Red does not enhance human performance in the Olympics

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A number of scientists have recently asserted that the color of sportswear can not only alter the behavior of athletes[1], but can also help competitors defeat their peers.[2-5] Evolutionary anthropologists R. A. Hill and R. A. Barton claim to have found statistically significant evidence of this effect in the results of the 2004 Athens Olympics.[6] Here, data from the 2008 Beijing Olympics are used to demonstrate that the effect Hill and Barton saw is likely not real.

Upon analyzing the outcomes of contests in four sports in which competitors were "randomly" assigned either red or blue attire (tae kwon do, boxing, Greco-Roman wrestling, and freestyle wrestling), Hill and Barton discovered that red-wearing participants beat their blue-wearing counterparts roughly 55 percent of the time (χ^2 = 4.19, d.f. = 1, P = 0.041). As a result, the researchers concluded that red attire confers a slight competitive advantage.

However, data from the 2008 Beijing Olympics do not show the same bias.[7-8] Indeed, in all four sports, the number of blue-wearing winners was at least the number of red-wearing winners. As a result, this particular dataset gives more support to the reverse hypothesis that *blue* apparel gives athletes an edge over red athletes.

There is the appearance of a statistically significant effect in freestyle wrestling, in which blue-wearing competitors won more than 60% of the contests (χ^2 = 7.01, d.f. = 1, P

= 0.0081). However, in the other three sports, blue's advantage was not statistically significant ($\chi^2 = 0.44$, d.f. = 1, P = 0.51; $\chi^2 = 0.13$, d.f. = 1, P = 0.72; $\chi^2 = 0$, d.f. = 1, P = 1 respectively); neither was it significant when all results were considered together ($\chi^2 = 2.98$, d.f. = 1, P = 0.084). Nevertheless, the data do allow a rejection of the hypothesis that wearing red allows an athlete to defeat a blue-wearing athlete 55% of the time ($\chi^2 = 18.0$, d.f. = 1, P = 0.000023). As a result, it is reasonable to conclude that either Hill and Barton encountered a statistical fluke or that one of their assumptions is flawed.

In fact, Hill and Barton erred in assuming that attire in the Olympics was randomly assigned. For the sports in question, athletes are placed in a table that pairs them up for bouts; the winner of each bout advances while the loser is eliminated from the competition or placed in a losers' bracket. In the Olympics, an athlete's position within the table determines the uniform color that he wears in each round of the competition.[9] In many tournaments, athletes are placed so that the best competitors -- as determined by preliminary rounds or by another form of ranking -- are unlikely to face each other in early rounds of the competition. This arrangement is, by necessity, not strictly random, potentially creating a bias toward one color or another.[10] Even if an athlete's initial position in the table is truly random, this is not equivalent to having randomly-assigned attire. For example, in the 2008 Olympic boxing and wrestling competitions, athletes at the top (redder) portion of the table often received byes in the qualification round, meaning that those at the bottom (bluer) positions had to compete in one more bout than their peers at the top of the table, potentially disadvantaging or advantaging them.[11]

This analysis will not end debate about whether red gives people an athletic or psychological advantage, as there are studies that do not assume randomness in a direct elimination tournament.[3,4,5,12] However, these results should stand as a reminder of how

many subtle things can go wrong when performing hypothesis tests -- and of the dangers of taking a "statistically significant" p-value too seriously.

[1] e.g. Frank, M. G. & Gilovich, T. J. "The dark side of self- and social perception: black uniforms and aggression in professional sports." *J. Pers. Soc. Psychol*. **54**, 74–85 (1988).

[2] Rowe, C., et al. "Seeing Red? Putting sportswear in context." *Nature*, **437**, E-10 (2005).

[3] Ioan, S. et al. "Red is a distractor for men in competition." *Evolution and Human Behavior* 28, 285– 293 (2007).

[4] Hagemann, N., et al. "When the Referee Sees Red..." *Psychological Science*, **19**, 769-771 (2008).

[5] Attrill, M. J. et al. "Red shirt colour is associated with long-term team success in English football." *Journal of Sports Sciences* **26**(6): 577-582 (2008).

[6] Hill, R. A. & Barton, R. A. "Red enhances human performance in contests." *Nature* **435**, 293 (2005).

[7] http://en.beijing2008.cn (currently defunct)

[8] http://www.2008.nbcolympics.com/

[9] An athlete's uniform color in round k of an Olympic direct elimination contest is determined by the formula FLOOR[(j-1)/k] (mod 2), where j is the initial position of the athlete in the table. For boxing and wrestling events, a value of 0 meant that the competitor would wear red while a value of 1 meant that the competitor would wear blue. (For tae kwon do, the reverse was true.)

[10] For example, if one were to use the above formula to assign jersey colors to the teams in the National Basketball Association playoff tables (as found on http://www.nba.com),

one would find that "red" teams eliminated "blue" teams nearly 70% of the time. (χ^2 = 8.64, d.f. = 1, P = 0.0033) over the past four years.

[11] In Dijkstra, Peter D. and Paul T. Y. Preenen. "No effect of blue on winning contests in judo," *Proc. R. Soc. B* **275**, 1157-1162 (2008), the authors discuss not only the biases caused by seeding and by stacking of byes at one end of the table, but also more subtle ones like inequalities in the time that athletes are given to rest between matches due to the structure of a direct elimination table.

[12] Elliot, Andrew J. et al. "Color and Psychological Functioning: The Effect of Red on Performance Attainment." *Journal of Experimental Psychology: General*, **136**, 154-168 (2007).