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Animal behaviour

Red clothing increases perceived dominance, aggression and anger

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The presence and intensity of red coloration correlate with male dominance and testosterone in a variety of animal species, and even artificial red stimuli can influence dominance interactions. In humans, red stimuli are perceived as more threatening and dominant than other colours, and wearing red increases the probability of winning sporting contests. We investigated whether red clothing biases the perception of aggression and dominance outside of competitive settings, and whether red influences decoding of emotional expressions. Participants rated digitally manipulated images of men for aggression and dominance and categorized the emotional state of these stimuli. Men were rated as more aggressive and more dominant when presented in red than when presented in either blue or grey. The effect on perceived aggression was found for male and female raters, but only male raters were sensitive to red as a signal of dominance. In a categorization test, images were significantly more often categorized as 'angry' when presented in the red condition, demonstrating that colour stimuli affect perceptions of emotions. This suggests that the colour red may be a cue used to predict propensity for dominance and aggression in human males.

1. Introduction

Red coloration is a sexually selected trait associated with dominance in many animal species (e.g. [1,2]) and appears to have similar associations in humans [3]. Skin redness in humans has been found to correlate with testosterone and fluctuates with emotional state, increasing with anger and decreasing with fear [4,5]. Red therefore appears to carry specific biological signals in both humans and other animals. Artificial stimuli may exploit these evolved responses to natural red signals. In birds, red leg bands enhance access to resources in male zebra finches [6], while rhesus macaques avoid red-wearing human experimenters [7]. In humans, several studies have shown that colour stimuli have similar effects on social perception [8,9] and behaviour such as the outcome of physical and virtual contests (see [10] for review). Being associated with or wearing red are also linked to higher heart rate, a greater pre-performance strength and higher testosterone levels [11,12]. These effects may be explained by psychological associations of red coloration with dominance and aggression that boost red-wearers' confidence and/or intimidate their opponents [13], although the effect may be restricted to males [14].

Targets presented in red are perceived as more aggressive, dominant, brave and also more likely to win a competition [15–17]. However, these experiments primed competitiveness or aggression in subjects by placing them in a competitive situation. To our knowledge, no study has yet investigated the effects of colour on social perceptions of dominance and aggressiveness in neutral settings. It is also unknown whether clothing colour influences attributions of emotional state: if colour is a cue to relative dominance in aggressive situations, red stimuli might be more likely to be categorized as angry. This study explores how digitally manipulated T-shirt colour influences rapid social judgements of character traits in strangers. We predicted that people presented in a red shirt would be rated as

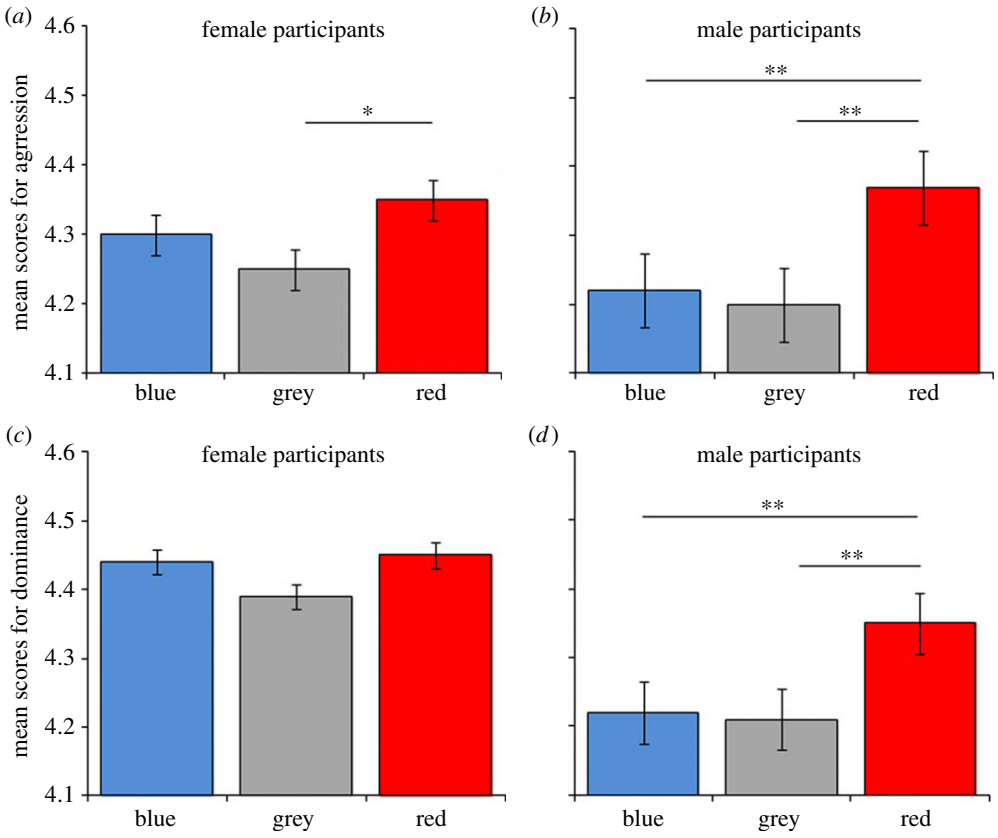

Figure 1. Mean scores of women (*a*,*c*) and men (*b*,*d*) rating targets wearing three different colours for aggression (*a*,*b*) and dominance (*c*,*d*); $*p \leq 0.05$, $**p \leq 0.01$. Error bars indicate 95% CIs. (Online version in colour.)

being more aggressive and more dominant and also perceived more often as 'angry' than when presented wearing blue or grey.

2. Material and methods

Stimuli were selected from two sources. Fourteen images of males were taken from a previously published set [18] and six additional images were selected from the Internet according to the criteria in that study. Clothing colour was first desaturated and luminance adjusted to mid-grey (producing the grey stimulus) using MicrografxPicturePublisher v. 10; the hue and saturation were then adjusted to produce the red and blue coloured stimuli (see the electronic supplementary material). Previous studies have not considered achromatic stimuli, and this study design thus allows a more robust assessment of how colour influences social perceptions.

Stimuli were presented under constant lighting conditions on a colour-calibrated computer screen. In a series of 60 randomly ordered trails, $N = 100$ participants (50 females and 50 males) were presented with images of 20 males wearing either a red, blue or grey shirt and two 7-point scales: aggression (ranging from 1, extremely aggressive to 7, extremely friendly) and dominance (1, extremely submissive to 7, extremely dominant)[1]; and a selection of emotional states (angry, happy, frightened or neutral). To facilitate data analysis, variables were coded so that high numbers represented high trait values (e.g. on the aggression scale, 7 = extremely aggressive, 1 = extremely friendly). Data were analysed using repeated-measures ANOVA with colour as a within-subjects variable. Greenhouse–Geisser correction was applied when sphericity could not be assumed (Mauchly's test for sphericity, $p < 0.05$).

While previous research on colour perception and its effects in competitive situations has shown that an effect of red colour is more likely to occur among men [14], we also investigated whether the rater's sex influenced perceptions in our non-competitive task.

3. Results

The analysis revealed a main effect of colour for aggression ($F_{1.747,\ 172.934} = 12.101$, $p < 0.001$, $\eta_p^2 = 0.109$) and dominance ($F_{2,98} = 5.821$, $p = 0.004$, $\eta_p^2 = 0.106$). Bonferroni pairwise comparisons showed that raters judged targets wearing red as more aggressive than when wearing blue ($p = 0.005$) and grey ($p < 0.001$), and also more dominant in red than grey ($p = 0.003$). There was a trend for participants to rate red targets as more dominant than blue targets ($p = 0.063$). By contrast, there were no significant differences between blue and grey targets on ratings of aggression ($p = 0.519$) or dominance ($p = 0.704$). Female participants rated red-wearing targets to be more aggressive than grey-wearing targets ($p = 0.025$), whereas male participants judged red-wearing targets to be more aggressive than targets wearing blue ($p = 0.007$) or grey ($p = 0.003$, figure 1). For ratings of dominance, colour did not influence female raters' perception, $F_{2,48} = 1.425$, $p = 0.251$, $\eta_p^2 = 0.056$, but males' ratings were significantly influenced by colour, $F_{2,48} = 6.939$, $p = 0.002$, $\eta_p^2 = 0.224$, with targets wearing red being rated more dominant than targets wearing blue ($p = 0.010$) and grey ($p = 0.002$). Ratings for targets wearing blue did not differ from those wearing grey ($p > 0.999$).

Colour had a significant effect on how often a stimulus was categorized as 'angry' (Friedman's test $\chi^2 = 13.861$, d.f. = 2, $p = 0.001$; figure 2) but not 'happy', 'neutral' or 'frightened' (all $p > 0.25$). Wilcoxon signed-rank tests for pairwise comparisons showed that a target presented in a red

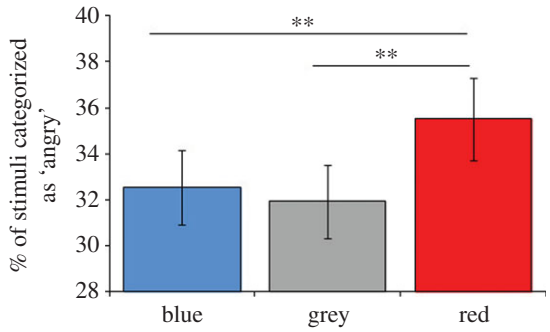

Figure 2. Percentage of stimuli categorized by each subject as 'angry' for three colour conditions, $^{**}p < 0.01$. Error bars indicate 95% CIs. (Online version in colour.)

shirt was more often categorized as 'angry' than when presented in blue ($Z = -2.685$, $p = 0.007$) or grey ($Z = -2.896$, $p = 0.004$), but there was no difference between blue and grey ($p = 0.203$). Colour significantly affected the perceptions of anger in the stimuli both among female ($\chi^2 = 12.471$, d.f. $= 2$, $p = 0.002$) and male raters ($\chi^2 = 10.812$, d.f. $= 2$, $p = 0.004$).

4. Discussion

We found that clothing colour biases the perception of aggression, dominance and anger in strangers, outside of competitive or achievements contexts. Men wearing red were rated as more aggressive and more dominant and were more often categorized as 'angry' than targets wearing grey or blue. Clothing colour did not influence female participants' perception of male dominance but did influence male participants' perceptions. Whether or not this sex difference reflects different biases in social perceptions requires further investigation. For example, the colour red distorts time perception in men but not in women [19], and wearing red enhanced the probability of winning combat sport bouts in male, but not female, athletes [13,14].

Participants categorized targets significantly more often as 'angry' when presented in the red condition. This indicates that colour influences the categorical judgement of emotional expression and, specifically, that red hue is associated with a bias towards angry judgements. Fetterman *et al*. [20] showed that priming anger concepts (versus sadness) led participants to be more likely to perceive the colour red. Taken together, these findings suggest a clear association between the colour red and perceptions of anger, possibly related to the role of facial reddening as a natural signal of anger [21].

While red images resulted in higher ratings for aggression and dominance, ratings for blue and grey images did not differ significantly. Hence, it seems to be specifically red that influences judgements of aggression and dominance. However, black has also been found to influence perception of aggression in athletes [22], and across cultures both black and red have been found to influence scoring of combat sport bouts [23]. In these studies, luminance and chroma were confounded, and it is known that these different dimensions have independent effects on social perceptions [16] and that skin darkness is sexually dimorphic and positively associated with testosterone [24]. Further work is needed to test for and separate out effects of hue and luminance and to determine whether there is an 'optimal red' related to biological signalling of traits such as aggressiveness and dominance.

An important area for further enquiry is the cross-cultural consistency versus variability in biasing effects of colour. Culture may reflect, reinforce or modify innate biases, or it might be responsible for establishing biases in the first place through arbitrary or coincidental associations. The latter would predict considerable variability in biases. Indeed, cultural variation in colour–emotion associations exist [25]. However, there is also considerable cross-cultural consistency in associations between red and physical dominance [23], anger [25] and danger [26]. An attentional bias towards red versus other colours is present from early infancy, consistent with the idea that innate predispositions may play a role in establishing colour associations [27]. The ontogeny of colour biases in social perceptions would be an interesting area for further study.

Ethics statement. This experimental protocol was approved by the Department of Anthropology Research Ethics sub-committee at Durham University (Wiedemann, March 2010). We obtained written consent from participants.

Data accessibility. An Excel file is included as electronic supplementary material.

Authors' contributions. D.W., D.M.B., R.A.H. and R.A.B. designed the study; D.M.B. developed the stimuli; D.W. ran the study and performed data analysis and interpretation with R.A.H., D.M.B. and R.A.B.; D.W, D.M.B, R.A.H and R.A.B wrote the manuscript; all authors approved the final version.

Conflict of interests. The authors declare no competing interests.

Endnote

[1]We also asked participants to rate stimuli for perceived 'trustworthiness' and 'confidence'. Electronic supplementary material, figure S3, presents findings for these two variables.

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