

Handedness in 'fast ball' sports: Do left-handers have an innate advantage?

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The study reported here examined whether left-handedness is an intrinsic advantage in three sports: cricket, tennis and football (soccer). An analysis of cricket yearbooks showed that over the last four decades there was a relatively high proportion of professional cricketers who bowled left-handed. In contrast, an analysis of handedness in top batsmen, as measured by bowling hand, failed to find any evidence of a handedness effect. Similarly, there was no clear, consistent excess of left-handed players among an overall sample of 500 male or 252 female professional tennis players or among 167 professional football goalkeepers. The latter group were of particular interest as left-handed goalkeepers are not tactically favoured by their relative rarity or by the symmetry of the sport. The most parsimonious explanation of the present findings is that any excess of left-handers in these sports is due to the nature of the game and not to any supposed neurological advantage.

It is often said that there is an unusually high proportion of left-handers among top sportsmen and sportswomen (Annett, 1985; Azemar, Ripoll, Simonet & Stein, 1983; McLean & Ciurczak, 1982). The most obvious explanation for this imbalance is that in many sports the right-hander is relatively unaccustomed to facing a left-hander and so the right-hander may have to reverse his or her usual strategies. For example, a 'southpaw' (left-handed) boxer has a different stance to an 'orthodox' (right-handed) boxer. This means that he can produce punches from directions and angles that differ from those used by an 'orthodox' boxer (Porac & Coren, 1981). In addition, the symmetry of many team games means that left-handed or left-footed players may have an automatic advantage in certain positions on the pitch. For example, in a soccer team of 11, it is desirable to have at least three left-footed players (i.e. left back, left midfield, left wing), a proportion which is higher than that found in the general population.

It has been suggested, however, that left-handers have an intrinsic advantage over right-handers due to superior spatio-motor skills, and that the relatively high proportion of top left-handed sportsmen and sportswomen is, in part, a reflection of this innate superiority. Although the cause of this supposed superiority is unknown, it has been assumed that it is the consequence of neurological differences between right- and left-handers. For example, Annett (1985) has suggested that the left

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hemisphere language specialization found in nearly all right-handers might, in some cases, be the consequence of an 'impairment' of the right hemisphere. This 'impairment' could handicap a number of the components of skilled performance including the capacity for visuo-spatial thinking, the fine control of both hands and the ability to make fast reactions to both sides (Annett, 1985). As such impairments will clearly affect sporting prowess, the proportion of left-handers amongst top competitors should be raised as a result of the exclusion of this group of right-handers with impaired abilities. Geschwind & Galaburda (1985) have proposed that left-handers may have relatively enlarged right hemispheric regions as a result of retardation of growth in the other hemisphere. This in turn may augment some functions subserved by the right hemisphere, among them spatial abilities (Nass & Gazzaniga, 1987). In addition, Geschwind & Galaburda (1985) suggest that left-handers may have a higher degree of overall skill in those tasks which require the use of both hands due to a higher rate of bilateral representation of axial motor control. Both of these influential theories of handedness have used the relative frequency of left-handed athletes to support their views.

The study described here had two aims. The first was to determine whether there was a higher than normal proportion of left-handed players in sports which make heavy demands upon rapid and accurate visuo-spatial coordination. The sports chosen were tennis, for which extensive world rankings are compiled for both male and female players, and cricket, which is well documented and provides detailed information on players over many decades. In both of these sports left-handed players might be thought to have a strategic advantage whenever facing a right-handed player because of their relatively unfamiliar style of play. These strategic advantages, coupled with possible innate neurological advantages, lead to the clear prediction that there would be an excess of left-handed players at the top levels of these sports. Previous reports of the frequency of left-handed players in cricket have been only anecdotal (Annett & Kilshaw, 1982) and while tennis has been examined in more detail (Annett, 1985; Azemar *et al.*, 1983) the findings are far from conclusive.

Azemar *et al.* (1983) reported finding a higher proportion of left-handed players among various divisions of the 1980 ATP world rankings (males) than in a control group, although no statistical support was provided for their conclusions, and the figure of 6 per cent left-handed for the control players appears considerably lower than that obtained from larger surveys of handedness (Annett, 1970; Bryden, 1977). In addition, Azemar *et al.* (1983) found that there was a significant increase in the proportion of left-handed players between the top 25 and the top four world rankings (males) for 1980. Annett (1985) reports that the proportions of left-handed male players in the 1978 Wimbledon programme (15.6 per cent, $n = 128$) and the proportion of left-handed male Wimbledon champions, counting by years and not individual players, between 1946 and 1978 (15.1 per cent, $n = 33$) are approximately twice the figure of 8.1 per cent she obtained in a survey of 2321 male and female undergraduates and service recruits. It should be noted the comparison figure of 8.1 per cent included both males and females and does not take into account the 2.6 per cent who reported holding a racket in 'either' hand (Annett, 1970). Furthermore, she found no differences when the same comparisons were made for female tennis players.

Annett (1985) also analysed the 1982 ATP rankings (males) and found a significantly higher proportion of left-handers among those players ranked 1–185 than in those ranked 186–369. However, these data are weakened by the accidental omission of certain left-handed players among those ranked 186–369.

The second aim of this study was to examine the proportion of left-handers in a sport which makes great demands on spatio-motor skills and yet for which there is no automatic advantage for the rarer left-handed player. Soccer goalkeepers were chosen because, like tennis players and cricketers, they are required to make accurate responses to a fast moving ball but, in contrast, they should display no inherent bias. Not only does the goalkeeper have to use both hands for many 'saves' but an analysis of 150 goals scored in the English First Division showed that there was no significant difference between the side of the pitch the scoring attempt came from or the side of the goal they went into (W. H. G. Wilkinson, personal communication). Lastly, goalkeeping requires no specialized equipment, unlike a sport such as hockey where all the sticks are 'right-handed', and so is free from any equipment bias which might influence handedness. In order to provide detailed information on handedness we sent a questionnaire containing the Edinburgh Handedness Inventory (Oldfield, 1971) to 273 professional goalkeepers in the English and Scottish Football Leagues. If left-handers do indeed have intrinsically superior spatio-motor skills then one would predict that there should be a higher than average proportion of left-handers among goalkeepers as well as cricketers and tennis players.

Method

Information concerning the handedness of tennis players and cricketers was taken from yearbooks which also provided the rankings or standings of the players in the previous season. Given the evidence that men are more likely to be left-handed than women (Oldfield, 1971), care was taken to treat data from the different sexes separately.

Tennis

Bibliographic information and the previous year's world rankings were obtained for male professional tennis players from *The Official Men's International Professional Tennis Council Media Guides* for 1986 and 1987 (Lansberry, 1986, 1987) and the 1981 *Slazinger World of Tennis* guide (Barrett, 1981). Similar information on top female tennis players was provided by the 1986 *Women's Tennis Association Media Guide* (Gossett, Kay & Page, 1986) and the 1981 *Slazinger World of Tennis* guide. It should be noted that every entry in the 1987 men's guide (Lansberry, 1987) and the 1986 women's guide specifies which hand is used to hold the racquet. The 1986 men's guide (Lansberry, 1986) listed handedness information for all but one of the 329 players described while the 1981 guide (Barrett, 1981) omitted handedness information for three male and two female players (out of a total of 192 males and 221 females).

Cricket

The Wisden Cricketers' Almanac (Brookes, 1938; Preston, 1950, 1962, 1974; Woodcock, 1986) provided detailed information concerning the playing handedness of batsmen and bowlers and their relative performances for a particular season (1937, 1949, 1961, 1973, 1985). The interval of 12 years between each season served to limit the number of cricketers who might be counted twice while the starting year (1937) was a consequence of *The Wisden Cricketers' Almanac* not providing handedness information prior to the 1935 edition.

Each edition of *The Wisden Cricketers' Almanac* gives the bowling and batting averages of first class county cricketers for a particular season and indicates whether a player bats or bowls left-handed. It should be noted that, unlike baseball, there are no 'switch-hitters' in cricket who bat with a different hand depending on the handedness of the bowler. The qualification for inclusion in the bowling averages is that a player must have bowled in at least 10 innings and have taken at least 10 wickets.

The batting information provided by *The Wisden Cricketers' Almanac* merely details which of the batsman's two hands are closer to the bottom of the cricket bat handle. There are, however, well-known examples of players (e.g. David Gower) who are right-handed by most other measures and yet bat left-handed. The reverse combination is also found (e.g. Tim Robinson). In order to determine whether batting handedness is an accurate predictor of general handedness we sent the 10-item Edinburgh Handedness Inventory (Oldfield, 1971) to the 42 cricketers in *The Wisden Cricketers' Almanac 1987* (Wright, 1987) listed as batting left-handed. In addition, we consulted the *Playfair Cricket Annuals* for 1988 and 1968 (Frindall, 1988; Ross, 1968), as these list the hand used by almost every player, apart from wicket-keepers, to hold the bat and bowl, regardless of batting and bowling ability.

Holding a cricket bat is not an item on any standard handedness questionnaire and in order to provide normative data we asked 765 male students (aged 11–18 years) at four schools in which cricket is compulsory (in London, Durham and Newcastle) whether they were right-handed, left-handed or had no preference for batting (bottom hand on handle), bowling and writing.

Football (soccer)

The original 22-item version of the Edinburgh Handedness Inventory (Oldfield, 1971) was sent to 273 goalkeepers in all four divisions of the English Football League and all three divisions of the Scottish Football League. The listing of goalkeepers was obtained from the *Rothman's Football Yearbook 1987–88* (Dunk, 1987). Two further questions were added to determine whether the goalkeepers themselves attached any importance to laterality: (1) Do you find it easier/prefer to save shots going to a particular side of the goal and if so which? (2) Do you find it easier/prefer to catch crosses coming from a particular side of the goal and if so which? The recipients were informed that these questions referred to their left/right sides.

Results

Given that there are likely to be various tactical advantages that left-handers enjoy in both tennis and cricket, we made the statistical comparisons for both of these sports one-directional, i.e. we expected to find a higher proportion of left-handers amongst the professional players. Unless otherwise stated all comparisons had one degree of freedom.

Tennis

The media guides provided handedness information for 316 (1987), 328 (1986) and 189 (1981) male players (Table 1) and 189 (1986) and 119 (1981) female players. Given the closeness of the years, it is, however, inevitable that many of the same players appeared in more than one guide. As a consequence an additional set of data was acquired by pooling the information from each yearbook for a particular sex and including each player only once. This pooled analysis provided a total of 500 male professional players and 252 female professional players.

Statistical comparisons were made with the results from large handedness surveys (Annett, 1970; Bryden, 1977). Both of these questionnaire surveys asked which hand was used to hold a racket. The Bryden study used the Crovitz-Zener questionnaire

(Crovitz & Zener, 1962) and obtained responses from 608 male and 471 female undergraduates, while the Annett study used the Annett (1970) questionnaire and obtained responses from 674 male and 419 female undergraduates, and 630 male service recruits. The detailed results for the items 'holding a racket' and 'throwing a ball' by sex were provided by Annett (personal communication). In order to provide as large a comparison group as possible the responses from these two surveys were combined making 1912 male and 890 female responses (Table 1).

Table 1. The preferred hand used to hold a racket by World ranked tennis professionals (Pros). The figures show handedness information for the total number of male (upper) and female (lower) professional players for whom handedness information is provided in the media guides for 1981, 1986, and 1987 and handedness information for just those players in the top 100 rankings in a particular year. Control data from Annett (1970) and Bryden (1977)

	Controls	Top 100 Pros			All Pros			
		1981	1986	1987	1981	1986	1987	1981+6+7
Male								
<i>n</i>	1912	85	100	100	189	328	316	500
% Left	8.9	16.5	14.0	13.0	11.6	12.5	13.6	12.2
% Either	3.0	0.0	1.0	0.0	0.0	0.3	0.3	0.2
χ^2		3.14*	2.11	0.68	0.28	1.68	3.45*	1.63
								(1981+6)
Female								
<i>n</i>	890	90	98		119	189		252
% Left	8.0	11.1	11.2		12.6	11.1		10.7
% Either	1.6	1.1	0.0		0.8	0.0		0.4
χ^2		1.18	0.65		2.72*	1.03		1.28

* $P < 0.05$ (one directional).

Table 1 shows the proportion of left-handed male and female professional players and the results of chi-squared comparisons with the control data for all players in a particular yearbook and for just those players in the top 100 rankings for that year. There were a small number of professional (one male, one female) and control (58 male, 14 female) tennis players who used both hands equally. These 'ambidextrous' responses which were too few to analyse separately, were divided equally between the 'right' and 'left' responses. For males two of the comparisons with the control data are significant – those for the players in the top 100 rankings in 1981 and for all the players in the 1987 yearbook (Table 1), whilst for females only one of the comparisons with the controls is significant – that for all the players in the 1981 yearbook (Table 1).

As it has been claimed that handedness differs between the upper and lower halves of the rankings (Annett, 1985) and that there is a significant rise in the proportion

of left-handed players between the top 25 and the top four rankings (Azemar *et al.*, 1983), comparisons were made between these groups. No differences were found, however, for any of the years examined.

Cricket

Normative data were provided by 765 schoolboys aged 11–18 years. The percentage of those who held a cricket bat left-handed (left hand at bottom of handle) was 8.8 per cent while 2.1 per cent said that they used either hand equally. Similarly, the percentage of those who bowled left-handed was 10.2 per cent while 1.2 per cent could bowl equally with both hands. In comparison, 12.9 per cent of the same sample preferred to write left-handed and 1.2 per cent used either hand. This figure for bowling may be compared with the item 'throwing a ball' from the surveys of Annett (1970) and Bryden (1977) who found that 9.6 per cent of males threw left-handed and 1.6 per cent used either hand (total $n = 1921$). Those few schoolboys who reported batting or bowling with 'either' hand were divided equally between 'right' and 'left' responses as there were no comparable professional players.

Bowlers. The incidence of left-handed bowlers in the years 1985 ($n = 139$), 1973 ($n = 119$), 1961 ($n = 141$), 1949 ($n = 137$) and 1937 ($n = 150$) ranged from 15.3 to 26.1 per cent. Statistical comparisons were made with the results from our survey of schoolboy cricketers (left-handed = 10.6 per cent). This comparison revealed that there was an unusually high proportion of left-handed bowlers in first class cricket in every season examined (1985, $\chi^2 = 8.09$, $P < 0.005$; 1973, $\chi^2 = 21.18$, $P < 0.001$; 1961, $\chi^2 = 5.37$, $P < 0.025$; 1949, $\chi^2 = 11.40$, $P < 0.001$) with the single exception of 1937 ($\chi^2 = 2.46$, $0.1 > P > 0.05$). Similar, but even more significant, results were found when using the item 'throwing a ball' (1937, $\chi^2 = 3.51$, $P < 0.05$; min χ^2 1949–1986 = 7.24, $P < 0.005$).

A final series of comparisons was made between the bowlers in the top and bottom halves of the bowling averages for a given season. There was no evidence that there was a disproportionate number of left-handers among the top half of the bowling averages for any season examined (1985, $\chi^2 = 2.38$; 1973, $\chi^2 = 0.98$; 1961, $\chi^2 = 1.13$; 1949, $\chi^2 = 0.14$; 1937, $\chi^2 = 1.28$; all comparisons two-directional).

Batsmen. The 25 replies from the 42 professional cricketers listed as batting left-handed in *The 1987 Wisden Cricketers' Almanac* highlighted the fact that handedness in batting can be a very misleading measure of overall handedness. We found that of the 25 replies all but two players were right-handed for virtually every item on the questionnaire, i.e. the vast majority of 'left-handed' batsmen in our survey were, in fact, right-handed by nearly all other measures.

In order to identify the true handedness of batsmen we therefore used the preferred bowling hand as provided by the 1988 and 1968 *Playfair Cricket Annuals*. Evidence that bowling preference is a good indicator of general handedness came from the finding that 93.2 per cent of the 765 schoolboys were consistent across writing and bowling. Similarly, for all but one of the 23 Handedness Inventory replies received from professional cricketers, for whom we also had bowling information, there was a perfect correlation between bowling and throwing a ball.

The bowling listings in *The Playfair Cricket Annuals* are far more extensive than those provided by *The Wisden Cricketers' Almanac*, detailing the bowling hand of all but 11 per cent of the players, excluding wicketkeepers. Only those players in the top two-thirds of the combined career batting averages for 1968 and 1988 were considered in order to focus on those players who were primarily batsmen or all rounders. Players who occurred in both editions were only counted once and then their 1988 career average was used. Comparisons with the schoolboy bowling data ($n = 765$, left-handed = 10.8 per cent) showed that there was a significantly higher proportion of left-handers, as measured by bowling hand, among the professional batsmen ($n = 371$, left-handed = 15.6 per cent, $\chi^2 = 5.26$, $P < 0.025$). Similar, but more highly significant, results were obtained using the data from the large-scale surveys of Annett (1970) and Bryden (1977) for the item 'throwing a ball' ($\chi^2 = 8.49$, $P < 0.005$).

Given that bowlers comprise more than one-third of a cricket team, and it was found that many more professional bowlers are left-handed than would be predicted by chance, we adopted a more stringent division in order to exclude nearly all players who are primarily bowlers. When only the players in the upper half of the combined career averages were considered ($n = 278$), neither the comparison with the schoolboy data nor the comparison with the item 'throwing a ball' reached significance (schoolboy, $\chi^2 = 0.62$, throwing, $\chi^2 = 1.21$). Furthermore, when the players in just the top one-third of the rankings ($n = 186$) were considered, the chi-squared statistics were further reduced (schoolboy, $\chi^2 = 0.35$; throwing, $\chi^2 = 0.68$).

A comparison was also made between the proportion of left-handers, as measured by bowling hand, in the top third and middle third of the combined career averages. Again, there was no evidence of a disproportionate number of left-handers among the best players ($\chi^2 = 3.02$). In fact, the proportion of left-handers was greater among the lower cohort.

As there can be no differences in the tactical advantages enjoyed by players who bat left-handed and are left-handed (as measured by bowling) and those players who bat left-handed but are right-handed (as measured by bowling), we compared the career averages of both groups of players. Similarly, we compared the averages of players who bat right-handed and are right-handed with those who bat right-handed but are left-handed. Again, in order to reduce the number of specialist bowlers in these analyses, we first considered those players in the upper two-thirds of the rankings. Neither of these comparisons were significant [players batting left-handed and bowling left-handed ($n = 21$) vs. players batting left-handed and bowling right-handed ($n = 51$): $t = 1.22$, d.f. = 29.2, $P = 0.23$; players batting right-handed and bowling right-handed ($n = 262$) vs. players batting right-handed and bowling left-handed ($n = 37$): $t = 1.31$, d.f. = 297.0, $P = 0.19$]. Similar analyses were also carried out with players in the top half and the top third of the batting averages and again none of the comparisons reached significance (min $P = 0.24$).

In contrast to handedness, as measured by bowling, a far greater proportion of professional cricketers bat left-handed than would be expected by chance. Our analyses of *The Wisden Cricketers' Almanac* showed that in every season examined since 1949 the proportion of players batting left-handed was remarkably stable and lay between 18.7 and 19.6 per cent (min $n = 224$, max $n = 258$). Chi-squared comparisons with the schoolboy batting data ($n = 765$, left-handed = 9.8 per cent)

Table 2. The responses of the professional goalkeepers and the control group for the 14 items for which comparisons with control data were possible. Control data from Bryden (1977)

	<i>n</i>	% R	% L	% E	χ^2 R vs. L vs. E (2 d.f.)	χ^2 R vs. Non-R (1 d.f.)
Writing						
Goalkeepers	167	90.4	9.6	0.0	N/A	0.63
Controls	620	88.1	11.6	0.3		
Drawing						
Goalkeepers	167	90.4	9.6	0.0	N/A	0.83
Controls	619	87.1	11.5	1.4		
Throwing						
Goalkeepers	167	87.4	6.0	6.6	3.25	0.88
Controls	620	84.5	10.3	5.2		
Scissors						
Goalkeepers	167	86.2	6.0	7.8	1.02	0.98
Controls	619	83.0	7.8	9.2		
Toothbrush						
Goalkeepers	167	86.2	7.2	6.6	6.06*	6.06*
Controls	619	77.5	11.8	10.7		
Knife without fork						
Goalkeepers	167	87.4	9.6	3.0	11.86***	6.84**
Controls	619	78.3	9.7	12.0		
Spoon						
Goalkeepers	167	83.8	9.0	7.2	7.02**	5.63*
Controls	619	75.2	10.3	14.5		
Broom						
Goalkeepers	167	74.3	10.8	14.9	50.59***	50.20***
Controls	616	43.4	20.1	36.5		
Match						
Goalkeepers	167	85.6	7.8	6.6	16.41***	14.20***
Controls	616	71.3	9.9	18.8		
Box						
Goalkeepers	166	62.1	8.4	29.5	15.12***	15.12***
Controls	617	45.1	12.3	42.6		
Hammer						
Goalkeepers	166	86.8	6.6	6.6	15.53***	1.21
Controls	620	83.2	14.7	2.1		
Racket						
Goalkeepers	167	89.2	6.6	4.2	5.50*	0.36
Controls	608	87.5	10.7	1.8		

Table 2. (cont.)

	<i>n</i>	% R	% L	% E	χ^2 R vs. L (2 d.f.)	χ^2 R vs. Non-R (1 d.f.)
Knife with fork						
Goalkeepers	166	79.5	14.5	6.0	2.42	1.57
Controls	618	83.7	10.2	6.1		
Needle						
Goalkeepers	167	80.8	8.4	10.8	13.73***	7.43***
Controls	604	70.2	20.9	8.9		

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$ (two directional).

were highly significant (min $\chi^2 = 14.24$, $P < 0.001$). When only those players in the top two-thirds, top half, and top third of the averages were considered, there was still a significantly higher proportion of batsmen playing left-handed among the professional cricketers for every season examined since 1949 (min $\chi^2 = 4.77$, $P < 0.025$). It may, however, be noted that the proportion of such batsmen in the 1937 season was appreciably lower at 11.2 per cent (all players) and did not differ significantly from the control data for any of the comparisons made.

Football

Of 273 professional goalkeepers who were sent the Edinburgh Handedness Inventory (Oldfield, 1971), 167 (61 per cent) sent replies. It was possible to compare directly the responses for 14 items (writing, drawing, throwing, holding scissors, holding a toothbrush, holding a knife without a fork, holding a spoon, holding a broom, striking a match, opening a box, holding a hammer, holding a tennis racket, holding a knife with a fork and threading a needle) with the results of a previous study (Bryden, 1977) in which 620 male undergraduates were surveyed using both the 10-item version of the Edinburgh Handedness Inventory and the Crovitz-Zener Questionnaire (Crovitz & Zener, 1962). All responses have been divided into three categories - 'left', 'right' and 'either'. It should be noted that for three items (hammering, holding a knife, threading a needle) minor differences do exist between the wording of these two questionnaires and these differences might complicate consideration of the control data.

Table 2 shows the frequency of 'left', 'right' and 'either' responses for these questionnaire items. All of the subsequent comparisons with the control data had two degrees of freedom with the exceptions of writing and drawing, for which there were too few 'either' responses, and so the data were treated in a manner similar to that used for the tennis analyses. For eight of the 14 comparisons there was a significant difference between the control subjects and the goalkeepers but in all of these cases the difference reflected a lack of 'left' and 'either' responses amongst the professional goalkeepers (Table 2). The same pattern of results was found when

comparisons were made between 'right' and 'non-right' ('left' and 'either' combined) responses (Table 2). Once again, for particular items the goalkeepers gave a significantly higher proportion of 'right' responses than the control group, and in all but one case (holding a knife with a fork) the controls, not the goalkeepers, contained the greater proportion of non-right-handers.

We also correlated the handedness of the goalkeepers, as defined by preferred writing hand, with their preference for the direction of crosses and shots on goal. The goalkeepers were asked to make one of three possible responses, 'left', 'right', or 'indifferent'. This additional analysis revealed no handedness differences for preferences of direction of crosses ($\chi^2 = 0.94$, d.f. = 2, two-directional), but a significantly higher proportion of left-handed goalkeepers did report finding it more difficult to save shots to their left ($\chi^2 = 6.78$, d.f. = 2, $P < 0.05$, two-directional).

Discussion

This study examined the frequency of left-handed players in three sports: cricket, tennis and football. Although a clear excess of left-handed bowlers was found in cricket, the findings for tennis, football, and those for batsmen in cricket, all cast doubt on the notion that left-handers have an inherent, neurological advantage in fast ball sports.

Although it has been suggested that there are many more left-handed professional tennis players than would be expected by chance, this effect is, at best, 'slight'. Indeed, the size and significance of this effect appear to depend largely on the year being examined and the size of the sample being considered. It should be emphasized that when the largest possible sample of either male or female professional players was considered there was no excess of left-handed players. This finding appears to contradict previous claims of a clear excess of left-handed players when smaller, select, samples have been considered (Annett, 1985; Azemar *et al.*, 1983), although, as has been pointed out, there are deficiencies in both of these studies. It has also been reported that there are more left-handed players in the top half of the world rankings (Annett, 1985) and that there is a significant increase in the proportion of left-handers at the very top of the rankings (Azemar *et al.*, 1983). This was carefully re-examined in the present study and no support for these claims was found for any of the years examined. In conclusion, while there may be a slight advantage to left-handed players, this effect is neither strong nor consistent.

The most parsimonious explanation of any left-handed advantage is that it is tactical rather than the consequence of any specific spatio-motor superiority. Tennis literature often refers to this supposed 'leftie advantage' (Crooke, 1985; Navratilova & Carillo, 1984). Navratilova points out that right-handers must reverse their usual strategies when facing a left-hander (Navratilova & Carillo, 1984). For example, many players have pet shots such as hitting the ball backhand cross court to their opponent's relatively weaker backhand. If they play this shot when facing a left-hander it will go to the left-hander's forehand. The most frequently cited advantage that the left-hander is supposed to have is due to his or her serve which swings away from the weaker backhand of the right-hander. However, it should be noted that the same is true of the right-hander's serve to the left-hander, though the left-hander will be more accustomed than the right-hander to returning this 'awkward' serve.

Whether or not left-handers have tangible advantages in tennis may be irrelevant as the very popularity of the notion that there is a 'leftie advantage' may give the left-hander a slight psychological edge when facing a right-handed opponent.

The analyses for cricket assumed that bowling handedness reflects general handedness, and in particular that it should correlate highly with the item 'throwing a ball'. The findings for batting had, however, to be treated differently as batting handedness is a poor predictor of general handedness. With these considerations in mind it was found that there was a consistently higher proportion of left-handed bowlers among the professional cricketers than would be expected by chance. This difference was found both for comparisons with our schoolboy bowling survey and for the item 'throwing a ball' from two large surveys (Annett, 1970; Bryden, 1977). It should be noted that the ages of those playing professional cricket and those participating in the two surveys (Annett, 1970; Bryden, 1977) were approximately similar.

While this proportion of left-handed bowlers might reflect an innate superiority, one must consider the various accepted strategic advantages that such players enjoy. The left-handed bowler has the benefit of unfamiliarity and in particular he is able to bowl at a different angle and to move the ball in the opposite direction to his right-handed counterpart. It is, however, interesting to note that the proportion of left-handed bowlers in 1937 was noticeably lower and much closer to those levels found in the control groups. This apparent relative decrease in left-handed bowlers may well reflect a greater degree of pressure for children in the past to 'conform' and use their right hand. There is, for example, clear evidence that fewer individuals wrote with their left-hand in the 1930s (Brackenridge, 1981; Levy, 1974) than at the time the control data were collected (1970s and 1980s).

The assessment of handedness in batsmen is complicated by the clear evidence that many 'left-handed' batsmen are, in fact, right-handed by almost any other measure. Our survey of the individual batting and bowling averages in *The Playfair Cricket Annuals* revealed that 71.4 per cent of the players listed as batting left-handed ($n = 98$) were right-handed (as measured by bowling), while 15.5 per cent of the players listed as batting right-handed ($n = 458$) were left-handed (as measured by bowling). For this reason batting handedness was ignored and bowling was taken as an estimate of general handedness. While this was possible for 90 per cent of the cricketers, excluding wicketkeepers, listed in *The Playfair Cricket Annuals*, bowling handedness was not listed for a small minority of batsmen. More detailed examination revealed that this 10 per cent of players was very evenly distributed between the top (37.5 per cent), middle (32.8 per cent), and bottom (29.7 per cent) thirds of the combined career averages. As a consequence the differential effects of omitting these players from the rankings is likely to be negligible.

Using the criterion of being in the top two-thirds of the career batting averages to identify specialist batsmen, we found that there was a higher than chance proportion of left-handers (as measured by bowling hand) among the professional batsmen. However, we also performed analyses using more stringent criteria (only those players in the top half and the top third of the averages) as it is likely that the initial criterion might not exclude all bowlers. This was because bowlers comprise more than one-third of a team.

Using these more stringent criteria the significant effect disappeared, i.e. there was

no evidence of an excess of left-handers (as measured by bowling hand) among top batsmen. Furthermore, when a comparison was made between the proportion of left-handers in the top (12.3 per cent) and middle thirds (18.9 per cent) of the batting averages, no significant difference was found, and in fact the proportion of left-handers was greater among the middle third.

An alternative method of investigating whether left-handers make better batsmen is to compare the averages of those players who bat left-handed and are left-handed by other measures with those players who bat left-handed but are right-handed by other measures. Similarly, comparisons can be made between players who bat right-handed and are right-handed with those players who bat right-handed but are left-handed. Such analyses using only those players in the top two-thirds, top half, and top one-third of the averages showed there to be no significant differences between these groups.

A similar set of comparisons has been made for baseball (McLean & Ciurczak, 1982) and it was found that those players who bat left-handed and throw left-handed (i.e. left-handers) had significantly higher career batting averages than those players who bat left-handed but throw right-handed (i.e. right-handers). As there are no tactical differences between these two groups, it was argued that this comparison may reveal a neurological difference between left- and right-handers (McLean & Ciurczak, 1982). However, this difference in baseball can also be explained by a consideration of the stance of the batter. Given the correlation between hand and foot preference (Porac & Coren, 1981) it is likely that the back foot of right-handers batting left-handed will be their non-preferred foot. In contrast, the back foot of left-handers batting left-handed will be their preferred foot. As the back foot in baseball supports the weight of the body and provides balance those players whose back foot is their preferred foot may have a slight advantage. This is not the case in cricket where either foot may be required to provide balance and support. Whether or not this fully accounts for the findings from baseball is unclear, but it may also be noted that no such difference was found between the career averages of those baseball players who bat right-handed and throw right-handed (i.e. right-handers) and those baseball players who bat right-handed and throw left-handed (McLean & Ciurczak, 1982). Such a difference might be expected if left-handers do, indeed, have an innate neurological superiority.

A clear excess of players who bat left-handed was found among the top professional cricketers. As batting handedness is a poor indicator of general handedness and we found no evidence for an excess of left-handers among top batsmen (using a more reliable indicator of handedness), this excess suggests that players who bat left-handed enjoy some sort of tactical advantage. The combination of a player batting right-handed and a player batting left-handed not only requires the bowler repeatedly to realign his deliveries but it also necessitates frequent fielding changes. These factors may help the bowler to lose his line and length and the fielders their concentration (Eastwood, 1972). In conclusion, there is an excess of left-handers among professional bowlers. This excess, however, may be accounted for without recourse to neurological explanations. Similarly, there is a significant excess of professional cricketers who bat left-handed but this may also be explained by a consideration of strategic factors. When a much more reliable indicator of general

handedness was used, no evidence was found for an excess of left-handers among top batsmen.

When the football goalkeepers were compared with the controls, eight out of the 14 comparisons showed a significant difference between the two groups. But it must be noted that for all of these cases there were more right-handers among the goalkeepers than the controls, a result contrary to the notion that there should be an excess of left-handers in fast ball sports. In fact, when these results are considered in the light of factor analysis of the items in the questionnaire (Bryden, 1977) the goalkeepers and the controls did not differ on those items thought best to describe handedness in terms of familiar activities, i.e. writing, drawing, throwing, holding scissors and holding a tennis racket. The only exception was that of holding a toothbrush for which there were more right-handers among the goalkeepers.

Another study which has considered handedness in sports which require rapid precise spatio-motor skills has noted the seemingly very high proportion of left-handed elite fencers (Azemar *et al.*, 1983). For example, in the 1981 World Championships, 35 per cent of the male ($n = 127$) and 32.3 per cent of the female ($n = 102$) entrants in the foil competition were left-handed. Similar high proportions were noted for the mens épée events (24.2 per cent, $n = 130$) but not, it should be noted, for the sabre (12.5 per cent, $n = 95$). Although the authors suggest that these findings reflect neurological advantages possessed by the left-handers, it is evident that left-handed fencers, like left-handed boxers, have clear strategic advantages and the only way to eliminate this factor is to concentrate on sports for which there are no such strategic advantages.

This study has considered in detail three different sports which require the participants to make very rapid and very accurate spatio-motor responses. Although the precise demands of the sports differ, the same pattern of results is found throughout: that is, a variable excess of left-handed players is present when such players have clear strategic advantages, e.g. cricket (bowlers) and tennis, but these effects may be remarkably slight (tennis). Furthermore, when considering a sport in which there should be no strategic advantage (soccer goalkeepers), no evidence was found for an excess of left-handed players. The most parsimonious explanation for the current findings is that any superiority of the left-hander in these sports reflects the nature of the game and not an innate neurological advantage.

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