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Original Article

Handedness and socioeconomic status in an urban population in Uzbekistan

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Abstract

The persistence of left-handers in every human population studied to date is an evolutionary puzzle in light of evidence of survival costs associated with left-handedness. Associations between left-handedness and socioeconomic advantages have been observed in Western countries and could provide left-handers fitness benefits through higher survival chances and greater reproductive success. We aimed to explore the generality of this result in another culture. For this purpose, we investigated several socioeconomic status indicators and the number of children alive for 917 men and women in Uzbekistan and compared results for two different measures of handedness: hand preferences for writing and for knife use. Among both men and women, left-handed writers were significantly more likely to own a car, own a washing machine and have a bank account. Left-handed women (using both measures) had a higher income than right-handed women. Among men, left-handers for knife use had a higher income than right-handers. The results of our study suggest that the previously observed socioeconomic advantage of left-handers in Western populations also applies to non-Western populations, at least in the urban environment studied. However, we did not detect any difference in the number of children. We discussed how the frequency-dependent socioeconomic status advantage could be responsible for the persistence of left-handers throughout human evolution.

Keywords: Hand preference; Cultural comparison; Reproductive success; Humans

1. Introduction

Right- and left-handers have coexisted in the human species since at least the Paleolithic Period (Raymond, Pontier, Dufour, & Moller, 1996). However, left-handers have been observed at lower frequencies than right-handers in all human populations studied to date, probably due to survival costs of left-handedness (for a review, see Llaurens, Raymond & Faurie, 2009). The persistence of this polymorphism throughout evolution is of considerable interest for several fields (e.g., neurology, psychology, evolutionary biology and genetics). It has been proposed that left-handedness may have a frequency-dependent advantage — the advantage being greater when the frequency is lower (Raymond et al., 1996). Theoretical approaches have confirmed that the maintenance of two opposite asymmetrical morphs by frequency-dependent selection could be a stable evolutionary strategy (Faurie & Raymond, 2005; Ghirlanda & Vallortigara, 2004), although this mechanism does not preclude the existence of other mechanisms affecting the evolution of handedness. Differences between right- and left-handers, for example, in body size, susceptibility to some diseases and cognitive skills or behavior, have been documented in various fields (see Llaurens et al., 2009 for a review). However, these differences have not been directly linked to fitness measures.

In humans, socioeconomic status has been shown to have an important positive influence on male reproductive success in traditional societies (Cronk, 1991; Hopcroft, 2006; Nettle & Pollet, 2008; Smith, 2004). In Western societies, male socioeconomic status seems to have a smaller effect on the

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number of children but a significant influence on the odd of ever having a child (Fieder & Huber, 2007; Nettle & Pollet 2008; Weeden, Abrams, Green, & Sabini, 2006). Concerning women, the positive relation between socioeconomic status and reproductive success seems to exist in traditional societies (Borgerhoff Mulder, 1987; Pettay, Helle, Jokela & Lummaa, 2007) but is typically negative in Western societies (Huber, Bookstein, & Fieder, 2010). Because socioeconomic status is a relative position within a group, it can be considered to be a candidate advantage for a frequency-dependent selection mechanism (Faurie, Goldberg, Hercberg, Zins & Raymond, 2008).

Differences between left and right-handers with respect to income have been detected in three different Western populations. In the United States, left-handed men have an income advantage over right-handed men, but this difference is not true for women (Ruebeck, Harrington, & Moffitt, 2007). In Great Britain, left-handedness has a significant positive effect on male earnings and a negative effect on female earnings (Denny & O' Sullivan, 2007). In France, a significantly higher income for left-handers was observed for both sexes, although this was more pronounced in men (Faurie et al., 2008). Taken together, these studies suggest an advantage of left-handedness with respect to income among men.

However, these studies all focused on Western countries; the applicability of the results to other countries is unknown. Hand preference has been shown to be influenced by sociocultural factors (Bryden, Ardila, & Ardila, 1993; Harris, 1992; Mandal, Ida, Harizuka, & Upadhaya, 1999; Needham, 1973; Teng, Lee, Yang, & Chang, 1976). Furthermore, the proportion of right- and left-handers has been shown to vary greatly across different geographical areas (Faurie, Schiefenhövel, Le Bomin, Billiard & Raymond, 2005; Raymond & Pontier, 2004). Social pressures against left-handedness are also widespread and variable across populations (McManus, 2002) but have been at least partially relaxed in Western countries (Hugdahl, Satz, Mitrushina, & Miller, 1993). Thus, the cultural component seems to be a crucial factor to take into account when studying the relationship between left-handedness and various social traits. Concerning socioeconomic status, there is clearly a need to compare Western and non-Western countries. Furthermore, it is necessary to investigate whether socioeconomic status differences actually translate into differences in reproductive success.

In this study, we investigated the socioeconomic status and the number of children of right- and left-handed men and women in a non-Western country, Uzbekistan.

2. Materials and methods

2.1. Study population

The population studied was located in Uzbekistan, a country in Central Asia, formerly part of the Soviet Union. The borders of this country were established during the Soviet Union period and do not correspond to the distribution of ethnic groups. Many ethnic groups with different languages and traditions, such as Uzbeks, Tajiks, Russians, Kirghiz, and Tatars, thus cohabitate.

Anonymous questionnaires in Russian were distributed in various work places (private companies and public hospitals) in the cities of Tashkent and Bukhara (Uzbekistan). People were asked to report their sex, age, marital status, number of children alive, ethnic group, and income, on a voluntary basis. There is notable black market activity in these cities such that people living in the cities often have several jobs or receive cash wage premiums; this income may not have been reported when volunteers answered the "income" question. Therefore, some questions were asked about possessions that were considered by the local scientists (Hegay T. and collaborators) as relevant to reflect the socioeconomic status: car, washing machine, and bank account.

To assess handedness, people were asked their hand preference when they write and when they use a knife. Although hand preference for writing is commonly used as a measure of handedness, it has been subjected to strong cultural pressures in the past, particularly in Uzbekistan. Cultural pressures are usually weaker for knife use. Furthermore, this task permits intercultural comparisons (Faurie, Schiefenhövel et al., 2005), as knife use is widespread throughout the world.

2.2. Statistical analysis

All statistical analyses were performed with R 2.11.0 software (www.r-project.org). The effects of handedness measures (writing and knife use) on income (continuous variable), possessions (binary variables) and number of children alive (counts variable) were evaluated in separate analyses using general linear models (GLMs). For each predicted variable, a complete model including the effect of handedness, marital status, sex, age, ethnicity and the interaction between sex and handedness was run first. When the interaction was nonsignificant, it was removed, and a model with the simple effects only was run. When the interaction was significant, two analyses were then run separately, within each sex.

Possession variables were analyzed assuming a binomial distribution. Income data were transformed with a Box–Cox transformation (using the R-package {MASS}) to fit the normality assumptions and were then analyzed assuming a normal distribution. The normality of the residuals was checked using a Shapiro test. The number of children was analyzed assuming a Poisson distribution, corrected for overdispersal. The statistical power of each analysis was assessed with the function pwr.f2.test (R-package {pwr}), using the degrees of freedom of the models, the effect size ($f^2=\{R^2_{\text{all.variables}}-R^2_{\text{all.variables.but.hand}}\}/\{1-R^2_{\text{all.variables}}\}$, where R^2 means "variance accounted for") and a significance level of .05.

3. Results

3.1. Descriptive statistics

We collected data for 917 individuals, including 385 men and 532 women. The ages of the subjects ranged from 15 to 80 years, with an average of 38.9±12.0 years. People belonged to different ethnic groups: 416 Uzbeks, 275 Russians and 215 others (Tajiks, Tatars, Koreans, Kazaks and Armenians); 11 subjects did not answer this question. Concerning the marital status in this sample, 45 people were widowed, 127 were divorced, 210 were single and 530 were married; 5 subjects did not answer this question.

Concerning hand preference for writing, 829 individuals reported using the right hand, 62 the left hand, and 4 both hands; 22 did not answer this question (i.e., 6.9% were left-handed writers). Concerning knife use, 778 people reported using the right hand, 117 the left hand and 2 both hands; 20 did not answer this question (i.e., 13.0% were left-handers for knife use). The individuals that reported the use of both hands were excluded from the further analyses (but note that including them in a non-right-hander category did not significantly change the results; data not shown). The proportion of left-handedness was higher in men than in women (9.9% and 4.8%, respectively, for writing; 15.2% and 11.5%, respectively, for knife use). Hand preferences for writing and knife use were significantly correlated (Pearson correlation coefficient: c=0.62, p<.001).

As shown in Table 1, raw data showed roughly a trend for a higher income and possession rate for left-handers as compared with right-handers. Concerning reproductive success, the number of children alive was slightly higher among right-handers, although the variance was very high.

3.2. Income

The average monthly reported income was $283±478. Fourteen individuals reported having no income (all right-handed), and 100 individuals did not answer this question and were scored as missing data. For further analysis, we considered only individuals who reported a nonnull income.

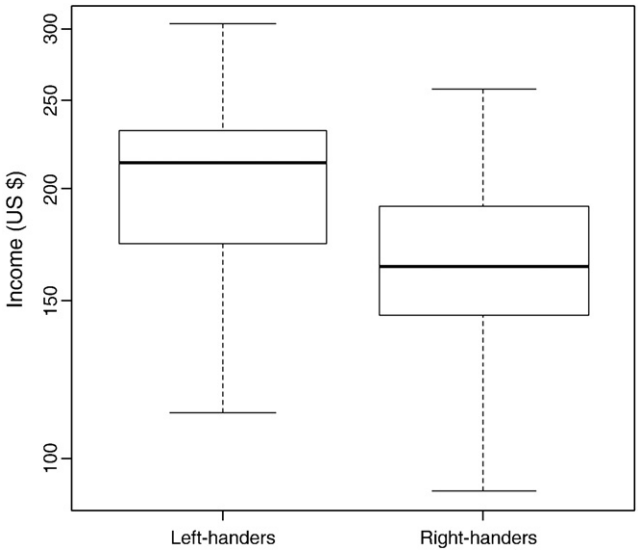

Fig. 1. Income (US dollars) as a function of hand preference for knife use (predicted values from a GLMs controlling for sex, age, marital status and ethnic group). Note that y-axis is log-scale.

No significant interaction was detected between sex and hand preference for knife use ($F_{1,767}$=0.0048; p=.9446); therefore, the effect of the interaction between sex and hand preference for knife use was removed from the model. Left-handers had a higher income than right-handers (Fig. 1), controlling for sex, age, marital status and ethnic group (Table 2; power=0.75). The residuals did not significantly depart from normality expectations (Shapiro test, W=0.996; p=.05).

A significant interaction between sex and hand preference for writing was observed ($F_{1,765}$=5.53; p=.018). We thus separately analyzed the data for men and women for this measure of handedness. Left-handed women had a higher income than right-handed women, controlling for age, marital status and ethnic group (Table 3; power=0.84). However, the residuals departed from the normality expectations (Shapiro test, W=0.989; p=.004). Among men, hand preference for writing was not associated with income, controlling for age, marital status and ethnic group

Table 1
Descriptive statistics of the sample

	All	By sex		By hand preference for knife use		By hand preference for writing	
		Male	Female	Left-handers	Right-handers	Left-handers	Right-handers
Income ($/month) — all	283±478	356±617	226±321	429±808	260±402	544±1047	262±396
Income ($/month) — zero excluded	288±481	362±620	230±323	433±810	264±404	544±1047	267±398
Car (proportion of individuals owning; %)	25.4	37.0	17.0	31.6	24.1	43.3	23.9
Washing machine (proportion of individuals owning; %)	53.5	53.5	53.6	55.9	54.0	70.7	52.7
Bank account (proportion of individuals owning; %)	16.3	16.8	16.5	16.7	17.0	26.7	16.3
Number of children	1.50±1.24	1.52±1.33	1.48 ± 1.17	1.48±1.43	1.50±1.21	1.33±1.46	1.51±1.22

Mean and standard deviation of income ($/month; with and without including people answering 0) and proportion of people having a car, a washing machine or a bank account in the whole sample, by sex and by hand preference for knife use and writing.

Table 2
GLM predicting the continuous variable "Monthly income" by hand preference for knife use

	Estimate	Standard error	p
Intercept	2.773	0.054	≤.001
Hand preference (knife use)	−0.042	0.016	.010
Sex	−0.059	0.011	≤.001
Age	−0.001	0.001	.109
Marital status (divorced)	0.073	0.030	.015
Marital status (single)	0.065	0.032	.039
Marital status (married)	0.079	0.028	.004
Ethnic group (Russian)	−0.031	0.016	.053
Ethnic group (Tajik)	−0.077	0.034	.022
Ethnic group (Uzbek)	−0.050	0.015	.001

Estimates (and standard errors) and p values corresponding to each factor tested.

(Table 3; power=0.05). The residuals did not depart from the normality expectations (Shapiro test, W=0.993; p=.14).

3.3. Possessions

3.3.1. Car

There was no significant interaction between hand preference and sex on the probability of owning a car, neither for writing (χ^2_1=1.23; p=.27) nor for knife use (χ^2_1=0.14; p=.71); the effect of this interaction was thus removed from the models. Left-handed writers were more likely to own a car than right-handed writers (χ^2_1=8.77; p=.003; power=0.83), controlling for age, sex, marital status and ethnic group (for details, see Supplementary Table 1). However, this trend was only marginally significant when considering hand preference for knife use (χ^2_1=3.14; p=.08; power=0.46), controlling for age, sex, marital status and ethnic group (Supplementary Table 1).

3.3.2. Washing machine

There was no significant interaction between hand preference and sex on the probability of owning a car, neither for writing (χ^2_1=1.07; p=.30) nor for knife use (χ^2_1=1.05; p=.30); the effect of this interaction was thus removed from the models.

Left-handed writers were more likely to own a washing machine than right-handers (χ^2_1=8.75; power=0.68), controlling for sex, age, marital status and ethnic group (for details, see Supplementary Table 2). However, this trend was not significant when considering hand preference for knife use (χ^2_1=0.73; p=.39; power=0.12), controlling for age, sex and ethnic group (Supplementary Table 2).

3.3.3. Bank account

There was no significant interaction between hand preference and sex on the probability of owning a bank account, neither for writing (χ^2_1=1.27; p=.26) nor for knife use (χ^2_1=0.65; p=.42); the effect of this interaction was thus removed from the models. Left-handers were more likely to have a bank account than right-handers (χ^2_1=4.19; p=.04; power=0.54), controlling sex, age, marital status and ethnic group (for details, see Supplementary Table 3). This trend was not significant when considering hand preference for knife use (χ^2_1=5.10^{-5}; p=.99; power=0.05), controlling for sex, age, marital status and ethnic group (Supplementary Table 3).

3.4. Reproductive success

Since there was no significant interaction between hand preference and sex in the models on the number of children, neither for writing (F^1_{859}= 0.04; p=.84) nor for knife use (F^1_{862}=0.55; p=.46), this interaction was removed from the models. Since the residuals were overdispersed, the QuasiPoisson correction was applied. The effect of hand preference was neither significant for writing (F^1_{860}=0.15; p=.70; power=0.07), nor for knife use (F^1_{863}=0.10; p=.75; power=0.06), controlling for sex, age, marital status and ethnic group (for details, see Supplementary Table 4).

4. Discussion

Overall, data from income and possessions tended to show a positive association between left-handedness and

Table 3
GLM predicting the continuous variable "Monthly income" by hand preference for writing

Females only				Males only			
	Estimate	Standard error	p		Estimate	Standard error	p
Intercept	2.733	0.083	≤.001	Intercept	2.826	0.105	≤.001
Hand preference (writing)	−0.090	0.033	.006	Hand preference (writing)	0.008	0.034	.807
Age	−0.001	0.001	.457	Age	−0.002	0.001	.092
Marital status (divorced)	0.037	0.035	.295	Marital status (divorced)	−0.094	0.031	.003
Marital status (single)	0.067	0.039	.085	Marital status (single)	−0.121	0.059	.040
Marital status (married)	0.045	0.033	.176	Marital status (married)	−0.100	0.028	.000
Ethnic group (Russian)	0.002	0.021	.919	Ethnic group (Russian)	0.209	0.073	.005
Ethnic group (Tajik)	−0.024	0.049	.618	Ethnic group (Tajik)	0.117	0.071	.098
Ethnic group (Uzbek)	−0.011	0.020	.595	Ethnic group (Uzbek)	0.192	0.066	.004

Estimates (and standard errors) and p values corresponding to each factor tested. Since a significant effect of the interaction between sex and hand preference was observed ($F_{1,765}$=5.53; p=.018), two separate models were built (females only and males only).

wealth. Despite the large sample size of this study, the statistical power (i.e., probability to reject the null hypothesis when false) was probably insufficient in cases where no significant association between hand preference and economic variables was detected (power ranging from 0.05 to 0.46), as compared to cases where a significant association was found (power ranging from 0.54 to 0.84). The significance of the results depended on the task considered to assess handedness.

Socioenvironmental pressures on hand preference could indeed differ between tasks and among economic levels in a society. In this regard, results using hand preference for knife use are probably more reliable because they are less likely to be biased, as this task is less subject to such socioenvironmental pressures.

Age, sex and marital status had an influence on economic status but did not affect the general positive relation between left-handedness and economic status (all interactions were tested and none was significant).

The global trend of a higher economic status of left-handers in this sample from Uzbekistan is consistent with the results of previous studies in Western countries (Denny & O'Sullivan, 2007; Faurie et al., 2008; Ruebeck et al., 2007). Our results thus permit some generalization of this advantage of left-handedness in human populations, at least in an urban environment (the data were collected in two large cities in Uzbekistan). Further investigations are needed in rural populations, where estimating economic status is more difficult because income cannot be measured solely in monetary units. Moreover, such a study in a rural environment will be more complex, at least in Uzbekistan, because (1) population densities are lower; (2) most individuals are illiterate, so the survey must be done orally; and (3) economic inequalities may be weaker such that differences between left- and right-handers will be more difficult to detect.

The socioeconomic advantages associated with left-handedness could be linked to differences in cognitive capacities, favoring an upward migration of left-handers across social classes. Several studies have investigated the relationship between laterality and various measures of intelligence, such as vocabulary tests, symbolic, non-verbal reasoning tests, IQ tests, memory tests, visual manipulation tests, reading, drawing and arithmetic abilities and foreign language learning. Several differences have been found, but no general trend has emerged (Faurie et al., 2008).

It is also possible that handedness and socioeconomic status are related through occupational choices or specific skills. Several studies have found left-handers to be more frequent in some professions and educational fields, such as the arts (Mebert & Michel, 1980), music (Byrne, 1974; Kopiez, Galley, & Lee, 2006), mathematics (Peters, 1991) and architecture (Peterson & Lansky, 1974). Studies have found evidence that creativity and novelty seeking are higher among left-handers (Coren, 1995; Newland, 1981). However, evidence is mixed (for a review, see Llaurens et al., 2009), and comprehensive scientific studies concerning the possible relationship between socioprofessional categories and hand preference are scarce. The mechanism responsible for the difference in economic status observed between right- and left-handers thus remains to be clarified.

4.1. Evolutionary consequences

We did not detect any significant differences in the number of children according to hand preference in this study, because the statistical power of these analyses was very low (statistical power=0.06 and 0.05 for hand preference for writing and knife use, respectively). The sample size of our study is probably too small to detect effects on fertility. For instance, studies in low-fertility populations (such as our Uzbek sample: mean number of children=1.50±1.24), which have detected an effect of a socioeconomic advantage on male fertility, used samples at least 10 times larger (e.g., Nettle & Pollet, 2008). Furthermore, a reproductive success advantage can sometimes only be detectable in the number of grandchildren, thereby taking into account offspring quality (Lahdenpera, Lummaa, & Russell, 2011). The data about the number of grandchildren were not available for this study; however, such data would be particularly interesting to investigate. This would allow testing whether the positive effects of socioeconomic status on male fitness could contribute to the persistence of left-handers in human populations.

However, it is sensible to consider that the general advantage of left-handers with respect to economic status could have positive consequences on their fitness. First, socioeconomic status has a positive influence on health (De Vogli, Mistry, Gnesotto, & Cornia, 2005) and could permit greater survival and fertility, for both men and women. Second, socioeconomic status is positively associated with reproductive success in males in both traditional (Cronk, 1991) and Western societies (Fieder et al., 2005; Hopcroft, 2006; Nettle & Pollet, 2008;), thus favoring an increased fitness of left-handed men. However, the influence of socioeconomic status on the reproductive success of women is typically found negative in Western societies (Huber et al., 2010). In traditional societies, when the socioeconomic status of a woman mainly depends on her husband's status, the influence of the household's socioeconomic status is positive (Roskaft, Wara, Viken, 1992). Moreover, it has been shown that left-handedness can persist among women even without a direct benefit: left-handed women could reap indirect benefits through their "sexy" left-handed sons (Faurie, Billiard, & Raymond, 2005).

The left-handed advantage is frequency dependent because socioeconomic status is a relative position within a population. When the number of people reaching a high socioeconomic status increases, the advantage linked to

this high status decreases accordingly. Such a frequency-dependent advantage could thus allow left-handers to be maintained in human populations, although at a lower frequency than right-handers. This type of balancing selection might contribute to the persistence of the handedness polymorphism in humans. In addition, another frequency-dependent advantage of left-handers has been proposed: an advantage during in fights (Faurie, Schiefenhövelet al., 2005; Raymond et al., 1996). How these two effects are distributed and interact requires further studies.

5. Conclusions

An economic advantage associated with left-handedness has been detected in an urban population in Uzbekistan. This result is consistent with previous findings in Western countries, suggesting that left-handers could persist in human population through frequency-dependent selection influenced by socioeconomic status.

Supplementary materials related to this article can be found online at doi:10.1016/j.evolhumbehav.2011.05.003.

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