

## SPORTING CONTESTS

## Seeing red? Putting sportswear in context

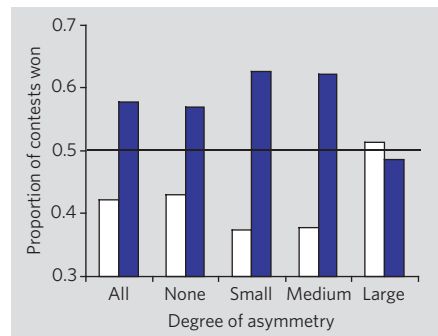
Arising from: R. A. Hill & R. A. Barton *Nature* 435, 293 (2005)

The shirt colour worn by sportsmen can affect the behaviour of the competitors<sup>1,2</sup>, but Hill and Barton<sup>3</sup> show that it may also influence the outcome of contests. By analysing the results of men's combat sports from the Athens 2004 Olympics, they found that more matches were won by fighters wearing red outfits than by those wearing blue; they suggest that red might confer success because it is a sign of dominance in many animal species and could signal aggression in human contests. Here we use another data set from the 2004 Olympics to show that similar winning biases occur in contests in which neither contestant wears red, indicating that a different mechanism may be responsible for these effects.

If, as Hill and Barton claim, there is something special about the colour red, then contests using other colour pairings should not be biased. We tested whether this could be the case by analysing data (www.athens2004.com) from contests in which red was not used for competitors' outfits: in judo matches, one player wears blue and the other wears white. We followed the methodology originally used by Hill and Barton<sup>3</sup> for boxing, taekwondo, and Greco-Roman and freestyle wrestling.

After ensuring that outfit (*judogi*) colour in judo contests was allocated at random (www.ijf.org), we found a significant winning bias for players wearing blue compared with those wearing white ( $\chi^2 = 7.34$ , d.f. = 1,  $P < 0.01$ ), and a similar effect of contest symmetry on winning bias to that reported by Hill and Barton (Fig. 1). We also found the winning bias for players wearing blue when considering only contests in the first round of competition ( $\chi^2 = 4.85$ , d.f. = 1,  $P < 0.05$ ). This result excludes the possibility that the observed bias might arise through skilled contestants being placed, by chance, in draw positions where they wear blue more often as they progress through the competition.

Our results indicate that there is nothing



**Figure 1 | Influence of *judogi* colour on the outcome of judo matches in the Athens 2004 Olympics.** The black line at 0.5 indicates the expected proportion of wins by blue or white under the null hypothesis that colour has no effect on contest outcome. Blue bars, proportion won by players in blue; white bars, proportion won by players in white. There were significant differences between the number of blue and white wins for all contests combined ( $\chi^2 = 7.34$ , d.f. = 1,  $P = 0.007$ ). This difference is most evident at low degrees of asymmetry in relative ability of the two competitors in each bout (subdivided using quartiles of points difference, after Hill and Barton<sup>3</sup>). Differences between the number of white and blue wins were as follows: no asymmetry ( $\chi^2 = 1.53$ , d.f. = 1,  $P = 0.22$ ), small asymmetry ( $\chi^2 = 6.31$ , d.f. = 1,  $P = 0.012$ ), medium asymmetry ( $\chi^2 = 3.19$ , d.f. = 1,  $P = 0.07$ ) and large asymmetry ( $\chi^2 = 0.57$ , d.f. = 1,  $P = 0.81$ ). Number of contests recorded are 301, 79, 99, 53 and 70, respectively.

inherently special about red in terms of colour-associated winning biases.

We can think of no plausible evolutionary explanation based on animal behaviour or evolutionary psychology that might account for a winning bias for blue contestants. We propose instead that outfit colour affects opponent visibility, which is crucial for avoidance and interception, and for anticipating behaviour. Visual abilities that could influence sporting performance include being able to

follow rapidly moving objects and perform fast visual searches<sup>4-6</sup>. And the hue, saturation, brightness and contrast of an object (or opponent) could enable it to be picked out against its background<sup>7,8</sup>. These factors are critical for combat sports and for detecting teammates on the field of play (<http://www.liv.ac.uk/research/intelligence/issue1/manunit.html>; 1999).

In judo, the white *judogi* is likely to be perceived as brighter than the blue and may have higher contrast against the background. Men wearing blue may therefore have a visual advantage in being able to anticipate their (white) opponents' moves. We do not know the reflectance spectra, lighting arrangements or other visual factors that might have affected the visual salience of the red and blue outfits worn in the sports studied by Hill and Barton. Although our hypothesis is untested, visibility differences could also explain the biases they found. The visual attributes of sporting wear should therefore be considered in this wider perceptual context.

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dominance and aggression. Rowe *et al.* find that, in a fifth combat sport, wearers of blue outperformed wearers of white. They attribute their and our results to perceptual rather than to psychological effects, arguing that visibility of the opponent is the critical factor.

In our view, this visibility explanation is unlikely in a situation where contestants fight at close quarters in brightly lit arenas, as in these combat sports. Crucially, in the combat sports we analysed, the hypothesis of Rowe *et al.* requires that blue-wearing opponents be more visible than their red-wearing opponents,

## SPORTING CONTESTS

## Hill &amp; Barton reply

Replying to: C. Rowe, J. M. Harris and S. C. Roberts *Nature* 437, doi:10.1038/nature04306 (2005)

Rowe *et al.* corroborate our finding that the colour of clothing influences the outcome of sporting contests<sup>1</sup>, but they offer a different mechanism to explain the effect. We found that in four combat sports wearing red was consistently associated with improved perfor-

mance relative to wearing blue<sup>2</sup>, and argued that wearing red enhances performance through psychological effects on the wearer and/or on the opponent. We suggested that these psychological effects reflect the evolutionary and cultural associations of red with

but, insofar as photographs provide an indication of this, the opposite seems to be true (see <http://www.athens2004.com/en/BoxingImageGallery/imagegallery>). Furthermore, the literature on visibility effects cited by Rowe *et al.* refers to sports where visuospatial judgements are made over distance. We also note that visibility has not been used to explain similar effects of artificially coloured leg bands on dominance interactions in birds<sup>3</sup>.

The visibility explanation proposed by Rowe *et al.* suggests that male and female contests should be equally affected by colour, whereas our sexual-selection hypothesis would predict stronger effects for males. The latter prediction is supported by the data: in the same sports in which significant effects were found for males, no such effects are evident for females (tae kwon do and freestyle wrestling (red against blue):  $\chi^2 = 0.32$ ,  $n = 155$ , d.f. = 1,  $P > 0.50$ ; judo (blue against white):  $\chi^2 = 0.30$ ,  $n = 214$ , d.f. = 1,  $P > 0.50$ ). Pooling

the data for the three combat sports in which both men and women participated, there is a significant association between sex and proportion of contests won by the advantageous colour ( $\chi^2 = 6.44$ , d.f. = 1,  $P = 0.011$ ).

We suggest that the impact of colour operates through its psychological and hormonal influences, rather than through its effects on visibility. Why then should blue provide an advantage over white? Although red reflects current dominance and testosterone levels<sup>4</sup> and indicates emotional arousal<sup>5</sup>, other bright colours, including blue, are known to indicate long-term developmental vigour<sup>6</sup> and may therefore have psychological effects relative to paler colours or white. In any case, our demonstration of enhanced performance in red relative to blue and other colours across a range of conditions suggests that, contrary to Rowe *et al.*'s claim, there is indeed something special about red.

Identification of the precise mechanisms

underlying the effects of colour will require more detailed experimental work. Meanwhile, the results of Rowe *et al.* lend further support to our claim that colour needs to be taken into account in ensuring a level playing field in sport.

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