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Sinister strategies succeed at the cricket World Cup

Robert Brooks[1*], Luc F. Bussière[1], Michael D. Jennions[2] and John Hunt[1]

[1]*School of Biological, Earth and Environmental Sciences, The University of New South Wales, Sydney, NSW 2052, Australia*
[2]*School of Botany and Zoology, Australian National University, Canberra, ACT 0200, Australia*
[*] *Author for correspondence* (*rob.brooks@unsw.edu.au*).

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Left-handers occur at unexpectedly high frequencies at top levels of many interactive sports. This may occur either because left-handed contestants are innately superior or because they enjoy a negatively frequency-dependent strategic advantage when rare relative to right-handers. We analysed the batting records from the 2003 cricket World Cup and showed that left-handed batsmen were more successful than right-handers, and that the most successful teams had close to 50% left-handed batsmen. We demonstrate that this was because left-handed batsmen have a strategic advantage over bowlers, and that this advantage is greatest over bowlers that are unaccustomed to bowling to left-handers. This provides a clear mechanism for negative frequency-dependent success of left-handed batsmen. Our results may also support a historical role for negative frequency-dependent success in fights and other contests in the maintenance of left-handedness by natural selection.

Keywords: handedness; frequency dependence; polymorphism; sport; cricket

1. INTRODUCTION

Left-handers enjoy an advantage in sports that feature interactive contests, such as tennis, fencing and boxing (Wood & Aggleton 1989), and are better represented in these sports than expected from their frequency of 10–13% in the general population (Raymond *et al.* 1996). This common pattern is of interest to evolutionary biologists for two reasons. First, it is possible that left-handers enjoy a negative frequency-dependent advantage in these sports. Negative frequency-dependent selection is a potentially important process in the maintenance of genetic variation in fitness traits (Endler 1988; Sinervo & Lively 1996; Barton & Keightley 2002), but few biological systems offer the wealth of data or the convenience for study that is afforded by sporting competitions. Second, a popular explanation for polymorphism in human handedness is that left-handedness has historically been favoured in important contests such as fights (Raymond *et al.* 1996), and similar advantages might be observable in the contests typical of some modern sports (Wood & Aggleton 1989; Aggleton & Wood 1990; Raymond *et al.* 1996).

Left-handers may derive an advantage in interactive sports if they are, on average, always better than right-handers at these sports. One suggestion is that left-handers are more successful because they have relatively larger right hemispheric brain regions and thus better visual and spatial skills than right-handers (Geschwind & Galaburda 1985). Such an advantage would always favour left-handers over right-handers, irrespective of their relative frequencies. Alternatively, left-handers might enjoy a strategic advantage because they are more accustomed to right-handed competitors than vice versa. This kind of advantage would be greatest when left-handers are extremely rare and would (everything else being equal) decrease until there is no advantage when the frequencies of left-handers and right-handers are equal (Wood & Aggleton 1989; Grouios *et al.* 2000, 2002). Whether the apparent overrepresentation of left-handers in some interactive sports is due to uniform or to frequency-dependent benefits of left-handedness (or a combination thereof) has yet to be conclusively demonstrated.

In favour of the frequency-dependent hypothesis, left-handers enjoy no advantage in non-interactive sports (e.g. tossing the caber; Aggleton & Wood 1990; Raymond *et al.* 1996; Grouios *et al.* 2000, 2002), and frequencies of left-handedness in interactive sports never appear substantially to exceed 50%, even at the highest levels of competition (Raymond *et al.* 1996). Moreover, game-theoretic modelling of handedness in both batting and pitching in baseball has found that models incorporating frequency dependence provide a good fit to historical data on handedness (Goldstein & Young 1996).

Cricket is one sport in which left-handers enjoy an advantage, and are present more often than expected from their frequency in the general population (Raymond *et al.* 1996). It is often asserted by television commentators that a combination of one left-handed and one right-handed batsman is more difficult to bowl to because the bowler has continually to readjust the line that he bowls. Such an effect would favour teams with similar numbers of left- and right-handers to create more batting combinations of mixed handedness, and thereby result in negative frequency-dependent batting success. We analysed the success of left- and right-handed batsmen at the 2003 cricket World Cup in South Africa to test several hypothesized benefits of batting left-handed. In particular, we wished to clarify whether the benefits were due to: (i) an advantage of batting with partners of opposite handedness; (ii) uniform superiority of left-handers over right-handers; or (iii) a strategic advantage of left-handers over right-handers due to bowlers being less familiar with bowling to left-handers.

2. METHODS

We analysed scorecards and ball-by-ball commentary records from 39 group matches (out of the 42 scheduled matches there were two walkovers, and data from the Netherlands–Namibia match could not be obtained) played by the 14 teams in the 2003 cricket World Cup in South Africa. We extracted data for every batting partnership. The level of replication was the individual batsman. To test for an advantage of batting in combination with a same- or opposite-handed batsman, paired-sample *t*-tests were used. Only batsmen that were paired at least once with a right-hander and once with a left-hander were used in this analysis. To test for overall advantages to batsmen of left-handedness over right-handedness, data from all batsmen were used. Batting averages and balls faced per innings were limited to batsmen that were dismissed at least once, and thus have smaller samples than run rate comparisons.

We used the official net run rate statistics and data aggregated to team level to test hypotheses about team success. To estimate the proportion of left-handed innings at which the net run rate was maximized, we differentiated the fitted quadratic regression and calculated

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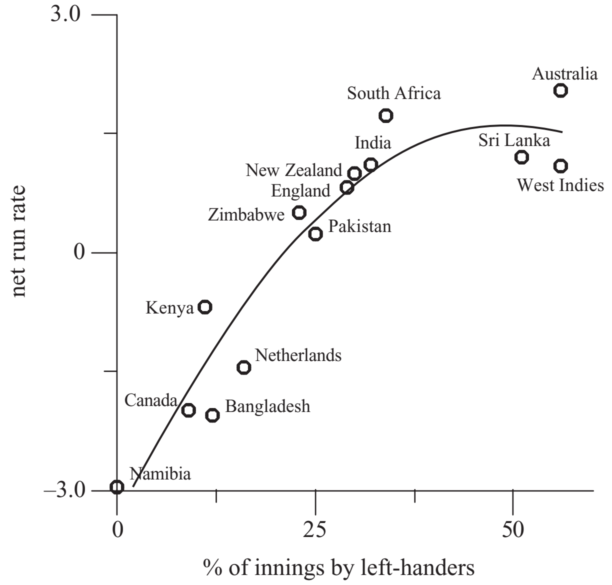

Figure 1. The success of teams at the World Cup was positively related to the prominence of left-handers in their batting line-up as described by the numbers of left-handed innings as a percentage of all team innings. Net run rate is a measure of the relative success of a team used in tournaments to separate teams with equal winning records: it is the difference between a team's batting run rate and the run rate that it concedes while bowling. Similar relationships exist for absolute run rate and for other measures of the prominence of left-handers. Net run rate $= 0.202x - 0.002x^2 - 3.38$. $r^2 = 0.902$, overall $p < 0.001$, linear coefficient $p < 0.001$, quadratic coefficient $p = 0.002$. Estimated maximum net run rate at 50.5% left-handed innings; bootstrapped 95% confidence intervals, 44.1–56.1%.

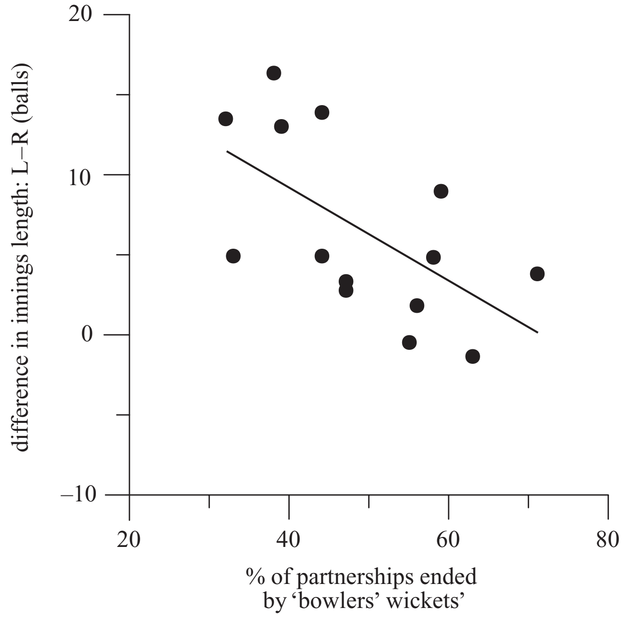

Figure 2. The advantage that left-handed batsmen enjoy over right-handers was strongly dependent on the proficiency of the bowling attack. Each point is one bowling team. Product–moment correlation: $r = -0.598$; $n = 14$, two-tailed $p = 0.024$.

the stationary point. To obtain 95% confidence intervals for this estimate, we conducted 100 bootstrap samples in each of which we drew 10 of the 14 teams at random without replacement, fitted a quadratic regression and calculated the stationary point. Summary statistics are presented as mean ± s.e.

3. RESULTS AND DISCUSSION

Out of 177 players who batted, 42 (24%) did so left-handed. The frequency of left-handers in the top three places in the batting order was 47%, falling to 12% among the last three batsmen, suggesting that left-handed batsmen enjoy an advantage in one-day international (ODI) cricket.

Team success was positively associated with the percentage of innings by left-handed batsmen, peaking at 50.5% (figure 1). This has two implications. First, batting success was maximized when teams had a mix of left- and right-handers, strongly suggesting frequency dependence. Second, this peak was close to 50%, suggesting that batting line-ups with similar numbers of left- and right-handed batsmen are optimal and that other factors linked to handedness (e.g. the need to select left-handed bowlers or fielders) do not alter the optimum balance in the batting line-up. In baseball, by contrast, considering the handedness of both pitchers and batters leads to a predicted evolutionarily stable strategy in which 31% of pitchers and 27% of batters are left-handed and 11% of batters can use either hand (Goldstein & Young 1996).

Batsmen did not perform better in left–right-hand combinations: comparison of the overall performance of individual batsmen with same-handed and opposite-handed partners revealed no difference in run rate ($t_{107} = 0.127$, $p = 0.899$), batting average ($t_{78} = 0.959$, $p = 0.351$) or balls per dismissal ($t_{78} = 0.652$, $p = 0.516$) (paired t-tests). There is thus no evidence to support the commentators' assertions that the partnership of a left- and a right-hander is of greatest value to a batting team.

Left-handers did not score at faster rates than right-handers (71.7 ± 4.7 versus 67.8 ± 4.1 runs per 100 balls; $F_{1,174} = 1.80$, $p = 0.181$). They did, however, bat for longer before being dismissed (25.1 ± 3.8 versus 15.3 ± 1.0 balls; $F_{1,171} = 5.14$, $p = 0.025$) and thus had higher batting averages (19.7 ± 3.9 versus 10.7 ± 0.9 runs; $F_{1,171} = 5.66$, $p = 0.019$), even when the effect of batting order was statistically removed (by fitting median batting position as a covariate in ANCOVA). Left-handers were less likely to be dismissed by a 'bowler's wicket' (the wicket types that best reflect bowling proficiency, i.e. bowled, caught behind, caught at slip and leg before wicket) than were right-handers (68 out of all 158 left-hand innings i.e. 43%, versus 238 of all 446 right-hand innings i.e. 53%; $\chi^2_1 = 4.98$, $p = 0.026$).

The ability of left-handers to bat for longer than right-handers may be due either to their inherent superiority or, as suggested by figure 1, to a frequency-dependent strategic effect of bowlers having less experience bowling to them. We therefore predicted that any such strategic benefit would be most pronounced against weaker bowling teams with less experience at bowling to left-handers. We used the proportion of all partnerships against a bowling side that were broken with a 'bowler's wicket' as an index of the side's bowling proficiency. The advantage enjoyed by left-handers was far greater against weaker bowling teams (figure 2), and disappeared against stronger bowling attacks. This suggests that the left-handers have a strategic advantage that decreases as left-handers become more common in a competition (e.g. a domestic league or the world ODI circuit) because bowlers become more adept at bowling when left-handers are relatively common.

The advantage enjoyed by left-handers over weaker bowling line-ups and the lack of a detectable cost to left-handed batting at the World Cup might lead one to predict that the relationship between batting success and proportion of left-handed innings should be linear rather than quadratic. The success of the quadratic fit (linear fit $r^2 = 0.75$, quadratic fit $r^2 = 0.90$, γ-coefficient $p = 0.002$) and the lack of teams with more than 56% left-handed batsmen is a subject ripe for further study, ideally in leagues where there are teams with substantially left-biased batting orders. It would be interesting formally to test whether left-handers become easier to dismiss at frequencies of greater than 50%.

We thus speculate that frequency-dependent selection within each nation's domestic league may have influenced our findings. Within the weaker cricketing nations, batting talent alone may influence the success of batsmen and thus their chance of national selection. In the stronger nations' leagues, the strategic advantage to left-handers may become an important additional determinant of batting success and thus national selection. To some extent, then, the success of teams with more left-handers at the World Cup may be due to a correlation between the strength of domestic leagues (and thus national teams) and the success of left-handers in winning national selection. This testable prediction is consistent with earlier findings that in many competitive sports, the frequencies of left-handers approach 50% at only the highest levels of competition (Raymond *et al.* 1996).

The extent to which modern sports like cricket meaningfully mimic natural selection on handedness in historic human populations is clearly debatable. Moreover, handedness is a complex trait that reflects, to a greater or lesser degree depending on the task, a continuum of underlying laterality (Yeo & Gangestad 1993). Batting handedness appears to be a very plastic trait, and is only partially correlated with handedness in other tasks (Wood & Aggleton 1989). In our study, there was a significant association between batting and bowling handedness ($\chi^2 = 29.6$, d.f. $= 1$, $p < 0.001$), but out of the 49 players who showed some left-handedness (they bowled or batted left-handed or did both), 86% batted left-handed, whereas only 49% bowled left-handed. Assuming that tasks such as bowling and throwing more faithfully reflect underlying laterality (Wood & Aggleton 1989; Raymond *et al.* 1996), it appears that batting handedness is very plastic and there is a strong tendency for otherwise right-handed individuals to bat left-handed, but not for left-handed individuals to bat right-handed.

Our results are consistent with frequency-dependent rather than uniform benefits of left-handedness in interactive contests. If similar processes historically influenced social status, survival or mating success (e.g. by influencing fighting prowess; see Raymond *et al.* (1996) for a fuller discussion of this), it is likely that negative frequency dependence may have played a role in maintaining left-handedness in human populations.

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