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Cognitive ability and academic performance among left-behind children: evidence from rural China

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ABSTRACT
Little attention has been paid to the role that low levels of cognitive development (or IQ) play among both left-behind children (LBCs) and children living with parents (CLPs) in the context of poor educational attainment in rural China. In this paper, we examine how general cognitive abilities contribute to the academic achievement gains of both LBCs and CLPs in poor areas of rural China. We measure the general cognitive ability of the 4,780 sample students using the Raven's Standard Progressive Matrices (Raven IQ) and assess academic achievement using a curriculum-based mathematics exam. We find that IQ and left-behind status predict achievement gains for the average student. Among low-IQ students, however, left-behind status does not correlate with a change in achievement, suggesting that the migration of parents does not immediately/automatically translate into a loss of academic achievement for students with delays in their general cognitive ability.

KEYWORDS
Cognitive abilities; academic achievement; left-behind children; primary school; rural China

Introduction

With China's rapid rate of development and urbanisation, during the last three decades, an increasing number of rural residents have migrated to urban areas for better jobs (Hu, Cook, and Salazar 2008; Wen and Lin 2012). At the same time, however, because of financial constraints, the absence of social services (due to the Hukou household registration system), and the transient nature of work in urban areas, a great number of children have found themselves in home communities without sufficient parenting. (Duan and Zhou 2005; Ye et al. 2006). Consequently, a new subpopulation of children, known as the 'left-behind children' (henceforth LBCs), who have been left in the countryside while their parents (henceforth migrant parents) migrate for work, has emerged in China (Duan and Zhou 2005). In recent decades, the size of the LBC population has increased dramatically, reaching over 60 million in 2010 as statistics from the Sixth Population Census suggest (National Bureau of Statistics of China 2016).

Numerous researchers have expressed concerns that when children are left behind, they risk facing negative effects on education, health, and, ultimately, overall human capital accumulation (Meyerhoefer and Chen 2011; Zhao et al. 2014) Therefore, the focus of many

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of the recent studies in the literature has been whether there is a difference between LBCs and children living with parents (henceforth CLPs). (Zhou, Murphy, and Tao 2014; Zhang et al. 2014; Yue et al. 2016). The increased parental out-migration may directly exacerbate educational inequality in the short run and indirectly exacerbate income inequality in the long run. With this understanding, the Chinese government has issued plans and implemented programmes to solve this problem. (National Bureau of Statistics of China 2016). For example, the government has in recent years developed pilot programmes to train and place mental health counsellors in schools to help LBCs cope with the absence of their parents (Jiangxi Department of Education 2013). Another programme was developed to train 'barefoot social workers' who work to ensure access to social services for LBCs (Wang 2017).

Literature has emerged suggesting that, while vulnerable, LBCs may not be the most, or only, vulnerable group of children in rural China. Researchers have found that, in certain cases, the outcomes for LBCs are the same as – or even better than – those for rural CLPs. For example, research by Luo et al. (2015) has shown that there are no differences in mental or psychomotor development between infants raised by their mothers and those raised by their grandmothers. Zhou et al. (2015) found few significant differences between school-aged LBCs and CLPs in any measures of health, nutrition, or education of school-aged children. Additionally, in the two cases where significant differences were found between these groups (soil-transmitted helminth infection and refractive error rates), LBCs exhibited better outcomes than CLPs. In this case, the differences between LBCs and CLPs are not the most important factors to examine. Instead, what makes both groups vulnerable (health concerns) is more worthy of attention and research.

These findings may arise because both LBCs and CLPs may express delayed cognitive development. Recent research suggests that students in rural China may experience persistent cognitive delays beginning in early childhood. Several recent studies of rural infants and toddlers have found that nearly half of rural children under the age of 3 are at risk for cognitive delay (Wang et al. 2018; Luo et al. 2019; Yue et al. 2017). Given the scale of such a trend, low levels of cognitive abilities might very well be inhibiting the academic achievement of students in rural China, contributing to the overall low levels of human capital in rural China.

To our knowledge, however, little attention has been paid to the role low levels of cognitive development play among both LBCs and CLPs in the context of poor educational attainment in rural China. To fill this gap, this study aims to estimate the effect of cognition on the educational performance of both LBCs and CLPs in elementary schools in rural China. To meet this goal, we first measure cognition in a sample of elementary school-aged students using a Raven Intelligence Quality, or IQ, scale. Second, we seek to identify the characteristics of students in these schools who are left behind. Third, we investigate whether being left-behind has different impacts on students with low IQ and normal IQ.

Materials and methods

Study area and sampling

We collected data from three counties in southern Jiangxi Province, China. The three counties, which lagged behind other regions in the province as well as the national average in terms of economic development, were designated as low-income counties

(State Council Leading Group Office of Poverty Alleviation and Development 2012). In 2015, more than 80% of the population of these three counties were rural residents, and their per capita GDP was less than 20,000 yuan (2,858 USD), only 40% of that of the national average (Ganzhou Municipal Bureau of Statistics & Survey Office of the National Bureau of Statistics in Ganzhou 2016; National Bureau of Statistics of China 2016). In sum, these three counties share characteristics of a typical low-income county in China. (Fang 2017; Ganzhou Municipal Bureau of Statistics & Survey Office of the National Bureau of Statistics in Ganzhou 2017; Huichang County Chronicles Compilation Committee 2010; Ruijin People's Government 2018).

The first step in our study design was to select a representative sample of schools from the three counties. We used official records from the County Education Department to create a demographic structure for all local public elementary schools. With a sampling rate proportional to the total number of schools, we randomly selected 120 out of a total of 458 schools. Among them, there were 37 schools in County A (30.8%), 25 schools in County B (20.8%), and 58 schools in County C (48.3%).

After selecting our sample schools, we then sampled classes and students from the fourth and fifth grades of each sample school. Due to limited financial support, we randomly selected at most two classes in each grade per school. In cases where there were only one or two classes in a grade, all classes in this grade were selected. We went on to survey half of all students in the sampled classes, in total surveying 4,780 students in 288 classes across 120 schools.

Data collection

After selecting the sample, we conducted the two waves of the survey. We first surveyed our sample at the end of the school year in May 2017, when they were fourth and fifth-grade students, and returned and surveyed the same students at the end of the academic year in May of 2018, when they were in grades four and five. These surveys included a 30-min standardised mathematics test, an IQ scale, and an eight-page student survey questionnaire.

In the first block of the student survey, we administered all sample students (4,780) a standardised maths test, where we gave separate tests for grade-four and grade-five students. Each test had 30 questions chosen from the Trends in International Mathematics and Science Study (TIMSS) test data bank, and all questions were consistent with the curriculum being taught in all sampled schools. The TIMSS test is one of the most common instruments for measuring academic performance in mathematics for primary school students in the world (Mullis et al. 2012) and in China (Zhao et al. 2014). We normalised test scores using the mean and distribution in the group with estimated effects expressed in standard deviations.

In the second block of the student survey, we measured the general cognitive ability of the students in 2017 using the Raven's Standard Progressive Matrices test (Zhang 2009). For simplicity, we refer to this assessment in the rest of the paper as the Raven's test. Originally designed by British psychologist J.C. Raven, the Raven's test is a nonverbal (language-neutral) intelligence test comprised entirely of pictorial questions related to spatial reasoning and pattern-matching. The Raven's test of cognitive skills is a cross-cultural reasoning tool and is one of the most commonly used tests in the world (Borghans et al. 2016). The test is divided into five parts, and each part has 12 questions sorted according to difficulty. The total score on these 60 questions is calculated based on an established norm to assign a final IQ.

Choosing an appropriate norm is important in order to compensate for the Flynn effect, a phenomenon in which the average IQ for a population rises over time (Raven 2000; Liu and Lynn 2013). To that end, we adopted a version of the test with an original norm that came from a 1989 assessment by Zhang Houcan (Zhang 1989). This is an older version of the test, which was chosen because there was no recent version available for Chinese populations. Several recent studies in China have also used this testing scale and published their results (Zhou et al. 2015; Lai et al. 2016; Liu et al. 2016). Although we used a test that was initially normalised in China nearly 30 years ago, this is not unusual. For instance, studies conducted in Japan in the 1990s (Shigehisa and Lynn 1991) used norms established by Jensen and Munro in 1979. Nevertheless, we recognised the need to compensate for using a nearly 30-year-old norm in our Raven's test. Because Raven's test scores generally change at the same rate across cultures and time (Raven 2000), we adjusted our final scores by using a Flynn effect of 6.19, which was given in a 2013 study of increasing scale norms from 1986 to 2012 (Liu and Lynn 2013).

Students who scored lower than 85 (1 standard deviation below the normal mean of 100, the internationally recognised cut-off for low IQ) were considered cognitively delayed. We also generated a dummy variable to distinguish students whose IQ was lower than the mean (IQ = 100).

In the third block of the survey, we collected data on student and family characteristics. Students were administered a questionnaire asking about their gender, age, boarding status, father's education level, mother's education level, and family asset value (indicators of wealth in the family).[1] A summary of student and family characteristics is presented in Table 2.

We also generated variables from the questionnaire to determine the migration status of each student's parents. For the students in the sample, the migration status of their parents allowed us to identify children living with parents (CLPs) and left-behind children (LBCs). CLPs are those students that have been living at home under the care and oversight of one or both of their parents for more than six out of the past 12 months. LBCs, in contrast, are students whose parents have both migrated and been gone for more than six out of the past 12 months. This definition is commonly used in other studies in China (Wang et al. 2019; Zhou et al. 2015; Zhou, Murphy, and Tao 2014; Wen and Lin 2012). CLPs and LBCs both attend rural public schools.

Statistical approach

Our analysis is comprised of three parts. First, we describe the distribution of IQ scores across our sample. We conduct t-tests to identify IQ scores, the percentage of students with low IQ scores, maths scores, and student and family characteristics of CLPs and LBSs. We also conduct t-tests to identify student and family characteristics that are associated with different levels of IQ and maths scores. The t-tests compare the mean Raven's IQ and maths scores of students in different individual and family characteristic groups (e.g. male & female; boarding & not boarding; father migrated & father not migrated) to identify specific personal and family characteristics that correlate with being vulnerable to cognitive delay and lower academic performance.

Second, we examine the relationship between student IQ and academic achievement as well as between grit and academic achievement while controlling for student and family characteristics. To do so, we run an ordinary least squares (OLS) regression model using the following equation:

$$Y_{ij} = \alpha_0 + \beta IQ_{ij} + \gamma LBC_{ij} + \delta X_{ij} + \theta \tau_j +_{ij} \quad (1)$$

using a value-added model, where the dependent variable Y_{ij} indicates the academic achievement of student I in class j at the end of 2018 (standardised achievement scores, converted into z-scores using the mean and standard deviation of the achievement distribution) of student i in class j. IQ_{ij} is the cognitive skills of student i, presented as IQ test scores; LBC_{ij} is a variable representing whether student i is a left-behind child. The coefficients β and γ are the coefficients we are interested in as they measure the correlation between IQ_i, LBC_i, and student academic achievement.

The vector X_{ij} is a vector of individual and family characteristics which we use as control variables. Student individual characteristics include gender (1 if female), boarding status (1 if boarding at school), and academic performance in 2017 (measured by standardised maths test scores). The family characteristic vector includes measures of parental education level (dummy variables for whether the father/mother of the student has graduated from junior high school), as well as a household consumption asset index.

We also include class-level dummy variables to control for variation in classroom characteristics (represented by $\tau_j$in the equation). Here, i represents each of the observations and ε represents random error that exists in a normal distribution.

To examine whether higher IQ (IQ≥85 & IQ≥100) has a greater impact on certain subgroups, we use a heterogeneous effects model to estimate treatment parameters. The heterogeneous effects model is essentially equation (1) with an additional interaction term between the higher-IQ variable (IQ higher than 85 & IQ higher than 100) and parental migration variable (LBCs and CLPs).

Third, using the same value-added model, we examine the effects of being left behind and IQ, respectively, on achievement gains for students with different levels of cognitive ability. To do so, we divide our sample students into two groups. The first group is ‘low-IQ students,’ students with IQ scores below 85 (the internationally recognised cut-off for low IQ). The second group is ‘normal-IQ students,’ students with IQ scores above 85. We use equation (1) to identify the contributions of IQ and being left behind towards academic achievement (controlling for student and family characteristics) for each group.

Results

Distribution of cognitive ability and academic performance

According to our data, a relatively large share of students in our sample are cognitively delayed. Figure 1 presents the distribution of IQ scores in our sample. The mean IQ for sample students is 91.9, and the share of students with a low IQ (defined as IQ below 85) is 27%.

The distribution is skewed to the left of the normally distributed set of scores, indicating that a large proportion of students face cognitive delays. A normal population,

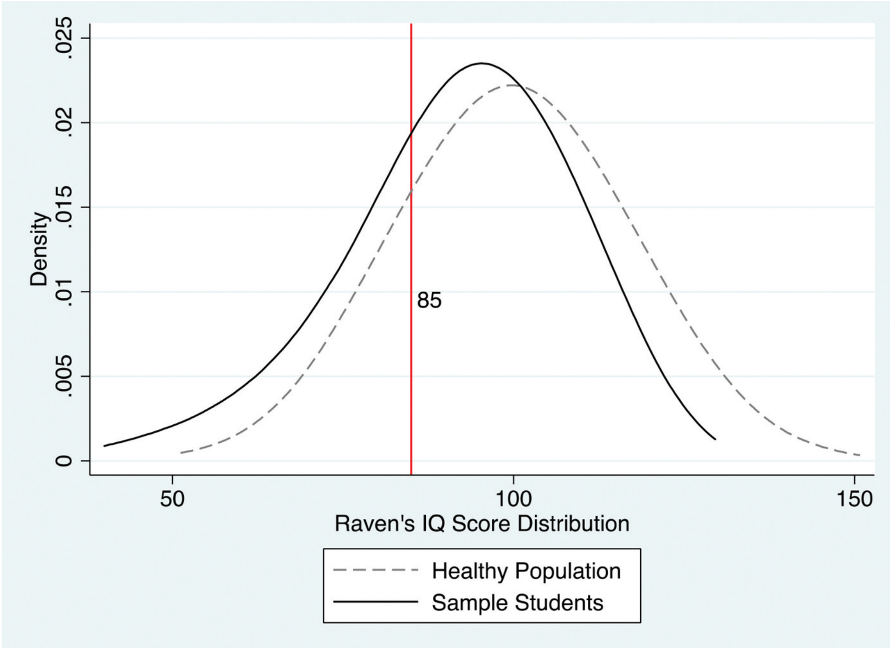

Figure 1. Distribution of Raven's IQ scores for sample students compared to healthy population. Note 1: The cut-off of low IQ is 85, visualised with a vertical-red line. Using this cut-off, we calculated that across all schools and counties, 1289 of the 4780 students surveyed were cognitively delayed, a population incidence of 27%.

by definition, has about 15% of its subjects scoring one or more standard deviations below the mean. Hence, our results show that the rate of low IQ is much higher in rural China than in a normal population. But this rate is, however, slightly lower than the rates found in studies of infants and toddlers in rural China (Wang et al. 2018; Luo et al. 2019), including toddlers from the same region as students in our sample (Yue et al. 2017). Furthermore, our results are almost identical to a 2019 study from Zhao et al., which shows that 33% of rural students are developmentally delayed (with an IQ of less than 85) using survey data from 59 private schools for rural migrants in Beijing and Suzhou and 60 rural public schools in Henan and Anhui provinces (Zhao, Wang, and Rozelle 2019). Together with the results from these previous studies, our findings suggest that there are high rates of developmental delay among students throughout rural China and that the delays are correlated with poor educational performance.

To see if there are differences between left-behind children (LBCs) and children living with parents (CLPs) in terms of IQ and academic performance, we perform t-tests to identify differences in IQ scores, the percentage of low-IQ students, and two waves of maths scores (maths scores from the 2017 and 2018 survey waves) of LBCs and CLPs. The results are presented in Table 1. We find that there is no significant difference between LBCs and CLPs in any of these outcomes, implying that parental migration generally does not improve the cognitive ability and academic performance of primary school students. A study by Chen et al. similarly found no difference between LBCs and CLPs in educational attainment (Chen et al. 2014). However, in the 2019 study from

Table 1. Summary statistics of sample students.

Variables	Definition	Total Mean (Std. Dev)	CLPs (1) Mean (Std. Dev)	LBCs (2) Mean (Std. Dev)	Difference (2)-(1)
IQ scores	Raven's IQ test scores	91.86 (14.64)	91.74 (14.90)	91.97 (14.38)	0.23
IQ higher than 85	1 = IQ≥85; 0 = IQ<85	0.73 (0.44)	0.73 (0.45)	0.73 (0.44)	0.01
IQ higher than 100	1 = IQ≥100; 0 = IQ<100	0.31 (0.46)	0.32 (0.47)	0.30 (0.46)	−0.02
Academic performances in 2018	Standardised maths score of 2018	0.00 (1.00)	0.02 (1.01)	−0.02 (0.99)	−0.04
Academic performances in 2017	Standardised maths score of 2017	0.00 (1.00)	−0.01 (1.01)	0.01 (0.99)	0.02
No. of observations		4780	2389	2391	

Data source: Author's survey. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 2. Difference between left-behind children and children living with parents.

Variables	Definition	Total Mean (Std. Dev)	CLPs (1) Mean (Std. Dev)	LBCs (2) Mean (Std. Dev)	Difference (2)-(1)
Gender	1 = female; 0 = male	0.50 (0.50)	0.51 (0.50)	0.50 (0.50)	−0.01
Grade	1 = 5th grade; 0 = 4th grade	0.52 (0.50)	0.53 (0.50)	0.51 (0.50)	−0.02
Student age	age measured by years	10.88 (0.84)	10.90 (0.84)	10.87 (0.83)	−0.03
Boarding status	1 = boarding; 0 = not boarding	0.11 (0.32)	0.11 (0.31)	0.12 (0.32)	0.01
Number of siblings	the number of siblings	2.25 (1.58)	2.31 (1.66)	2.19 (1.50)	−0.12***
Father education level	1 = at least 9 years; 0 = less than 9 years	0.58 (0.49)	0.56 (0.50)	0.61 (0.49)	0.05***
Mother education level	1 = at least 9 years; 0 = less than 9 years	0.42 (0.49)	0.37 (0.48)	0.47 (0.50)	0.10***
Household consumption asset index	numeric; Continuous variable of family assets	0.00 (1.06)	−0.10 (1.09)	0.11 (1.03)	0.21***
Number of observations		4780	2389	2391	

Data source: Author's survey. *** p < 0.01, ** p < 0.05, * p < 0.1.

Zhao et al., LBCs were found to have lower IQ scores than CLPs, and the LBC group contained a higher proportion of low-IQ individuals. In that study, however, differences in maths scores between the two groups were not investigated, nor were any impacts of being left behind on low-IQ students.

For personal and family characteristics, presented in Table 2, we find several differences between LBCs and CLPs. Left-behind children tend to have fewer siblings, but their parents generally have higher levels of education and their family has higher family assets, which is consistent with the literature. With more children at home, parents may be less likely to migrate to the city for work, potentially explaining the fact that the CLPs in our sample have more siblings. Parents with a higher level of education (which translates into superior labour skills and better job opportunities) are more likely to migrate for work, leaving their children behind in rural areas. While parents with lower education are mostly farmers or work at nearby low-tech factories, migrant workers can obtain higher salaries, resulting in relatively higher family assets for families of LBCs (Zhou, Murphy, and Tao 2014; Yue et al. 2016; Chen et al. 2014; Gao et al. 2010)

To help identify students that may be vulnerable to cognitive delay and low academic performance, Table 3 presents the results of statistical tests attempting to identify the differences in cognition scores (IQ scores) and maths scores among students of different characteristics and family backgrounds. We find that parental education levels are significantly correlated with both student IQ and maths score. Students whose parents received more than 9 years of schooling have IQ scores that are 2.27 points (fathers) and 0.80 points (mothers) higher than students whose parents received less than 9 years of schooling (significant at the 1% & 10% levels, respectively). Students with more educated parents score 0.21 points higher on the 2018 maths exam and 0.17 higher points on the 2017 maths exam (fathers) and 0.07 points higher in both years (mothers). Students with more educated parents also have higher in IQ scores (significant at the 1% & 5% levels, respectively).[2]

We find that certain characteristics are correlated with maths scores, but not IQ scores. Boys have maths scores that are 0.16 points higher than girls in 2018 and 0.12 points higher than girls in 2017 (significant at the 1% level), which agrees with the findings of Else-Quest, Hyde, and Linn (2010). Students boarding at school score 0.12 points lower on the 2018 maths exam and 0.10 points lower on the 2017 maths exam than students who live at home (significant at the 5% level), which is similar to the findings of Kannangara et al. (2018).

Table 3. IQ and maths scores comparisons between different subgroups of students.

Variables		Obs.	Mean IQ Score	Difference Between Groups	Mean Maths Score 2018	Difference Between Groups	Mean Maths Score 2017	Difference Between Groups
Left-behind child status	Left behind	2391	91.97	0.23	−0.02	−0.04	0.01	0.02
	Live with parents	2389	91.74		0.02		−0.01	
Gender	Male	2371	91.60	−0.50	0.08	0.16***	0.06	0.12***
	Female	2409	92.10		−0.08		0.07	
Boarding status	Boarding	535	90.91	−1.07	−0.11	−0.12**	−0.09	−0.10**
	Not boarding	4245	91.98		0.01		0.01	
Only child	Yes	138	91.13	−0.75	0.13	0.13	−0.08	−0.08
	No	4642	91.88		−0.00		0.00	
Father education level	At least 9 years	2787	92.80	2.27***	0.09	0.21***	0.07	0.17***
	Less than 9 years	1993	90.53		−0.12		−0.10	
Mother education level	At least 9 years	2005	92.32	0.80*	0.04	0.07**	0.04	0.07**
	Less than 9 years	2775	91.52		−0.03		−0.03	
Household consumption asset index	Over average	2120	91.67	−0.48	−0.03	−0.07**	−0.01	−0.04
	Below average	2596	92.15		0.04		0.03	

For definition of Variables see Table 1. Data Source: Author's survey. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

We also find that students from less wealthy families are more likely to score higher on the 2018 maths exam compared to students from wealthier families. Students with family asset values in the bottom half score higher than students with family asset values in the top half by 0.07 points (significant at the 5% level). In fact, the relationship between family asset value and maths score in our sample is not surprising, as students in our sample all have relatively low family assets. Among them, families invest less in fixed assets[3] may invest slightly more resources in their children's nutrition and learning. Poverty has been shown to affect the nature of a family's child-rearing environment and poor environmental factors are closely associated with poor developmental outcomes of infants and toddler during early childhood (Parker, Greer, and Zuckerman 1988; Duncan and Brooks-Gunn 2000). If the children in our sample are suffering from early childhood cognitive delays due to persistent and ongoing poverty, the absence of resources could exacerbate these delays. Poverty hinders academic performance, leading students from poor households to perform worse than their peers (Kautz et al. 2014).

IQ, LBC and gains in academic achievement

Table 4 presents the relationships between academic achievement and both IQ and parental migration (controlling for student and family characteristics).

According to the findings, IQ score can significantly affect academic achievement. In our sample, a one-point increase in IQ score corresponds to a 0.01 standard deviation (SD) increase in academic achievement (row 1, columns 1 & 2, significant at 1%). 14.64 IQ points is equal to one SD. This means that a one-SD increase in IQ scores is correlated with a 0.15 SD increase in academic achievement, equal to almost half a year of learning (Hill et al. 2008; Li, Loyalka, and Rozelle 2020).[4]

Furthermore, students in the higher-IQ group have significantly higher academic achievement than students in the lower IQ group. Students with an IQ higher than 85 score 0.26 SD above students with a lower IQ (row 3, column 3; significant at 1%), and students with an IQ higher than 100 score 0.29 SD above students with a lower IQ (row 3, column 4, significant at 1%). These differences are equivalent to nearly 1 year of schooling (Hill et al. 2008; Li, Loyalka, and Rozelle 2020). In other words, students with lower IQ are up to one grade level behind their higher-IQ peers. It is clear that a student's IQ is an important determinant of gains in academic achievement.

However, we find that parental migration is not associated with academic achievement, regardless of whether we control for IQ scores and use a lower IQ dummy variable (row 2, columns 2, 5, 6 & 7).

We are interested in determining whether higher IQ (IQ≥85 & IQ≥100) has a differential impact on different subgroups of students. To test this, we examine heterogeneous effects by applying the treatment variable separately to left-behind children (LBCs) and children who live with parents (CLPs). This analysis shows no significant heterogeneous impacts of higher IQ on student academic achievement for these two subgroups (Table 4, row 5, column 6 & row 6, column 7). We do find, however, that the coefficient of students with 'normal' IQs (not cognitive delayed, IQ≥85) for CLP (0.27, Showing in the bottom of Table 4, significant at 1%) is higher than that for LBCs (0.25, significant at 1%). This means that for students with normal IQs, living with their

Table 4. Relationship between maths score, IQ, left-behind status for full sample.

	Academic Performances in 2018						
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
IQ scores	0.01***	0.01***					
	(0.00)	(0.00)					
Left-behind child status (1 = left behind)		−0.03			−0.03	−0.01	−0.04
		(0.02)			(0.02)	(0.04)	(0.03)
IQ higher than 85			0.26***			0.27***	
			(0.03)			(0.04)	
IQ higher than 100				0.29***			0.27***
				(0.03)			(0.03)
Interaction (Higher IQ85*LBC)						−0.03	
						(0.05)	
Interaction (Higher IQ100*LBC)							0.04
							(0.05)
Academic performances in 2017	0.55***	0.55***	0.59***	0.58***	0.64***	0.59***	0.58***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Gender (1 = female)	−0.12***	−0.12***	−0.11***	−0.11***	−0.11***	−0.11***	−0.11***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Student age (years)	−0.02	−0.02	−0.04***	−0.04**	−0.06***	−0.04***	−0.04**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Number of siblings	−0.01**	−0.01**	−0.02**	−0.02**	−0.02***	−0.02***	−0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Boarding status (1 = boarding at school)	−0.04	−0.04	−0.05	−0.04	−0.06	−0.05	−0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Father education level (1 = at least 9 years)	0.08***	0.08***	0.08***	0.08***	0.08***	0.09***	0.08***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Mother education level (1 = at least 9 years)	−0.03	−0.03	−0.04	−0.04	−0.03	−0.03	−0.03
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Household consumption asset index	−0.00	−0.00	−0.00	−0.00	−0.00	0.00	−0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Class fixed effect	yes	yes	yes	yes	yes	yes	yes
Constant	−1.15***	−1.11***	−0.00	0.01	0.41	0.02	0.04
	(0.31)	(0.31)	(0.30)	(0.30)	(0.30)	(0.30)	(0.30)
Observations	4,780	4,780	4,780	4,780	4,780	4,780	4,780
R-squared	0.569	0.570	0.561	0.564	0.551	0.561	0.564
Coefficient of normal-IQ left-behind students						0.25***	
						(0.04)	
Coefficient of normal-IQ students who live with parents						0.27***	
						(0.03)	

For definition of Variables see Table 1. Data Source: Author's survey. *** p < 0.01, ** p < 0.05, * p < 0.1

parents benefits them slightly more in terms of academic performance than their peers who are left behind.

We additionally examine the strength of the relationship between IQ and academic achievement gains relative to other factors that may also be associated with academic achievement. To do so, we compare the effect sizes of a one-SD shift in IQ to that of the other statistically significant explanatory variables, namely, the gender dummy, number of siblings, and father's education level (Table 4, column 2). After comparing the effect sizes, it is clear that IQ has a much stronger influence: a one-SD difference in IQ is associated with a 0.15 SD increase in academic achievement, much higher than the increases caused by a difference of gender (−0.12 SD), number of siblings (−0.01 SD) and father's education level (0.08 SD).

Academic achievement among low- and normal-IQ students

Finally, we isolate the contributions of IQ and parental migration (LBCs and CLPs) to academic achievement gains for low-IQ students and normal-IQ students. The results of this analysis are presented in Table 5. For both groups, IQ is still a significant predictor of academic achievement gains. A one-point increase in IQ score corresponds with an increase in academic achievement gains of 0.01 SD for low-IQ students (row 1, columns 1; significant at 1%) and 0.02 for normal-IQ students (row 1, columns 4; significant at 1%). In other words, a difference of one SD in IQ corresponds to about half of a year of schooling for low-IQ students and 1 year of schooling for normal-IQ students (Hill et al. 2008; Li, Loyalka, and Rozelle 2020).

Most importantly, we find that the relationship between parental out-migration (LBCs and CLPs) and academic achievement gains changes when we examine low- and normal-IQ students separately. For students in the normal-IQ group, living with parents significantly contributes to gains in academic achievement: being left behind corresponds to a decrease in academic achievement of 0.05 SD with or without controlling for IQ (row 3, columns 5 & 6, significant at 1%). For students in the low-IQ group, however, the relationship between parental out-migration and academic achievement gains is no longer statistically significant (row 3, columns 2 & 3).

This finding suggests that for students with a low IQ, parental company or other benefits students may receive from living with their parents do not improve academic achievement. The results of our study indicate that when students are cognitively delayed

Table 5. Relationship between maths score, IQ, and left-behind status by IQ subgroups.

	Academic Performances in 2018					
	IQ Lower than 85			IQ Higher than 85		
Variables	(1)	(2)	(4)	(5)	(6)	(8)
IQ scores	0.01***		0.01***	0.02***		0.02***
	(0.00)		(0.00)	(0.00)		(0.00)
Left-behind child status (1 = left behind)		−0.00	−0.00		−0.05*	−0.05*
		(0.04)	(0.04)		(0.03)	(0.03)
Academic performances in 2017	0.43***	0.45***	0.43***	0.58***	0.64***	0.58***
	(0.03)	(0.02)	(0.03)	(0.02)	(0.01)	(0.02)
Gender (1 = female)	−0.07*	−0.07*	−0.07*	−0.14***	−0.12***	−0.14***
	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
Student age (years)	0.02	0.01	0.02	−0.04*	−0.07***	−0.04**
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
Number of siblings	−0.02	−0.02	−0.02	−0.01*	−0.02**	−0.02*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Boarding status (1 = boarding at school)	−0.08	−0.07	−0.08	−0.03	−0.05	−0.03
	(0.08)	(0.08)	(0.08)	(0.05)	(0.05)	(0.05)
Father education level (1 = at least 9 years)	0.08*	0.09*	0.08*	0.08***	0.09***	0.08***
	(0.05)	(0.05)	(0.05)	(0.03)	(0.03)	(0.03)
Mother education level (1 = at least 9 years)	−0.07	−0.07	−0.07	−0.01	−0.01	−0.01
	(0.05)	(0.05)	(0.05)	(0.03)	(0.03)	(0.03)
Household consumption asset index	−0.03	−0.03	−0.02	0.01	0.01	0.01
	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Class fixed effect	yes	yes	yes	yes	yes	yes
Constant	−1.85***	−1.33**	−1.85***	−1.46***	0.79**	−1.42***
	(0.57)	(0.55)	(0.58)	(0.41)	(0.36)	(0.41)
Observations	1,289	1,289	1,289	3,491	3,491	3,491
R-squared	0.554	0.550	0.554	0.556	0.541	0.556

For definition of Variables see Table 1. Data Source: Author's survey. *** p < 0.01, ** p < 0.05, * p < 0.1.

(as defined by IQ scores below 85), the negative effects on academic performance cannot be compensated by parental company.[5]

Conclusion

This paper examines the influence of cognition on educational performance of LBCs and CLPs in elementary school in rural China. Using data from 4,780 grade four and grade five students in rural southeast China, we describe the distribution of IQ scores as well as factors correlated to IQ and maths score. Most importantly, we examine the relationship between IQ, parental out-migration, and academic achievement gains, both for the full sample and for students with low and normal IQs, respectively.

Our results show that 27% of the students in our sample are cognitively delayed. This is nearly twice the rate of cognitive delay in a normal population. However, this rate is similar to the rate of cognitive delays found in rural infants and toddlers in the same region and across rural China.

The fact that such a high proportion of students have below-average IQ is particularly troubling, as it indicates that many children are at risk of falling behind in school. In fact, we find that IQ is positively correlated with academic achievement and has the greatest association with academic achievement compared to all other student and family characteristics. Additionally, when we look at low- and normal-IQ students separately, we find that the academic achievement of low-IQ students is up to 0.26 SD behind that of normal-IQ students. We also find that the negative relationship between a child being left behind and their academic achievement is only significant among normal-IQ students. In other words, cognitive delays significantly lower the ability of students to learn at the level and pace of primary school, and parental company cannot make up for this achievement gap. Therefore, both LBCs and CLPs in rural areas of China are vulnerable and face the challenges of delayed cognitive development.

Our results indicate that poor cognition contributes to the poor educational outcomes of China's rural students, which has significant implications for China's future economic growth. China has already made plans to base its economy on higher value-added, high-wage industries, suggesting a high demand for skilled labour. International experience demonstrates that individuals will need to have acquired skills taught at the level of high school or above if they hope to be competitive in these higher value-added industries (Bresnahan and Greenstein 1999; Bresnahan, Brynjolfsson, and Hitt 2002; Katz et al. 1999). If cognitive delays are inhibiting the academic achievement of rural students, China will fail to endow its rural labour force with such skills. This deficiency not only means that many individuals may have a difficult time finding employment, but newly emerging industries may also falter from a short supply of skilled labour. As a result, China's economy may experience overall slower development. (Khor et al. 2016)

The high levels of cognitive delays, in fact, are a result of many factors at school and at home, including both poor levels of education and health inputs. The literature, however, demonstrates that to improve cognitive ability, measures must be taken as early as possible. Early childhood is the period during which the brain has the greatest malleability and neurobiological capacity for cognitive development (Heckman 2013). According to the literature, cognitive ability has usually stabilised by the time children reach adolescence (Luna et al. 2004). Therefore, we recommend that policymakers increase investments in early childhood development before children enter school.

Additionally, measures must also be taken to address the needs of current primary school students. Considering that nearly 27% of primary school students are cognitively delayed and that cognitive delays are linked to lower academic achievement, there is a need for effective programmes and education resources that address the learning needs of cognitively delayed students and prepare them for life after school.

Notes

1. To measure the household consumption asset index in our sample, we ask a series of questions related to whether the household owned certain household items, livestock, or small businesses; the material used to construct their home; and the size of their home. Most responses to household asset ownership variables in our data set are dichotomous, so we use polychoric principal component analysis (PCA – Kolenikov and Angeles 2009) to construct a standard index for household wealth among our sample students, which we refer to as the household asset index. We do so because studies suggest that using household asset indicators and PCA to construct continuous measures for household wealth is more reliable than self-reported income (for a review, see Kolenikov and Angeles 2009). The household asset index is a standardised index ranging from −2.81 to 2.12. Negative values indicate that the value of a family's household assets is below the average value for our sample.
2. This difference may be due to the fact that less educated rural parents are less likely to engage in interactive parenting practices with their children from an early age, which is important for cognitive development and future learning ability. Indeed, two studies of infants and toddlers in rural China have found that mothers with educational attainment beyond middle school (i.e. more than nine years of education) are more likely to read, sing and play with their children, leading to lower rates of developmental delay (Yue et al. 2017; Luo et al. 2017).
3. To measure the wealth of the households in our sample, we asked a series of questions related to household assets: whether the household owned certain household items, livestock, or small businesses; the material used to construct their home; and the size of their home.(Kolenikov and Angeles 2009).
4. According to a study by Hill et al. (2008), the growth of standardised mathematics scores of students is approximately 0.30 standard deviations from 6th to 7th grade, 0.32 standard deviations from 7th to 8th grade, and 0.22 standard deviations from 8th to 9th grade.
5. LBCs on average did not have any gains in maths. Among low-IQ students, the maths gains for LBCs were much less than the maths gains for CLPs. This indicates that LBCs with low IQ are facing double learning challenges. Specifically, both high levels of developmental delay and the absence of parental support may be negatively associated with academic achievement.

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Author contributions

X.H., H.W and Y.S. devised the research questions and analytical strategy. X.H. and H. W. conducted the statistical analysis. All authors collaborated on the interpretation of the results and on writing and revising the paper.

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