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Competitiveness, gender and handedness

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ABSTRACT

We conduct an intercultural experiment in three locations on three different continents to elicit competitiveness and study whether individual differences in competitiveness are related to handedness. Being a "lefty" (i.e., having either a dominant left hand or a dominant left foot) is associated with neurological differences which are determined prenatally, and can therefore be seen as a proxy for innate differences. In large-scale data with incentivized choices from 3664 participants from India, Norway and Tanzania, we find a significant gender gap in competitiveness in all cultures. However, we find inconsistent results when comparing the competitiveness of lefties and righties. In north-east India we find that lefties of both genders are significantly more competitive than righties. In Norway we find that lefty men are more competitive than any other group, but women's competitiveness is not related to handedness. In Tanzania, we find no relationship between handedness and the competitiveness of either gender. The merged data show weak evidence of a positive correlation between being a lefty and competitiveness for men, but no such evidence for women. Thus, our data provide suggestive but not robust evidence that individual and gender differences in competitiveness are partially determined by innate factors, where innate factors are proxied by the complex, prenatally shaped trait of handedness.

1. Introduction

Recent research in economics suggests that noncognitive skills are important in determining education and labor market outcomes (Cunha and Heckman, 2007). To what extent these skills are innate or otherwise determined prenatally is still largely an open question. In this paper we focus on competitiveness, which is an economically relevant trait. A large literature finds that men are more competitive than women (Gneezy et al., 2003; Niederle and Vesterlund, 2007; Croson and Gneezy, 2009; Niederle and Vesterlund, 2011), and this difference is often cited as a potential explanation for gender differences in labor market outcomes (Zhang, 2012; Buser et al., 2014; Reuben et al., 2015; Berge et al., 2015; Buser et al., 2017a, b; Buser et al., 2020). In this paper we study whether prenatally determined neurological differences play a role in determining individual differences in competitiveness.

There are important evolutionary arguments that point towards a biological basis of gender differences in competitiveness. Men historically invested less in parenting which means that their number of offspring was determined largely by their number of mates. In contrast, a woman's number of offspring was constrained by her resources, but not significantly affected by increasing the number of mates. A man's number of offspring therefore strongly depended on his ability to outcompete other men, while this does not apply to women. This explains why men would be more aggressive and invest more in weaponry and ostentatious display (Trivers, 1972).

In this paper, we use handedness and footedness as proxies for underlying neurological differences (see Section 2 for a review of the literature). Being a "lefty" (i.e., having either a dominant left hand or a dominant left foot) is associated with neurological differences which are fixed prenatally. Some of the purported mechanisms behind the determination of left-handedness – such as the prenatal testosterone hypothesis – and some observed neurological differences between lefties and righties point towards left-handedness being correlated with a more male-typical neurology. Moreover, handedness is a gendered trait with men being more likely to be left-handed. We then explore whether prenatally determined neurological differences can partially explain individual and gender differences in competitiveness by relating handedness to an incentivized experimental measure of willingness to compete.

Our study is also a large-scale cross-cultural replication of the gender

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gap in competitiveness as measured by tournament entry (Niederle and Vesterlund, 2007). Participants in our experiments choose between competitive and non-competitive payment schemes for their performance in real-effort tasks. We look at three diverse groups on three different continents: villagers in India, high-school students in Norway and high-school students in Tanzania for a total of 3664 participants. We find an economically and statistically significant gender gap in each location. The raw gap in choices ranges from 14 percentage points in India to 21 percentage points in Norway.[1] We vary the nature of the experimental task but find no evidence of this affecting the gender gap in competitiveness.

In the first society, a tribe in North-East India, we find that lefties (defined as people who are either left-handed, left-footed or both) are significantly and strongly more competitive than righties, both for men and women. The size of the effect is so large that it trumps the well-documented gender difference: lefty women are weakly more likely to choose the competitive option than the average man and the lefty effect is larger than the gender effect. Moreover, we find that this difference cannot be explained by differences in actual or expected performance.

These results suggest that competitiveness is partially determined by innate factors and that the gender gap in competitiveness may have neurological roots. However, handedness may also partially be a social "treatment" because in some cultures, lefties may be treated differently. A purely neurological effect should be constant across countries and cultures. We therefore ran two more studies with high-school students in two very different countries, Norway and Tanzania.[2]

Norway is considered the most gender-equal society in the world, while Tanzania is considered one of the least gender-equal societies in the world.[3] Yet, in Norway, we find a larger gender gap than in India, confirming earlier experimental evidence (Almås et al., 2015). However, in contrast to our findings from India, the relationship between being lefty and competitiveness in the Norwegian sample is gender specific. Lefty men are more competitive than righty men. Lefty women and righty women are equally competitive and are less competitive than lefty or righty men. In Tanzania, we again find a significant gender gap in competitiveness, but in contrast to what we observe in both India and Norway, handedness and footedness do not predict the competitiveness of either men or women.

In sum, we conclude that our data do not provide robust evidence that gender differences in competitiveness are related to innate factors. The results do not fit any clear cultural narrative either. Out of the three countries in our sample, Norway is the most gender-equal and arguably the least biased against left-handers. Yet, in terms of the link between handedness and willingness to compete, the results from Norway are "in between" the results from India and Tanzania. It may also be the case the two tasks we use have different stereotypes attached to them in terms of gender and handedness – the ball tossing task is literally executed with the hand – but we do not find strong handedness differences in actual or expected performance in either task or location.

A potential issue with using handedness as a proxy for underlying neurological differences is that handedness can be influenced by social pressure. In our data, left-handed participants are relatively scarce in India and Tanzania compared to Norway. This could be evidence for social bias against being left-handed that introduces a selection problem since some lefties may adapt to the culture and not be registered as lefty in our study. However, using only footedness, which should be less affected by social pressure (Porac et al., 1986), hardly affects the results. It is important to point out that the issue of the "missing lefties" – due to social pressure to convert to the right hand – is separate from the issue discussed above that the effect of handedness may reflect the effect of social influences – due to left-handers being treated differently. Using footedness tackles the first issue but not the second. We also find different patterns in India and Tanzania. Our findings thus suggest a more complex relationship between handedness and competitiveness involving both biological and cultural factors.

Our study contributes to the growing literature assessing the role of biological factors in shaping economics preferences. Comparing the behavior of monozygotic and dizygotic twins, a series of studies demonstrate that giving and reciprocity in the trust game (Cesarini et al., 2008), responder behavior in the ultimatum game (Wallace et al., 2007), generosity in the dictator game and risk attitudes (Cesarini et al., 2009) are partly hereditary. Other studies find links between specific genes and behavior in the dictator game (Knafo et al., 2008; Israel et al., 2009). Economists have also looked into the effect of hormones on social preferences (Kosfeld et al., 2005; Zak et al., 2007; Zethraeus et al., 2009; Eisenegger et al., 2010; Buser, 2012a, b) and on risk attitudes (Apicella et al., 2008; Zethraeus et al., 2009).

Some studies have looked into the relationship between biological factors and competitiveness. Buser (2012a, b) and Wozniak et al. (2014) both find that for women, the inclination to compete varies over the menstrual cycle and with the intake of hormonal contraceptives, but Ranehill et al. (2017), in a placebo-controlled study, find no impact of contraceptives. Apicella et al. (2011) find no effect of testosterone on tournament entry in men. The question of the origins of gender differences in willingness to compete has also motivated research on young children (Gneezy and Rustichini, 2004; Sutter and Glätzle-Rützler, 2014; Dreber et al., 2011) and across cultures (Gneezy et al., 2009), with some evidence suggesting that gender differences in competitiveness are partially due to socialization. For example, Gneezy et al. (2009) compare patriarchal and matrilineal societies and find a large gender gap in a patriarchal society in Tanzania but not in a matrilineal society in India. Andersen et al. (2013) obtain a similar result comparing a matrilineal and a patriarchal society from the same region in India. Our study contributes to this literature by taking a new approach to studying the role of biological factors, focusing on handedness and footedness as proxies for neurological differences. It also provides a large-scale cross-cultural replication study of competitiveness across a diverse set of cultures, where we find robust evidence of a significant gender gap in competitiveness independent of culture and the nature of the task.

2. Handedness as a proxy for neurological differences

Handedness is interesting for our purposes because it is shaped prenatally, is associated with well-documented neurological differences, and exhibits gender differences, with virtually all studies finding a greater proportion of male lefties than female lefties (Halpern, 2000). It has long been known that the brains of lefties exhibit lower rates of brain hemisphere specialization, meaning that lefties more commonly use both sides of the brain for a given task (Coren, 1993; Hellige, 2001). This is reflected in physiologically observable brain differences.[4]

The best-documented neurological handedness difference is that while language ability is controlled by the left side (hemisphere) of the

[1] Dariel et al. (2017) survey the literature and calculate unweighted averages across published studies using variations of the Niederle and Vesterlund (2007) design. They calculate an average gender gap of 25 percentage points for studies using university students but a smaller average gap of 10 percentage points for studies that use other samples, including studies that use pre-university students. The gender gaps we find in our large and diverse sample are therefore well within the range of previous findings.

[2] Other studies documenting gender differences in competitiveness in European high-school students include Sutter and Glätzle-Rützler (2014); Buser et al. (2014); Buser et al. (2017a,b).

[3] See http://hdr.undp.org/en/data.

[4] The main connection between the two hemispheres of the brain called corpus callosum, which contains millions of nerves and acts as a data-wire that allows the two hemispheres to speak to each other, is thicker in lefties. See Witelson (1985) for a seminal study and Driesen and Naftali (1995) for a meta-analysis.

brain in almost all righties, it is bilateral or controlled by the right side in a significant proportion of lefties. Warrington and Pratt (1973) demonstrate this by temporarily shocking one side of the brain (a method known as E.C.T.). Lesion studies (using participants who experienced permanent damage to either the right or left side of their brain) demonstrate comparable results (Piercy, 1964), as do sodium amytal studies (where participants have half their brain put to sleep for a few minutes) (Branch et al., 1964), TMS studies (which use electric current to stimulate parts of the brain; Khedr et al., 2002) and simple reaction-time studies (where participants are presented with stimuli to one ear or one visual field, and reaction times and performance for various tasks are measured; Levy and Reid, 1978). While differences between left and right-handers are well-documented, the exact determinants of the underlying neurological differences that determine handedness are not fully clear, with genes (Medland et al., 2009), prenatal hormone exposure (Geschwind and Galaburda, 1987; Nass et al., 1987; Smith and Hines, 2000; Stoyanov et al., 2009), and differential brain structures caused by stressors during pregnancy or birth (Goodman, 2014) all seemingly playing a role.

Psychologists and economists have also conducted research that documents differences between left-handers and right-handers. Traits such as creativity (Coren, 1995), novelty-seeking (Goldberg et al., 1994), spatial ability (Sanders et al., 1982) and performance at mental rotation tasks (Porac and Coren, 1981) are positively correlated with left-handedness. On the other hand, left-handedness is associated with worse average outcomes in a range of early childhood development indicators (Johnston et al., 2009) and a higher prevalence of mental illness (Coren, 1993). In terms of economic outcomes, Denny and O'Sullivan (2007) find that left-handed men, but not women, have higher wages while Ruebeck et al. (2007) find no strong overall effect of handedness on earnings. Faurie et al. (2008) find that left-handers of both genders have better educational and professional career outcomes. Lefties have also been found to be overrepresented in male-dominated professions such as architects (Peterson and Lansky, 1974), mathematically oriented scientists (Temple, 1990), chess players (Coren, 1993) and U.S. presidents.[5] Goodman (2014), in an attempt to reconcile these disparate results, combines five datasets from the UK and the US and finds that, on average, left-handers earn less and have lower human capital.

3. Design and data collection

3.1. India

We measured handedness, footedness, and competitiveness among 1132 participants from seven villages in the Meghalaya region of India in 2010. Several weeks before the study, village headmen were asked to enroll villagers interested in the study. Headmen were asked to inform villagers that they would be paid a 100-rupee (approximately $2 at the time) show-up fee for half a day's participation in experiments, and that they may earn additional money depending on their performance in the experiments. All participants signed a consent form and were 18 years or older.

On arrival at each experimental site, participants were directed to stand in two separate lines, one for each gender, outside of the experimental room. The first six participants from each line were taken aside and an experimenter explained the task to them. The instructions were translated from English to the local language (Khasi) and were checked by having a different person translate them back into English. The instructions were read aloud first to the group of participants and then one on one. Participants were also given some test questions to make sure they understood the instructions.

The experimental task (adopted from Gneezy et al., 2009) was to toss a tennis ball into a bucket that was placed 3 m away. Participants were informed that they would have 10 chances to toss the ball. A successful shot meant that the tennis ball entered the bucket and stayed there. Participants approached an experimenter individually and were randomly and anonymously matched with another participant. The random other participant was from another group that had previously performed the experiment, and the matching was not dependent on the payment choice of either player. No other information was given about the individual to whom they were matched.

The only decision participants were asked to make was whether they wanted to be paid according to a piece rate payment scheme or a competitive scheme. This choice serves as our measure of competitiveness. The two options were (i) 20 rupees per successful shot, regardless of the performance of the participant they were matched with, and (ii) 60 rupees per successful shot if they outperformed the other participant, 20 rupees if they tied, and zero if they underperformed relative to the other participant.[6] Participants made their choice before performing the task but only after they fully understood the instructions and the payment schemes. After choosing the incentive scheme, participants completed the task and were told how the other participant performed. Some participants were asked to guess their performance after making their choice but prior to completing the task. In line with the given instructions, participants were never given the opportunity to learn with whom they were paired.

Finally, participants were asked which hand they primarily used to write with and which foot they primarily used to kick with. If participants were not sure, we asked them to try kicking or writing. We discussed the topic of prejudice against left-handers with village headmen and participants, who denied that there was prejudice or pressure to convert. The ball-throwing task was chosen because it was simple to explain and implement. Furthermore, we are not aware of any other popular task in this society that is similar to the ball-throwing task. Indeed, the villagers play cricket and soccer for sport, but because our task can only be completed with an underhand toss, these traditional skills do not advantage individuals with experience in any of these games.

3.2. Norway

We collected the Norwegian data in 2014. A team of research assistants visited 20 high schools in the Hordaland region of Norway and collected data from 571 participants. The team recruited students during breaks from the students' classes.

To participate in the experiment, students first had to complete a pre-experimental task that revealed whether they were lefty or not.[7] To incentivize participation in the pre-experimental task, the team informed the students that five randomly selected participants would receive an Apple iPad. The task consisted of first throwing a ball into a standing bucket from a distance and then try to kick the ball into a lying bucket from the same distance. Students who wanted to complete the pre-experimental task provided their contact details (name and phone number) as well as gender. To obfuscate the purpose of the pre-experimental task, the students were asked whether they are engaged in "any forms of sport."

When the pre-experimental task was completed, the team informed

[5] Since, 1929, half of the U.S. presidents have been left-handed or ambidextrous (Hoover, Truman, Ford, Reagan, Bush Sr., Clinton, and Obama).

[6] In the typical lab design, the competition winner receives the piece rate multiplied by the number of competitors (in our case two). However, many studies that do not use university subjects find relatively low competition rates (see e.g. Buser et al., 2020). With this in mind, we chose to make competing more attractive by paying three times the piece rate to the winner.

[7] We introduced the pre-experimental task in Norway to reduce the overall costs of implementing the study, since it enabled us to target all the lefties when inviting a subsample to the main experiment.

the students that some of them would be invited to participate in a classroom experiment later the same day for a show-up fee of 100 NOK (about 13 dollars) and the potential to earn additional money during the experiment. Since the schools allowed students to participate in the experiment during their normal class hours, nearly all of the students who were invited to participate in the experiment could attend if they wanted.

Later the same day, the team sent out text messages to all the invited students. All the students who had used their left hand or left foot during the initial task and a random subset of the righties were invited to the experiment. In the experiment, the participants were assigned to a classroom and a session leader read instructions aloud from a script that was identical across schools. To ensure full anonymity, all participants were assigned an anonymous participant number that would be used for assigning payments after the experiment.

The experimental task consisted of counting the number of white cells in large matrices of white and black cells. The participants had five minutes to complete a maximum of 20 such matrices. We first elicited participants' beliefs about how good they were relative to other participants doing the same task in a different room. After the belief elicitation, the participants could choose whether they wanted to work for a piece rate or a tournament rate. The piece rate was five NOK for each correct answer, whereas the tournament rate was 15 NOK for each correct answer if they scored higher than a randomly selected participant from a different room (or five NOK for each correct answer in case of a tie). After the participants had completed the experimental task (under a piece rate or competitive pay structure), they were asked about their self-reported tolerance for risk and a few questions on background characteristics (including their parents' education levels). The students would pick up an envelope with their assigned participant number and cash earnings at a scheduled time after the experiment.

3.3. Tanzania

We collected data from six high schools in Tanzania in 2015. A team of research assistants visited the schools and recruited participants for the experiment. The students answered questions about their name, age, and gender and were assigned a unique participant number. All participants in the experiment completed two tasks, but the order of the experimental tasks varied between the participants. The first experimental task was like the ball-throwing task used in India and the second experimental task was like the matrix task used in Norway.

The first experimental task (for half of the participants) was a ball throwing exercise where the participants would have 10 chances to throw a tennis ball into a standing bucket placed three meters away from the participant. Before the participants were allowed to start the task, they had to choose whether they wanted to be paid according to a piece rate (500 TZS for each successful shot; i.e., around 20 Eurocents) or a tournament rate (1500 TZS for each successful shot if they scored higher than a randomly selected participant from a different room; 500 TZS in case of a tie). Before the participants made their decision on piece rate versus tournament rate, the team of research assistants asked a series of control questions to test for understanding of the payment schemes. Participants were also asked to throw and kick a ball to measure their handedness and footedness.

The second task (which was the first task for the other half of participants) consisted of counting the number of white cells in large matrices of white and black cells. The task consisted of 20 matrices and the participants had five minutes to complete as many matrices as possible. As in Norway, the participants first indicated confidence in how good they were compared to participants doing the same task in a different room. The participants were then asked to choose whether they wanted a piece rate pay (500 TZS for each correct answer) or a tournament pay (1500 TZS for each correct answer if they scored higher than a randomly selected participant from a different room; 500 TZS in case of a tie). After completing the task, the participants answered questions on their self-reported tolerance for risk and background characteristics of their parents.

When all the students had completed both tasks, the team of research assistants calculated their payments and prepared envelopes with the earnings. The participants could then pick up the envelope that contained their unique participant number and the cash earnings.

4. Descriptive statistics

Table 1 shows descriptive statistics and sample size separately for each location.[8] The proportion of participants who compete varies across location. 31 percent of villagers in India, 48 percent of high-school students in Norway, and 23 and 25 percent of high-school students in Tanzania (depending on the task) chose the competitive option. The rate of left-handedness (and to a lesser degree left-footedness) also varies across countries, with rates highest in Norway, where roughly 11 percent of the students in the pre-selection sample are either left-handed or left-footed, and lowest in Tanzania, where only roughly 5 percent of the students in the sample are either left-handed or left-footed. In particular, only 3 percent of participants in Tanzania are registered as left-handed, hinting at potential cultural bias against left-handedness.

Table 1
Descriptive statistics.

	(1) India	(2) Norway	(3) Norway (pre-sample)	(4) Tanzania
Competition (ball task)	0.309			0.231
	(0.462)			(0.422)
Competition (matrix task)		0.477		0.251
		(0.500)		(0.433)
Performance (ball task)	3.173			5.051
	(1.776)			(1.981)
Performance (matrix task)		7.301		8.776
		(2.929)		(3.585)
Confidence (ball task)	5.158			6.846
	(2.159)			(2.106)
Confidence (matrix task)		6.287		6.219
		(1.756)		(2.878)
Risk seeking		6.169		7.831
		(1.986)		(2.671)
Lefty	0.068	0.342	0.113	0.049
	(0.252)	(0.475)	(0.316)	(0.217)
Left-footed	0.049	0.250	0.085	0.043
	(0.215)	(0.433)	(0.279)	(0.202)
Left-handed	0.051	0.246	0.080	0.026
	(0.221)	(0.431)	(0.272)	(0.160)
Female	0.516	0.514		0.508
	(0.500)	(0.500)		(0.500)
Age	33.0			
	(14.4)			
N	1129	568	2397	1967

Note: confidence/performance are measured as the expected/actual number of successful tosses (0–10) in case of the ball task and expected/actual performance decile (relative to other participants) in the matrix task. Risk seeking is their self-reported willingness to take risk (0–10). A person is defined as lefty if left-handed or left-footed (Porac and Coren, 1981).

[8] To keep the sample constant across analyzes, we drop a small number of observations because they are missing control variables. In India, we drop three observations where the performance in the task was not recorded. In Norway, we drop three observations because confidence is missing. In Tanzania, we drop 13 observations because either risk preferences or confidence in one of the two tasks is missing. We also lack confidence information for 347 participants in India. Rather than dropping all these observations, we decided to not control for confidence in the analysis using the India data.

Tables A1 and A2 in the appendix show gender and handedness differences in performance and expected performance. In Table A1, we regress performance on a gender dummy and a handedness dummy separately for each location and task, and in Table A2, we do the same for expected performance. The regression coefficients show that the ball task favors men, who do significantly better than women both in India and Tanzania. Men also expect to do better than women in both locations. The matrix task, on the other hand, favors women, who do better than men both in Norway and Tanzania. However, this is not reflected in beliefs, with women expecting to do significantly worse than men in Norway and similarly to men in Tanzania.

We find much less evidence that performance or expected performance differ between lefties and righties. Lefties do marginally significantly better at the matrix task in Tanzania, but coefficients are small for the other locations and tasks. Because the ball task is directly linked to using one's hands, it might be that lefties expect to have a (dis)advantage over righties. This is not the case in India, where lefties expect to perform similarly to righties. In Tanzania, lefties expect to do worse, but note that this difference is only about 30 percent of the size of the gender difference in beliefs.

5. Results

5.1. India

Of the 1129 participants taking part in the experiment for whom we have all relevant information, 6.8 % were lefty (4.5 % of women and 9.3 % men; Fisher's exact test, $p = 0.001$) and 48 % were male. On average, participants completed 3.2 successful tosses out of 10. They were on average highly overconfident, expecting to make 5.2 successful tosses. We find no significant difference between lefties and righties in performance (ranksum test; $p = 0.514$) or confidence ($p = 0.468$). Men perform significantly better at the task, managing 3.50 successful tosses versus 2.87 for women ($p < 0.001$). Men are also more confident, expecting on average to make 5.38 tosses versus 4.95 for women ($p < 0.001$).

We find a sizeable gender difference in competitiveness: 38.3 % of men and 24.0 % of women chose to compete; $p < 0.001$, Fisher's exact test. Lefties are more likely to compete than righties, both among men (54.9 % vs. 36.6 %; $p = 0.015$; Fisher's exact test) and among women (42.3 % vs. 23.2 %; $p = 0.034$). Strikingly, the effect of being a lefty is so strong that it trumps the effect of gender: the difference in the likelihood to compete between lefties and righties is larger than the difference between men and women.

Table 2 reports marginal effects from probit regressions of the choice to compete on being a lefty. The regression in Column 1 replicates the above result that men are significantly more likely than women to choose competition. Column 2 adds a lefty dummy to the regression and shows that the estimated effect of being lefty is even larger than the gender difference. Column 3 controls for performance which hardly affects the results because there is no significant gender difference or handedness difference in performance.[9] In column 4 we additionally interact gender and handedness. The lefty effect is similar across gender and not statistically significantly different ($p = 0.817$).

To study whether social pressure to switch to the right hand may contribute to explain our results, we also implement this analysis separately for being left-footed. Social pressure against using the left hand may exist, but no such pressure exists to kick with the right foot. The difference between righties and lefties is bigger in magnitude using the footedness measure than the handedness measure. 60.0 % of left-footers vs. 29.4 % of right-footers chose to compete ($p < 0.001$). These regression results are reported in Table A3 in the appendix, which show marginal effects from probit regressions of the choice to compete on being left-footed, where we omit individuals who indicated being left-handed but not left-footed from the sample in order to not include lefties in the control group. It confirms that also focusing on left-footed, we find that being a lefty is stronger than the effect of gender and is significant within each gender.

If the correlation of being lefty with competitiveness truly reflects an effect of prenatally determined differences rather than a cultural effect of society treating left-handers differently, we would expect it to replicate in culturally different settings. We therefore implemented this study also in Norway, one of the richest and most gender-equal societies in the world, and in Tanzania, one of the poorest and least gender-equal societies in the world.

Table 2
Probit Regressions of Competitiveness on Being a Lefty (India).

	(1)	(2)	(3)	(4)
Female	−0.141***	−0.132***	−0.132***	−0.134***
	(0.026)	(0.026)	(0.027)	(0.027)
Lefty		0.168***	0.168***	0.160**
		(0.051)	(0.051)	(0.063)
Female*lefty				0.025
				(0.108)
Performance			√	√
N	1129	1129	1129	1129

Notes: Marginal effects are from probit regressions of being a lefty on choosing the competitive payment scheme. The dependent variable equals 1 if the participant chose the competitive payment scheme and 0 otherwise. Lefty equals 1 if the participant indicated to be left-handed or left-footed. Robust standard errors in parentheses; 3, 2, or 1 stars indicate significance at the 1 %, 5 %, or 10 % level respectively.

5.2. Norway

Of the 568 Norwegian high-school students taking part in the experiment for whom we have all the relevant information, 34.2 % were lefty (24.9 % of women and 43.9 % of men) and 49 % were male. This sample is smaller compared to the other locations but contains a larger share of lefties, since we used a pre-experimental task to target the recruitment of lefty participants. 11.3 % of the 2398 students in the pre-sample were lefty (8.4 % of women and 13.2 % of men; Fisher's exact test, $p < 0.001$).

On average, participants completed 7.31 matrices. Righties performed slightly better, solving 7.44 matrices on average while lefties solved 7.04 matrices (ranksum test; $p = 0.046$). However, righties are slightly less confident, scoring themselves 6.21 on a 1–10 scale versus 6.44 for lefties ($p = 0.201$). Lefties and righties also score themselves similar for risk seeking ($p = 0.507$). Women perform significantly better at the task, managing 8.00 matrices versus 6.56 for men ($p < 0.001$). Men are nevertheless much more confident, scoring themselves as 6.82 versus 5.78 for women ($p < 0.001$). Men are also more risk seeking ($p < 0.001$).

Despite Norway being considered the most gender-equal society in the world, we again find that men are more likely to choose competition compared to women (59 % vs 37 %; $p = 0.000$; Fisher's exact test). We find that lefty men are slightly more likely to compete than righty men, but the raw difference is not statistically significant (64 vs 55 percent; $p = 0.140$), and there is no difference between lefties and righties for women (36 vs 37 percent; $p = 0.889$).

In Table 3, we report probit regressions. We observe that the gender gap in competitiveness is highly significant and robust to controlling for performance. Controlling for confidence and risk preferences reduces

[9] Performance is measured in the task after choosing the incentive scheme (since we do not have a baseline measure of performance). Using this control potentially biases the estimates of gender and handedness differences in competitiveness because the choice of competing (or not) might itself affect performance. In particular, it could bias against finding group differences if individuals who choose not to compete put in a lower effort.

Table 3
Probit Regressions of Competitiveness on Being a Lefty (Norway).

	(1)	(2)	(3)	(4)	(5)
Female	−0.221***	−0.213***	−0.215***	−0.110***	−0.062
	(0.037)	(0.038)	(0.040)	(0.042)	(0.052)
Lefty		0.043	0.043	0.054	0.114**
		(0.043)	(0.043)	(0.042)	(0.056)
Female*lefty					−0.133
					(0.086)
Performance			√	√	√
Confidence				√	√
Risk				√	√
N	568	568	568	568	568

Notes: Marginal effects are from probit regressions of being a lefty on choosing the competitive payment scheme. The dependent variable equals 1 if the participant chose the competitive payment scheme and 0 otherwise. Lefty equals 1 if the participant is lefthanded or left-footed. Robust standard errors in parentheses; 3, 2, or 1 stars indicate significance at the 1 %, 5 %, or 10 % level respectively.

the gender gap roughly by half. However, in contrast to what we observed in India, we find no statistically significant effect of being a lefty overall, also when controlling for performance, confidence, and risk preferences. Lefty men, but not women, are significantly more likely to compete conditional on performance in the task, risk attitudes and confidence. In Table A4 in the appendix, we show that these findings are robust to only using footedness in the analysis.

5.3. Tanzania

In our sample of 1967 Tanzanian high-school students for whom we have full information on all variables for both tasks, 4.9 % were lefty (2.9 % of women and 7.0 % of men; Fisher's exact test, $p < 0.001$) and 49 % were male. On average, participants completed 8.77 matrices and made 5.05 successful tosses. Lefties and righties performed similarly with lefties, solving 9.31 matrices on average while righties solved 8.75 matrices (ranksum test; $p = 0.150$) and lefties scoring 4.98 balls and righties 5.05 balls ($p = 0.928$). Righties and lefties are similarly confident in both the matrix ($p = 0.771$) and balls ($p = 0.607$) tasks but righties see themselves as slightly more risk taking ($p = 0.090$). Women perform significantly better at the matrix task, managing 8.95 matrices versus 8.59 for men ($p = 0.016$), and significantly worse at the ball task, scoring 4.46 balls versus 5.66 balls for men ($p < 0.001$). Men are more confident than women in the balls task ($p < 0.001$) but not the matrix task ($p = 0.474$). There is no significant gender difference in risk seeking ($p = 0.686$).

We find that men are more likely to choose competition compared to women in both tasks (31 vs 15 percent in the ball task and 33 vs 17 percent in the matrices task; $p < 0.001$ in both cases; Fisher's exact test). Hence, we find that the gender gap in competitiveness is robust both across different cultures and different experimental tasks. We find no strong differences between lefties and righties on either task for men (26 vs 32 percent, $p = 0.418$; and 29 vs 34 percent, $p = 0.594$) or women (17 vs 15 percent, $p = 0.793$; and 17 vs 17 percent, $p = 1.000$).

Using probit regressions in Tables 4 and 5, we confirm these results controlling for performance in the task, confidence, risk attitudes, and task order. We observe that the gender gap in competitiveness is highly significant and robust to controlling for performance. After additionally controlling for confidence and risk preferences for either task, the gender difference is equal to 9 percentage points in the balls task and 16 percentage points in the matrix task (and highly statistically significant in both cases). However, in line with what we observed in Norway, we find no effect of being a lefty overall or separately for men or women, also when controlling for performance, confidence, and risk. In Tables A5 and A6 in the appendix, we report the corresponding analysis using footedness only, where we observe the same patterns.

5.4. Merged data

In Table 6, we merge the data from all three locations and control for country-fixed effects and full interactions of country-fixed effects with the control variables.

The overall gender difference in choosing to compete across societies is 16 percentage points (39 % of men and 23 % of women compete in the pooled dataset; $p = 0.000$, Fischer's exact test). Using probit regressions controlling for gender, we find that lefties are roughly 5 percentage points more likely to compete, an effect that is marginally statistically significant. The effect is slightly larger when we control for performance, confidence, and risk attitudes.[10] Interacting gender and handedness in columns 4 and 5, we find some effect of being a lefty for men but not for women, but again, the coefficients for men are small and not very precisely estimated and the difference in coefficients between men and women is not statistically significant. These results are robust to using footedness only, see Table A7 in the appendix.

5.5. Power

Lefties, and particular lefty women, are comparatively rare in the population and consequently in our samples, with the exception of Norway where we oversampled them. This raises the question of statistical power. To get an indication of the effect sizes which we have reasonable power to detect with our sample, Table 7 shows the handedness difference in the proportion of individuals choosing competition which we can detect at the 5-percent level with 80 percent power using a simple chi-squared test by country and gender.

For the sample as a whole, we can detect a lefty effect of 7 percentage points with 80 percent power (relative to 30 percent of righties choosing competition). As a point of comparison, the gender difference in the sample as a whole is 16 percentage points. Looking at each country separately. Power is highest in Norway, where we are reasonably powered to detect a lefty effect of 12 percentage points, and lowest in India, where we are reasonably powered to detect a lefty effect of 16 percentage points. Looking at men and women separately, we are reasonably powered to detect effects of 10 and 11 percentage points for men and women respectively in the sample as a whole, but power is much lower in each country separately, in particular for women. In summary, we are well-powered to detect moderate handedness differences in competitiveness in the sample as a whole, but power is more of an issue when analyzing each country sample separately, especially when it comes to gender differences in the lefty effect.

6. Conclusion

We have used handedness and footedness as a proxy for underlying neurological differences to investigate whether individual differences in competitiveness are partially determined by prenatal factors. We find a strong relationship between handedness (and footedness) and competitiveness in a sample of Indian villagers of both genders. To study the robustness of this relationship across cultures, we conducted further studies in two culturally very distinct settings, Norway and Tanzania. The results are mixed. In Norway, we find a weak effect of handedness for men only, while we find no meaningful effect for either gender in Tanzania. Using footedness instead, which should be less subject to social pressure than handedness, does not significantly change any of these results. Overall, the data do not provide robust evidence that gender differences in competitiveness are partly driven by innate differences.

Our study also constitutes a large-scale, intercultural replication of

[10] For India, we replace the confidence and risk measures with a constant and interact them with a dummy that indicates whether confidence or risk is missing. For Tanzania, we use the first decision and control for a task dummy (interacting the controls with the task dummy).

Table 4
Probit Regressions of Competitiveness on Being a Lefty (Tanzania; balls).

	(1)	(2)	(3)	(4)	(5)
Female	−0.157***	−0.158***	−0.128***	−0.089***	−0.091***
	(0.018)	(0.018)	(0.019)	(0.020)	(0.020)
Lefty		−0.026	−0.019	−0.002	−0.021
		(0.043)	(0.043)	(0.042)	(0.048)
Lefty*female					0.073
					(0.094)
Performance			√	√	√
Risk				√	√
Guess				√	√
Task order				√	√
N	1967	1967	1967	1967	1967

Notes: Marginal effects are from probit regressions of being lefty on choosing the competitive payment scheme. The dependent variable equals 1 if the participant chose the competitive payment scheme and 0 otherwise. Lefty equals 1 if the participant is lefthanded or left-footed. Robust standard errors in parentheses; 3, 2, or 1 stars indicate significance at the 1 %, 5 %, or 10 % level respectively.

Table 5
Probit Regressions of Competitiveness on Being a Lefty (Tanzania; matrices).

	(1)	(2)	(3)	(4)	(5)
Female	−0.159***	−0.160***	−0.164***	−0.158***	−0.159***
	(0.018)	(0.019)	(0.019)	(0.018)	(0.019)
Lefty		−0.026	−0.035	−0.029	−0.036
		(0.044)	(0.044)	(0.043)	(0.050)
Lefty*female					0.025
					(0.097)
Performance			√	√	√
Risk				√	√
Guess				√	√
Task order				√	√
N	1967	1967	1967	1967	1967

Notes: Marginal effects are from probit regressions of being lefty on choosing the competitive payment scheme. The dependent variable equals 1 if the participant chose the competitive payment scheme and 0 otherwise. Lefty equals 1 if the participant is lefthanded or left-footed. Robust standard errors in parentheses; 3, 2, or 1 stars indicate significance at the 1 %, 5 %, or 10 % level respectively.

Table 6
Probit Regressions of Competitiveness on Being a Lefty (merged).

	(1)	(2)	(3)	(4)	(5)
Female	−0.155***	−0.152***	−0.126***	−0.148***	−0.124***
	(0.014)	(0.014)	(0.015)	(0.015)	(0.016)
Lefty		0.046*	0.051**	0.058*	0.057*
		(0.025)	(0.025)	(0.030)	(0.030)
Female*lefty				−0.033	−0.018
				(0.050)	(0.050)
Performance			√		√
Risk			√		√
Confidence			√		√
Country FE	√	√	√	√	√
Task order	√	√	√	√	√
N	3664	3664	3664	3664	3664

Notes: Marginal effects are from probit regressions of being lefty on choosing the competitive payment scheme. The dependent variable equals 1 if the participant chose the competitive payment scheme and 0 otherwise. Lefty equals 1 if the participant is lefthanded or leftfooted. Robust standard errors in parentheses; 3, 2, or 1 stars indicate significance at the 1 %, 5 %, or 10 % level respectively.

Table 7
Size of the lefty effect we can detect with 80 percent power by subsample.

	All	India	Norway	Tanzania
All	0.072	0.156	0.124	0.133
Men	0.095	0.201	0.163	0.171
Women	0.112	0.252	0.187	0.224

Notes: The table shows the difference in the proportions of lefties and righties who choose competition that can be detected with 80 percent power at a significance level of 5 percent in each subsample using a chi-squared test. The power calculations use the actual size of the lefty and righty groups in each subsample and fix the proportion of individuals who compete at the observed level for righties.

the gender gap in willingness to compete, which is well-documented in incentivized laboratory experiment using students at Western universities and which is particularly robust when using math-related tasks. We find an economically and statistically significant gender gap in all locations using both a ball-tossing task (India and Tanzania) and a numerical task (Norway and Tanzania).

A growing number of studies find that competitiveness predicts educational choices and success in the labor market, and may explain gender differences therein (Zhang, 2012; Buser et al., 2014; Reuben et al., 2015; Berge et al., 2015, Buser et al., 2017a, b; Buser et al., 2020). This makes it important to investigate the sources of individual differences and gender differences in competitiveness. In particular, if competitiveness is partially determined by prenatally determined factors (or by social processes that are difficult to target through public policy), then rather than coming up with interventions to increase the willingness to compete of individuals belonging to underrepresented groups, we should focus on adapting educational and labor market settings to also attract individuals who are not attracted to competitive environments.

Our results may suggest that using handedness or footedness as proxies for innate differences might not be the best way to tackle the question of the role of prenatally determined factors in shaping competitiveness or other individual traits. We believe that an important avenue for future research is to find new ways for studying the relative importance of innate factors in shaping willingness to compete, and economic preferences more generally, and to study how innate differences interact with cultural factors in shaping individual behavior.

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Appendix A. Supplementary data

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