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The sins of the parents: Persistence of gender bias across generations and the gender gap in math performance

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How important are beliefs about gender differences in math ability? Transmission across generations and impacts on child outcomes

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Abstract

We study the transmission of beliefs about gender differences in math ability from adults to children and how this affects girls' math performance relative to boys. We exploit randomly assigned variation in the proportion of a child's middle school classmates whose parents believe boys are better than girls at learning math. An increase in exposure to peers whose parents report this belief increases a child's likelihood of believing it, with similar effects for boys and girls and greater effects from peers of the same gender. This exposure also affects children's perceived difficulty of math, aspirations, and academic performance, generating gains for boys and losses for girls. These effects are not driven by other sources of peer effects, such as peer cognitive ability, peer parent traits such as education and income, or the gender composition of the classroom.

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1 Introduction

Historically, average levels of education among men far exceeded those of women (Goldin et al., 2006). Over the past 30 years, however, this gender gap in educational attainment has closed and then reversed in a large number of countries (Asadullah and Chaudhury, 2009; Bailey and Dynarski, 2011; Rosenzweig and Zhang, 2013). Despite this reversal of the gender gap in educational attainment, in many countries the majority of children continue to believe that boys are better than girls at learning math (Beilock et al., 2010; Jayachandran, 2015; OECD, 2015).

These beliefs can be harmful if they affect behavior and, in so doing, translate into real outcomes.[1] Prior work has shown that cultural norms about gender translate to differential effort, enthusiasm, and performance in school (Nollenberger et al., 2016; Rodríguez-Planas and Nollenberger, 2018; Bordalo et al., 2019). Other work has shown that the more "pro-male" these norms are, the greater is the gender gap in labor market outcomes (Antecol, 2000, 2001; Rodríguez-Planas et al., 2018).

In this paper, we use nationally representative data from Chinese middle schools to study how beliefs about the innate math ability of men and women transmit across generations and how this affects girls' academic performance relative to boys. Our identification strategy exploits the random assignment of children to classrooms in these schools to generate plausibly exogenous variation in the proportion of peers whose parents believe that boys' innate math ability (B_m) is superior to girls' innate math ability (G_m). For shorthand, we refer to this as the proportion of peers whose parents believe $B_m > G_m$. We use this variation to estimate how increases in exposure to such peers affect four main child outcomes: one, the child's likelihood of believing $B_m > G_m$ herself; two, the child's assessment of her own math ability; three, her educational aspirations; and four, her academic performance in math.

A central problem in studying the transmission of beliefs across generations is that some difficult-to-measure family traits and behaviors may affect both child beliefs and child outcomes (Dhar et al., 2018; Fruehwirth et al., Forthcoming). For example, parents who believe boys are better than girls at learning math may also behave differently towards their children, e.g., through the rewards and encouragement they offer the child. Such behavior affects the child's beliefs indirectly, separate from the direct transmission of beliefs from parent to child. To isolate the direct transmission of beliefs and avoid confounding from these unobserved family-level investments and behaviors, we focus on the transmission of beliefs to children from

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[1] As early as age 7, boys and girls begin to exhibit preferences and make decisions that reflect gender norms about appropriate hobbies and behavior (Bian et al., 2017).

their peers whose parents hold the belief in question.

We find that a one standard deviation (SD), or roughly 11 percentage point, increase in the proportion of peers whose parents believe boys are better than girls at learning math increases the likelihood that a child holds the belief herself by 4.6 percentage points, from a baseline of 52 percent. These effects are monotonic over the distribution of the proportion of peers whose parents hold this belief in our data, and are similar for boys and for girls. Moving a child from the classroom in our sample with the lowest level of parents who hold the belief (no peers whose parents believe $B_m > G_m$) to the one with the highest level (where more than 83 percent of peers' parents hold the belief) would generate an increase of 34.8 percentage points in the likelihood of the child holding this belief herself.

We next test for homophily: the tendency of individuals to associate with and learn from similar others (Currarini et al., 2009). In this setting, the most obvious similarity is by gender. We generate two new gender-specific measures for peer parent beliefs – one for the proportion of girl peers whose parents hold the belief and another for the proportion of boy peers whose parents hold the belief. We then estimate the effects of exposure to each type of peer. We find that exposure to girl peers whose parents hold the belief has roughly twice the impact on girls' beliefs as it does for boys' beliefs, and vice versa for exposure to boy peers whose parents hold the belief. Our results provide evidence of homophily in belief transmission.

Next, we show that exposure to peers whose parents believe $B_m > G_m$ helps boys and harms girls in their performance in school. We estimate that a one SD increase in exposure to peers whose parents hold this belief increases girls' likelihood of perceiving math to be difficult, relative to boys', by 1.9 percentage points (a 25 percent increase in the gap between girls' and boys' perceived difficulty of math). This exposure also worsens girls' relative performance on standardized math exams by 0.06 SD. These effects, too, are monotonic over the distribution of the peer parent beliefs measure, with greater changes in peer parent beliefs generating larger impacts on girls' relative math performance. The effects on test scores are also remarkably similar to the 0.07 SD change in the gender test gap in PISA scores that both Nollenberger et al. (2016) and Rodríguez-Planas and Nollenberger (2018) find is associated with a one standard deviation change in a country's gender equality index. Here again we see evidence of homophily: we estimate larger test score effects from exposure to own-gendered peers whose parents hold the belief than from exposure to other-gendered peers.

We then conduct a series of analyses to interpret our results. First, we characterize the stability of parent beliefs. We conduct two tests for the possibility that parents' beliefs are affected by the classroom their child is assigned to. The first test is for reverse causality: here, the possibility that parents may update their beliefs in response to observing ability differences between boys and girls among their child's randomly assigned peers. The second test is for the reflection problem, as in Manski (1993) and Angrist (2014): here, the possibility that parents may update their beliefs in response to observing the beliefs of the other parents in their child's randomly assigned classroom. Our tests find no evidence of either phenomenon. We argue that this result is consistent with a simple model of belief formation. Child beliefs are malleable because of their shorter cumulative exposure to the world. Adults' beliefs were largely formed when they themselves were children.[2] By the time a person has their own middle school-aged children, their cumulative exposure to the world comprises 30-50 years of experience which has formed their beliefs. As a result, we argue, adults' beliefs are firmer than those of children and less likely to update in response to a given source of (new) information.

Next, we study the relative importance of two separate channels that contribute to our results. The first channel is from peer parent beliefs to peer child beliefs, and then on to the child herself. The second channel is the wide variety of other well-known sources of peer effects. These include the benefits that come from being assigned to a classroom with peers of higher ability (Zimmerman, 2003; Feld and Zölitz, 2017), one with peers who have highly educated parents or parents with other beneficial traits (Fruehwirth, 2017; Olivetti et al., Forthcoming), or simply one with more girls in it (Hu, 2015). We examine the extent to which these two channels are distinct or whether, instead, our peer parent belief measure is merely another way to capture the broader, latent peer effect. We conduct a series of horse race regressions to evaluate this question. We begin with our original specification and add in controls, one-by-one, for other well-known sources of peer effects. Were our estimates of the effects of exposure to peers whose parents believe $B_m > G_m$ to attenuate, this would suggest that the broader source of peer effects was driving these results. Our coefficient estimates are largely stable, both in magnitude and significance, to adding controls for these other sources of peer effects. This highlights the specific, independent role of the belief transmission channel in driving our main empirical results.

We next study how these results vary across different lengths of exposure to peers. To do so, we compare

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[2] This may also explain the genesis of these views: when today's adults were children and their beliefs were still being formed, the stereotype of boys' superiority in math was likely more "representative," as in Bordalo et al. (2016). One measure of this is the proportion of female top scorers, or "zhuangyuan," in China's college entrance exam, over time. In the 1970's, 1980's, and 1990's, more than half of the top scorers (there are two top scorers per province) were male. Since 2004, the majority of top scorers have been girls, with roughly 60% of them female in 2014 (data from https://zhuanlan.zhihu.com/p/43956503, accessed May 8, 2019). This proportion for children in the "science track" shows lower absolute levels for girls, but a similar trend over time.

children who have spent more than two years with their randomly assigned peers to those who have only spent three to six months with these peers. We find little evidence that more time spent with peers whose parents believe $B_m > G_m$ increases the likelihood a child will herself hold that belief.[3] Consistent with recent work suggesting that small differences in enthusiasm or effort can have compounding effects on academic performance over time (Cunha and Heckman, 2007), we find that the negative effects of exposure to peers whose parents believe $B_m > G_m$ on girls' test scores increase with the duration of exposure.

Finally, we look more closely at impacts on girls. We find that exposure to peers whose parents believe $B_m > G_m$ is more harmful for girls whose own parents also hold this belief. We find that girls who have no close friends in their randomly assigned classroom experience much greater harms in aspirations and test scores from increases in exposure to peers whose parents believe $B_m > G_m$, while girls whose five closest friends are all in the classroom experience no detectable harms.[4] We also find no evidence that girls reallocate their efforts away from studying math towards other subjects or hobbies in response to being exposed to the message that boys are better than girls at learning math: our estimates can exclude even small gains in performance on standardized Chinese and English tests. We find no evidence of effects on time spent on homework or various after-school activities.

Our paper contributes novel, causal evidence on the transmission of beliefs about the innate math ability of boys and girls from one generation to the next. We show that this transmission is independent of other sources of peer effects, and is larger from peers of the same gender. We find that this contributes to the gender gap in math, improving boys' confidence and performance in math and reducing girls'. These findings advance new work studying how beliefs form in children and the process of belief transmission from parent to child (e.g., González de San Román and de la Rica Goiricelaya, 2016; Olivetti et al., Forthcoming; Rodríguez-Planas and Nollenberger, 2018; Dizon-Ross, Forthcoming; Dhar et al., 2018). Our findings also provide new evidence of an important contributor to gender gaps, both overall and in STEM fields (e.g., Dee, 2007; Niederle and Vesterlund, 2010; Ellison and Swanson, 2010; Jayachandran, 2015). Finally, we contribute evidence of an important, distinct channel in the larger set of peer effects (e.g., Sacerdote et al., 2011; Lavy and Schlosser, 2011; Jain and Kapoor, 2015; Feld and Zölitz, 2017), and, specifically, in studying the impact of peers' parents on children's outcomes (e.g., Carrell and Hoekstra 2010; Bifulco et al. 2011;

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[3] This is consistent with the Bayesian notion that individuals only update their priors in response to new information. After a child's peers share their views with the child and the child internalizes them, the information provided by exposure to these views is no longer new.

[4] This finding aligns with recent work from Israel (Lavy and Sand, Forthcoming) and Bangladesh (Hahn et al., Forthcoming)

Fruehwirth 2017; Olivetti et al. Forthcoming).

The rest of the paper proceeds as follows. Section 2 describes the setting we study, our data, and our construction of the peer parent beliefs measure. Section 3 describes our empirical approach and Section 4 provides our main empirical results. Section 5 presents a series of analyses to guide interpretation of Section 4's estimates. Section 6 shows further analyses, and Section 7 concludes.

2 Background

In this section, we describe the setting which we study and the data we use. We finish by characterizing our peer parent beliefs measure, a key innovation of our paper, in greater detail.

2.1 Setting

Our analysis takes place in Chinese middle schools. This setting has three features which facilitate causal inference and the study of belief formation in children. The first feature is commonly but not universally held beliefs that boys are better than girls at learning math: in our sample, 41 percent of parents and, among children, 58.4 percent of boy and 47.4 percent of girl middle school students respond "yes" when asked whether they agree with the statement "boys' natural ability in studying math is greater than that of girls."[5] As described in the previous section, for ease of exposition we refer to this as believing $B_m > G_m$ or, equivalently, that "boys are better than girls at learning math." The second feature which aids our analysis of belief formation is the period of life we study. In China, the difficulty of the math curriculum in middle school increases substantially from that of primary school. This sudden increase in difficulty suggests that student priors about their own math ability and those of each gender are more likely to be updated at this juncture than in the later years of primary school.[6]

The third feature is the random assignment of children to classrooms within schools. Students are usually allotted to middle schools by their local educational authority based on geographic proximity to schools. China's compulsory education law requires that, within middle schools, students be randomly assigned to classes.[7] Several previous studies have used this policy and the random assignment it creates as a source

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[5] Despite this fact, the girls in our data outperform boys in math. The distribution of math test scores for the two groups is shown in Figure A.1.

[6] In Chinese primary school, the math curriculum usually covers arithmetic and basic conceptual reasoning. Middle school math content accelerates quickly, covering algebra, geometry, and more advanced logic and spatial reasoning.

[7] We discuss the potential for and extent of deviation from this rule below.

of exogenous variation in classroom characteristics to study peer effects and the effects of teacher-student gender match on child performance (Hu, 2015; Eble and Hu, 2017; He et al., 2017; Gong et al., 2018). As we describe in Section 3, this random assignment prevents against the possibility that sorting by academic ability or parent preferences might confound our estimates.

2.2 Data

We use the first wave of the China Education Panel Survey (CEPS) for our empirical analysis. The CEPS is a nationally representative sample of Chinese middle school students, collecting a series of data from the students, their parents, their teachers, and their principals, planned to continue over several waves. The CEPS follows all students in two randomly selected seventh grade classes and two randomly selected ninth grade classes in each of 112 randomly selected schools.[8] These schools were selected using a nationally representative random sampling frame with selection probability proportional to size. The dataset comprises approximately 20,000 students, and the first wave was collected in the 2013-2014 academic year.[9]

The CEPS student data includes administrative data on the child's academic performance in mathematics, Chinese, and English, as well as the child's responses to a survey about her beliefs, hobbies, and aspirations. The parent data include a variety of demographic data as well as parent beliefs. The teacher and administrator data include information on teacher characteristics and the method used to assign children to classes. We use the same sample restriction as prior work using these data: we analyze data from only those within-grade classroom pairs that report using random assignment of children to classrooms (Hu, 2015; Gong et al., 2018).[10] This leaves us with 9,361 children in 215 classrooms spread across 86 schools, the estimation sample we use for our analysis. These children are assigned to a peer group at the start of seventh grade and remain with them throughout middle school. The excluded grade-by-school classroom pairs report either using methods other than random assignment to place children in classes or re-sorting children to classrooms in the years after the initial random assignment. These are predominantly either

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[8] Chinese middle schools typically span three grades: seven, eight, and nine. The median school in our dataset has six seventh grade classrooms and six ninth grade classrooms (mean: 7.3 and 6.9, respectively). There are not enough schools in our sample with only two classes per grade, i.e., where we would have all students in a grade, to study those as a separate subgroup.

[9] The second, latest available wave collects data only for a subset of children. We do not use it here because of its smaller sample size, and because it does not contain key data such as parent or child beliefs.

[10] Across China, various methods are used for assignment of children to classes, including random number generators, alphabetical assignment based on surname, and the system described in He et al. (2017) wherein an alternating sequence assigns students to classrooms sequentially based on entrance exam scores in a way that preserves mean test score balance and avoids stratification across classrooms. The randomness of assignment of children to classrooms in Chinese middle schools and its appropriateness for causal inference has been probed in several recent papers, many of which use this same dataset (Hu, 2015; Eble and Hu, 2017; He et al., 2017; Gong et al., 2018).

ninth grade classrooms, where re-sorting often occurs due to administrative concerns about placing children in good high schools[11], or classrooms in rural areas, where enforcement of such rules is less strict overall.

We use four main outcome variables in our analysis. The first is children's yes/no response to the question, "do you agree with the following statement: boys' natural ability in studying math is greater than that of girls?" For ease of exposition, we refer to this as the belief that boys are better than girls at learning math, or just $B_m > G_m$.[12] An important feature of this question is the fact that it refers to the innate math ability of each gender, not just the relative performance of boys and girls in the child's current school or class. The second outcome is the child's answer to the question "how difficult do you find your current math class?" The possible answers are "very hard," "somewhat hard," "not so hard," and "easy." We code this as a dummy variable equal to one if the response is "very hard" or "somewhat hard." The third outcome is the child's aspirations for her ultimate educational attainment, which we code as a dummy for aspiring to at least a university degree. Finally, to measure children's performance, the fourth outcome we use is administrative data on the child's test score on the midterm math test administered in her middle school. The same subject tests are used in all classrooms in a grade, within a school. In our sample, we have two classrooms in a given grade in each school, but the average school has seven classrooms per grade in total. This ensures that one classroom's gain in scores does not cause a mechanical loss in the performance of children in the other classroom. We use a variety of predetermined characteristics of the child, her parents, and her teacher as independent variables in addition to the peer parent beliefs measure. We describe them in the next section when we present our empirical strategy.

Table 1 presents summary statistics for students, by gender, for those students randomly assigned to classrooms. The girls in our sample are slightly younger than the boys, and they are more likely to have wealthier, more educated parents. Girls also have more siblings, consistent with traditional norms and fertility responses to birth control policy in China which permits further parity, in some cases, if the first child is a girl (Qian, 2008). Finally, there is a "reverse gender gap" in all subjects, i.e., girls perform better

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[11] In Table A.2, we show summary statistics of schools in our estimation sample separately by whether or not they contain grade 9 classrooms that maintain the randomization initiated in grade 7 (in other words, schools that do not re-sort students by ability in subsequent years). They are balanced on most observable characteristics (size, number of teachers, percent of teachers with a BA, whether they are private or public). The only significant difference we observe is that schools whose ninth grade classrooms do not maintain randomization are slightly higher-ranked than schools whose ninth grade classrooms do maintain randomization. This pattern is consistent with the fact that re-sorting of children by ability is regarded as a way for middle schools to improve the likelihood of sending top children to higher-ranked high schools, and middle school ranking partly reflects this placement record.

[12] The wording of this question is identical to the wording of the question asked to parents which we use to generate the peer parent beliefs measure.

Table 1: Summary statistics

	(1) All children	(2) Girls only	(3) Boys only	(4) Difference (column 2 - (column 3)	(5) P-value of difference
Age	13.23	13.17	13.28	-0.11	0.00
Holds agricultural hukou	0.49	0.48	0.51	-0.03	0.04
Number of siblings	0.71	0.76	0.66	0.10	0.00
Household is poor	0.19	0.18	0.20	-0.02	0.01
Father's highest credential					
Middle school	0.41	0.41	0.42	-0.01	0.44
High school	0.26	0.25	0.26	-0.01	0.69
College	0.19	0.20	0.18	0.02	0.03
Mother's highest credential					
Middle school	0.38	0.39	0.37	0.02	0.01
High school	0.23	0.23	0.23	0.00	0.56
College	0.16	0.17	0.16	0.01	0.12
Ethnic minority	0.12	0.12	0.11	0.01	0.23
Math test score	70.1	70.9	69.4	1.50	0.00
English test score	70.1	73.0	67.4	5.60	0.00
Chinese test score	70.0	73.2	67.1	6.10	0.00
Number of observations	9,361	4,492	4,869	—	—

Note: this table presents summary statistics for observations in our estimation sample. The variables are all coded as 0 = No, 1 = Yes, except for age and number of siblings, which are self-explanatory, and test score (mean = 70, SD = 10). "Holds agricultural hukou" means the residence permit of the household was given in a rural, agricultural (as opposed to non-agricultural, urban) locality. The fourth column presents the difference between the mean for girls and that for boys, and the fifth column presents the p-value of this difference.

than boys.[13] In Figure A.1, we show the distribution of test scores by gender. The distribution for girls first-order stochastically dominates that for boys (p-value < 0.001), with the largest difference in the left tail of the distribution.

2.3 Peer parents' beliefs

In this subsection, we further characterize the peer parent beliefs measure. First, we describe how we believe parent beliefs are formed. We then describe what parent characteristics are correlated with the belief that boys are better than girls at learning math. Finally, we show the dispersion of parent beliefs between classrooms in each within-school, within-grade pair (the level of comparison used in our empirical strategy).

First, we discuss how we believe parents' beliefs are formed. We conceive of this as a process of simple Bayesian updating over time. When a child comes into the world, she knows nothing about it. From her parents and, later, her peers, teachers, and environment, she learns about the world and her place in it. Early in life, her beliefs are malleable. As she ages, her cumulative exposure to the world increases and her beliefs become firmer. By the time she is a parent of a middle schooler herself, her beliefs have been influenced by 35-50 years' worth of information. As a result, parent beliefs have two features relevant to our analysis. One, they were most likely formed when the parent was a child, a period when boys outperforming girls was far more common (e.g., the majority of top scorers on China's college entrance exam were then male, as described in footnote 2). Second, because of parents' age, we expect their beliefs to be firmer, and thus harder to change, than children's.[14]

Next, we show the extent to which predetermined characteristics are correlated with parent beliefs about the relative ability of boys and girls in math. In Table 2, we show summary statistics of predetermined characteristics separately for parents who do and do not believe $B_m > G_m$. Though there are differences for some characteristics (household income, number of siblings), they are small. Our interpretation of the patterns in this table is that, overall, these two groups of parents are remarkably similar on most observable characteristics associated with the other traditional drivers of peer effects. This suggests that much of the variation in parent beliefs we measure is idiosyncratic to previously studied sources of peer effects. We probe this claim further in Section 5.2.

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[13] In the 2009 PISA results for China, boys significantly outperformed girls in math. In the 2015 PISA results, this difference was no longer significant. These data, however, apply only to a select group of children from urban areas: Shanghai (2009) or Beijing, Shanghai, Jiangsu, and Guangdong (2015). Our data come from a nationally representative sample of middle schools across China and include both rural and urban areas.

[14] We present empirical tests of this claim in Table 7.

In Section 5.1, we address the extent to which parent beliefs are affected by actual gender gaps in the classroom, i.e., that parents beliefs are shaped by what they see among their children's peers. Our tests for this reject even small effects on a given parent's beliefs from having her child assigned to a classroom where boys happen to outperform girls, or where the top performing child is a boy. This result is consistent with the argument, discussed earlier in this section, that adults' beliefs about the relative math ability of the genders were largely formed when they themselves were children – decades prior to our measurement of them – and when the stereotype was more "representative" (Bordalo et al., 2016).

In our data there is substantial variation in the peer parent beliefs measure between classrooms. At the child level, the maximum value of the peer parent beliefs measure is 0.833, the minimum is 0, and the mean is 0.410 (at three significant figures, the mean is the same for girls and boys). Once standardized, the variable ranges from -3.69 SD to 3.64 SD. The distribution of parent beliefs at the classroom level mirrors the distribution for children.

There are two sources of variation in the classroom average proportion of parents who believe $B_m > G_m$: one, differences between schools, and two, differences between classes, within schools (the latter being our level of comparison). We next characterize the contribution of each source to the overall variation we see in our peer parent beliefs measure. Were our variation to come predominantly from between-school differences, then our comparison between classes, within a grade within each school, could precisely estimate the impact of small changes in peer parent beliefs. This comparison, however, would have little to say about larger changes, as they would necessitate out-of-sample predictions.

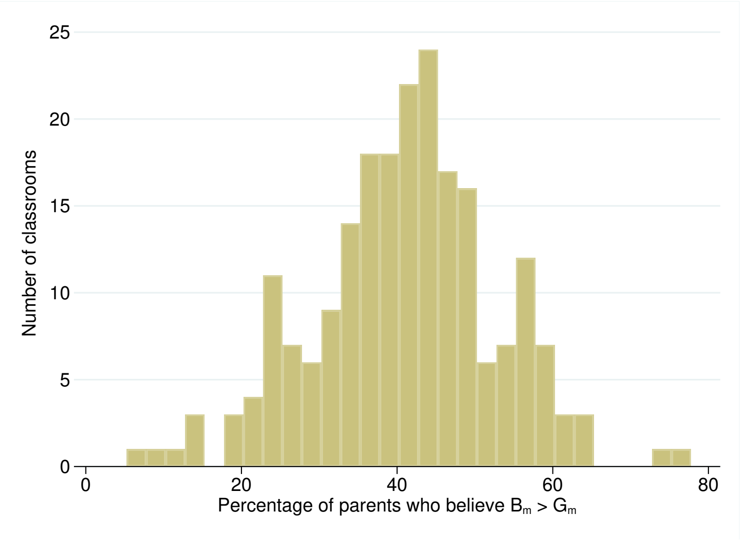
In Figure 1, we show two plots describing the variation between classrooms in the proportion of parents who hold this belief. Panel A shows, for each classroom, the proportion of all parents who agree with the statement that boys are better than girls in learning math. This shows a roughly symmetric distribution around 41%, the mean, with a range from 7% to almost 80% (the peer parent beliefs measure extends this range slightly, as it is a leave-one-out average). Panel B shows how our measure of parent beliefs varies within each of the 86 within-school, within-grade pairs of classrooms in our data. We plot each pair as a point, with the standardized class-average parent beliefs for class 1 shown on the x-axis, and that for class 2 on the y-axis. We overlay the 45-degree line onto this figure. Each point's distance from the line shows the within-school, within-grade, between-classroom difference in the proportion of parents who believe $B_m > G_m$ for that pair of classrooms. We see large differences in parent beliefs between classrooms in these pairs. A simple decomposition of variance finds that between-school variation explains less than a third of

Table 2: Characteristics of children, by whether parents report $B_m > G_m$

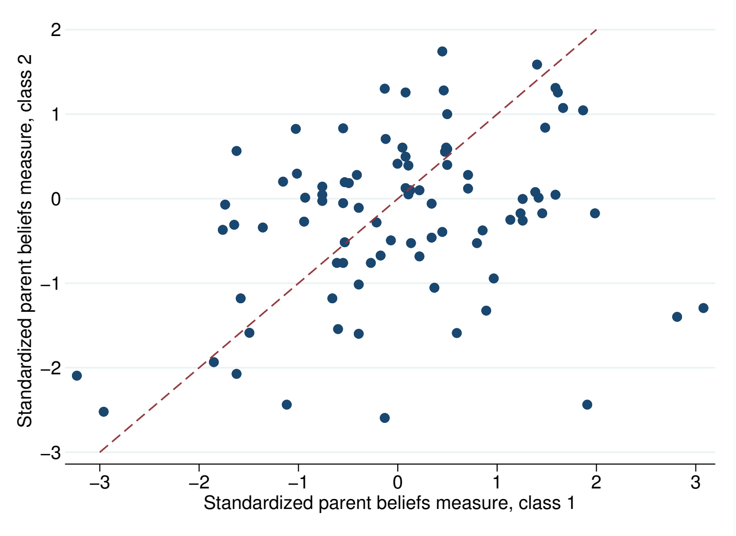
	(1) Full sample	(2) Believes $B_m > G_m$	(3) Does not believe $B_m > G_m$	(4) Difference (column 2 - column 3)	(5) T-test p-value
Ethnic minority	0.12	0.12	0.11	0.01	0.12
Agricultural hukou	0.49	0.48	0.50	-0.02	0.12
Number of siblings	0.71	0.66	0.69	-0.03	0.08
Low income household	0.19	0.17	0.19	-0.02	0.02
Mother’s years of schooling	9.88	10.04	9.95	0.09	0.27
Father’s years of schooling	10.61	10.76	10.66	0.10	0.20
Number of observations	9,361	3,675	5,294	—	—

Note: this table gives summary statistics for children in our estimation sample, separately for those whose parents do (column 2) and do not (column 3) claim to believe that boys are better than girls at learning math. The variables are all coded as 0 = No, 1 = Yes, except for age, number of siblings, and parental years of schooling.

Figure 1: Dispersion of parent beliefs across classrooms



Panel A: Dispersion of parent beliefs across classrooms, raw data



Panel B: Our standardized classroom-level measure of parent beliefs by within-school, within-grade classroom pair

Note: Panel A of this figure shows the distribution of the classroom average of the (non-standardized) parent beliefs measure across all classrooms in our estimation sample. Panel B shows the average (standardized) parent belief measure in classroom 1 and classroom 2 for each of our within-grade, within-school classroom pairs. Variation between classrooms in a pair is the dimension of variation we use in our analysis; for comparison, we overlay the 45 degree line on this figure to represent the special case with no such variation.

the overall variation in classroom-level parent beliefs. A separate way to capture the differences between classrooms, within grades, within each school, is to calculate the absolute value of the difference in parent beliefs between classroom 1 and classroom 2. We calculate this value for every grade-by-school pair of classrooms; its value varies between 0.1 and 4.35 SD, with a mean of 1 SD. We show the distribution of these values in Figure A.2.

3 Empirical strategy

This section explains our approach to estimation in the paper and discusses a few key issues related to the interpretation of our main coefficient estimates.

3.1 Estimation

In our empirical analysis, we focus on estimating two key relationships: one, the effect of exposure to peers whose parents believe $B_m > G_m$ on a child's outcomes; and two, how this varies with the child's gender. Our identification strategy is to exploit random variation between classrooms in a given grade, within a given school, in the proportion of peers whose parents hold this belief. Our main estimating equation is as follows:

$$\begin{gathered} Y_{icgs} = \beta_0 + \beta_1 PPB_{icgs} + \beta_2 PPB_{icgs} * F_{icgs} + \beta_3 OPB_{icgs} + \beta_4 OPB_{icgs} * F_{icgs} \\ + \beta_5 F_{icgs} + \beta_6 SC_{icgs} + \beta_7 TC_{cgs} + \eta_{gs} + \varepsilon_{icgs} \end{gathered} \tag{1}$$

In this equation, Y_{icgs} refers to the outcome of interest for child i in class c in grade g in school s.[15] PPB_{icgs} is the proportion of child i's peers in her or his classroom whose parents believe $B_m > G_m$. This is a leave-one-out average: in calculating the peer parent beliefs measure, we exclude the child's own parent's response to the question about the relative innate math ability of boys and girls. In our data, this measure varies from zero to 0.833 (mean 0.410). We follow the example of Chetty et al. (2014) in standardizing the variable by subtracting the mean and dividing by the SD. This ensures that our coefficient estimates for β_1 and β_2 are easily interpretable as the effect of a one SD, or 11 percentage point, increase in exposure to peers whose parents believe $B_m > G_m$. This measure is more policy-relevant than the raw variable, which would capture the effect of moving from a classroom with no peers whose parents hold this belief to one where all peers' parents hold the belief (this latter case does not appear in our data).

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[15] This setup follows convention among studies using plausibly random assignment to classrooms as a source of identification, e.g. Ammermueller and Pischke (2009) and Feld and Zölitz (2017).

F_{icgs} is an indicator for the child being female. OPB_{icgs} is an indicator for whether the child's own parent believes $B_m > G_m$. SC_{icgs} is a vector of characteristics specific to the student, including: rural vs. urban household residency (hukou) status; mother's years of education; father's years of education; household income (a 0/1 variable for being classified as "poor" by the school); these three interacted with the child's gender; the child's ethnicity; her number of siblings; and her perceived ability, proxied by her perceived difficulty of mathematics in the sixth grade (that is, prior to entering middle school). TC_{cgs} is a vector of teacher characteristics including: teacher gender; teacher gender interacted with child gender; years of experience; type of degree; and receipt of various teaching awards. η_{gs} is a grade-by-school fixed effect[16], and ε_{icgs} is a standard error, clustered at the grade-by-school level.

We include the child's own parent's beliefs for three reasons. One, prior empirical work estimating peer parent to child effects usually includes the child's own parents' characteristic of interest in addition to those of peers' parents (Bifulco et al., 2011; Fruehwirth, 2017; Olivetti et al., Forthcoming). Two, the own-parent-to-child correlation is an object of separate interest – for example, it is the main focus of Dhar et al. (2018) – and this correlation helps benchmark the relative importance of peer parents' and own parent's beliefs. Finally, we include own parent beliefs because later in the paper we study the interaction effects between peer parent beliefs and own parent beliefs on child outcomes. In the appendix we present a series of parallel tables for our main analyses which show the results generated when excluding the own parent's belief variable from the list of controls. Our findings are robust to choice of specification.

3.2 Interpretation

Our main coefficients of interest are β_1 (on peer parent beliefs) and β_2 (on peer parent beliefs interacted with the female child dummy). Our main goal is to use our estimation of these parameters to study the extent to which there is an important path from parents' views to student views and performance. For this reason, we do not require an exogenous shifter of parent beliefs. Rather, we need two conditions to hold: one, that children are randomly assigned to their classrooms; and two, that parent beliefs are stable in response to observing the beliefs of other parents and the ability of other children in their child's class. In this section we present the results of our tests for random assignment. In Section 5.1, we present a series of tests evaluating the stability of parent beliefs.

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[16] We do not use classroom fixed effects because we wish to exploit the variation in peer parent beliefs between classrooms within a grade within a school.

The random assignment of children to classes prevents our estimates of β_1 and β_2 from being confounded by potential non-random sorting of children to classrooms, either by ability or parent preference. Were such sorting to exist, our estimates of the effect of exposure to more peers whose parents believe $B_m > G_m$ would also comprise the other effects of such sorting. For example, since girls outperform boys in math in our sample (see Figure A.1), placing more able students together would lead to more girls in higher performing classrooms. This would lead to two differences: one, more girl-to-girl (boy-to-boy) exposure in high-performing (low-performing) classrooms; two, greater salutary effects of having more girl peers in high performing classrooms (Hu, 2015). Random assignment also prevents two other potential confounders: one, that schools reallocate teacher and classroom resources towards (or away from) higher-ability classrooms; two, that parents with certain characteristics request their children to be among the children of similar parents.

We evaluate the assumption of random assignment by regressing our peer parent beliefs measure on the (predetermined) characteristics in SC_{icgs}. This approach follows Antecol et al. (2015), Bruhn and McKenzie (2009), and Hansen and Bowers (2008). We present our results in Table 3: in column 1, we show the results for regressing peer parent beliefs on the vector of predetermined characteristics without any fixed effects; in column 2, we present results from a similar regression, now including the grade-by-school fixed effects we use in our main empirical specification. At the bottom of the table, we report the F-statistic and p-value from a Wald Test of the joint significance of the regressors. In column 2, we fail to reject the null that the regressors do not significantly predict our measure of peer parent beliefs. We find similar results if we conduct the test separately by the grade a student is in, reported in Table A.1.

We further differentiate between two closely related but separate types of effect estimate for girls. The first type type is the effect of exposure to peers whose parents believe $B_m > G_m$ on the gender gap, captured by β_2. This is the primary effect of interest. The second type is the overall effect of exposure to peers whose parents believe $B_m > G_m$ on girls' outcomes, captured by $\beta_1 + \beta_2$.

4 Main empirical results

In this section, we present our main estimates of the effect of being exposed to peers whose parents believe that boys are better than girls at learning math. The dependent variables we study in this section are children's likelihood of holding this belief themselves, their assessment of their own math ability, their

Table 3: Test for randomization / balance

	(1)	(2)
Age	0.124***	-0.010
	(0.050)	(0.007)
Holds agricultural hukou	-0.120	0.014
	(0.074)	(0.019)
Number of siblings	-0.081**	-0.006
	(0.041)	(0.008)
Household is poor	-0.064	0.044**
	(0.071)	(0.020)
Female	0.024	0.015
	(0.029)	(0.011)
Mother's highest credential		
Middle school	-0.060	0.013
	(0.070)	(0.016)
High/technical school	0.071	0.026
	(0.080)	(0.021)
College or above	0.108	0.023
	(0.082)	(0.025)
Father's highest credential		
Middle school	-0.023	0.004
	(0.046)	(0.017)
High/technical school	0.067	0.007
	(0.068)	(0.029)
College or above	0.060	0.018
	(0.081)	(0.032)
Ethnic minority	0.148	-0.009
	(0.250)	(0.023)
Number of observations	8,964	8,964
R-squared	0.05	0.69
Joint test F-statistic	2.19	1.13
[p-value]	[0.02]	[0.35]

Note: this table presents a balancing test, as in Antecol et al. (2015), which tests for our set of predetermined characteristics' joint ability to predict the peer parent beliefs measure by regressing the peer parent belief measure on them, using our estimating equation, and calculating the joint F-statistic and its p-value. Grade-by-school fixed effects are added to the estimating equation to generate the estimates in column 2. Variables are all coded as 0 = No, 1 = Yes, except for age and number of siblings, which are self-explanatory. The dependent variable, peer parent beliefs, is standardized (mean = 0, SD = 1).

educational aspirations, and their performance on standardized math examinations.

4.1 Beliefs

First, we estimate the relationship between exposure to peers whose parents believe $B_m > G_m$ and three variables capturing children's beliefs, as described in the previous section. The first variable is whether or not the child herself believes $B_m > G_m$. The second is the child's perceived ability in math, which we proxy for with a variable capturing whether she finds her current math class "very difficult" or "somewhat difficult" (as opposed to "a little difficult" or "not difficult at all"). The third is whether the child aspires to complete a BA or higher.

We present these results in Table 4. This table follows the convention that we will use for most of our main result tables: we present coefficient estimates for exposure to peers whose parents believe $B_m > G_m$ (β_1, labeled as "peer parent beliefs" or "PPB" in the tables) and its interaction with whether the child is female (β_2, or "PPB x female"). We also present the coefficients for own parent beliefs (β_3, labeled as "own parent beliefs" or "OPB" in the tables) and its interaction with the female dummy (β_4, "OPB x female"). Finally, we present the coefficient estimate for the child being female (β_5). At the bottom of our result tables we show the sample mean of the dependent variable and the number of observations used for estimation. Unless otherwise noted, variation in the number of observations comes from variation in the number of missing values across dependent variables. Our results are robust to restricting the sample to only those observations who have non-missing values for all dependent variables.

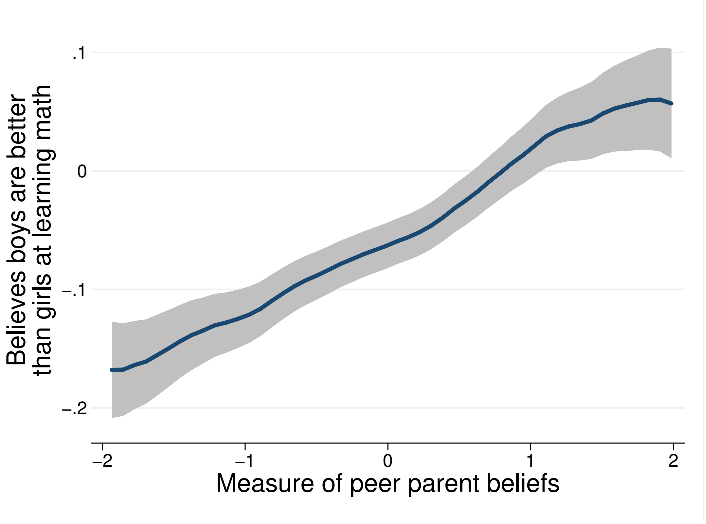
In the first column, we present our estimates of how exposure to peers whose parents believe $B_m > G_m$ affects children's beliefs. We estimate that a one standard deviation increase in the peer parent belief measure is associated with a 4.6 percentage point (8.7%) increase in the likelihood that a child will believe $B_m > G_m$ herself (β_1 / PPB). Our estimate of the effect of exposure to peers whose parents believe $B_m > G_m$ is similar for girls and boys; that is, β_2 (PPB x female) is not statistically distinguishable from zero. In Figure 2, we plot this relationship non-parametrically, separately for boys and for girls. To isolate variation at our level of comparison, we remove grade-by-school fixed effects from the child beliefs measure. We then show a kernel-weighted local polynomial regression of this residual child beliefs measure on the peer parent beliefs measure. The figure shows that the relationship between exposure to peers whose parents believe $B_m > G_m$ and children's own likelihood of reporting the belief is monotonic over the support of our peer parent beliefs measure. Going from a classroom in which roughly 25 percent of peers' parents believe $B_m > G_m$ to one

Table 4: Effects on beliefs and aspirations

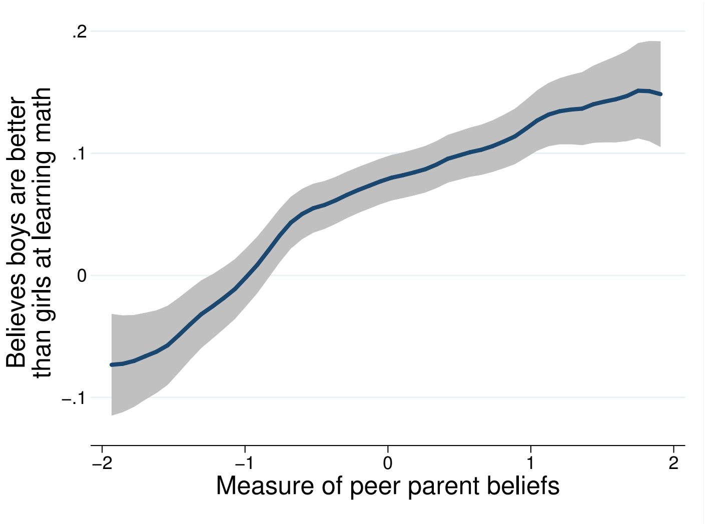
	(1) Believes boys are better than girls at learning math	(2) Perceives current math class to be difficult	(3) Aspires to complete at least a BA
Peer parent beliefs (PPB)	0.046***	-0.011	0.002
	(0.012)	(0.016)	(0.017)
PPB x female	0.002	0.019**	0.008
	(0.014)	(0.009)	(0.010)
Own parent beliefs (OPB)	0.286***	-0.065***	0.018
	(0.016)	(0.016)	(0.014)
OPB x female	0.030	0.152***	-0.013
	(0.020)	(0.023)	(0.020)
Female	-0.129***	-0.013	0.101***
	(0.032)	(0.028)	(0.023)
Mean in sample	0.526	0.570	0.658
Observations	8,057	8,212	8,173

Note: this table shows results from estimating equation 1 using the dependent variable named in the column heading and described in the text. Variation in the number of observations across columns stems from differences in missing values for the dependent variables. The dependent variables are given below the column numbers and are coded as 0 = No, 1 = Yes. In Table A.3, we show the analog to these results generated without own parent beliefs on the right hand side.

Figure 2: Non-parametric relationships between exposure to peers whose parents believe $B_m > G_m$ and child beliefs, by gender



Panel A: Girls



Panel B: Boys

Note: this figure shows a kernel-weighted local polynomial regression of a child's likelihood of reporting that boys are better than girls at learning math (0 = No, 1 = Yes) on the exposure to peers whose parents hold this belief, after removing grade-by-school fixed effects from the dependent (y-axis) variable. Panel A presents this relationship for girls in our sample, and Panel B presents it for boys. Note that a one unit increase in the peer parent beliefs measure (the x-axis variable) is equivalent to an 11 percentage point increase in the proportion of peers whose parents believe $B_m > G_m$.

where 75 percent of peers' parents do generates a 20.6 percentage point (39%) change in the likelihood that a child will also hold that belief.[17] The patterns in the figure also mirror the regression results showing that this relationship is similar for girls and for boys.

Referring back to the results in column 1 of Table 4, we note that the coefficients on own parent beliefs and its interaction with gender are large in magnitude: children whose parents believe boys are better than girls at learning math are 29 percentage points (56%) more likely to also hold that belief and, again, the relationship holds similarly for boys and for girls.[18] These coefficients are comparable in magnitude to going from the classroom with the fewest possible peers whose parents who hold the belief (none) to the classroom with the largest proportion of peers (83.3%) whose parents believe $B_m > G_m$. This difference in coefficient magnitude between the peer parent beliefs measure and own parent beliefs will continue to appear in our later estimates. It serves as a useful benchmark for the relative importance of peer parent and own parent influence on child outcomes. Finally, the coefficient on the female gender dummy shows a pattern that we also see in the raw data: overall, girls are less likely than boys to espouse the belief that boys are better than girls at learning math.

In the next column, we show results for perceived difficulty of math. Here the signs of the estimates diverge for boys and girls, and we observe a significant effect of exposure to peers whose parents believe $B_m > G_m$ on the gender gap in perceived difficulty (the coefficient estimate for "PPB x female"). This pattern is the first in a series of evidence we present that exposure to peers whose parents hold this belief affects children's beliefs about themselves in ways that embody the message of the belief, i.e., that boys are better than girls at learning math. We estimate that a one SD increase in exposure to peers whose parents believe $B_m > G_m$ increases the gender gap in girls' perceived difficulty of math, relative to boys', by 1.9 percentage points, or an increase of 25 percent in the (7.7 percentage point) gap between girls and boys seen in the raw data. This pattern also holds for own parent beliefs, and the estimates are again large: our estimated coefficient of a child having her own parent believe $B_m > G_m$ on the gender gap is a 15.2 percentage point increase in the likelihood that a girl perceives math to be difficult, relative to the likelihood for boys. For boys, own parent beliefs are associated with a 6.5 percentage point decrease in the likelihood the child will perceive math to be difficult. Finally, we find no evidence that exposure to peers whose parents believe $B_m > G_m$ affects aspirations to complete at least a BA. In Section 6, however, we show that these results

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[17] Going from 25% of peers whose parents believe $B_m > G_m$ to 75% comprises a 4.48 SD change in peer parent beliefs.

[18] This estimate is substantially larger than the 11 percentage point increase found among Indian secondary school children in Dhar et al. (2018).

mask important heterogeneity among girls.

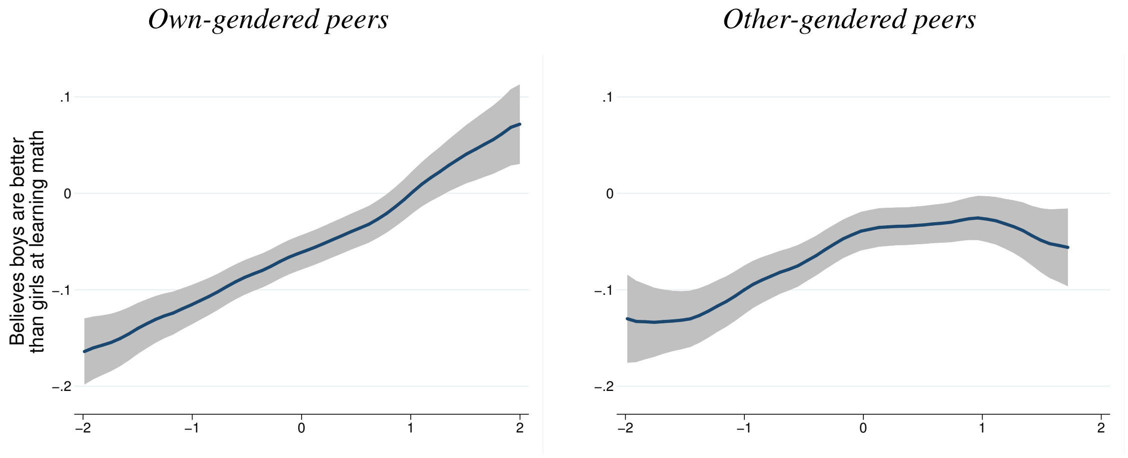
We next study how beliefs transmit across peers of different genders. For each child, we compute two class-specific measures of the proportion of peers whose parents believe $B_m > G_m$, one for girl peers' parents and one for boy peers' parents. This is a test for homophily, the idea that children who share an identity (e.g., gender) are more likely to interact and/or serve as credible sources of information, and thus are more "influential" in the transmission of beliefs than are children outside the identity group (Currarini et al., 2009). We present these results in Table 5. Columns 1 and 3 show that own-gendered peers have a greater impact on a child's likelihood of holding the belief than do other-gendered peers. The the boy peer-to-boy estimate (β_1, or the PPB estimate in column 3) is 0.043, and the girl peer-to-girl estimate ($\beta_1 + \beta_2$, or the PPB + PPB x female estimate in column 1) is 0.042. The magnitude of these estimates from exposure to other-gendered peers are substantially smaller: for girl peers-to-boys – the PPB estimate in column 1 – this is 0.017. For boy peers-to-girls – the PPB + PPB x female estimate in column 3 – this is 0.028. The estimates in columns 2 and 4 are less precise than their counterparts in Table 4, but we show in Table A.4 that taking out the control for own parent beliefs generates homophily estimates for perceived difficulty of math whose magnitudes are similar to those shown here and which are statistically significant at the 1% level.

In Figure 3, we show the peer gender-specific analogue to the non-parametric relationship between peer parent beliefs and child beliefs shown in Figure 2. These show a monotonic mapping from exposure to peers whose parents believe $B_m > G_m$ and the child's likelihood of holding the belief, with visibly steeper gradients from exposure to own-gendered peers than from exposure to other-gendered peers. As a whole, we interpret the results from Table 5, Table A.4, and Figure 2 as evidence that the effects of exposure to peers whose parents believe that boys are better than girls at learning math are characterized by homophily, i.e., that a child's beliefs are more affected by exposure to peers of the same gender whose parents believe $B_m > G_m$ than by exposure to peers of the opposite gender whose parents hold the belief.

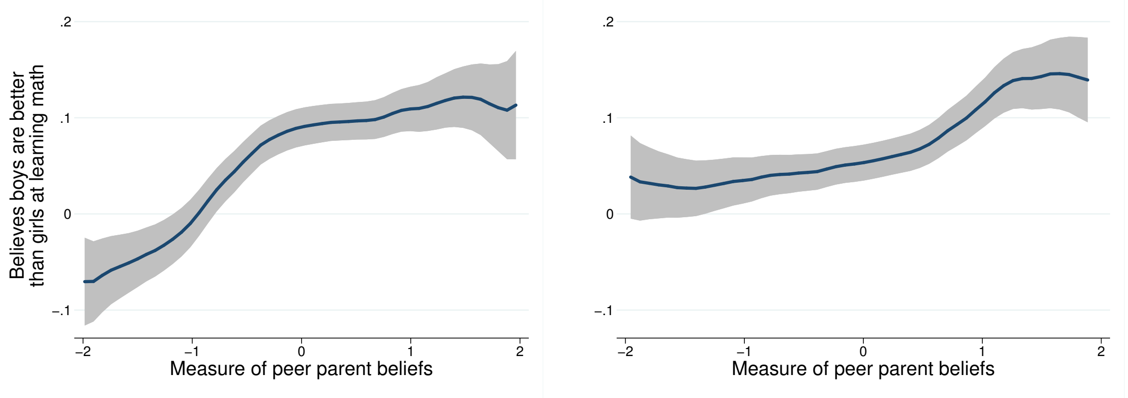
4.2 Performance on math examinations

Next, we study the effect of exposure to peers whose parents believe that boys are better than girls at learning math on children's performance in math. Recall that the same midterm math test is administered across all classes within a grade, within a school; we standardize these test scores to be mean 0, SD 1. In Table 6, we present results from estimating equation 1 with these math test scores as the dependent variable. Column 1 shows results for exposure to all peers whose parents believe $B_m > G_m$; columns 2 and 3 show results for

Figure 3: Homophily in the effects of exposure to peers whose parents believe $B_m > G_m$



Panel A: Girls



Panel B: Boys

Note: this figure shows a kernel-weighted local polynomial regression of a child's likelihood of reporting that boys are better than girls at learning math (0 = No, 1 = Yes) on the exposure to peers whose parents hold that belief, after removing grade-by-school fixed effects from the dependent (y-axis) variable, as in Figure 2. Here the four plots are divided by child gender (girls in the first panel, boys in the second) and the gender of the peers used to create the peer parent beliefs measure (parents of own-gendered peers in the left column, and those of other-gendered peers in the right). As in Figure 2, a one unit increase in the peer parent beliefs measure (the x-axis variable) is equivalent to an 11 percentage point increase in the proportion of own- or other-gendered peers whose parents believe $B_m > G_m$.

Table 5: Evidence of homophily among peers

	Girl peers' parents' beliefs		*Boy peers' parents' beliefs*	
	(1) Believes boys are better than girls at learning math	(2) Perceives math to be difficult	(3) Believes boys are better than girls at learning math	(4) Perceives math to be difficult
Gender-specific peer parent beliefs (PPB)	0.017	-0.005	0.043***	-0.006
	(0.014)	(0.015)	(0.011)	(0.012)
Gender-specific PPB x female	0.025*	0.020*	-0.015	0.005
	(0.014)	(0.011)	(0.014)	(0.008)
Own parent's beliefs (OPB)	0.282***	-0.066***	0.285***	-0.067***
	(0.016)	(0.016)	(0.016)	(0.016)
OPB x female	0.031	0.154***	0.027	0.156***
	(0.021)	(0.023)	(0.020)	(0.024)
Female	-0.131***	-0.013	-0.126***	-0.013
	(0.032)	(0.028)	(0.032)	(0.028)
Mean in sample	0.526	0.570	0.526	0.570
Observations	8,056	8,211	8,057	8,212

Note: this table shows results for estimating the effects of exposure to girl and boy peers whose parents believe $B_m > G_m$ separately, as indicated in the two table headings. The dependent variables are given below the column numbers and are coded 0 = No, 1 = Yes. In Table A.4, we show the analog to these results generated without own parent beliefs on the right hand side.

Table 6: Effects on performance

	(1) All peers' parents' beliefs	(2) Boy peers' parents' beliefs	(3) Girl peers' parents' beliefs
Peer parent beliefs (PPB)	0.039	0.081**	-0.054
	(0.039)	(0.037)	(0.037)
PPB x female	-0.057**	-0.045*	-0.023
	(0.025)	(0.023)	(0.025)
Own parent beliefs (OPB)	0.169***	0.178***	0.172***
	(0.027)	(0.027)	(0.026)
OPB x female	-0.291***	-0.305***	-0.308***
	(0.041)	(0.042)	(0.043)
Female	0.355***	0.358***	0.357***
	(0.056)	(0.056)	(0.055)
Observations		8,028	

Note: in all regressions, the dependent variable is the student's test score on a midterm math test. The math test score variable is continuous and standardized to be mean 0, SD 1. The observations in this sample reflect all students for whom we have a math test score. Different columns pertain to different measures of peer parent beliefs as labeled in the column headings. In Table A.5, we show the analog to these results generated without own parent beliefs on the right hand side.

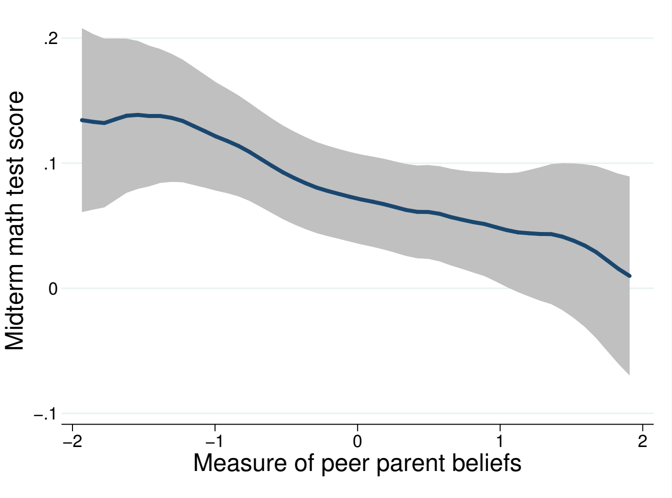
exposure to boy and girl peers whose parents hold the belief, respectively, akin to the results shown in Table 5.

As with perceived difficulty, our estimates of the effect of exposure to peers whose parents believe $B_m > G_m$ on test scores differ in sign for girls and for boys. We estimate that a one SD increase in exposure to peers whose parents hold the belief worsens girls' performance, relative to boys', by 0.057 SD. We plot this relationship non-parametrically in Figure 4, separately for boys and for girls. This figure shows a kernel-weighted local polynomial regression of the math test scores of either boys or girls, after removing grade-by-school fixed effects from the score variable, on the proportion of peers whose parents believe $B_m > G_m$. These plots show a similar monotonic relationship between exposure to peers whose parents hold the belief and children's performance in mathematics, with gains for boys and losses for girls.

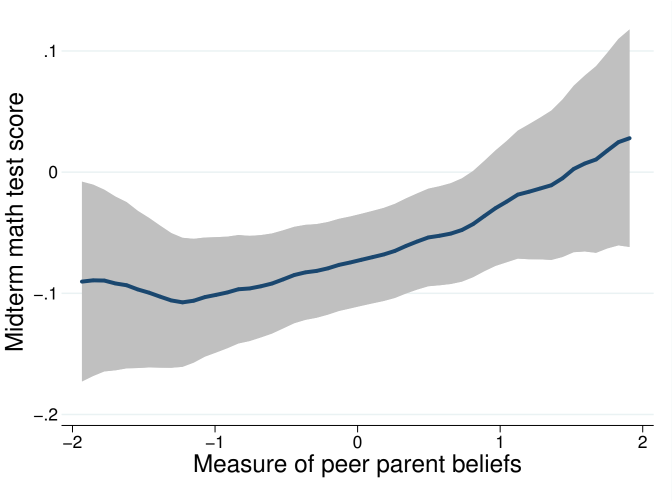
In columns 2 and 3 of Table 6, we study homophily in the effects of exposure to peers whose parents believe $B_m > G_m$, expecting similar results to those we found for belief transmission. Our estimated effects for boys' test scores are significant, with a large and significant estimate of β_1 and a negative, marginally significant estimate of β_2. For girls, we see negative estimates of both coefficients. The total effect of exposure to girl peer parents who believe $B_m > G_m$ on girls is $\beta_1 + \beta_2 = -0.077$, roughly symmetric to the effect of exposure to boy peer parents who hold this belief on boys, $\beta_1 = 0.081$. While neither coefficient in the girl peer parent beliefs estimates is significant at traditional levels by itself, an F-test rejects the null that the total effect for girls, $\beta_1 + \beta_2$, is zero (F-stat 5.86, p-value 0.017). Analogue results estimated without the own parent beliefs coefficients, shown in Table A.5, give similar results suggesting homophily, with more precise effect estimates. In Figure 5, we show the same kernel-weighted local polynomial regression of child test scores on exposure to peers whose parents believe $B_m > G_m$, separately for own-gendered and other-gendered peers, as in Figure 3. The differences in the magnitude of the gradient between own-gendered and other-gendered peers in these figures also show evidence of homophily.

We also see a large and significant correlation between own parent beliefs and performance – the scores of boys whose parents believe that boys are better than girls at learning math are 0.17 SD higher than for boys whose parents do not believe this, and for girls, having a parent who holds this belief pushes the child's test score down, relative to boys' scores, by 0.29 SD. Finally, we see clear evidence of the "reverse" gender gap in math performance in spite of the prevalence of the belief that boys are better than girls at learning math: after conditioning on our set of controls and removing grade-by-school fixed effects, on average girls score 0.35 SD better than boys on these midterm math tests.

Figure 4: Non-parametric relationships between exposure to peers whose parents believe $B_m > G_m$ and test scores, by gender



Panel A: Girls

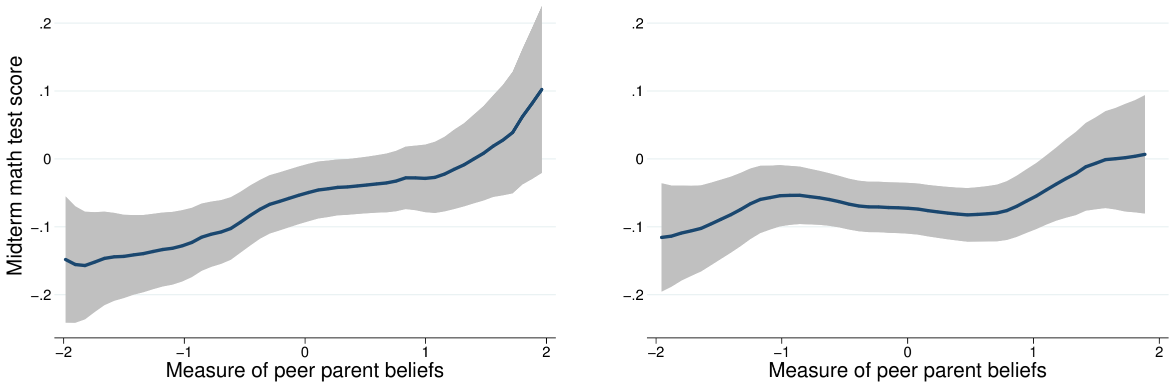


Panel B: Boys

Note: this figure shows the kernel-weighted local polynomial regression of the child's performance on her midterm math test (mean 0, SD 1) on the individual-level measure of exposure to peers whose parents believe $B_m > G_m$, again with grade-by-school fixed effects removed from the y-axis variable. Panel A presents this relationship for girls in our sample, and Panel B presents it for boys. A one unit increase in the peer parent beliefs measure (the x-axis variable) corresponds to an 11 percentage point increase in the proportion of peers whose parents hold the belief.

Figure 5: Homophily in the effects of exposure to peers whose parents believe $B_m > G_m$ on math test performance

Panel A: Girls



Panel B: Boys

Note: this figure shows a kernel-weighted local polynomial regression of children's performance on midterm math examinations on exposure to peers whose parents believe $B_m > G_m$, again with grade-by-school fixed effects removed from the y-axis variable (which is in SD units). Here the four plots are divided by child gender (girls in the first panel, boys in the second) and the gender of the peers used to create the peer parent beliefs measure (parents of own-gendered peers in the left column, and those of other-gendered peers in the right). A one unit increase in the peer parent beliefs measure (the x-axis variable) corresponds to an 11 percentage point increase in the proportion of peers whose parents hold the belief.

5 Robustness and mechanisms

In this section, we generate two sets of results. The first set shows that our findings are robust to the main threat to identification, that parent beliefs are affected by the children in a child's randomly assigned classroom or their parents. The second set shows that the main mechanism behind our findings is the transmission of beliefs from peers' parents, and not the many other sources of peer effects.

5.1 Robustness

In this subsection, we study to what extent parents adjust their beliefs in response to two factors: one, exposure to the beliefs of the other parents' in their peers' classroom, and two, observing the relative ability of boys and girls in their child's classroom. Such adjustment is a possible confounding factor because the parental survey in the CEPS is administered after children are assigned to classrooms. As a result, when parents are asked the question about girls' and boys' relative ability in math used to generate our peer parent beliefs measure, they will have interacted with the other parents in their child's classroom and will have observed the relative ability of boys and girls in the child's classroom. Our results suggest that our parent beliefs measure is stable to these interactions. We also comment on the extent to which parents may update their beliefs in response to their own child's gender and ability.

We first test whether parent beliefs adjust in response to exposure to other parent beliefs; in other words, the extent of the "reflection problem," as in Manski (1993) and Angrist (2014). To test for this, we regress peer parent beliefs on own parent beliefs using our core specification. Note that regressing an individual's given characteristic on the leave-one-out average of this same characteristic in an individual's randomly assigned cluster yields a mechanical negative correlation. The intuition behind this is as follows: given the random assignment of students into classes, the law of large numbers predicts that, in a given class, the proportion of students with a certain characteristic (e.g., average parent beliefs or percent female) will be distributed normally. A student's characteristic is thus negatively correlated with the leave-one-out average because the proportion (including the student herself) is equivalent to the sum of the student's characteristic and this average.

To formalize this intuition, we conduct a permutation test, randomly assigning to each child 1,000 "placebo own parent belief" random variables with the same potential values (0/1) and expected value (0.410) as the true parent belief variable. We generate 1,000 new "placebo peer parent beliefs" measures, using the 1,000 placebo belief draws for the parents of each student's peers in her classroom. We standardize these and then run one regression for each of the 1,000 draws, regressing the random variable of each student's own parent's placebo beliefs on the placebo peer parent beliefs measure, its interaction with the female dummy, and the other controls as given in our estimating equation. This generates $\tilde{\gamma}$, the mean of our permutation test estimates. We find $\tilde{\gamma} = -0.107$ ($SE = 0.026$). Using the true data, we estimate $\hat{\gamma}$, the effect of a one SD increase in the proportion of peers whose parents believe $B_m > G_m$ on a child's own parent's likelihood of holding the belief, to be $\hat{\gamma} = -0.072$. Because our estimate of $\hat{\gamma}$ falls well within the 95% confidence interval around $\tilde{\gamma}$ generated by the permutation test, we conclude there is no evidence of this reflection problem.

We next describe and present a series of tests for the second possibility, that parents may adjust their beliefs after viewing the (relative) math ability of girls and boys among their child's peers, i.e., reverse causality. Using our main estimating equation, we design two empirical tests for this possibility. In both tests, the dependent variable is a dummy for whether the parent believes $B_m > G_m$. In the first test, our main explanatory variable is a leave-one-out average of the difference between the math test scores of the child's peer boys and peer girls, i.e., the gender gap among peers. This test estimates how an increase in boys' math performance, relative to girls, among the children in a child's classroom, affects her parent's beliefs. In the second test, we create a dummy variable equal to one if the highest performing child in the class is male. This tests for the informational salience that comes with the recognition top performers are often given, and the potential for this to have asymmetric effects by gender (Cools et al., 2019).

We present our results in Table 7. In Panel A, we present our results for the effect of an increase in boys' performance, relative to girls, on a parent's beliefs. We find no evidence that a parent is more likely to believe $B_m > G_m$ when her child is assigned to a classroom where boys outperform girls in math. Our estimated coefficients are small and not distinguishable from zero, but precise: we can reject that a 0.1 SD increase in peer boys' performance, relative to peer girls, generates anything larger than a 0.8 percentage point change in the likelihood that a parent believes boys are better than girls at learning math (from a baseline of 41%). In Columns 2 and 3, we estimate these effects separately for parents of seventh graders and ninth graders. Recall that the seventh grade children of these parents have been with their peers for three to six months when the parent is interviewed, and the ninth grade children have been with their same peer group for two years and three to six months. This analysis tests for the possibility that as the time parents are exposed to their child's peers increases, so will the likelihood they update their beliefs. Our coefficient

Table 7: Estimating the extent to which a parent's beliefs change in response to the gender gap in performance among her child's peers

	Dependent variable: *Parent believes boys are better than girls at learning math*		
	(1)	(2)	(3)
Panel A: Gender gap in peer test scores			
Gender gap in child's peers' test scores	0.004	0.004	0.002
	(0.003)	(0.004)	(0.005)
Gender gap in child's peers' test scores x own child is female	-0.002	-0.006	0.005
	(0.003)	(0.004)	(0.003)
Mean in sample	0.409	0.394	0.441
Number of observations	8,028	5,428	2,600
Panel B: Top student in class is male			
Top student in class is male	0.023	0.021	0.006
	(0.019)	(0.023)	(0.042)
Top student in class is male x own child is female	-0.004	-0.008	0.011
	(0.016)	(0.020)	(0.030)
Mean in sample	0.409	0.394	0.441
Number of observations	8,228	5,553	2,675
Sample			
Grade seven	X	X	
Grade nine	X		X

Note: this table presents a series of tests for the possibility that a parent's beliefs are affected by the relative performance in math of boys and girls among her child's (randomly assigned) classroom peers. In Panel A, we generate a leave-one-out measure of the difference between boys' and girls' test scores in the midterm math exam for the child's peers in her randomly assigned classroom. Using the specification in Equation 1, we regress the child's parent's likelihood of believing boys are better than girls at learning math on this measure. In Panel B, we generate an indicator function equal to one if, in the child's class, a boy earns the top midterm math test score, and regress the child's parent's beliefs on it.

estimates provide no evidence of this phenomenon either. In Panel B, we present analog results using a dummy for the top scoring student on the midterm math test being male as the main explanatory variable. We see no evidence of parents' beliefs changing in response to the gender of the top performer. Our results suggest that even a large change in the relative gender performance in math among a child's peers, or a change in the gender of the top performer, is unlikely to generate more than a very small change in parent beliefs. We find but do not show similar results using the proportion of the top three students in the class who are male.

We cannot empirically evaluate the extent to which a child's own ability affects her parents' beliefs about the relative ability of boys and girls in math.[19] We assume, however, that the primary interaction between parents and their child is parents' beliefs and actions shaping those of their children, and not child ability shaping parent beliefs. This assumption is based on three arguments: one, the vast child development literature documenting the great extent to which parents influence their children's development (c.f., Siegler et al., 2003); two, the argument we make earlier in this paper about how parents' beliefs are relatively harder to manipulate than children's because of the longer time over which they have been formed; and three, the fact that even if child ability were to affect parent beliefs, we show in the next subsection that controlling for peer cognitive ability does not substantially change our belief transmission results or the estimated effects on test scores.[20]

5.2 Mechanisms

This section addresses two questions. First, is the transmission of beliefs we study separate from, or consistent with, other sources of peer effects? Second, what can we say about the potential for direct interaction between peer parents and the child[21], as opposed to from peer parents to the peer, and on to the child, in driving our results?

In this paper, we wish to study how parent views affect child views. We focus on the views of peer parents to isolate the direct transmission of beliefs from indirect transmission through a parent's behavior

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[19] This is because we lack panel data on the child's ability and her parents' beliefs from earlier in the child's life.

[20] We can also measure how parent beliefs about gender differences in math ability vary with the gender of their child(ren). The revelation of child gender is potentially a large information shock, especially in China, where son preference often prevails. More than half of the families in our sample have multiple children. On average, among parents who have only girls, 38.0 percent believe $B_m > G_m$; among parents who have both, 40.8 percent hold the belief; among parents with only boys, 43.7 percent do. The correlation between child gender and parent beliefs is small compared to the idiosyncratic variation in parent beliefs across classrooms. We interpret this as further evidence of our claim that beliefs about gender differences in math ability are much more likely to shift in childhood than in adulthood.

[21] As in Olivetti et al. (Forthcoming).

towards her child, e.g., the rewards, punishment, and encouragement the parent offers. While focusing on peers shuts down this particular indirect effect, there are many other consequences of exposure to peers with different characteristics which could drive our results (c.f., Sacerdote et al., 2011). We wish to know to what extent are the effects we estimate separate from or coincident with exposure to the other sources of peer effects studied in prior work, such as peer ability and peer parent education (c.f., Feld and Zölitz, 2017; Fruehwirth, 2017).

To disentangle these two possible mechanisms, we conduct a series of horse race regressions where we add controls for other variables known to generate peer effects in prior work and study how our coefficient estimates change. These other sources of peer effects include various traits of peers' parents, including education, income, and whether their residence permit (hukou) is rural or urban (Fruehwirth, 2017; Chung, 2018); the gender composition of the child's classroom (Hu, 2015); and peers' cognitive ability (c.f. Sacerdote et al., 2011; Feld and Zölitz, 2017). For peer parents' education, we add variables capturing the average number of years the child's peers' mothers and fathers spent in school, respectively. For income, we add the proportion of peers who fall in the "low income" category according to the school. For hukou status, we use the proportion with a rural hukou. The proportion of girl peers in the child's classroom is self-explanatory. The cognitive ability measure is from a proprietary test designed by the CEPS team using items similar to those in a Raven's Matrices test, standardized to be mean 0, SD 1. We add these controls and their interaction with the child's gender, one source at a time, to see how their inclusion affects our estimates of the impact of exposure to peers whose parents believe $B_m > G_m$. We focus on the extent to which our main estimates on PPB and PPB x female attenuate as we add these controls. This serves as a coarse measure of the extent to which peer parent beliefs are a proxy for a broader, latent peer effect measure.

We present the results of this test in Table 8. Panel A shows that our estimates of the effects of exposure to more peers whose parents believe $B_m > G_m$ on a child's beliefs vary little with the inclusion of additional controls for various peer parent traits, the gender composition of the classroom, and the average cognitive ability of peers. Panel B shows similar results for the stability of our estimates for math test scores. We interpret these patterns as evidence that the transmission of beliefs from parents to children and on to their peers, and not the other important peer effect mechanisms, generate most of the effects of exposure to this type of peers on child beliefs and girls' relative math performance we estimate in Section 4.

In Tables A.6-A.10 we provide several alternative versions of this table. Table A.6 shows these estimates when the own parent beliefs variables (OPB and OPB x female) are removed from the estimating equation.

Table 8: Disentangling the effects of exposure to peers whose parents believe $B_m > G_m$ and other sources of peer effects

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A outcome: Believes boys are better than girls at learning math						
Peer parent beliefs (PPB)	0.046***	0.043***	0.043***	0.041***	0.041***	0.038***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
PPB x female	0.002	0.005	0.007	0.007	0.006	0.012
	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)
R-squared	0.167	0.168	0.169	0.169	0.169	0.170
Number of observations	8,057	8,057	8,057	8,057	8,057	8,057
Panel B outcome: Midterm math test score						
Peer parent beliefs (PPB)	0.039	0.027	0.035	0.033	0.033	0.030
	(0.039)	(0.036)	(0.035)	(0.035)	(0.035)	(0.034)
PPB x female	-0.057**	-0.049**	-0.050**	-0.049*	-0.051**	-0.045*
	(0.025)	(0.024)	(0.025)	(0.025)	(0.025)	(0.026)
R-squared	0.193	0.197	0.198	0.198	0.198	0.199
Number of observations	8,028	8,028	8,028	8,028	8,028	8,028
Specification						
Baseline controls	X	X	X	X	X	X
Peers' parents' education		X	X	X	X	X
Peers' parents' income			X	X	X	X
Peers' parents' hukou status				X	X	X
Proportion of peers female					X	X
Peers' cognitive ability scores						X

Note: this table shows a series of horse-race regressions, including additional independent variables as listed in the “specification” legend at the bottom of the table, to assess the relative importance of peer parent beliefs and other determinants of peer effects in generating our estimates from Tables 4 and 6. The dependent variable in Panel A is coded as 0 = No, 1 = Yes (mean 0.526), and, in Panel B, the test score variable is in standardized SD units. There are 8,057 observations in the Panel A regressions and 8,028 in those of Panel B. In Table A.6, we show the analog to these results generated without own parent beliefs on the right hand side.

Table A.7 shows these estimates for girl peer parents' beliefs using the original covariates, and Table A.8 shows the girl peer parents' beliefs estimates when the own parent beliefs variables are removed from the right hand side. Tables A.9 and A.10 show these same analyses, respectively, but using boy peer parents' beliefs. The patterns they display are similar to those in Tables 3 and A.4: removing own parent beliefs dampens the estimates of the effect of exposure to all peers whose parents believe $B_m > G_m$ on child beliefs, but amplifies them for the homophily results, particularly for girls.

Another question of interest is the relative importance of two channels of peer parent belief transmission to children: one, from peers' parents directly to the child herself; two, from the peers' parents to the peer, and then from the peer to the child. Olivetti et al. (Forthcoming) show that the direct channel is an important factor in shaping girls' beliefs about their place in the labor market. The only related datapoint collected in the CEPS is each parent's response to the following yes/no question: "do you know the friends that your child often spends time with?" A high proportion – 87.8 percent of parents – respond "yes" to this question. In the appendix, we describe our attempts to study the relative importance of the two channels. We find that using this interaction to estimate whether peer parents who know their children's friends have greater transmission of beliefs has no more descriptive power than using a random sample of an equal proportion of parents (who may or may not interact with their children's friends). Given the flaws of this particular measure, we argue that this test is inconclusive.

6 Heterogeneity and further impacts on girls

In this section, we conduct a series of analyses to investigate potential heterogeneity in the effects of exposure to peers whose parents believe that boys are better than girls at learning math. We also provide a richer characterization of how this exposure affects girls' beliefs, aspirations, and performance in school.

6.1 Heterogeneity analyses

In this subsection we show results from three tests for heterogeneity and discuss the results of several others. First, we estimate the relationship between duration of exposure to peers and effect size. Next, we evaluate whether the effect of exposure to peers whose parents believe that boys are better than girls at learning math varies by a child's own parent's reported beliefs. Finally, we discuss the results of tests for heterogeneity by income, parental education, and rural/urban residence.

How does the duration of time that a child is exposed to her peers condition our effect estimates? We have two sets of children in our data – seventh graders, who have been with their peers for three to six months when interviewed, and ninth graders, who have been with their peers for two more years than the seventh graders (recall that the children in our sample are assigned to a peer group in seventh grade and remain with them throughout middle school). Economic intuition generates disparate predictions for how increases in the duration of exposure to peers may condition our estimates for child beliefs and performance.

For beliefs, there are two predictions which point in opposite directions. Prediction one is consistent with a simple model of Bayesian updating. A child's priors are particularly ripe for updating when she enters seventh grade and encounters a large increase in the difficulty of the math curriculum. She updates her priors based on the new information she is confronted with – the curriculum, the overall middle school environment, and the information conveyed to her by her peers. Once that information is incorporated into her posterior, it is no longer "new" to her, and so we would expect only small subsequent changes in beliefs as exposure lengthens. Prediction two is that learning from peers may be a slow or iterative process, and so we would expect to see larger belief changes among the ninth graders than among the seventh graders.

For test scores, the predictions are clearer. Our intuition here comes from the fact that learning builds on itself. Initially, exposure to the belief $B_m > G_m$ is likely to cause girls (boys) to exert marginally less (more) effort or enthusiasm for math, which leads to marginally worse (better) performance. This performance signal then provides information about the returns to subsequent effort, which can affect future enthusiasm/effort allocation decisions and lead to a cycle of effects compounding over time. This predicts larger effects in tests scores for ninth graders than for seventh graders.

In Table 9, we present coefficient estimates for three outcomes – believing that boys are better than girls at learning math, perceiving the current math class to be difficult, and the child's standardized midterm math test score – estimated separately by the grade the student is in.[22] For the beliefs estimates, our results are indeterminate: none of the coefficient estimates for seventh grade children are statistically distinguishable from those for ninth grade children, but their magnitude suggests the effects for girls may grow somewhat over time. As predicted, we estimate larger effects of exposure to peers whose parents believe $B_m > G_m$ on both math test scores and perceived difficulty of math for those in grade nine than for those in grade seven.

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[22] As discussed in Footnote 11 and shown in Table A.2, the schools in our estimation sample with and without grade 9 classrooms that maintain the randomization initiated in grade 7 are balanced on most observable characteristics. Table A.12 shows the same analyses as given in Table 9, but restricting the sample to only schools which have grade 9 classrooms that maintain the randomization. The two sets of results are very similar.

Table 9: Effect size by duration of exposure to peers

	Believes boys are better than girls at learning math		*Perceived difficulty of current math class*		*Midterm math test score*	
	(1) Grade 7	(2) Grade 9	(3) Grade 7	(4) Grade 9	(5) Grade 7	(6) Grade 9
Peer parent beliefs (PPB)	0.032*	0.034**	0.007	-0.028	0.044	0.046
	(0.019)	(0.017)	(0.020)	(0.020)	(0.058)	(0.032)
PPB x female	-0.004	0.025	0.012	0.029**	-0.027	-0.089***
	(0.020)	(0.020)	(0.013)	(0.015)	(0.031)	(0.030)
Own parent beliefs (OPB)	0.271***	0.299***	-0.058***	-0.076***	0.181***	0.135***
	(0.019)	(0.028)	(0.020)	(0.029)	(0.031)	(0.050)
OPB x female	0.026	0.032	0.135***	0.187***	-0.277***	-0.291***
	(0.026)	(0.033)	(0.028)	(0.040)	(0.052)	(0.064)
Female	-0.099	0.293**	-0.330***	0.155	0.591**	1.087***
	(0.164)	(0.141)	(0.121)	(0.128)	(0.289)	(0.365)
Mean in sample	0.504	0.572	0.546	0.619	-	-
Observations	5,414	2,643	5,538	2,674	5,428	2,600

Note: This table presents results for the effect of exposure to peers whose parents believe $B_m > G_m$ on children's beliefs and performance, estimated separately for those in grade seven and those in grade nine. The dependent variables are labeled above the column numbers here. In columns 1-2, the dependent variable is coded as 0 = No, 1 = Yes. In columns 3-4, the dependent variable is coded as 0 for low perceived difficulty and 1 for high perceived difficulty. In columns 5 and 6, the dependent variable is continuous with SD = 1. In Table A.11, we show the analog to these results generated without own parent beliefs on the right hand side. Table A.12 shows the analysis with own parent beliefs included, but restricting our sample to only schools which have grade 9 classrooms that maintain the random sorting assigned in grade 7.

Do the effects of exposure to peers whose parents hold this belief vary by the beliefs the child is exposed to in her own home? To answer this question, we add two variables to our estimating equation: the interaction of peer parent beliefs and own parent beliefs, and this variable's interaction with the child's gender. We present our results in Table 10. We find that increased exposure to peers whose parents believe that boys are better than girls at learning math appears to generate greater harms for girls whose parents also hold this belief, both in terms of the likelihood of the child holding that belief herself and her performance in mathematics. The standard errors in this analysis are large, however, suggesting that adding further interaction terms to our main specification pushes the limits of what we can precisely estimate using this estimation strategy on a dataset with this sample size.

We also test for the possibility that other predetermined factors might condition our results. For the sake of brevity, we describe the results but do not include the tables in the paper. We consider family income, parents' education, and whether the family lives in a rural or urban area.[23] For the first two, we interact a dummy for either low income or low parental education, respectively, with peer parent beliefs (and its interaction with child gender) to test for potential heterogeneity. Our coefficient estimates for β_1 and β_2 do not differ substantially in magnitude, and the interaction coefficients are indistinguishable from zero. For the rural/urban comparison, we estimate results separately for urban and rural schools, as we do for seventh and ninth graders in Table 9. For this comparison as well, we find no evidence of heterogeneity in the effect estimates for either beliefs or performance in math.

6.2 How do girls respond?

We have shown that girls exposed to more peers whose parents believe that boys are better than girls at learning math are, ceteris paribus, more likely to believe that boys are better at math than girls, more likely to perceive math as difficult, and score worse on math exams. In this subsection, we further analyze how girls respond to this exposure.

First, we study whether girls reallocate effort away from mathematics and towards other subjects or hobbies in which the belief $B_m > G_m$ suggests they have a comparative advantage. To test for this, we look at the child's performance in Chinese and English. We show these results in Table 11; our results can reject even small gains in girls' test scores for either subject. We conduct a series of other empirical tests to look for evidence of a reduction in enthusiasm or effort for girls. We report but do not show analysis of other

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[23] Recall that each of these variables and its interaction with child gender are already controls in our estimating equation

Table 10: The interaction of own and peer parent beliefs

	(1) Believes boys are better than girls at learning math	(2) Midterm math test score
Peer parent beliefs (PPB)	0.055***	0.037
	(0.015)	(0.043)
PPB x female	-0.014	-0.038
	(0.016)	(0.028)
Own parent beliefs (OPB) x PPB	-0.023	0.008
	(0.017)	(0.026)
OPB x PPB x female	0.042**	-0.053
	(0.020)	(0.034)
OPB	0.285***	0.170***
	(0.016)	(0.027)
OPB x female	0.031	-0.292***
	(0.020)	(0.041)
Female	-0.130***	0.356***
	(0.032)	(0.056)
Mean in sample	0.526	-
Observations	8,057	8,028

Note: This table presents estimates of the effect of exposure to peers whose parents believe $B_m > G_m$ on children's beliefs and performance, using our main specification with additional interaction terms one, between own parent beliefs and our measure of peer parent beliefs, and two, this interacted with child gender. The dependent variable in column 1 is coded as 0 = No, 1 = Yes. In column 2, the dependent variable is continuous with SD = 1.

Table 11: The impact of exposure to peers whose parents believe $B_m > G_m$ on Chinese and English test scores

	(1) Midterm Chinese test score	(2) Midterm English test score
Peer parent beliefs (PPB)	0.068	0.046
	(0.044)	(0.048)
PPB x female	-0.042	-0.037
	(0.027)	(0.026)
Own parent beliefs (OPB)	0.024	0.054*
	(0.034)	(0.029)
OPB x female	-0.021	-0.054
	(0.045)	(0.040)
Female	0.549***	0.438***
	(0.085)	(0.090)
Observations	7,713	7,713

Note: this table shows an analog to column 1 of Table 6 for performance on standardized (mean = 0, SD = 1) Chinese and English midterm test scores. Note that we have slightly more missing scores for these tests than for mathematics.

outcomes potentially affected by this exposure, including girls' expressed confidence in their own future, time use (hours spent studying, in cram school, and on hobbies), or beliefs that math, English, or Chinese are helpful for their future. We find no evidence of changes in these, though our results are imprecise.

We conduct an analysis building on the work of Lavy and Sand (Forthcoming) and Hahn et al. (Forthcoming), who show that exogenous increases in proximity to friends, either in class or in a study group, have positive impacts on girls' academic performance. The CEPS collects information from the child on whether her five closest friends are in the same randomly assigned class as she is.[24] We add the number of friends in the class, its interactions with the child's own gender and our measure of peer parent beliefs, and the triple interaction, as additional independent variables in our estimating equation. We study the estimated coefficients on these new explanatory variables to determine whether having friends in class conditions the effects of exposure to peers whose parents believe $B_m > G_m$ on child beliefs or performance. Note that this set of results is only suggestive, as our survey data on the number of friends inside or outside of the class are collected during the school year. As a result, who the child regards as one of her five closest friends is potentially endogenous to other factors, such as a child's overall experience in the school and the classroom, which may also affect, or be determined by, our outcome variables.

We present our results in Table 12, using the following four dependent variables: holding the belief that $B_m > G_m$; the child's perceived difficulty of math; her aspirations to finish at least a BA; and her midterm math test score. This analysis reveals substantial heterogeneity in the effect of exposure to peers whose parents hold this belief on girls' aspirations and performance. We find a much stronger negative effect on aspirations to complete college and on performance in mathematics (our estimates of PPB x female in columns 3 and 4). These negative effects, however, capture the effect for children with no friends in their classroom. The coefficient on the triple interaction (PPB x female x friends in class) shows that the harms of exposure decrease as the number of friends the child has in her class increases. A child with five close friends in her class appears to be entirely immune to the negative effects of exposure to peers whose parents believe $B_m > G_m$ on aspirations and math performance.[25] We see no evidence of heterogeneity by the number of friends in class in our estimates for either the child's likelihood of holding the belief or her perceived difficulty of math. We also see no evidence of this heterogeneity in any of the outcomes for boys.

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[24] Unfortunately, we do not have access to friends' names or links to their identifiers and so cannot link a child's list of friends to other children in our dataset.

[25] To arrive at this conclusion, we take the [peer parent beliefs x female] coefficient and add to it the [peer parent beliefs x female x number of friends in class] coefficient multiplied by five, to capture the impact of all five friends being in the class.

Table 12: The moderating role of friends in class

	(1) Believes $B_m > G_m$	(2) Perceived difficulty	(3) Aspires to BA or higher	(4) Math test score
Peer parent beliefs (PPB)	0.034*	0.008	0.003	-0.009
	(0.018)	(0.019)	(0.023)	(0.054)
PPB x female	0.018	0.009	-0.037*	-0.142**
	(0.022)	(0.022)	(0.021)	(0.061)
PPB x number of friends in class (FIC)	0.004	-0.006	-0.000	0.016
	(0.004)	(0.005)	(0.004)	(0.010)
PPB x female x FIC	-0.005	0.003	0.015***	0.028*
	(0.007)	(0.006)	(0.006)	(0.015)
FIC	0.011**	-0.009*	0.014***	0.011
	(0.005)	(0.005)	(0.004)	(0.010)
FIC x female	-0.006	-0.004	-0.010*	0.006
	(0.007)	(0.006)	(0.006)	(0.013)
Own parent beliefs (OPB)	0.289***	-0.068***	0.022	0.167***
	(0.016)	(0.016)	(0.014)	(0.027)
OPB x female	0.025	0.153***	-0.018	-0.288***
	(0.021)	(0.024)	(0.021)	(0.042)
Female	-0.108***	-0.004	0.131***	0.324***
	(0.040)	(0.035)	(0.029)	(0.074)
Mean in sample	0.526	0.570	0.658	-
Observations	7,890	8,024	8,006	7,850

Note: this table shows results from estimating equation 1 with the addition of four variables: number of close friends in the child's class (FIC), FIC x child gender, FIC x peer parent beliefs, and FIC x peer parent beliefs x child gender. The estimate on peer parent beliefs now shows pertains to a child with no friends in her randomly assigned class. The FIC coefficients show the estimated effect of one additional friend being in the class. The dependent variables in columns 1 and 3 are coded as 0 = No, 1 = Yes. In column 2, the dependent variable is coded as 0 for low perceived difficulty and 1 for high perceived difficulty. In column 4, the dependent variable is continuous with SD = 1. In Table A.13, we show the analog to these results generated without own parent beliefs on the right hand side.

Related work from sociology and psychology (Wentzel, 1998; Roseth et al., 2008) suggests a possible explanation for this pattern of results: friendship may increase girls' resilience in the face of stressors, such as being told that girls (like you) are worse than boys at learning math. This finding may provide weak evidence of the potential for outreach to vulnerable children, particularly girls, in minimizing the harm caused by the intergenerational transmission of beliefs about the relative math ability of boys and girls. The greater problem to resolve, of course, is how to prevent this transmission altogether. This question is beyond the scope of the current research.

7 Conclusion

In this paper, we study how beliefs about gender differences in math ability transmit across generations. We find that exposure to peers whose parents believe that boys have greater innate math ability than girls makes a child more likely to hold this belief herself. This transmission of beliefs harms girls and helps boys. It affects both children's assessment of their own ability in math and their actual performance in the subject. We find that this transmission of beliefs from peer parents to peers, and on to the child, is largely independent of other well-known sources of peer effects identified in the literature. We also find that transmission is strongest from peers of the same gender, and that the test score harms we observe for girls increase with the length of time she is exposed to her peers.

There are a few key limitations of our approach. First of all, we study only data in the cross-section. As a result, we are unable to track the longer-term academic and career effects of exposure to these beliefs, questions of central policy concern. We also work in a setting in which girls outperform boys, even in math, which may lead to an underestimation of the harms that come from exposure to beliefs about innate ability. This could occur, for example, if lower perceived ability children responded more to such exposure, as in Eble and Hu (2017).

Given the importance of beliefs about one's own ability in shaping decisions and outcomes, a key problem facing policymakers in both developed and developing countries is better understanding how these beliefs are transmitted, the impacts of this transmission, and what can be done to prevent any harms that this causes. Overall, our results document that the intergenerational transmission of beliefs about the innate math ability of boys and girls occurs both within and across families. These results also shed light on how such beliefs are self-reinforcing through their impact both on children's beliefs about their own ability and their actual performance in mathematics.

We know much less about how to address these issues. The negative effects on girls' performance and aspirations lessen with the number of close friends the child has in her class, in line with prior work finding similar benefits to assigning girls to classes or study groups with their friends. In other work, we have shown that positive role models such as female math teachers can counter the harms that exposure to these beliefs can cause for particularly vulnerable girls (Eble and Hu, 2017). The larger problem of how to prevent the transmission of beliefs such as the one we study, and the harmful effects this transmission can have on child development, remains unresolved.

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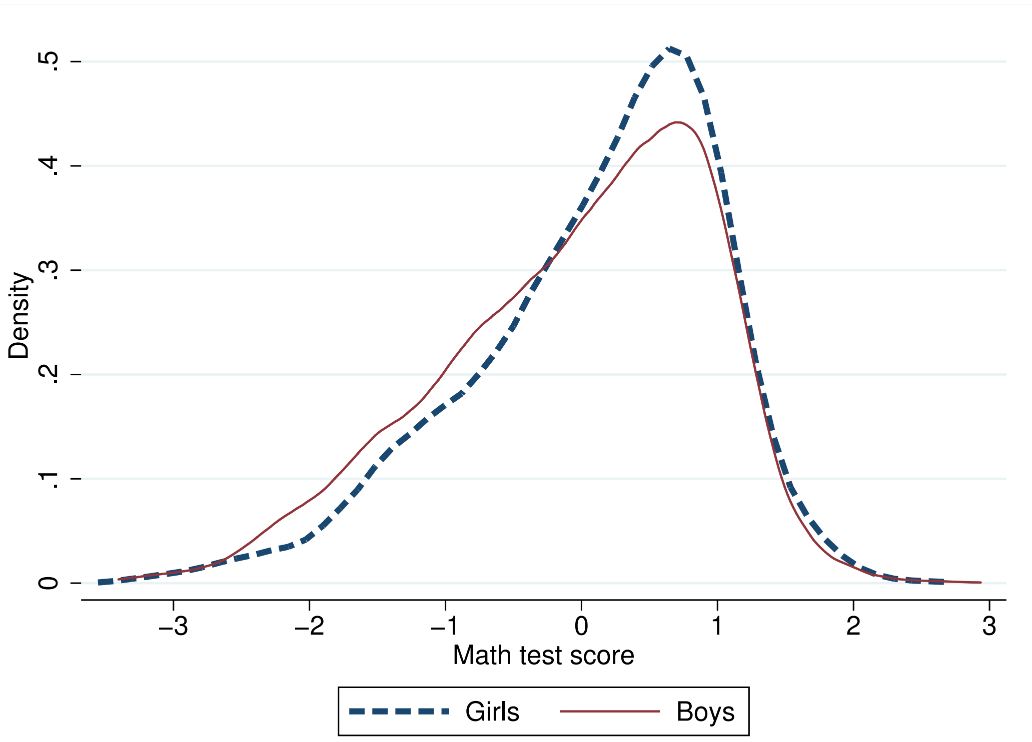
Appendix - for online publication only

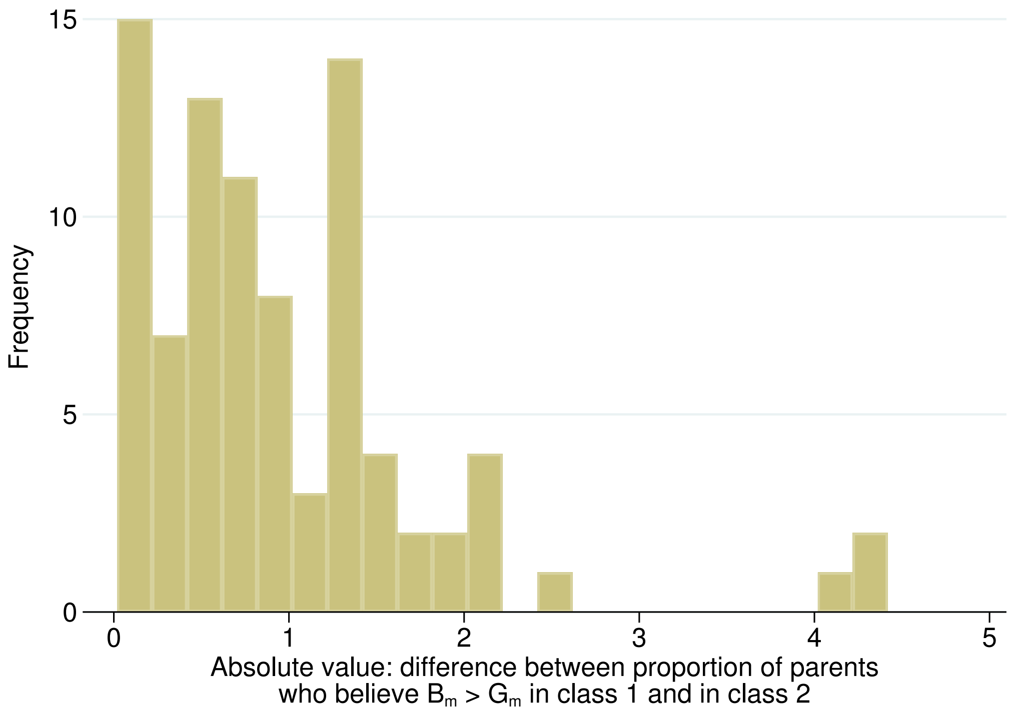
Appendix figures

Figure A.1: Distribution of test scores, by gender



Note: This figure shows the distribution of standardized math test scores for all children in our estimation sample, separately by gender.

Figure A.2: Distribution of difference between average parent beliefs in within-school, within-grade class pairs



Note: this shows the distribution of the value $\| Beliefs_{c_1} - Beliefs_{c_2} \|$ across our 86 within-school, within-grade class pairs, where $Beliefs_{c_x}$ is the mean of all parents' responses to the question "do you believe that boys are better than girls at learning math" in class x.

Appendix tables

Table A.1: Balancing test conducted separately by grade

	(1) Grade 7	(2) Grade 9
Age	-0.075***	-0.006
	(0.029)	(0.013)
Holds agricultural hukou	-0.075	-0.017
	(0.066)	(0.036)
Number of siblings	-0.087**	-0.001
	(0.040)	(0.020)
Household is poor	-0.019	0.047
	(0.064)	(0.042)
Female	0.021	0.023
	(0.027)	(0.024)
Mother's highest credential		
Middle school	0.006	0.029
	(0.020)	(0.025)
High/technical school	0.008	0.068
	(0.022)	(0.054)
College or above	0.026	0.017
	(0.028)	(0.046)
Father's highest credential		
Middle school	-0.005	0.021
	(0.024)	(0.025)
High/technical school	0.000	0.021
	(0.036)	(0.058)
College or above	-0.008	0.076
	(0.036)	(0.075)
Ethnic minority	0.015	-0.063
	(0.023)	(0.050)
Number of observations	6,040	2,924
R-squared	0.73	0.60
Joint test F-statistic	0.68	1.22
[p-value]	[0.77]	[0.30]

Note: this table presents a balancing test, as in Antecol et al. (2015), which tests for our set of predetermined characteristics' joint ability to predict the peer parent beliefs measure. Column 1 presents the results for seventh graders and Column 2 presents those for ninth graders. Both regressions include grade-by-school fixed effects. The variables are all coded as 0 = No, 1 = Yes, except for age and number of siblings. The dependent variable, peer parent beliefs, is standardized to be mean 0, SD 1.

Table A.2: Characteristics of schools with and without randomized ninth grade classrooms

	(1) Full sample	(2) Does not have ninth grade classroom	(3) Has ninth grade classroom	(4) Difference (column 1 - column 2)	(5) P-value
Private school	0.09	0.10	0.09	0.01	0.89
Total number of students in the school	1025	1118	947	171	0.29
School ranking	3.95	4.12	3.80	0.32	0.05
Proportion of teachers with BA	0.81	0.76	0.86	-0.10	0.27
Number of teachers	87	89	86	3	0.79
Number of observations	86	41	45	—	—

Note: This table gives summary statistics of schools with and without ninth grade classrooms that maintain the randomization established in seventh grade. The only significant difference is that schools without ninth grade classrooms that maintain randomization are slightly higher ranked than schools who do have such classrooms. This pattern is consistent with the pattern that re-sorting of children by ability is regarded as a way for middle schools to improve the likelihood of sending top children to higher-ranked high schools, and school ranking partly reflects this placement record.

Table A.3: Analog to Table 4 - effects on beliefs

	(1) Believes boys are better than girls at learning math	(2) Perceives current math class to be difficult	(3) Aspires to complete at least a BA
Peer parent beliefs (PPB)	0.021	-0.018	0.002
	(0.016)	(0.014)	(0.017)
PPB x female	0.003	0.028***	0.004
	(0.015)	(0.009)	(0.010)
Female	-0.130***	0.025**	0.128***
	(0.018)	(0.011)	(0.011)
Mean in sample	0.526	0.570	0.658
Observations	8,709	8,885	8,845

Note: this table is the analog to Table 4 but excluding the own parent beliefs variable and its interaction with student gender from the right hand side of the estimating equation. It shows results from estimating equation 1 using the dependent variable named in the column heading and described in the text. Variation in the number of observations across columns stems from differences in missing values for the dependent variables. The dependent variables are coded as 0 = No, 1 = Yes.

Table A.4: Analog to Table 5 - homophily in the transmission of beliefs

	Girl peers' parents' beliefs		*Boy peers' parents' beliefs*	
	(1) Believes boys are better than girls at learning math	(2) Perceives math to be difficult	(3) Believes boys are better than girls at learning math	(4) Perceives math to be difficult
Gender-specific peer parent beliefs (PPB)	-0.007	-0.010	0.036***	-0.008
	(0.017)	(0.014)	(0.014)	(0.012)
Gender-specific PPB x female	0.033***	0.027***	-0.022	0.012
	(0.014)	(0.011)	(0.014)	(0.008)
Female	-0.135***	0.052**	-0.129***	0.053**
	(0.030)	(0.025)	(0.030)	(0.025)
Mean in sample	0.526	0.570	0.526	0.570
Observations	8,364	8,534	8,365	8,535

Note: this table is the analog to Table 5 generated by excluding the own parent beliefs variable and its interaction with student gender from the right hand side of the estimating equation. It shows results from estimating equation 1 using the gender-specific peer parent beliefs measure named in the first heading and the dependent variable named in the column heading (and described in the text). Variation in the number of observations across columns stems from differences in missing values for the dependent variables. The dependent variables are coded as 0 = No, 1 = Yes.

Table A.5: Analog to Table 6 - effects on performance

	(1) All peers' parents' beliefs	(2) Boy peers' parents' beliefs	(3) Girl peers' parents' beliefs
Peer parent beliefs (PPB)	0.045	0.074**	-0.040
	(0.040)	(0.037)	(0.038)
PPB x female	-0.080***	-0.053**	-0.049*
	(0.026)	(0.026)	(0.027)
Female	0.241***	0.235***	0.235***
	(0.052)	(0.051)	(0.050)
Observations		8,334	

Note: this table is the analog to Table 6 generated by excluding the own parent beliefs variable and its interaction with student gender from the right hand side of the estimating equation. In all regressions, the dependent variable is the student's test score on a midterm math test (standardized to be mean 0 SD 1).

Table A.6: Analog to Table 8 - horse race regressions after removing own parent beliefs

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A outcome: Believes boys are better than girls at learning math						
Peer parent beliefs (PPB)	0.022	0.019	0.016	0.014	0.014	0.010
	(0.017)	(0.016)	(0.017)	(0.017)	(0.016)	(0.017)
PPB x female	0.003	0.005	0.006	0.006	0.005	0.013
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)
R-squared	0.083	0.085	0.086	0.086	0.087	0.089
Number of observations	8,057	8,057	8,057	8,057	8,057	8,057
Panel B outcome: Midterm math test score						
Peer parent beliefs (PPB)	0.044	0.031	0.038	0.037	0.037	0.034
	(0.039)	(0.036)	(0.035)	(0.035)	(0.035)	(0.034)
PPB x female	-0.071***	-0.064***	-0.064***	-0.063***	-0.065***	-0.059**
	(0.025)	(0.025)	(0.025)	(0.025)	(0.026)	(0.026)
R-squared	0.188	0.192	0.193	0.193	0.193	0.194
Number of observations	8,028	8,028	8,028	8,028	8,028	8,028
Specification						
Baseline controls	X	X	X	X	X	X
Peers' parents' education		X	X	X	X	X
Peers' parents' income			X	X	X	X
Peers' parents' hukou status				X	X	X
Proportion of peers female					X	X
Peers' cognitive ability scores						X

Note: this table is the analog to Table 8 generated by excluding the own parent beliefs variable and its interaction with student gender from the right hand side of the estimating equation. It shows a series of horse-race regressions, including additional independent variables as listed in the "specification" legend at the bottom of the table, to assess the relative importance of peer parent beliefs and other determinants of peer effects.

Table A.7: Analog to Table 8 - horse race regressions using the girl peers' parents' beliefs measure

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A outcome: Believes boys are better than girls at learning math						
Peer parent	0.017	0.015	0.013	0.012	0.011	0.011
beliefs (PPB)	(0.014)	(0.014)	(0.014)	(0.015)	(0.014)	(0.014)
PPB x female	0.025*	0.028**	0.031**	0.033**	0.032**	0.033***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
R-squared	0.166	0.168	0.168	0.168	0.169	0.170
Number of observations	8,056	8,056	8,056	8,056	8,056	8,056
Panel B outcome: Midterm math test score						
Peer parent	-0.054	-0.061	-0.056	-0.058	-0.058	-0.057
beliefs (PPB)	(0.037)	(0.037)	(0.038)	(0.038)	(0.037)	(0.036)
PPB x female	-0.023	-0.014	-0.016	-0.014	-0.015	-0.014
	(0.025)	(0.025)	(0.025)	(0.026)	(0.026)	(0.025)
R-squared	0.194	0.198	0.199	0.199	0.199	0.200
Number of observations	8,027	8,027	8,027	8,027	8,027	8,027
Specification						
Baseline controls	X	X	X	X	X	X
Peers' parents' education		X	X	X	X	X
Peers' parents' income			X	X	X	X
Peers' parents' hukou status				X	X	X
Proportion of peers female					X	X
Peers' cognitive ability scores						X

Note: this table is the analog to Table 8, but using the index for girl peers' parent beliefs instead of that for all peers' parents. It shows a series of horse-race regressions, including additional independent variables as listed in the "specification" legend at the bottom of the table, to assess the relative importance of peer parent beliefs and other determinants of peer effects.

Table A.8: Analog to Table 8 - horse race regressions using the girl peers' parents' beliefs measure and removing own parent beliefs

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A outcome: Believes boys are better than girls at learning math						
Peer parent beliefs (PPB)	-0.006	-0.007	-0.010	-0.012	-0.012	-0.012
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.015)
PPB x female	0.036***	0.038***	0.039***	0.040***	0.040***	0.040***
	(0.015)	(0.015)	(0.015)	(0.016)	(0.016)	(0.015)
R-squared	0.084	0.086	0.087	0.087	0.088	0.090
Number of observations						
Panel B outcome: Midterm math test score						
Peer parent beliefs (PPB)	-0.042	-0.049	-0.044	-0.046	-0.046	-0.045
	(0.037)	(0.037)	(0.038)	(0.038)	(0.037)	(0.036)
PPB x female	-0.034	-0.024	-0.026	-0.024	-0.025	-0.024
	(0.025)	(0.026)	(0.026)	(0.027)	(0.027)	(0.026)
R-squared	0.188	0.193	0.193	0.193	0.193	0.194
Number of observations						
Specification						
Baseline controls	X	X	X	X	X	X
Peers' parents' education		X	X	X	X	X
Peers' parents' income			X	X	X	X
Peers' parents' hukou status				X	X	X
Proportion of peers female					X	X
Peers' cognitive ability scores						X

Note: this table is the analog to Table 8, but using the index for girl peers' parents' beliefs instead of that for all peers' parents, and excluding the own parent beliefs variable and its interaction with student gender from the right hand side of the estimating equation. It shows a series of horse-race regressions, including additional independent variables as listed in the "specification" legend at the bottom of the table, to assess the relative importance of peer parent beliefs and other determinants of peer effects.

Table A.9: Analog to Table 8 - horse race regressions using the boy peers' parents' beliefs measure

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A outcome: Believes boys are better than girls at learning math						
Peer parent beliefs (PPB)	0.043***	0.040***	0.040***	0.039***	0.037***	0.034***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
PPB x female	-0.015	-0.012	-0.012	-0.012	-0.011	-0.005
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
R-squared	0.166	0.168	0.168	0.168	0.169	0.170
Number of observations	8,057	8,057	8,057	8,057	8,057	8,057
Panel B outcome: Midterm math test score						
Peer parent beliefs (PPB)	0.081**	0.066*	0.069**	0.069**	0.067*	0.062*
	(0.037)	(0.035)	(0.034)	(0.035)	(0.034)	(0.033)
PPB x female	-0.045*	-0.042*	-0.040*	-0.041*	-0.039*	-0.033
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)	(0.024)
R-squared	0.194	0.198	0.198	0.199	0.199	0.199
Number of observations	8,028	8,028	8,028	8,028	8,028	8,028
Specification						
Baseline controls	X	X	X	X	X	X
Peers' parents' education		X	X	X	X	X
Peers' parents' income			X	X	X	X
Peers' parents' hukou status				X	X	X
Proportion of peers female					X	X
Peers' cognitive ability scores						X

Note: this table is the analog to Table 8, but using the index for boy peers' parents' beliefs instead of that for all peers' parents. It shows a series of horse-race regressions, including additional independent variables as listed in the "specification" legend at the bottom of the table, to assess the relative importance of peer parent beliefs and other determinants of peer effects.

Table A.10: Analog to Table 8 - horse race regressions, using the boy peers' parents' beliefs measure and removing own parent beliefs

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A outcome: Believes boys are better than girls at learning math						
Peer parent beliefs (PPB)	0.033**	0.029**	0.028**	0.026*	0.025*	0.020
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
PPB x female	-0.022	-0.018	-0.019	-0.019	-0.018	-0.010
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
R-squared	0.084	0.086	0.086	0.086	0.087	0.089
Number of observations						
Panel B outcome: Midterm math test score						
Peer parent beliefs (PPB)	0.076**	0.061*	0.064*	0.063*	0.061*	0.056*
	(0.037)	(0.035)	(0.034)	(0.034)	(0.034)	(0.032)
PPB x female	-0.057***	-0.053**	-0.052**	-0.052**	-0.051**	-0.044*
	(0.024)	(0.023)	(0.023)	(0.024)	(0.024)	(0.025)
R-squared	0.188	0.192	0.193	0.193	0.193	0.194
Number of observations						
Specification						
Baseline controls	X	X	X	X	X	X
Peers' parents' education		X	X	X	X	X
Peers' parents' income			X	X	X	X
Peers' parents' hukou status				X	X	X
Proportion of peers female					X	X
Peers' cognitive ability scores						X

Note: this table is the analog to Table 8, but using the index for boy peers' parents' beliefs instead of that for all peers' parents, and excluding the own parent beliefs variable and its interaction with student gender from the right hand side of the estimating equation. It shows a series of horse-race regressions, including additional independent variables as listed in the "specification" legend at the bottom of the table, to assess the relative importance of peer parent beliefs and other determinants of peer effects.

Table A.11: Analog to Table 9 - effects by duration of exposure after removing own parent beliefs

	Believes boys are better than girls at learning math		*Perceived difficulty of current math class*		*Midterm math test score*	
	(1) Grade 7	(2) Grade 9	(3) Grade 7	(4) Grade 9	(5) Grade 7	(6) Grade 9
Peer parent beliefs (PPB)	0.004	0.028	0.004	-0.030**	0.039	0.086*
	(0.028)	(0.018)	(0.023)	(0.014)	(0.068)	(0.045)
PPB x female	-0.020	0.017	0.018	0.038***	-0.048	-0.123***
	(0.020)	(0.018)	(0.012)	(0.013)	(0.032)	(0.046)
Female	-0.163***	-0.083*	0.010	0.129***	0.315***	0.078
	(0.038)	(0.048)	(0.033)	(0.033)	(0.061)	(0.093)
Mean in sample	0.504	0.572	0.546	0.619	-	-
Observations	5,571	2,794	5,706	2,829	5,585	2,749

Note: this table is the analog to Table 9 but excluding the own parent beliefs variable and its interaction with student gender from the right hand side of the estimating equation. It presents results for the effect of exposure to peers whose parents believe $B_m > G_m$ on children's beliefs and performance, estimated separately for those in grade seven and those in grade nine. Those in grade nine have been exposed to their peers for two years longer than those in grade seven. The dependent variable in columns 1-2 are coded as 0 = No, 1 = Yes. In columns 3-4, the dependent variable is coded as 0 for low perceived difficulty and 1 for high perceived difficulty. In columns 5 and 6, the dependent variable is continuous with SD = 1.

Table A.12: Analogue to Table 9 - effects by duration of exposure, only schools with grade 9

	Believes boys are better than girls at learning math		*Perceived difficulty of current math class*		*Midterm math test score*	
	(1) Grade 7	(2) Grade 9	(3) Grade 7	(4) Grade 9	(5) Grade 7	(6) Grade 9
Peer parent beliefs (PPB)	0.030	0.034**	0.006	-0.028	-0.089	0.046
	(0.032)	(0.017)	(0.034)	(0.020)	(0.065)	(0.032)
PPB x female	0.021	0.025	0.035	0.029**	-0.030	-0.089***
	(0.022)	(0.020)	(0.024)	(0.015)	(0.050)	(0.030)
Own parent beliefs (OPB)	0.285***	0.299***	-0.051**	-0.076***	0.165***	0.135***
	(0.027)	(0.028)	(0.026)	(0.029)	(0.039)	(0.050)
OPB x female	0.012	0.032	0.130***	0.187***	-0.307***	-0.291***
	(0.033)	(0.033)	(0.040)	(0.040)	(0.067)	(0.064)
Female	0.116	0.293**	-0.110	0.155	0.946***	1.087***
	(0.259)	(0.141)	(0.146)	(0.128)	(0.384)	(0.365)
Mean in sample	0.521	0.571	0.533	0.617	-	-
Observations	2,849	2,643	2,915	2,674	2,846	2,600

Note: This table presents results for the effect of exposure to peers whose parents believe $B_m > G_m$ on children's beliefs and performance, estimated separately for those in grade seven and those in grade nine, and restricting our sample to only schools that maintain the random assignment introduced in grade 7 through to grade 9. The dependent variable in columns 1-2 are coded as 0 = No, 1 = Yes. In columns 3-4, the dependent variable is coded as 0 for low perceived difficulty and 1 for high perceived difficulty. In columns 5 and 6, the dependent variable is continuous with SD = 1. In Table A.11, we show the analog to these results generated without own parent beliefs on the right hand side.

Table A.13: Analog to Table 12 - the moderating role of friends in class

	(1) Believes $B_m > G_m$	(2) Perceived difficulty	(3) Aspires to BA or higher	(4) Math test score
Peer parent beliefs (PPB)	0.015	0.002	-0.002	-0.002
	(0.022)	(0.018)	(0.023)	(0.053)
PPB x female	0.018	0.016	-0.033	-0.159***
	(0.024)	(0.022)	(0.021)	(0.063)
PPB x number of friends in class (FIC)	0.002	-0.005	0.001	0.016
	(0.004)	(0.004)	(0.004)	(0.010)
PPB x female x FIC	-0.005	0.003	0.013**	0.027*
	(0.007)	(0.006)	(0.006)	(0.015)
FIC	0.012***	-0.009**	0.014***	0.009
	(0.005)	(0.004)	(0.004)	(0.010)
FIC x female	-0.009	-0.004	-0.010*	0.010
	(0.007)	(0.006)	(0.006)	(0.013)
Female	-0.106***	0.061*	0.122***	0.197***
	(0.040)	(0.032)	(0.027)	(0.072)
Mean in sample	0.526	0.570	0.658	-
Number of observations	8,182	8,329	8,311	8,137

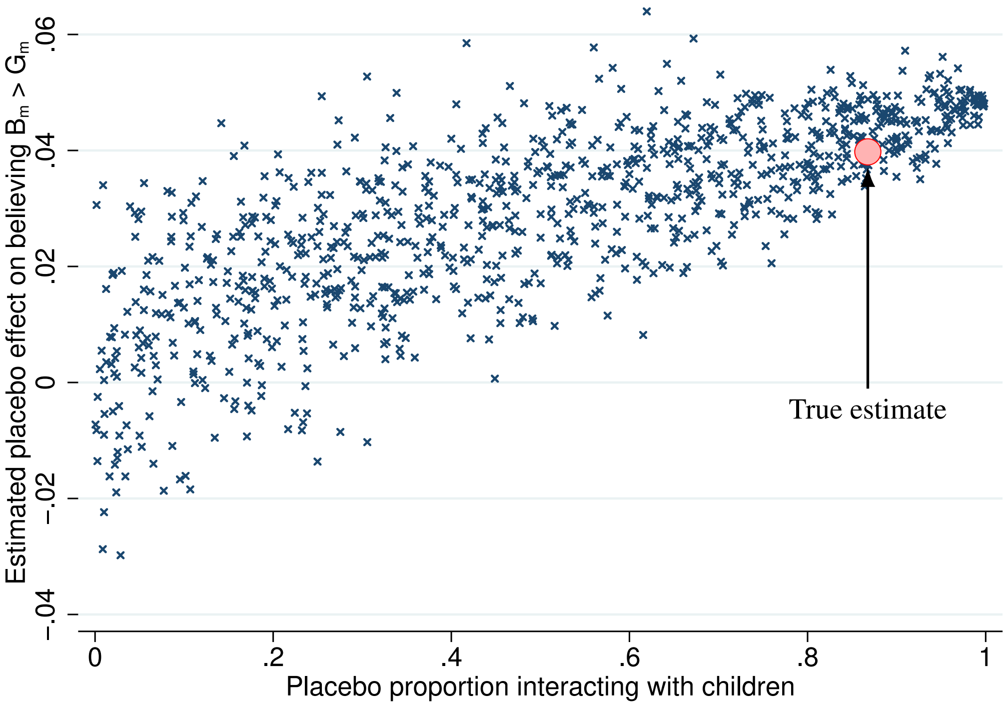
Note: this table is the analog to Table 12 but excluding the own parent beliefs variable and its interaction with student gender from the right hand side of the estimating equation. It shows results from estimating equation 1 with the addition of four variables: number of close friends in the child's class (FIC), FIC interacted with child gender, FIC interacted with peer parent beliefs, and FIC interacted with peer parent beliefs and child gender. Note that in this new specification, the estimate on peer parent beliefs now shows the effect for a child with no friends in her randomly assigned class, and the FIC coefficients show the estimated effect of one additional friend being in the class or the interaction of this with other variables, as specified. The dependent variables in columns 1 and 3 are coded as 0 = No, 1 = Yes. In column 2, the dependent variable is coded as 0 for low perceived difficulty and 1 for high perceived difficulty. In column 4, the dependent variable is continuous with SD = 1.

Appendix: interaction between peer parents and children

We would like to measure the extent to which belief transmission from peer parents travels from the peer parent to the peer, and then to the child, as opposed to directly from the peers' parents to the child. Our best proxy for this is to use the variable which records each parent's response to the question of whether or not she knows at least some of her child's friends. We interact this with the peer parent beliefs test, generating an alternative measure of peer parent beliefs: a measure of the proportion of parents who report knowing their child's friends *and* who believe $B_m > G_m$. We call this "PPB_{int}." We then substitute PPB_{int} for our normal peer parent beliefs measure in equation 1, and estimate the effect of exposure to *this* type of peer on whether or not the child herself believes that boys are better than girls at learning math. This generates an estimate of β_1 of 0.41, slightly smaller than the 0.46 we get with the un-interacted measure of peer parent beliefs in Table 4.

To simulate how our estimate of β_1 for PPB_{int} varies with the proportion of parents included in the measure, as opposed to the proportion who actually interact with their children's friends, we run another simulation. We generate 1,000 draws of a random variable, uniformly distributed between 0 and 1, for the "placebo" proportion of parents who interact with their children's friends. For each draw, we then generate a new random variable for each child's parent with the same potential values (0/1) as the interaction and the same expected value as that draw's overall placebo proportion of parents who interact with their children's friends. We use this to generate a new, placebo PPB_{int} variable for each child within her classroom. We use this to then generate an estimate of β_1 for each of these 1,000 placebo versions of PPB_{int}. We plot these in Figure A.3, overlaying onto the plot the original estimate of β_1 for the true PPB_{int} variable. This plot shows a monotonic increase in effect size as the proportion increases. Furthermore, the estimate of β_1 for the true PPB_{int} variable falls well within the range of estimates for placebo interaction levels similar to the true interaction level. This suggests that the true variable has no more descriptive power than a random sample of an equal proportion of parents (who may or may not interact with their children's friends).

Figure A.3: Simulation: placebo interaction between parents and kids and belief transmission



This figure shows the 1,000 estimates of β_1 generated using 1,000 draws of placebo PPB_{int} variables, i.e., interacting the peer parent beliefs variable with a random variable (possible values 0/1) with expected value of each draw (itself sampled randomly from the uniform distribution over [0,1] for each draw) shown on the x-axis.