ATTRIBUTION TO RED SUGGESTS SPECIAL ROLE IN DOMINANCE SIGNALLING

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Abstract. In many animals red is a signal of dominance and in humans there is evidence that red colouration may provide an advantage in sporting competition. This has been disputed by findings showing that colours other than red can also provide a competitive advantage. Here we examine basic perception of red versus blue in simple shapes by human judges to address the social signalling properties of red. We show that red is seen as more likely to win in physical competitions, more aggressive and more dominant then blue. When hue information is removed, however, the darker contrast of the blue shapes leads to a reversal in the attributions. This confirms that red hue is special in social attribution consistent with it being a signal of competitive quality and that darker contrast, through a potential link to testosterone signalling, could also act as a signal of dominance.

Keywords: colour/color, vision, attribution, masculinity, dominance, sexual selection

INTRODUCTION

Recently there has been a resurgence of interest in the signal properties of red colouration in sexual selection. Red colouration of some traits is associated with dominance in fish (MILLINSKI and BAKKER 1990), birds (PRYKE and GRIFFITH 2006), and non-human primates (SETCHELL and WICKINGS 2005; WAITT et al. 2003) and so linked to both inter-sexual (attracting the opposite-sex) and intra-sexual (within-sex competition) selection. Recent evidence has suggested that in

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primates trichromatic vision is an adaptation to distinguish colour modulations in skin based on blood flow in order to assess state or mood of conspecifics (CHANGIZI et al. 2006). It has been noted that primates with trichromatic vision are generally bare faced (CHANGIZI et al. 2006) and that, at least in humans, facial flushing is associated with anger and confrontation (DRUMMOND and QUAH 2001).

In animals the addition of red stimuli can increase social dominance (CUTHILL et al. 1997) and in humans it has been shown that wearing red in a variety of physically competitive sports is associated with an increased chance of winning over opponents (HILL and BARTON 2005). This has been interpreted as natural associations of red with dominance being extended to artificially displayed red in the same way that artificial stimuli can exploit innate responses to natural stimuli (BURLEY et al. 1982; CUTHILL et al. 1997). In contrast, it has also been recently shown that wearing blue colouration also increases chances of winning against white (ROWE et al. 2005). The authors suggest that this indicates that red is not special and that some aspect of the visibility of the colours leads to competitive sports advantage for red and blue.

Research on colour and emotion associations has a long history in anthropology. For example, one classic study found that observers from 20 countries viewed light colours as good and dark colours as bad. (ADAMS and OSGOOD 1973). The same study also showed that red was associated with the words "active" and "strong". More recent cross cultural studies support these findings generally showing that bright colors elicited mainly positive emotional associations, while dark colors elicited negative emotional associations (HEMPHILL 1996) and, for specific colours, the colours associated with anger are black and red (HUPKA et al. 1997).

Previous research then has mainly focused on emotional associations (HEMPHILL 1996) and has sometimes used responses to verbal labels of color (e.g., "red", "blue") instead of using actual color stimuli (HUPKA et al. 1997). Here we examine human perceptions beyond emotion looking at associations with aggression, dominance, and physical competitiveness using red and blue coloured shapes with and without hue (colour information, see *Figure 1*). While aggression is tied closely to anger our two other questions tap issues of human competition more directly. We presented male and female judges with pairs of shapes (circles or rectangles), one of which was red and one of which was blue, and asked which shape was 'more aggressive', 'more dominant' and which was 'most likely to win in a physical competition'. Presentation as competing stimuli is another novel aspect of our study as previous studies have generally examined associations. We included presentations of the same shapes changed to greyscale which removes colour information to control for hue and any influences of ambient lighting on colour perception (which would remain the same between viewing of colour and greyscale stimuli).

METHODS

Participants

75 females (aged 18–45, mean = 26.5, SD = 8.1) and 30 males (aged 18–45, mean = 29.1, SD = 8.7) took part in the study. All participants were volunteers recruited over the Internet by advertisement on the University of Liverpool's electronic poster system.

Stimuli

Stimuli were pairs of coloured shapes, either red versus blue or greyscale vs greyscale and pairs were always either both circles or both rectangles. The circles and rectangles were 535 and 534 pixels in total respectively. Red and blue colours were applied to these base shapes using Corel Photopaint 12 by maximising R or B in the image (moved to 256) and minimising the remaining 2 colour vectors (moved to 0). Greyscale images to remove colour information were made by converting coloured images to greyscale using the same software package. Greyscale images act as a control for differences between the red and blue images that are not hue. These images can be seen in *Figure 1*.
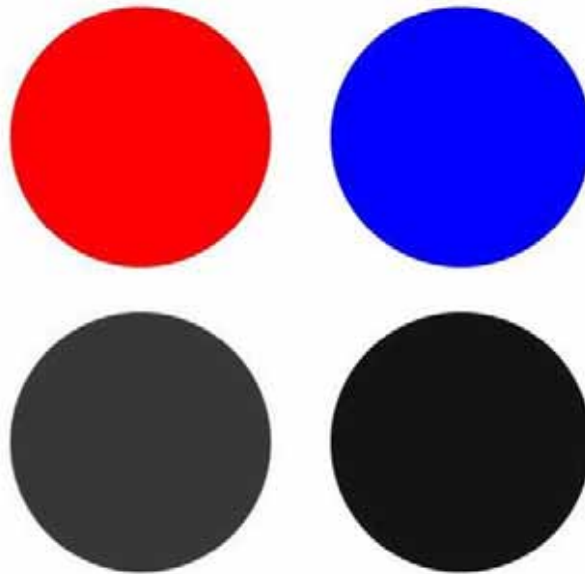

Figure 1. Red and blue circles used as stimuli in the study with their greyscale counter parts directly underneath (colour version of figure available at www.akademiai.com)

Procedure

Participants were administered a short questionnaire assessing age and sex, followed by the colour tests. Order of rating for the trials was set as "Please indicate which shape you think looks most likely to win a PHYSICAL COMPETITION by clicking below", "Please indicate which shape you think looks most AGGRESSIVE by clicking below", "Please indicate which shape you think looks most DOMINANT by clicking below". Coloured shapes were shown as pairs with both order and side of presentation randomised. Participants were asked to choose which of the pair they found most of a particular trait and clicking a button underneath the chosen shape moved on to the next shape trial. The red versus blue pairs were presented four times, once as a pair of differently coloured circles and once as a pair of differently coloured rectangles, as well as the same trials with greyscaled images.

RESULTS

For analysis we computed a continuous variable by taking the average score for the circle and square judgements separately for the coloured and greyscale stimuli (scores for each participant can be 0, 0.5, and 1). All statistics are computed 2-tailed. D denotes Cohen's D, η_p^2 denotes partial Eta^2.
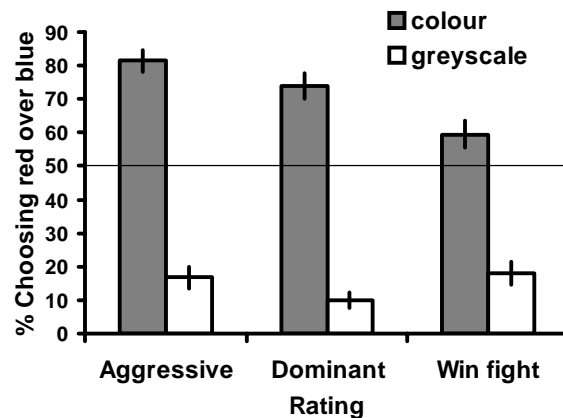
Figure 2. Percentage of participants choosing red colour over blue colour for different traits and in colour and in greyscale (+/ – 1SE of mean). Note that scores over 50% indicate choice of red over blue for all traits when stimuli were shown in colour and that when stimuli were shown in greyscale blue is chosen over red for all traits

Using one-sample t-tests against chance (50%, no preference), we found that for the coloured stimuli, red was seen as more dominant ($t_{104} = 6.1$, $p < .001$, D = 1.2), more aggressive ($t_{104} = 9.4$, $p < .001$, D = 1.8), and more likely to win in

physical competition ($t_{104} = 2.3$, $p = .024$, D = 0.5) than blue (see *Figure 2*). In the greyscaled images these findings were reversed, with blue being seen as more dominant ($t_{104} = -18.3$, $p < .001$, D = 3.6), more aggressive ($t_{104} = -9.9$, $p < .001$, D = 1.9), and more likely to win in physical competition ($t_{104} = -9.2$, $p < .001$, D = 1.8) than red. There were significant differences between colour and greyscale versions for all trait ratings using paired-samples t-tests (dominant, $t_{104} = -13.1$, $p < .001$, D = 2.6, aggressive, $t_{104} = -12.6$, $p < .001$, D = 2.5, win, $t_{104} = -7.1$, $p < .001$, D = 1.4).
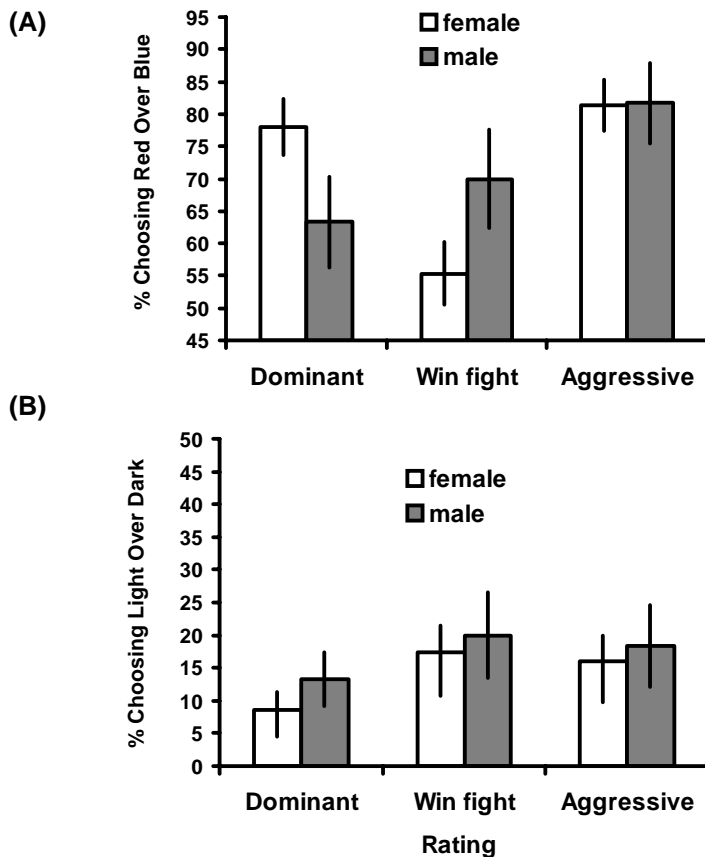
Figure 3. Percentage of participants choosing red colour over blue colour for different traits split by sex of judge in colour (A) and in grey scale (B) (+/ − 1SE of mean). Blue appears darker than red in greyscale and so choice reflects choice of light over dark. Note that there is a significant interaction between sex of judge and trait rated only for stimuli presented in colour ($F_{1,103} = 5.8$, $p = .017$), with females more likely to think red is dominant over blue than males and males more likely to think red will win in physical competition over blue than females

Previous studies have demonstrated sex of judge may influence attention to particular types of stimuli (LITTLE et al. 2001) and here sex of judge was found to

differentially influence colour perceptions based on question (*Figure 3*). We conducted repeated measures ANOVA's with 'question' as a within-participant factor and 'sex' as a between-participant factor. For the colour stimuli this revealed a significant effect of question ($F_{1,103}$ = 5.6, p = .004, η_p^2 = .052) and a significant interaction between sex and question ($F_{1,103}$ = 3.4, p = .036, η_p^2 = .032). This reflects that red was generally most associated with aggressiveness and that women judged red as more dominant than men, while men judged red as more likely to win a physical fight than women. For the greyscaled images there was no significant effect of question ($F_{1,103}$ = 1.7, p = .19, η_p^2 = .016) and no interaction between question and sex ($F_{1,103}$ = 0.1, p = .96, η_p^2 < .001). See *Figure 3* for sex differences in judgements.

Splitting by sex, for the colour images, red was significantly associated with dominance by women (t_{74} = 6.7, p < .001, D = 1.6) but not men (t_{29} = 1.7, p = .103, D = 0.6) and red was significantly associated with winning over blue by men (t_{29} = 2.7, p = .012, D = 1.0) but not women (t_{74} = 1.1, p = .28, D = 0.3).

DISCUSSION

Our findings show that red dominates blue, but that this pattern reverses when hue information is removed demonstrating dissociation between hue (colour) and contrast (lightness/darkness) in social perception. As the greyscale images remove hue they act as a control and the data then suggest we can attribute the dominance of red to hue information in the stimuli. Red hue then elicits perceptions consistent with it signalling dominance in a way seen in other non-human animals (MILLINSKI and BAKKER 1990; PRYKE and GRIFFITH 2006; SETCHELL and WICKINGS 2005; WAITT et al. 2003). Our data are also consistent with previous cross cultural work on associations between emotion and colour demonstrating that light colours are seen as good and dark colours as bad (ADAMS and OSGOOD 1973; HEMPHILL 1996) and that red colour is seen as strong and angry (ADAMS and OSGOOD 1973; HUPKA et al. 1997). We also show that females are more are sensitive to the dominance signalling properties of red colour whereas males are more sensitive to the physical competitiveness between combatants. While aggression has implications for both males and females, dominance may be most salient to women judging colour if they are using it to estimate male quality (WAITT et al. 2003). Males on the other hand, may be most sensitive to red as dominant in judgements of potential physical conflicts with other males. Of course assessing both traits is important to both sexes, as evidenced that the directions are the same for both men and women – it is only the relative associations that differ between the sexes.

It is of course possible that colour associations are learnt within an individual's life-time. For example, English as a language contains links between the colour red and volatility via a link to red coloured fire, for example, fiery tempered, and feeling 'blue' is to feel sad, an emotion unlikely to be associated with dominance.

This does not necessarily mean colour associations are learnt via their associations within language though, we must consider why certain associations with colour and words are there in the first instance and potentially it is because the colours evoke social perception and language describes these associations. 'Colourful' metaphors are after all ones that evoke emotions. Another possibility is that individuals could observe that people turn red when angry and learn that angry individuals are more likely to win fights. If this is true then this may serve as a proximate mechanism for an association between red and dominance. Future work might usefully examine the development of the association between colour and social perception and how automatic the process is.

Previous studies have suggested that the explanation for blue winning over white can only be a difference in visibility and that red may win over blue for similar reasons (ROWE et al. 2005). In response it has been argued that blue is also a common sexually selected signal (BARTON and HILL 2005), and hence blue may win over white as it also acts a signal of dominance. There is another plausible evolutionary signalling explanation for the dominance of blue over white that is supported by our results. The current findings suggest that darker shades are seen as more dominant than lighter shades, which could then also account for blue beating white, as white will be seen as submissive to any colour (possessing darker contrast). In this way blue hue is not acting as the signal dominance, just the darker contrast. In human skin, darker colouration is associated with higher levels of testosterone (MANNING et al. 2004) resulting in females being lighter than males (FROST 1994) and so dark colours may beat light colours by an association with testosterone and masculinity. There certainly is a tendency for negative attributions to dark colours (ADAMS and OSGOOD 1973; HEMPHILL 1996). As a putative biological link, testosterone has long been associated with dominance, at least in human males (MAZUR and BOOTH 1998). Of course learning and stereotyping may play a role in the different perceptions of red and blue and light and dark, and, while the influence of such effects remains to be studied, the origin of such stereotyping may have its basis in signalling.

Our results then suggest that red hue is indeed special in sexual selection, signalling dominance more so than dark contrast, but also that darkness may also be a signal of dominance. Sex-specific effects in perception indicate that our effects are unlikely to represent by-products of the visual system in terms of visibility. Moving to basic perceptual processes indicates that signal properties of colour are fundamental in human vision, not requiring even basic social contest, and that colour perception may have far reaching social and biological implications beyond sporting competitions.

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