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Seeing red? The effect of colour on intelligence test performance

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ABSTRACT

A series of recent studies reported that seeing red was associated with poor intelligence test performance in university students. Here we test for the first time the effect of colour on intelligence test scores in an adult sample and across a large battery of ability tests. Overall 200 British adults completed Raven's matrices without colour manipulation (i.e. baseline assessment); afterwards, they viewed a string of letters and digits in either red or green before completing six additional ability tests (i.e. word fluency, logical reasoning, vocabulary, syllogisms, verbal reasoning, and knowledge) and rating their self-perceived performance for each measure. We found no evidence for an association between colour and intelligence test scores or self-perceived performance, before and after adjusting for intelligence at baseline. The discrepancy with previous findings is likely to be due to testing adult rather than student samples, which in turn has implications for the recruitment and selection of study samples in future intelligence research.

Intelligence test scores result from the interaction between the characteristics of an individual, who is taking the test, and those of the situation, in which the test is administered. Thus, intelligence test scores vary as a function of individual differences in the ability to master an ability tests' items within the testing environment. Intelligence research concentrates traditionally on individuals' ability differences rather than on the properties of assessment settings; as a consequence, our knowledge of situational factors that influence intelligence test performance is to date incomplete. Previous studies in this area have focused mainly on the role of auditory and sound environments (Bates & Rock, 2004; Pietschnig, Voracek, & Formann, 2010), but recently visual perceptions of or stimuli in the testing situation have been suggested to affect cognitive task performance. More specifically, the perception of specific colours is thought to influence performance outcomes in achievement-related contexts (Elliot & Maier, 2014). For example, viewing green prior to task performance enhances creative achievement (Lichtenfeld, Elliot, Maier, & Pekrun, 2012), while viewing red impairs cognitive task performance, as indicated by lower intelligence test scores (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007). In previous studies, the effects of colour on cognitive task performance could not be attributed to individual differences in intelligence at baseline or gender (Elliot, Payen, Brisswalter, Cury, & Thayer, 2011; Elliot et al., 2007), suggesting a true relationship between colour and cognitive functioning. Accordingly, Elliot et al. (2007) argued that colour communicates a deeper meaning that is either inferred through learned associations or through biological nativism, rather than merely serving aesthetic purposes. Specifically, people may have learnt to associate the colour red with poor intellectual performance outcomes, because teachers traditionally used red ink for marking school and course work (Elliot et al., 2007). Alternatively, the colour red may have an evolutionary history (Mollon, 1989), following Charles Darwin's (1872) observation that anger is associated with redness in the skin. Here, colour is thought to work as a subtle prime or danger warning, affecting psychological functioning, without the individual's conscious awareness (Elliot et al., 2007).

Previous studies on the negative effect of red on cognitive performance have employed various methods of colour manipulation. For example, high school students who were shown a red rectangle (12.7 cm × 18.4 cm) on the cover of a numeric subtest of the Intelligence Structure Test (IST; Amthauer,

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Brocke, Lipmann, & Beauducel, 1999) performed significantly worse than those who had viewed a grey rectangle (N = 20 overall; Maier, Elliot, & Lichtenfeld, 2008). Furthermore, a study of 71 university students reported that those participants who had viewed their study identification or participant number in red (1.3 cm × 1.9 cm) performed significantly worse in an anagram test compared with students who had viewed their number in green or black (Elliot et al., 2007). In this study, the participants had been requested to verify that their participant number was written on all pages except the cover page to enforce the effectiveness of the colour manipulation. Even more impressive are the findings of Lichtenfeld, Maier, Elliot, and Pekrun (2009) in this context, who showed that only reading the word "red" compared with reading a neutral colour word was significantly associated with lower IST analogy test scores in overall 49 high school students. The authors also showed that even the very small change of including the word "red" (Arial, 10 pt) in the copyright label's text on the testing booklet's introductory pages resulted in differential performance on the IST numeric test in overall 40 high school students (Lichtenfeld et al., 2009). Across all these studies, the participants were unaware of the colour manipulation and its effects, supporting the theory that colour works as a subtle prime outside the individual's conscious awareness (Elliot & Maier, 2007).

Notwithstanding, previous studies suffer from three limitations. First, they have only tested school and university students, with overall sample sizes ranging from a minimum of 20 to a maximum of 71 participants *across* all study conditions (Elliot et al., 2007, 2011; Lichtenfeld et al., 2009; Maier et al., 2008). No comparable data from adult samples have been reported, who may be less sensitive to the effects of red in achievement contexts because they are neither as often nor as recently exposed to feedback from a teacher's red marking pen. Second, previous studies reported the effect of colour on selected performance measures, mainly abstract reasoning or fluid-type intelligence tests. It is unknown, however, if the performance impairing effect of red is specific to reasoning tests or if it holds also true for more information-, experience- and knowledge-based tests (i.e. crystallized intelligence) that are particularly relevant in typical intellectual performances, for example in the work place and educational settings. Third, no previous study has explored the extent to which the colour red may affect participants' perception of their abilities, as a potential mediating variable. Self-estimated ability to perform in a task is an important determinant of task engagement and persistence (Dweck & Leggett, 1988) and thus, influences cognitive performance outcomes (von Stumm, 2013). Viewing red before completing a task may lower the participants' expectation of their performance level and as a result, exert an indirect effect on the latter.

Overcoming these limitations, we report here data from 200 British adults, who completed a battery of ability measures and estimated how well they expected to perform in them before and after being exposed to colour manipulation.

1. Methods

1.1. Sample

A sample of 200 British adults (97 men and 103 women) was recruited in the London metropolitan area through online advertisements, flyers in public places (e.g. cafes), and research volunteer databases. Participants met these criteria: a) native to the United Kingdom and having lived in the United Kingdom since age 10; b) at least 18 years old; and c) not dyslexic or colour-blind. The sample's age ranged from 18 to 69 years with a mean of 34.6 (SD 11.8). As their highest educational qualification, 14% of the participants reported GCSEs; 15% A-levels; 18% a vocational qualification or equivalent; 33.5% an undergraduate degree and 19% a postgraduate degree. About half of the sample reported to earn less than £15.000 per annum, while about 8% declared to earn more than £35.000 per annum. Data from this sample have been previously reported elsewhere (e.g. von Stumm, 2012).

1.2. Measures

1.2.1. Ability tests. Raven's progressive matrices (set E; Raven, 1968)

Twelve items showed grids of 3 rows × 3 columns each with the lower right hand entry missing. Participants chose from eight alternatives the one that completed the 3 × 3 matrix figure. The test was timed at 4 min. *Verbal fluency* (Ekström, French, Harman, & Derman, 1976): the participants listed as many words as possible that started with one of two prefixes in 60 s. *Letter sets* (Ekström et al., 1976): the participants identified the mismatching 4-letter set, inferring a rule underlying the composition of four other 4-letter sets. The test had 15 items and was timed at 6 min. *Vocabulary* (Ekström et al., 1976): the participants identified the correct synonym for a given word out of five answer options. The test had 18 items and was timed at 4 min. The score was corrected for guessing (−.20 for every incorrect answer). *Nonsense syllogisms* (Ekström et al., 1976): the participants judged if a conclusion that followed two preceding statements (premises) showed good (correct) reasoning or not. The test had 15 items and was timed at 4 min. The score was the number of items marked correctly minus the number marked incorrectly. *Verbal reasoning* (Ekström et al., 1976): the participants identified the correct pair of words from five options to complete a comparison sentence, whose first and last words were missing. The test had 14 items and was timed at 7 min. The score was corrected for guessing (−.20 for every incorrect answer). *Knowledge* (von Stumm, 2013): overall 13 knowledge domains, including art, music, literature, geography, politics, history, finance, sports, fashion, film, medicine, science, food and health, and technology, were assessed with overall 132 open-ended questions. Domain scores mapped onto two knowledge factors, one based on popular culture and one on academic disciplines (von Stumm, 2013).

1.2.2. Self-estimated intelligence

(1) A bell curve of IQ scored was shown with a mean of 100 and 3 SD of 15. Participants estimated their IQ with reference to it. An IQ of 55 was labelled as 'mild retardation', and IQ of 75 as 'borderline retardation', and IQ of 100 as 'average ability', an IQ of 115 as 'higher intellect', and an IQ of 145 as 'gifted ability'. (2) For each intelligence test (see above), the participants rated on a 1–5 point Likert scale from very poor to very well on how well they thought they had done on the test.

1.2.3. Personality (NEO-FFI, Costa & McCrae, 1992)

A 60-item measure of personality assessed the Big Five Personality traits, including Neuroticism, Extraversion, Openness