extraversion, Neuroticism, Agreeableness, Conscientiousness, and O/I) along with each of their two lower level *aspects* (DeYoung et al., 2007). Respondents indicate the extent to which they agree or disagree with each of the items on a 5-point rating scale ranging from 1 (strongly disagree) through 3 (neutral) to 5 (strongly agree). Cronbach's alpha for each trait domain and its component was acceptable (see Table 2).

2.1.3. Binocular rivalry

2.1.3.1. Apparatus and stimuli. The rival targets were stationary green and red gratings (stimulus sizes 1.4°, with a spatial frequency of 4 cpd) oriented ±45° from vertical, within a circular frame. Stimuli were generated in Matlab™ using the Psychophysics Toolbox extension (Brainard, 1997; Pelli, 1997), displayed on an Apple computer monitor (23-in. monitor, 60 Hz frame rate, 1280x800pixel resolution), and viewed through a mirror stereoscope (viewing distance 33 cm).

2.1.3.2. Instructions. Participants were instructed to continuously report what they were experiencing via key press. When perceiving the red or green grating they had to press and hold down the left or right arrow key, respectively. Participants were instructed to report any instances of mixed percept (time where the two stimuli appeared as a grid or patchwork combination of the two percepts) by holding down both the left and right arrow keys simultaneously.

2.1.3.3. Response recording. Data were recorded continuously throughout a single 120 s trial. While some rivalry studies use multiple short (e.g., 10–20 s) trials, we opted for a single 120 s trial to